TECHNOLOGY FOR IMPROVED EDUCATION

RESULTS AND LEARNINGS

FROM A PROJECT IN GUATEMALA (2019 - 2020)

AMMID

MUNDO POSIBLE

60 million girls

Change for Children

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- Change for Children – managed overall project implementation and evaluation;
- Mundo Posible – configured RACHEL for the Guatemalan context and provided technical training;
- AMMID – managed project operations in the communities;
- Ministry of Education Municipal Coordinators – supported the engagement of local schools and advised on integration into existing education system.

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EXECUTIVE **SUMMARY**

Photo Credit: Josiane Farand

This study examines the results of a Project using technology, Mobile Learning Labs (MLLs), to improve the quality of education for students in grades one to nine in ten rural indigenous schools in Guatemala. The MLLs consist of an off-line server (RACHEL) containing a digital library and educational resources which connects to a classroom set of tablets. The project was to be implemented over the course of two school years (January to October, 2019 and 2020). However, schools were closed in Guatemala in March 2020 due to the global COVID-19 pandemic. As a result, full implementation in the classroom occurred March, 2019 to October, 2019 and January to February, 2020 (10 months).

The Project theorizes that technology can build and strengthen the three key elements that lead to improved student learning: 1) accessible high quality content; 2) skilled teachers; and 3) engaged students. Qualitative and quantitative data collected in the project were assessed using a theoretical model for how student learning occurs with technology. Despite the truncated project implementation period, the Project deepens our understanding of the comparative advantages of using technology for education in the Global South.

The findings of this research study provided additional evidence and detail to the four critical contributions of technology to education recently identified (Brookings, 2020):

1. Scaling up standardized instruction
2. Facilitating differentiated instruction
3. Expanding opportunities for practice
4. Increasing learner engagement

It was found that “increasing learner engagement” (#4) and “expanding opportunities for practice” (#3) were of significant importance in the rural Guatemalan context. In this setting, increased “learner engagement” not only made learning more entertaining (i.e. with games and videos), but also more self-directed and student-centred, which led to increased self-confidence in the ability to learn and master skills and knowledge. Both students and teachers highlighted the extensive opportunities afforded by technology for additional “practice” of new subject matter (i.e. math formulas or new vocabulary) which can be individually-paced and reinforce new knowledge.

In addition, the study found evidence of four additional contributions of technology that need further examination:

5. Providing access to high-quality educational resources
6. Building teacher capacity
7. Developing digital literacy
8. Integrating family, community, and cultural perspectives and knowledge

“Access to resources” (#5), “learning technology skills” (#6), and “building teacher capacity” (#7) may seem overly obvious advantages of technology in education, however, these are extremely critical for marginal communities if students are to have the possibility of overcoming educational disparities. The strategies and tools required to strengthen these three contributions need to be researched further. There is also evidence that technology has unexplored potential for “integrating family, community, and cultural perspectives and knowledge” (#8) into education, particularly in remote, small-language groups which often have orally-based knowledge that is transmitted to the next generation through experiential learning.

A comparison of student performance in 10 intervention and 10 control schools on Standardized National government pre and post-tests did not show a statistically significant difference in outcomes after eight-months (March – October, 2019). Analysis of the data collected and the existing research in other similar project, suggests that a single school year is too short a period to demonstrate significant improvements in student learning outcomes.

Recommendations for Project Implementation:

- Offer more and on-going training for teachers on how to integrate technology into their lessons;
- Include intentional digital literacy training for students;
- Extend after-school opportunities for students to use the technology;
- Develop the student and community ability to create and share cultural educational resources;
- Work closely with education authorities to develop and implement technology programs so that initiatives are sustainable and closely integrated into national planning and curriculums.

Recommendations for further impact research:

- Utilize context-specific learning outcome evaluations rather than standardized national tests to assess student learning results;
- Investigate further the differential experiences of girls and boys in the use of technology;
- Undertake a longitudinal study which follows the experience and learning results over the course of at least three-years of full implementation.

A MODEL OF TECHNOLOGY FOR LEARNING

The impact of technology on student learning outcomes is difficult to observe in short-term projects. Several research studies of the use of MLLs over one to two-year periods, demonstrate small percentage improvements greater in intervention classrooms than in control classrooms, however, none do so with strong statistical significance or a low margin of error.[i]

On the other hand, it is possible in a one or two-year Project to identify specific pathways and intersections that technology can create and facilitate to increase student learning. Using the theoretical model of *The Instructional Core*, the potential paths to improved educational outcomes can be detected and investigated. Progress on the path towards the ultimate outcome of improving student learning can be tracked.

The Instructional Core Model is composed of a **teacher** and **student** in the presence of **content**.[ii] The model outlines the interactions between these three elements that facilitate student learning (Graphic 1). The relationship between these three elements, and not the qualities of any one element, determines the nature of instructional practice and the resulting student learning. The instructional task (learning task) is based on the learning outcomes found in the curriculum, and is what students are asked to do in the classroom. An instructional task is an activity engaged in by teachers and students during classroom instruction that is oriented toward the development of a particular skill, concept, or idea. Examples of instructional tasks are memorizing, copying information off the blackboard, practicing examples of an arithmetic operation, or reading for comprehension. Students' mastery of tasks at the instructional core could predict student performance of the learning outcomes.

GRAPHIC 1: THE INSTRUCTIONAL CORE MODEL

According to this model, there are only three ways to improve student learning *at scale*, that is, in more than just one or two classrooms:

1. Increase the teachers' instructional knowledge and skill (teacher capacity)
2. Improve the quality and level of the content students learn (quality content)
3. Change the role of the student in the instructional process (student engagement)

Everything else in the school or district is important only insofar as it affects the core. An example of this is the presence of technology. Technology has the potential to affect all elements of the model and the core, and it can certainly seem to be a valuable innovation, but if the technology only substitutes for static resources it does not substantively change the core. For example, students doing worksheets on a tablet are still doing worksheets or students memorizing historical dates from a digital text are still memorizing.

The three components are interdependent: in order to change one, all components have to change. If teacher skill and knowledge are improved but the content remains poor, teachers will not be able to improve their instructional practice. If access to quality content is improved but teachers do not have the skill and knowledge to utilize it, the potential of the improved content is wasted. If content or instructional practice are improved, but role of students in the learning process is not changed, there will not be an overall improvement.

