

UNDERSTANDING THE POTENTIAL OF DIGITAL INTERVENTIONS TO SUPPORT ENGLISH LANGUAGE LEARNERS IN RWANDA

An investigative report of a tablet-based digital learning suite supporting primary students transitioning to English-based instruction in Kagina, Rwanda

Educational technology has the power to transform learning by improving educational outcomes as well as widening access to quality education for students in developing countries.

According to the World Bank, roughly 250 million disadvantaged children never reach their full potential because they miss out on early learning (2017). In countries with large refugee and immigrant populations or where the language of instruction changes from the student's mother tongue to English, as is the case in Rwanda for example, challenges around access and the quality of education as well as their long-term effects are compounded. In the face a global learning crisis, Kitkit School – a comprehensive tablet-based digital learning solution for early learners - is designed to support Sustainable Development Goal 4 (SDG 4) towards quality education and lifelong learning for all.

In Rwanda where the pilot tablet-based self-learning session was introduced, most children have not acquired age-appropriate literacy and numeracy skills, which have been considered to be a contributing factor that hampers the achievement of universal and quality primary education. While Rwanda was on pace to achieve near-universal access to primary education in recent years, primary school drop out and repetition have risen while completion and transition to secondary rates have stagnated. According to the Ministry of Education, nearly one third (28.3%) of all primary school children drop out in grade 5 (P5) (MINEDUC, 2015). To

account for this undesirable trend, concerns on the quality of education, and particularly the policy of switching the language of instruction from French to English from P4 adopted in 2008, has been in the center of the discussion. Rwanda's Education Sector Strategic Plan (ESSP) 2013 - 2018 states that teachers in P1-P3 classes should use Kinyarwanda as the mother-tongue language of instruction to help students learn to read, before transitioning in P4 from Kinyarwanda to English. The shift to English was a strategy of the government to facilitate its economical entry into global market, but it has been implemented with limited resources in particular with teacher shortages who has adequate proficiency of English (Williams.T.P, 2017). According to findings from the Ministry of Education, only 15% of primary teachers are proficient to teach in English (MINEDUC, 2009) and it inevitably amplifies the challenges around primary learning across the country.

Where the change is sudden, with inadequate English instruction in the first three grades leaves students ill-prepared to use English at the language of instruction, it is unsurprising that P4 students would face considerable limitations on their learning. Teachers are instructing in a language with which they have limited fluency, while students struggle across subjects due to a lack of basic fluency in the medium of instruction. Per a recent study, increasing repetition and dropout rates in P4 and P5 are likely to have a direct relationship with the change in the language of instruction, including the highest dropout at the end of P5, the year before taking the primary leaving national exam for transition to lower secondary school (Moulton, 2016).

To address this challenge, most of the responses of the government and international agencies have focused on equipping teachers by providing capacity-building professional development programs for teachers. The Rwandan English in Action Program (REAP) provided English-language training to teachers during school vacation for more than 88,000 teachers since 2008. Additionally, the Rwanda Education Board under the Ministry introduced a school-based mentorship (SBM) program which sends 1,000 English teachers hired from neighbouring countries like Kenya and Uganda to Rwandan schools to help local teachers. The study concludes, however, the program has been met with mixed results with difficulties recruiting SBM mentors and lack of understanding by head teachers, further impeded by the absence of a monitoring and evaluation system (Wilson, J, 2013 cited in Willian.T.P. 2017). As a consequence, the SBM program was no longer funded in 2016.

In the response to this urgent issue, Good Neighbors (GN), an international NGO which aims to improve the access to quality education in their catchment communities, implemented an intervention, "Kitkit Session" utilizing the tablet-based learning apps developed by Enuma. The Kitkit Session, is designed to provide an extra-curricular opportunity over the course of three months that provides supplementary literacy (English) and math learning support for 684 students enrolled in P1-P3 in the Kagina Primary School located 25km away from Kigali, the capital of Rwanda, from September to December of 2018.

This case study explores the potential of use of digital-learning technology as an intervention to increase learning outcomes on basic literacy (English) and mathematics for lower primary students in Rwanda. By giving them access to a high-quality tablet-based learning experience, facilitating self-paced learning, the study aims to find the potential of education technology as a solution to tackle the challenging task of enhancing lower primary student's English capacity in cost-efficient way.