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, and would help achieve "inclusive and equitable quality education for all (Sustainable Development Goal 4) by 2030, the results have not met expectations. In a recent review of the research evidence (2020), the Brookings Institution concluded the following:

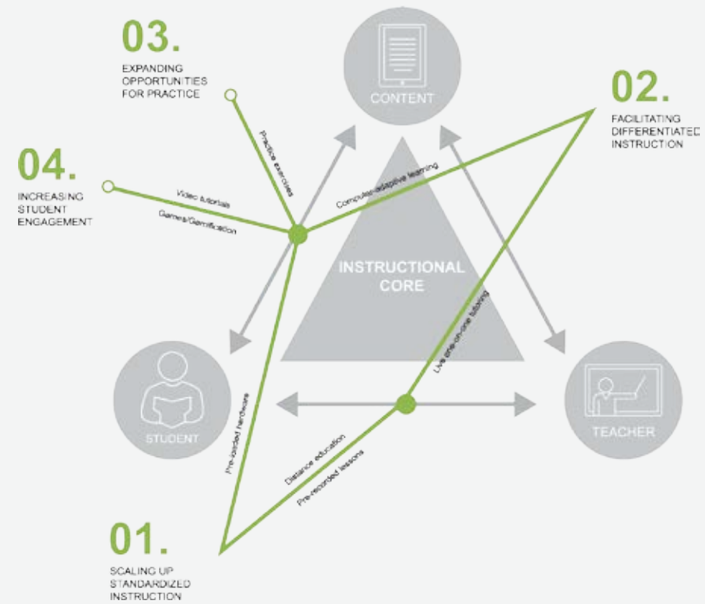
> "…in spite of the relentless optimism that has characterized the movement for education technology, its results have been mostly disappointing…Most notably, evidence from randomized experiments, which are designed to estimate the causal effect of programs and policies, suggests that merely equipping a school or a student with hardware (e.g. tablets, laptops, or desktop computers), has had little effect on student learning…Educational software that allows students to practice what they learned at school has been slightly more successful, but is has largely had modest effects…In short, the potential of education technology has not yet been realized." [iii]

Nevertheless, the Brookings study identified four potential comparative advantages of technology to improve learning outcomes, based on reviews of the most rigorous evidence available on interventions from developing countries. These following four critical contributions of technology are illustrated in Graphic 2 (*Source: Brookings, 2020, p.29).*

1. **Scaling up standardized 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.

This model provides a framework to organize and explore the data gathered and the lessons learned from the Guatemala Project. The data collected in this pilot will provide additional evidence regarding the critical contributions of technology already identified, as well as contribute new elements and critical points where technology can support improved student learning in the context of marginalized schools in remote, indigenous communities.

GRAPHIC 2: COMPARATIVE ADVANTAGES OF EDUCATION TECHNOLOGY



CONTEXT

Overall, Guatemala has made significant progress in educational accessibility and attendance in the last 25 years. From 1990 to 2015, the average number of years of schooling per person more than doubled from 3.1 years to 6.3 years. The expected years of schooling for students beginning school increased from 6.5 in 1990 to 10.7 in 2015.[iv] However, as in many countries, these overall positive numbers conceal two major challenges in the drive towards inclusive and equitable quality education for all: 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. (IDRC, 2020)[v] While the national average in Guatemala is now 6.3 years of schooling, in rural areas this drops to only 3.7 years.[vi] Drop-out rates are higher in rural and indigenous communities where students often leave school due to poverty.[vii] About 60% of Guatemalans live on less than $4 US per day; and 40% on less than $2.5 US per day.[viii] Of those living with poverty, 52% are indigenous.[ix]

Photo Credit: Josiane Farand

The quality of education in Guatemala is generally poor: a recent (2017) study revealed that the majority of graduating secondary students in Guatemala did not pass the achievement exams for math (92% failed) and language (75% failed) the first time they wrote the tests.[x] An international comparative study (2018) indicated that in Guatemala, student performance in reading and mathematics is among the lowest in Latin America, with 70% of students below average performance in reading and 89% in mathematics.[xi] 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.

The Municipality (county) of Comitancillo, where this Project was implemented, has characteristics typical of communities in western Guatemala. The population identifies as 99% Mam, one of the 31 Maya language groups in Guatemala. Comitancillo has a population of 60,000 people in an area of 113 sq. kilometers, which results in a high population density of about 530 people per sq. km. 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 the USA. The community rates high on national indexes of food insecurity and occupational precariousness.

Primary schools function in about 80 rural communities of the municipality; therefore there is a primary school within less than a one-hour walk for all children. There are Junior High schools (Grade 7-9) in over 25 communities. Of these, eight are tele-secondary schools which use television and audiovisual programs to provide education in communities without junior high schools. Each school has one or two teachers assist the students. There are nine High schools (grades 10-12), however, only four of these are located outside in the town centre.

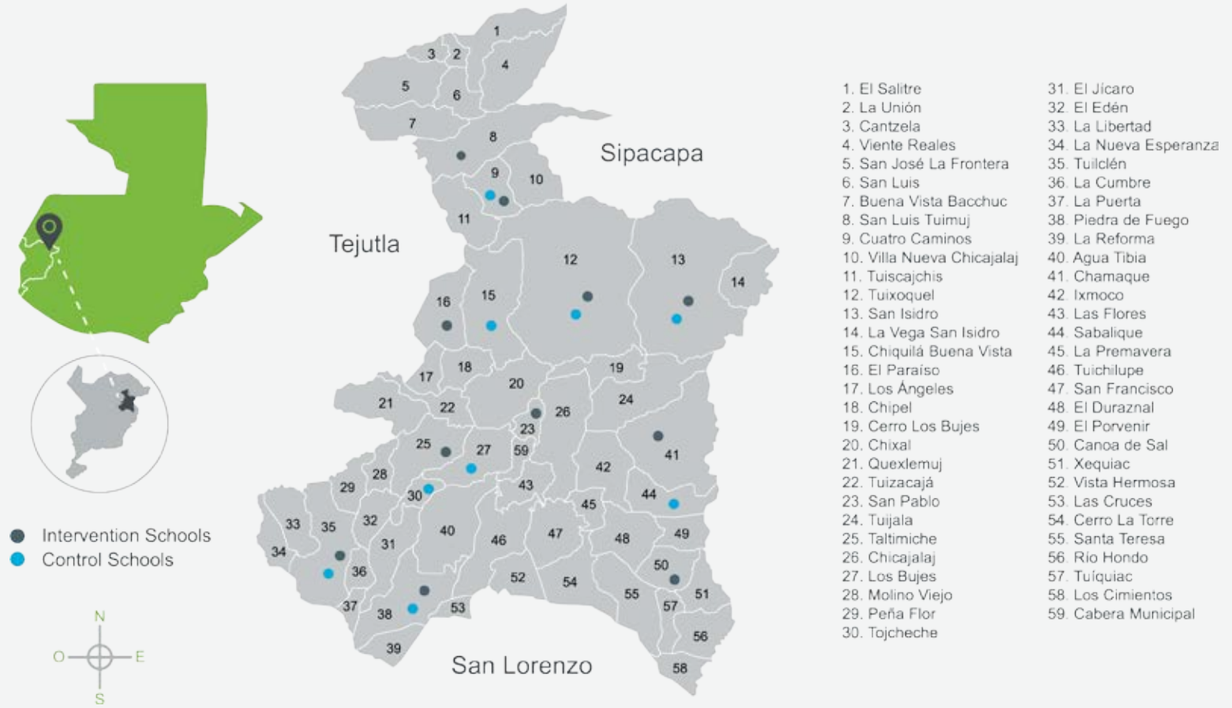
While an almost equal number of boys and girls attend school in Comitancillo (see Table 1), the drop-out rate is high. Of those completing primary school, only half continue on to Junior High. Of those completing grade 9, only 42% continue on to High School. Access to the internet in Comitancillo is poor, and in some communities it is lacking completely. While most households now have a cell phone, cellular signals can be unreliable in some remote parts of the municipality. The majority of households do not have smartphones, laptops or computers, nor do the majority have access to the internet. Library and other teaching resources are also limited, particularly in isolated communities. In Comitancillo, there are nine schools that have some computers provided by the Ministry of Education.

TABLE 1: SCHOOL REGISTRATIONS IN COMITANCILLO

Grade Levels	Boys	Girls	Total	Ave students per grade
Primary (Grades1-6)	6,116	6,055	12,171	2,028
Básico (Grades 7-9)	1,796	1,796	3,395	1,132
Secondary (Grades 10-12)	708	738	1,446	482

(Ministry of Education, 2016 data)

COMMUNITIES OF COMITANCILLO, GUATEMALA



DESCRIPTION OF PROJECT

Ten schools were selected to participate in the project based on the following criteria:

- Public primary and junior high schools in rural communities (i.e. not in the town centre) with primarily subsistence farming, low household incomes, and high rates of out-migration for work;
- Geographically dispersed in the municipality; representing all geographic sectors;
- A mix of schools with single grade classes and multi-grade classes;
- Proactive Mam-Spanish teachers;
- Schools without much support from other organizations nor technology;
- A school principal who was open to innovation and had effective leadership abilities;
- Good communication between school staff and local community leaders.

Using these criteria, 10 schools were selected for the MLL intervention. (Table 2 and Map p. 8). The 10 schools with MLLs employed 87 teachers and had 1,638 students in all grades during the 2019 school year. There is an average of 19 students per teacher in these schools.

TABLE 2: PARTICIPATING SCHOOLS

	SCHOOL	Number of students	Number of teachers
1.	EORM* San Isidro	330	16
2.	EORM Cuatro Caminos	205	10
3.	EORM El Paraíso	170	10
4.	EORM Villa Nueva	51	4
5.	EORM La Florida	131	9
6.	EORM Chamaque	270	16
7.	EORM San Pablo	182	9
	Junior High Schools (Grades 7-9)		
8.	Taltimiche	160	7
9.	Tele-secondary Tuixoquel	62	3
10.	Tele-secondary Canoa de Sal	77	3
	TOTAL	1,638	87

*EORM = Official Mixed [Gender] Rural School

The MLLs [Mobile Learning Labs] in this project consisted of a RACHEL Plus 3.0 and a classroom set (20) Tablets (10”) with keyboards. RACHEL (Remote Area Community Hotspot for Education and Learning) is a portable, battery-powered, device that contains copies of educational websites in offline format, educational resources, school curriculums, and various digital libraries. RACHEL wirelessly delivers free digital educational content to nearby tablets, laptops, or smartphones with no internet or data plans required (Graphic 3). The MLLs are utilized off-line, however, content can be updated and new content can be uploaded. Each MLL also included a Backup Power Source of 500 VA. The total cost was $4,840 per MLL; which is equivalent to about $2.90 for 2-3 hours per week per student for a full school year.

Mundo Posible provided orientation and training sessions for all participating school staff, Ministry of Education Supervisors, and project staff. In addition, Mundo Posible set-up the MLLs in each school and trained school staff to manage and maintain the equipment. In each school, a technology commission was organized to schedule the use of the equipment, streamline teaching activities, provide support for equipment maintenance, and maintain communication with the Project's technical team about technical applications.

Throughout the first year (March-October, 2019), joint monthly workshops were held for principals and teachers from all schools to continue to train teachers on how to use the RACHEL content for lesson planning, content, educational resources, and learning strategies.

In addition, the two full-time staff, a pedagogy trainer and a technical facilitator, visited each school for one day each week to provide individual and group training to teachers and to work alongside teachers in their classes. The project staff also led a process of collecting additional contextually-specific educational content to upload to the RACHELs.

In the second year of the project, (2020), implementation was disrupted in March by the closure of schools due to the COVID-19 pandemic. In-classroom instruction and support for the use of the MLLs ended in March. However, the project staff continued to work for several more months, conducting interviews for the second phase of the qualitative research, preparing the research report, and compiling and uploading additional information and resources on the RACHELs.

GRAPHIC 3: MOBILE LEARNING LAB (MLL) CONFIGURATION

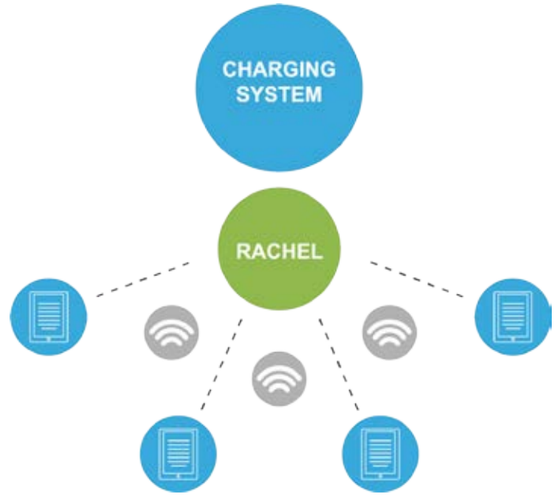


Photo Credit: Josiane Farand

RESEARCH METHODOLOGY

The Research Team consisted of six school directors and educators with both educational practice and research experience. This team designed and conducted the research study with the support of the project staff and the advisory input of the five local education supervisors for the Ministry of Education.

A mixed methods approach with both quantitative and qualitative data was utilized in order to measure learning progress as a result of the introduction of MLLs and to deepen understanding of the experience of teachers and students with the technology. Research was conducted in two phases:

1) Phase 1 (2019): A quantitative study of pre-tests and post-tests in intervention and control schools over the course of the 2019 school year (January-October) with qualitative data through focus groups with teachers and students, and systematic classroom observations;

2) Phase 2 (2020): An in-depth qualitative study based on 40 individual interviews with a representative sample of principals, teachers, and students in June-August, 2020.

Phase 1: Quantitative and Qualitative Data Collection

The quantitative study focused on student learning in mathematics and reading in grade six and seven. Control schools were identified which had characteristics and contexts similar to those of the intervention schools (Table 3 and Map p. 8.). Pre and post-tests to measure mathematics and reading performance were administered near the beginning of the school year in February 2019 and at the end of the school year in October 2019. The test data was analyzed to determine any changes in student performance and whether there was a statistically difference between the intervention and control groups.

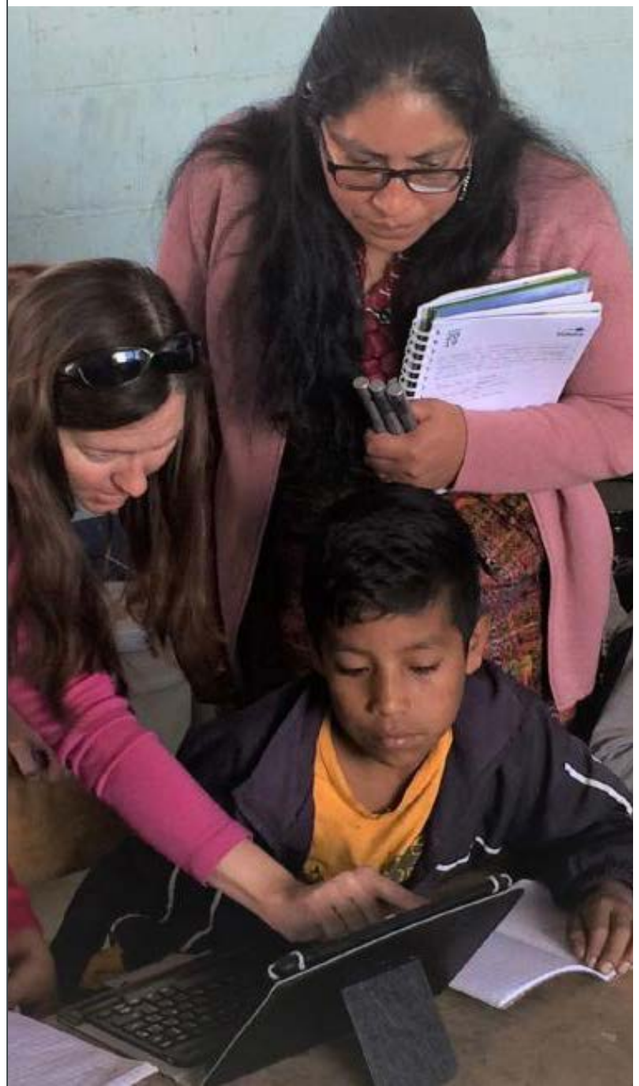
TABLE 3: INTERVENTION AND CONTROL SCHOOLS