The report presents key findings of the Kitkit session pilot program evaluation:

1. Baseline data reveals very low English literacy levels, even in P3
2. Students demonstrated significant learning gains (Pre-/Post-Assessment Overall Results)
3. Positive correlation of intervention time to higher achievement

As key findings in this study demonstrate, there is promising evidence that the tablet-based learning suite can directly contribute to strengthening children's literacy (English) and math skills even via short-term supplementary interventions. In fact, lower grade students in Rwanda face the dual challenge of mastering basic literacy in Kinyarwanda to "learn to read" as well as building basic proficiency in English to "read to learn", at the same time. Enhancing student's readiness to enter P4 seems urgent and a definite entry point to tackle existing challenges in quality primary learning in Rwanda. This study shows that this intervention provide a compelling solution to tackle these dual tasks and to unleash the potential of digital education for P3 students in particular.

Case study overview

Kitkit Session used to provide basic literacy and numeracy skills

Good Neighbors Rwanda partnered with Enuma, Inc. to equip lower primary school students with basic English literacy and math skills to prepare them for the transition of the language of Instruction from Kinyarwanda to English in Grade 4.

The Kitkit Session targeted children in grades 1 to 3, who were all entitled to attend, though attendance was not compulsory since it was designed as an after-school program.

Kitkit Session allows 1:1 free-play for students

From September to December 2018, 684 students of Kagina Hope School in Rwanda were enrolled in the Kitkit School Session. The session was offered as voluntary-based participation without any charge. Initially the session was planned for 75 weekdays; however due to holidays and national examination dates, it was only conducted for a total of 62 weekdays.

For three months of the trial, students were given access to Kitkit School daily Monday through Friday. With one tablet available per child, they were ensured to free-play at least 30 minutes per session. The tablets, which include Kitkit's suite of English and math learning games and contents, and e-book library and videos were given to the children from the first day without direct

instruction on how to use, as Kitkit School is designed to be highly intuitive, without the need for guided instruction by adults. A total of 167 tablets were used for 684 enrolled student as the software provides multiple user registration functionality.

It should be noted that the school is operated as a double-shifting system under the government policy, because it considers the effective way to expand access within the constraints of infrastructure, and resources available. Since the Kitkit Session was extra-curricular, students were not mandated to attend. With this freedom to attend, children could come and go they chose.



Daily sessions were held in the library and the cafeteria during the school day, and participating students were given access to Kitkit School either before or after their regular classes. Good Neighbors provided eight sessions per day on average, and students were allocated to elect a specific session. This means all students attended only their registered sessions. In this way, the implementation team ensured every student could be

engaged, learning in a 1:1 tablet device arrangement with user registration tracking their progress in every play log.

Due to limitations of the available space in the school, however, it occasionally resulted in 2-3 hours waiting time for students.

Roles of Kitkit School session facilitators

Supporting the enrollment of 684 lower primary students, the Kitkit Session was overseen and operated by four 'Kitkit facilitators' employed by Good Neighbors (GN) from the school and surrounding communities. Facilitators were primarily responsible for distributing the tablets to children, but did not intervene with their play.

The facilitators were in charge of the daily administration of the site, including charging 167 tablets, and maintaining the library and cafeteria where the Kitkit Session was held. In addition, 2 staff members

in the GN Rwanda office were responsible for the project management and the collection of data for evaluation.

Enuna, the developers of Kitkit School, provided on-site and remote support. In preparation for implementation, Enuna delivered a 5-day training course for facilitators that covered co-design of the activities, instruction on Kitkit's pedagogy and curriculum, technical capacity-building for software and hardware management, and data collection. It also included an introductory workshop with the school teachers, enumerator training, and on-site pilot administration of EGRA and EGMA assessments.



Evaluation Methodologies

The following field data was collected for project evaluation:

- Play Log data
- For a selected sample of students, oral evaluation of literacy and numeracy (EGRA and EGMA)
- Digital literacy and numeracy assessment data

All play log data of 167 tablets with all 684 registered children are automatically collected through a local server system every two weeks and transmitted to Enuma, Inc. The analysis of play log data provides statistics on play time, game progress, and digital assessment scores.