	Intervention Schools	Control Schools
Primary Schools		
1.	El Paraíso	Chiquilá Buena Vista
2.	Villa Nueva, Tuilelén	La Puerta, Tuilelén
3.	San Pablo	Unido La Esperanza, Los Bujes
4.	Chamaque	Sabalique
5.	ELa Florida, Piedra De Fuego	La Reforma
6.	San Isidro	Tuixoquel
7.	Cuatro Caminos	La Puerta, Tuimuj
Junior High Schools		
8.	Taltimiche, Basico	Chixal, Básico
9.	Telesecundaria de Tuixoquel	Telesecundariade San Isidro
10.	Telesecundaria Canoa de Sal	Telesecundaria Tojcheche

The total number of grade six and seven students was 512 in the 20 schools in 2019: 269 in the intervention schools and 243 in the control schools. A sample size of 200 students was selected from the 20 schools; that is, a random sub-sample of 10 students (5 girls and 5 boys) were selected from each of the 20 schools. A total of 193 students completed the pre-test and 192 students completed the post-test.

Standardized national tests of the Ministry of Education were used to evaluate student performance based on the learning objectives of the national curriculum for grades six and seven. The tests were comprised of forty questions in each subject. The reading test measured abilities such as knowledge, recall, usage, comprehension, and analysis. The math test measured such subject areas as probability, geometry, patterns, sets, fractions, decimals, percentages, and problem solving. The test results were graded manually and electronically, and then the data was analyzed using a statistical software program by the research team.

The research team designed instruments to collect information related to the perception of teachers and students about the use of technology in the classroom consisting of a 7-question questionnaire for each group. Qualitative data was analyzed with the theoretical framework focused on “six core investigative criteria (Situation Specificity, Cultural Sensitivity, Practical Usability, Theoretical Applicability, Economic Scalability, and Viable Sustainability)” (Kim, 2009, p. 416). The framework has shown to be effective in studying literacy learning of migrant children through MLLs in Latin America, and is applicable in this context due to similarities of context and intervention. Data collected in the teacher and student questionnaires was collated and analyzed by the research team to identify key findings and areas for further investigation.



Phase 2: Additional Qualitative Data Collection, June-August, 2020

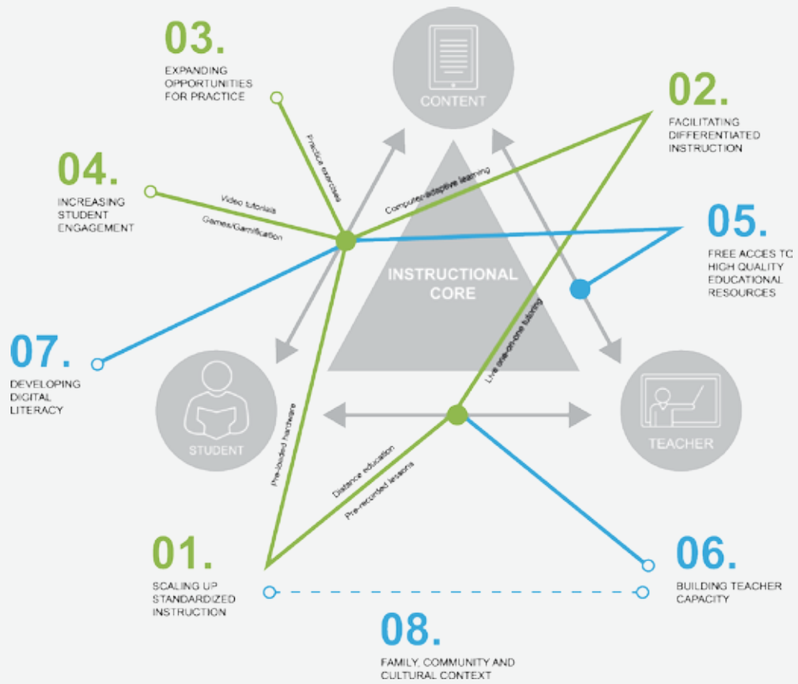
In order to delve more deeply into the perceptions and experiences of the student and teacher participants, a second phase of qualitative data collection was undertaken in 2020. In June and July 2020, semi-structured interviews were conducted with Pedagogical Advisors, school principals, teachers,and students of grade six and seven. A stratified sample of participants was selected for interviews because this allowed for representation of each sub-population: students, teachers, and school principals. Twenty-five students, ten teachers, and five school principals and administrators were selected from among the ten intervention schools with 50% female and 50% male participants. In addition, interviews were conducted with three pedagogical advisors of the Ministry of Education who were closely involved with the participating schools.

FINDINGS

Photo Credit: Josiane Farand

The findings corroborated and further nuanced the four comparative advantages of education technology identified in the Brookings review (2020). In addition, four new advantages or key intervention points emerged from the Project in Guatemala. The findings are illustrated in Graphic 4.

GRAPHIC 4: THEORETICAL MODEL WITH FINDINGS FROM GUATEMALA PROJECT



01. SCALING UP STANDARDIZED INSTRUCTION

Both students and teachers valued the instructional videos and audio files that provided standardized teaching of basic concepts, particularly for math and sciences. The Khan Academy instructional videos were referenced by 80% of students and 100% of teachers as effective tools for supporting student learning.

> "I have a student who has difficulties with the math course; she has a hard time doing the exercises. However, when we started using the technology, it was amazing what happened. First, we turned on the tablets and connected to RACHEL. Then, I shared the instructions. We watched a video about a mathematical operation. Next, exercises were assigned. I left them to work alone for a while. When I returned to the classroom, the surprise that I got was that the student had solved the exercises without any difficulty. Incredible but true." - *Teacher, Chamaque Primary School*

> "The videos on RACHEL are very good, because they help me to learn how to add, subtract, multiply, and divide." - *Student, Grade 6, Cuatro Caminos Primary School*

The standardized lessons help in several ways. They enable students to repeat the lesson if they did not understand it the first time the teacher explained it. They overcome any deficiencies in the individual teachers' presentation of the topic, as not all teachers have the knowledge or ability to clearly teach all subject matter. Finally, the videos are particularly valuable to students who learn better through visual, auditory, and kinesthetic means.

When questioned specifically about learning math and reading, 40% of students indicated that the MLLs facilitated "standardized instruction;" in other words, the MLLs helped to explain and clarify concepts they had learned in class.

Teachers reported frequently using the MLLs to facilitate Mathematics or Spanish language instruction. Students' ability to read was advanced through instruction videos, explanatory exercises, and reinforcement exercises. The teachers indicated that the most useful didactic applications on the RACHELs were: Khan Academy, Wikipedia, Guatemalan Educational Collection, Aprendiendo Mathematica [Learning Mathematics], and Aprendiendo Inglés [Learning English].

> "The tablet is an educational tool where you get the most out of the classes; it facilitates proper content for teaching and contains educational games." - *Teacher, San Isidro Primary School*

This finding agrees with results of two evaluations in 2016 of the use of Khan Academy educational videos to support math instruction. A study in the Municipality of 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." [xii] 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.[xiii]

Two of the three Junior High Schools in the Project (Tuixoquel and Canoa de Sal) are tele-secondary schools; that is, they use distance education through radio and television, with one or two teachers in person to assist students. These schools find the resources on the RACHEL to be an extremely valuable supplement to the national curriculum.

> "The RACHEL allows us to do summaries, watch videos about human anatomy and learn about the processes of human reproduction. It does allow us to obtain better information through images and videos." - *Student Canoa de Sal, Tele-secondary School*

> "Students learn best by seeing and doing themselves. The MLL is a research tool that enriches contents, provides definitions and concepts of topics that are not included in the text that teachers use, and helps to reaffirm learning."*- Teacher, Canoa de Sal, Tele-secondary School*

02. FACILITATING DIFFERENTIATED INSTRUCTION

The findings from the Project strongly substantiated the use of education technology for facilitating differentiated instruction tailored to the specific needs of each student; in other words, boosting student-centered learning. This included facilitating individually-paced learning, project-based learning, and different learning styles. Teachers used the MLLs to diversify their teaching strategies. With support from the project staff, the teachers learned ways to utilize the MLLs to create the setting for learning in groups, pairs, and individually.

> "The boy or the girl has the technology in his/her hands and can research a subject or word that they do not understand." - *Teacher*

> "The RACHEL helps a lot: it permits the completion of work in group and individual forms, and offers the opportunity for students to do presentations on school assignments, and to do reading in different formats, among other things." - *Teacher*

> "It provides a diversity of resources for learning in different forms of group organization. Students learn more quickly, and helps to understand the different types of learning styles." - *Teacher*

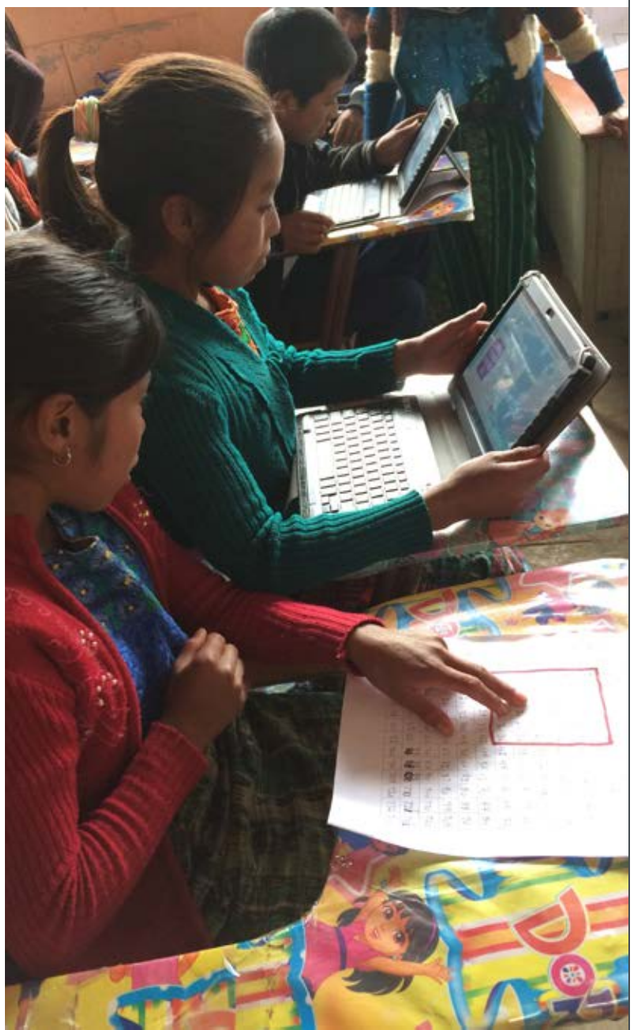
This is verified by 83% of the students who reported that the MLLs enabled diverse forms of organization in the classroom; working in groups, pairs, or individually; rather than the traditional teacher-lecture format.

Numerous students highlighted the visual and auditory ways of learning that the MLLs offered. Traditional teaching strategies which are based on teacher lectures and students copying and memorizing continue to predominate in classrooms in Comitancillo. These traditional methods do not necessarily respond to the individual learning styles of all students. The MLLs presented some alternatives. About 20% of students highlighted that the MLLs facilitated “learning by seeing,” through videos, images, graphics, pictures, and games, and “learning by hearing,” through listening to books read aloud, to presentations, and to music; which they reported enabled them to learn new concepts more quickly.

The majority (80%) of teachers felt that the most valuable contribution of the MLLs was that they generated opportunities for students to learn on their own on topics that interest them in fun ways,

> "Having a tablet in his or her hands, the student has the opportunity to choose the educational theme in the area in which they are interested and can navigate that with RACHEL." - *Teacher*

> "The MLL generated confidence in the students to utilize the technology for their own learning." - *Teacher*



03. 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) which can be individually-paced and reinforce new knowledge. In Comitancillo, the most common pattern is that class time is primarily dedicated to lecture, in which the teacher explains the topic and the students passively copy explanations from the blackboard. As students focus on writing in their notebooks, they may have difficulty absorbing the content. There is little time for students to grasp new concepts or to gain confidence through practice, before a new topic is introduced.

During the Project, 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 repeat the exercise until they were confident in their learning. Students reported that the MLLs enabled them to practice and reinforce math and language concepts that they had learned from the teacher in the class (65%) and to better understand subject matter that had been presented in the class (35%).

> "The use of the tablets helps us practice [what we learned in] our lessons through games and videos… You can take videos on the phone to review at home." - *Student, Grade 6, Villa Nueva*

> "When learning math and reading in Spanish, the RACHEL provided tools to practice the writing of the word, correctly using punctuation marks; and to perform different mathematical operations. 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 practice the different exercises. In reading, the students have the opportunity to read the same text, where the teacher puts into practice the guided reading, and also evaluates them with questions that each story or text contains." - *Teacher, Villa Nueva Primary School*

Research has shown that student learning is improved by how much they engage in “deliberate practice.” Deliberate practice is not the same as rote repetition. Rote repetition is simply repeating a task, which will not by itself improve performance. Deliberate practice involves attention, trial and repetition and leads to new knowledge or skills that can later be developed into more advanced knowledge and skills.[xiv] Thus the opportunities for deliberate practice offered by the MLLs are particularly important to student acquisition and command of new knowledge and skills.

> *Deliberate practice is not the same as rote repetition. Rote repetition is simply repeating a task which will not by itself improve performance. Deliberate practice involves attention, trail, and repetition and leads to new knowledge or skills that can later be developed into more advanced knowledge and skills.*

04. INCREASING LEARNER ENGAGEMENT

In the Project it was clear that “learner engagement” not only involved more entertaining and interactive ways of learning (i.e. games and videos), but also more self-directed and autonomous opportunities driven by individual student 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 a good experience to use the technology… 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*

> "When students look at the calendar for using the RACHELs, they are motivated and always ready to enter the RACHEL classroom and acquire new learning. They never miss a class." - *Teacher, La Florida Primary School*

> "RACHEL taught me many things. Before we had RACHEL, it was boring in the daily classes. But when RACHEL came, we all had fun while we learned, because there are songs, videos, and applications to develop reading and math knowledge. I learned to read through reading on RACHEL, and also to correctly write words." - *Student, Grade 6, San Pablo*

> "In the sixth grade class, what is interesting is the interest and dedication of the students when working with RACHEL. When they realize that it is time to work with RACHEL, they jump for joy because, then, a different environment is presented. 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 and have the opportunity to interact with technology." - *Teacher, Cuatro Caminos Primary School*

> "Using RACHEL has motivated me to learn new things like tablet applications and with the teacher's help it has piqued my interest in exploring the virtual library. Tablets also contain games, educational videos and these resources help us to think differently. Now our classes are not boring. Also, as a student, I have improved my participation in the classes, thanks to RACHEL." - *Student, Grade 6, La Florida*

However, “learner engagement” went beyond just making learning “fun”; with the MLLs students could unlock and develop their own innate curiosity and motivation to learn. Students strongly felt that the MLLs supported increased learner engagement in their own learning; not as much through games and video tutorials, although some (10%) of students did report that the visuals and games were motivating. Rather, the majority of the students felt the MLLs increased engagement through offering opportunities for self-directed learning (38%), and enabling students to build self-confidence in their understanding of concepts and content (25%). Unfortunately, 25% of students felt 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 teachers also noted that in addition to the novelty of learning with technology, the MLLs enabled students to engage more directly in their own learning. They felt that the MLLs enabled students to generate new ideas, pace their own learning, and to explore new ideas and subjects of individual interest.

> "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*

> "Being a teacher…what I like to see the most is that in the mathematics course the atmosphere in the classroom has changed from being tedious and uninteresting to being dynamic and participatory. Now students participate in group work and demonstrations; they have greater autonomy and motivation to learn and practice mathematics content." - *Teacher, Taltimiche Junior High School*

Photo Credit: Josiane Farand

The students indicated that the activities they liked to do best on the RACHELS were to:

- Explore information on topics of interest;
- Access multimedia information, such as videos;
- Find content to analyze and discuss in class;
- Practice exercises to reinforce new knowledge and skills.

> "I like to investigate, summarize, copy, display, use comparison charts, maps, group work, videos of science and stories." - *Student, Grade 6, Villa Nueva*

05. 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 limited resources. In communities without libraries or readily available internet connections, the RACHEL provides access to extensive libraries and reference materials, covering all subject material with textual as well as visual and audio materials. This is not just the replacement of print materials with digital materials; it is the first time many schools and communities have access to an extensive collection of high-quality educational resources and an enormous library.

Students had an average of two to three hours per week with the MLLs, according to a timetable organized in each school. Usage records from the RACHELs indicate that between 11,000 and 44,000 pages were accessed in each school during the project.

The RACHELs used in this program contained the complete Guatemalan National Curriculum, as well as Spanish digital libraries, and the equivalent of an off-line Wikipedia. The prohibitive cost of providing access to this wealth of knowledge in rural, remote, and poor communities is made affordable by providing these resources in a digital off-line form rather than in a physical library or through a continuous connection to the worldwide web.

> *This is not just the replacement of print materials with digital materials; it is the first time many schools and communities have access to an extensive collection of high-quality educational resources and an enormous library.*

All (100%) of the teachers felt that the MLLs provided an excellent source of educational resources that they would not otherwise be able to offer their students. Teachers appreciated the access to a diversity of information sources, including visual and audio sources, which enable students to do individual and group research, and offer students the option of following their own learning interests.

> "It is a beautiful experience because it gives access to many subjects, it facilitates learning. It is a very open program for the learning of students of any grade, different content, books are structured for all levels, RACHEL is an effective tool for the student to learn effectively and the educator has access to facilitate the process of learning. *- Teacher, El Paraiso Primary School*

For students, particularly those in higher grades, to learn to do research, and then synthesize and present information has been a valuable new opportunity.

> "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. 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)*

The majority (64%) of students interviewed in grades 6 and 7, felt the greatest advantage of the MLLs was the access to the libraries and resources on the RACHEL. Many mentioned the fact that this was free; because there are no libraries and is no general internet access in the rural communities, students must pay to utilize an internet café in the nearest centre when they are required to research and prepare for 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 and leaving school.

> "It has been a good experience to use the technology and I like it because now I do not have to spend money to research my school assignments. I confess that before we had RACHEL, classes were a little boring, but now with the presence of the technology, that classes have become fascinating, very interesting, and more engaging." *- Student, Grade 7, Taltimiche*

> "RACHEL is very important, because now we do not need to go to do research at the internet café. This means that we have less economic expenses. RACHEL contains all types of educational content, games, and videos that can help us to learn a lot." - *Student, Grade 7, Canoa de Sal*

> "RACHEL has motivated me to continue studying and not drop out of school. It has taught me much mathematics and strengthened my writing and reading of texts through practice." - *Student, Grade 7, Taltimiche*

Students interviewed indicated that they used the MLLs for the following subjects: communications and language: atonic syllables, discussion, classes of nouns , the media, learning, reading, writing, watching cartoons, researching jobs, games, adding, subtracting and multiplying activities, videos, songs, riddles, poems; natural sciences: cells, the nervous system and neurons; social sciences: culture of violence and culture of peace; math: Decimal numbers, fractions, multiplication, and division with decimals.

Of all the materials on the RACHEL for language learning, the students and teachers were the most familiar with Wikipedia, the Guatemalan Government Curriculum and the two Library Collections: Grandes Libros del Mundo and Biblioteca Latinamericana. It is unclear if this familiarity is a reflection of just what they used the most in their classes or because these were the programs that were the most useful to them.

Of the materials on the RACHEL for math learning, students and teachers were most familiar with Ka-Lite and Aprendo Mates, and GFC Aprende Libre. Again, it is unclear if this familiarity is a reflection of just what they used the most in their classes or because these were the programs that were the most useful to them. Teachers found the inclusion of the full Guatemalan national curriculum to be particularly useful and easy to access, compared to the often out-dated, worn, and limited copies of the curriculum available in their schools.

Twenty-first Century Skills

The teachers and school principals noted that the RACHEL content included resources for “Twenty-First Century Skills” such as critical thinking, communication, collaboration, and creativity. Both the content and the act of using the technology facilitated the beginning of development of the so-called, Twenty-First Century Skills (see Graphic 5).[xv]

The RACHEL contains materials developed by Mundo Posible showing teachers how to teach these skills in their classrooms. The materials are in the form of a MOOC (Massive Open Online Course) which is offline, and provides eight modules of strategies for teachers to utilize with students, such as: mental maps, critical thinking, and idea generation. In addition, the ability to individually access and interact with knowledge resulted in the beginning of the development of these skills among the students.

While the majority identified ways in which the technology enhanced and facilitated their learning, several went one step further and noted that the technology can also provide a new way of learning that: “liberates my imagination,” “enables me to create my own learning,” and “empowers me to create and share new knowledge.”

The following quotes illustrate this:

> "I really like using the MLLs because I like to have opinions and motivate my classmates, and in this way to be able to develop my ability to manage technology." - *Student*

> "When I turned on the tablet and began to interact with it, I gained many learnings and experiences, and the same with my classmates. Then we shared new ideas that helped us have different points of view." - *Student*

> "To learn to operate the tablet has been a great experience for me and my classmates. With the use of the tablets, we have more opportunity to share ideas, feelings, and opinions in the educational context." - *Student*

> "I like to work with the RACHEL and tablets because we can construct our learning through videos, educational games, books, and other educational resources contained in the virtual library." - *Student*

GRAPHIC 5: TWENTY-FIRST CENTURY SKILLS

Critical Thinking: Information and discovery, reasoning, problem-solving, systems-thinking	**Collaboration:** Cooperation, flexibility, leadership, initiative
Communication: Effective listening, communication using digital media, engaging in discussions	**Creativity:** Idea generation, openness to explore, work creatively with others

06. BUILDING TEACHER CAPACITY

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

The School Principals confirmed this, reporting that from their perspective the benefits of the technology for teachers were: they gained skills and confidence with the technology (50%), they had access to a wealth of educational resources (33%), and they learned new teaching strategies (17%).

In order to maximize the potential of the technology in the classroom, and ultimately of student learning, teachers and administrators identified three areas in which teachers need training:

1) How to operate the technology confidently;
2) How to integrate technology into their existing lesson plans in innovative ways;
3) How to generate and share new knowledge.

However, the training and appropriation of technology for educational purposes are processes that require time and practice. These are not changes that can occur quickly, but rather, they are long-term processes that need continuous support, particularly as technology is constantly changing.

Most of the teachers have very limited previous experience with technology. While most have cell phones, the majority do not have smart phones, laptops or computers. Few have experience with using the internet or digital apps for research or educational purposes. In addition, while younger teachers are often more familiar with using technology, most older teachers have no experience and are hesitant to try. 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 on-going 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 were able to begin to utilize the technological resources to improve their pedagogy practice. The RACHELs were useful to teachers preparing classes and enabled them to ensure that they had accurate information to share with their students. They explored the virtual library to get more information as needed for their lessons. For example, teachers indicated that they retrieved content on the following subjects: in mathematics, content on geometry, fractions, and algebra; in biology, content on physiology, zoology, and botany; in language arts, content on grammar, sentence construction, and synonyms; and in English language instruction, content on vocabulary and pronunciation.

> *"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*

> "I consulted the content on the MLL when I had to teach classes on types of triangles, living beings, the environment, multiplication and division." - *Teacher, Chamaque Primary School*

> "Useful content on the MLLs are in physics, contents such as temperature, thermometer; in artistic expression, crafts and painting; and in chemistry, water and its components." *- Teacher, Canoa de Sal, Tele-secondary school (Junior High)*

All teachers (100%) felt that they needed further orientation and training to fully use the potential of the MLLs: they requested more training on how to integrate technology into their lessons; on specific subjects such as math, health, culture, and sciences. The School Principals also stressed the need for further capacity-building with teachers so that they can continue to improve the integration of technology into their lessons.

07. DEVELOPING DIGITAL LITERACY

Learning to use technology was a very important part of the MLLs for both teachers and students. For the majority (63%) of teachers this was the first time they were using this type of technology, as most only had limited experience with cellular phones, and possibly a computer in an internet café in town. 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 areas. [xvi]

As noted in the previous section, 50% of School Principals felt that increased teacher capacity to use technology was the most valuable outcome of the Project.

Similarly, for the majority (70%) of students, this was the first time they had the opportunity to work with technology, to learn to operate a tablet and to perform basic functions. The remainder (30%) of students indicated that they had some limited experience, most with cell phones, and during the Project their abilities advanced in terms of how to search the database and utilize various applications.

> "The MLLs developed the capacity of the children to browse, open, and download documents." - *Teacher, Chamaque Primary School*

> "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 text books. 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*

Digital literacy, the technical and cognitive skills to use information and communication technologies to access, manage and communicate information is becoming imperative for young people entering the work force. It is clear that offering everyone a phone and a computer screen will not in itself help bridge the "digital divide" opening up across the world. Technology is of little value unless people are equipped with the knowledge and ability to use it. Those who cannot use it confidently, whether communities, teachers, or students, will become increasingly marginalised within the modern world.

> *It is clear that offering everyone a phone and a computer screen will not in itself help bridge the "digital divide' opening up across the world. Technology is of little value unless people are equipped with the knowledge and ability to use it. Those who cannot use it confidently, whether communities, teachers, or students, will become increasingly marginalised within the modern world.*

While digital literacy is not an element included in the original theoretical model from the Brookings Institute (Graphic 2), according to the participants in this Project, it is an essential comparative advantage, and needs to be highlighted in the model as well as intentionally integrated and developed in technology for education initiatives. While improved digital literacy may be an unintended side benefit of technology for education programs in upper-income countries, for marginalized communities in the Global South, this is vital to young people's ability to survive and thrive in the globalized world.

08. INTEGRATING FAMILY, COMMUNITY, AND CULTURAL PERSPECTIVES AND KNOWLEDGE

An important element, not included in the original theoretical model (Graphic 4) used in this study is **the role of families and communities**, particularly in relation to the student, but which also affects relationships and interactions with teachers and content. This family and community context is particularly important in remote and marginalized communities, like the indigenous communities of Guatemala, because the social and cultural context may have a stronger effect on schooling and learning than in larger urban contexts with a wider range of social and cultural influences and norms.

The Project supports the existing research evidence that technology has comparative advantages for "integrating family, community and cultural perspectives and knowledge" (#8) into education, particularly in remote, close-knit, or small-sized cultural and language communities. This is an advantage that permeates all aspects of the learning process (see Graphic 4).

Family Involvement in Education

Family and community support for education is critical to the success of students, especially those in marginalized communities. According to a recent study in indigenous communities in Canada, New Zealand, and Australia, the three key elements to improve indigenous education are: 1) quality and effectiveness of teaching; 2) engagement of families and communities, including involving parents in the children's educational goals and enabling parents to play an active role in their children's learning; and 3) provision of direct support to students (OECD, 2017).[xvii]

Technology in the classroom 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. Fathers and mothers showed great interest in their sons' and daughters' learning the use of technology and tried to support their children in learning to use the MLLs. In the intervention schools, parents contributed with the purchase of materials to protect the technological equipment and reinforce the safety of 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 in their community, and their desire to ensure that this new initiative is a success.

Community Cultural and Linguistic Content

The potential of technology to facilitate culturally and linguistically-specific knowledge and learning was explored in the Project. Small language groups and more traditional indigenous communities often maintain and communicate cultural knowledge through oral transmission, such as stories and songs, and experiential learning, such as working alongside an Elder. Technology has the capacity to capture and share cultural knowledge through audio, visual and interactive means. This is an opportunity to build on traditional ways of knowing and create an innovative path for knowledge transmission and strengthening.

Studies of indigenous education have identified the need for "decolonizing" learning processes and content and strengthening gender-equitable perspectives.[xviii] This includes respecting indigenous knowledge and their unique approaches to learning, respecting indigenous holistic vision/perspectives, integrating indigenous and local community content, and reducing gender-based barriers to education. In many ways, there are parallels between indigenous ways of learning and innovative learning approaches currently in mainstream education. These include such congruent elements as: experiential learning, critical thinking, self-directed learning, and drawing from community contexts to create relevant and engaging curriculum. Research in Latin American indigenous education programs also 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.[xix]

Photo Credit: Josiane Farand

The government of Guatemala has been committed to bilingual/intercultural education for more than 40 years, however, given the diversity of cultural and language groups, it has been a challenge to achieve the goal of high-quality bilingual and intercultural education for the twenty-one Mayan languages spoken in Guatemala. Mam, the language spoken in the Municipality of Comitancillo, is the fourth largest, with about 500,000 speakers. Many of the students in the rural communities of the Municipality of Comitancillo start school only speaking Mam, and they begin to learn Spanish, the predominant language of education, during primary school. While the majority of teachers in Comitancillo are bilingual Mam-Spanish speakers, 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 educational resources for teaching the Mam language and culture. During the Project, a total of 134 documents and educational resources of culturally and linguistically-specific Maya-Mam content (Annex 2), including Mam language learning materials, information on local culture and history, and research studies on the community were uploaded to RACHEL.

All teachers received about two hours of instruction on the Maya-Mam materials and potential ways of using these. All teachers reported using the new content, particularly for teaching Mam reading and writing. For younger grades, they especially liked the printable words in Mam and Spanish that they could place around the classroom on various objects. For the Junior High students, they appreciated the reference information about their own community, such as the research studies of 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 PDF documents; the full potential of the technology to be used for audio, visual, and video formats has not yet been developed in the Project region. In the future, teachers and students would like to experiment making video and audio recordings, as well as creating more interactive educational materials.

STUDENT LEARNING OUTCOMES: THE DATA

As noted in the Methodology Section, the total number of grade six and seven students was 512 in the 20 schools in 2019: 269 in the intervention schools and 243 in the control schools. A sample size of 200 students was selected from the 20 schools; that is, a random sub-sample of 10 students from each school. A total of 193 students completed the pre-test and 192 students completed the post-test.

The tests administered were the Official Grade 6 national exams of the Ministry of Education of Guatemala for assessing learning based on the National Curriculum. The Reading test included elements of recognition, memory, utilization, comprehension, and analysis for reading in Spanish at a Grade 6 level. The mathematics test for Grade 6 assessed learning in probability, geometry, simple and complex numbers, problems with natural numbers, fractions, and decimals, percentage, measurements, money, and problem solving.

Table 3 outlines the results of the pre and post-tests in the intervention and control schools, demonstrating a lack of any statistically significant difference between the two groups. The research group did a detailed analysis of the performance of the students in the various components of the test, without finding any significant difference in any of the components. 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 case of Grade 7 Reading test did the students Intervention Schools show a greater, and statistically significant different improvement over the students in the Control Schools.

TABLE 3: AVERAGE PERCENTAGE SCORES ON PRE AND POST-TESTS

	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	31.67	+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.

As noted earlier, the length of time of the intervention was not enough to see a significant change in student learning outcomes. The school closures in March 2020 due to the global pandemic shortened the study from two years (2019-2020), to only gathering data from one year (9 months) of classes (2019).

As noted in other studies, it is unlikely that significant changes in student learning outcomes will be evident within a one-year period. In a study conducted in 2018 of a Mundo Posible project elsewhere in Guatemala of student performance in reading and math in eight intervention and eight control schools after one year of implementation, showed improved performance of students with access to technology at a rate that was statistically significant but not to a level of 95% confidence. [xx]

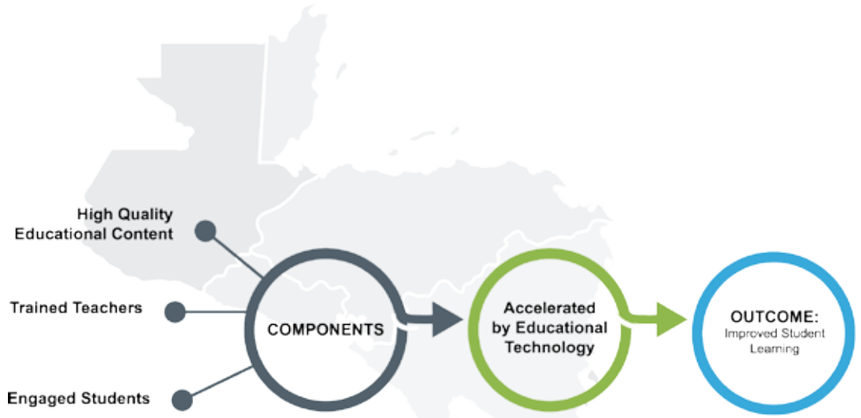
In another example, a large-scale randomized evaluation of the One Laptop per Child program in Peru was conducted in 2011, using data collected after 15 months of implementation in 319 primary schools in rural areas of the country (BID, 2012).[xxi] "The results indicated that the program increased the number of computers per student from 0.12 to 1.18 in the beneficiary schools. This expansion in access resulted in a considerable increase in the use of computers both at school and at home. There was no evidence of effects on enrollment or academic performance in math and language" (BID 2012, p, 4). However, the study did find some positive effects in general cognitive abilities that provided evidence of possible advantages and potentially longer-term impacts on learning outcomes, if students and teachers have the proper support.

The second observation that must be highlighted is the overall low scores. These Comitancillo students are achieving between 28% and 34% on national exams on which they would be ideally earning marks over 60% at the end of the school year when they have completed the curriculum of studies. Overall in Guatemala, the most recent evaluations of grade six students indicate that only 29% passed the reading exams, and 45% passed the math exams for that grade.[xxii] Thus, the Comitancillo student performance is similar to the rest of the country, and reflects the generally poor quality of education in Guatemala.

CONCLUSIONS AND RECOMMENDATIONS

Student learning is an outcome of the interaction of content, teachers and students, according to the theoretical model used to assess this Project. Therefore, there are three ways to improve student learning at scale: 1) improve the quality of the content that students are asked to learn; 2) enhance teachers' knowledge and skills; and 3) increase students' engagement in their own learning. Changes in any one of these components necessitates and generates changes in the other two. This project has strengthened and enlarged the evidence-base which indicates that appropriate educational technology can contribute to improvement in all three of these components and thus ultimately increase student learning (Graphic 6).

GRAPHIC 6: THE PROJECT THEORY OF CHANGE



Despite the shortened length of the Project due to school closures as a result of the COVID-19 pandemic, the findings of the research study indicated that the comparative advantages identified in existing research had potential to improve student learning in this context as well. The technology showed promise in:

1) Scaling up standardized instruction;
2) Facilitating differentiated instruction;
3) Expanding opportunities for practice;
4) Increasing learning engagement.

In addition, the research identified further ways that the technology could potentially facilitate improved student learning outcomes:

5) Free access to high-quality resources;
6) Teacher capacity-building;
7) Student learning to use technology;
8) Creating and sharing family, community, and cultural knowledge and engagement.

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 educational technology programs.

> *Free access to educational resources and development of digital literacy may seem like obvious or unimportant outcomes of technology in the classroom in Canada and other higher-income countries. However, for marginalized and economically-deprived communities around the world, access to resources and digital literacy can be ground-breaking and transformative.*

All the participating students, teachers, and school administrators felt that there should be continued implementation of the MLLs in their schools because it motivates and improves their ability to learn.

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

- Offer more and on-going 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 the 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 impact research:

- Utilize context-specific learning outcome evaluations rather than standardized 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 use of technology;
- Undertake a longitudinal study which follows the experience and learning results over the course of at least three-years of full implementation.

END NOTES

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