For learning progress evaluation, 1:1 oral assessments were carried out both at baseline and endline. These assessments ensured equal participation and detected early progress even for children with insufficient skills to understand the paper-based test. Using the Early Grade Reading Assessment (EGRA) and the Early Grade Mathematics Assessment (EGMA) tools, a randomly selected subgroup of 105 students participated in the

test at baseline. At the endline, however, the numbers of students was decreased to 99. Thus, data from the 99 students who took both tests were used for evaluation of the oral assessment. Enumerates were trained for ensuring consistent translation of test administration among facilitators. As such, the pilot of assessment administration was conducted as practiced prior to the baseline.

In addition, digital literacy and numeracy assessments were also conducted during the first (and last) three days of the Kitkit School session as the baseline and endline. Among 684 students, 367 children participated in both pre- and post-tests. The primary purpose of the data collection was to provide information on individual's learning progress for educators, rather than for project evaluation.

Thus, this case study evaluates the learning outcomes of students by using both play log data and orally assessments.



(Pilot administration of EGRA and EGMA with same-aged children in non-intervention school near community)



(Baseline administration of EGRA and EGMA at the Kaniga primary school)

Using Digital Solutions To Provide Quality Education

The use of technology to support literacy and numeracy acquisition in resource-limited areas had been attracting much attention from governments, international agencies, and NGOs. Research has found that digital technologies can provide an important platform to tackle the challenging task of reaching children who have little or no access to quality education (Gottwald, Morris, Wolf & Galyean, 2017).

However, research on the process and the impact on which of these technologies can improve learning outcomes has been limited in general and shown mixed learning results across regions. For example, in India, a highly significant academic impact was observed through technology-led after-school instructional program, Mindspark. Middle-school students could learn from individually customized content. Both math and Hindi scores increased among students who participated (Muralidharan et al., 2019). Meanwhile, computer-aided instruction (CAI) in Israel had limited impact on the math scores of 4th year students, which could have been due to the higher priority given to CAI could have replaced other school resources, or the time it takes for students and teachers to adjust to CAI may be longer than a year (Angrist and Lavy, 2002). As shown by inconclusive research on the impact of computers on learning, there is a need for improved understanding of how other digital learning solutions can be tailored to best serve students and teachers in low-resource settings, especially in sub-Saharan Africa. Researchers argue that more active and learning attitudes need to be embodied within teaching-learning process as children need to convert information form technology into knowledge (Luckin et al., 2012; Fullan and Langworthy, 2013).

In line with that, tablet-based interventions have gained increased attention. Instead of using technology merely as a tool to gather information, tablet-based interventions enable an individualized learning plan by proving that regionally-tailored and uniquely-integrated hardware and software solutions can help fill critical learning gaps.

In contexts with teacher and resource scarcity, it becomes even more challenging to meet each individual child's unique learning needs. Classroom instruction can be differentiated or scaffolded to better meet the needs of students, but digital solutions offer new ways to tailor learning to address the specific needs of individual children, and can offer students more choice in terms of learning modalities and pace. Still, rigorous evaluation is scarce in both developed and developing countries (Haßler et al. 2015; Hubber et al. 2016). The only peer-reviewed study on a developing country setting is the study by Pitchford, who finds that a tablet program improves early mathematical skills for primary school children in Malawi (2015).

Consequently, this study aims to contribute to these efforts to provide quality education by detailing how a tablet-based educational experience can motivate students to self-learn literacy and mathematical skills as well as provide a foundational intervention for English language learners.

ABOUT GOOD NEIGHBORS

Good Neighbors is an international humanitarian development NGO founded in Korea in 1991 to make the world a place without hunger, where people live together in harmony. The first community development project in Bangladesh was launched in 1992 and currently Good Neighbors is working in 192 communities in 40 countries with a focus on inclusive community development approach and child protection.

Good Neighbors has attained General consultative status with the United Nations Economic and Social Council (UN ECOSOC) in 1996. In recognition of valuable efforts in providing universal primary education all over the world, Good Neighbors was awarded the Millennium Development Goals (MDG) Award by the International Association of Economic and Social Councils and Similar Institutions (AICESIS) in 2007.

Good Neighbors also works in cooperation with our partners including UN World Food Program (UN WFP), UN Refugee Agency (UNHCR), UN Development Program (UNDP), UN Capital Development Fund (UNCDF) and other aid agencies.

ABOUT KITKIT SCHOOL

Kitkit School was created by the Enuma, Inc. team as a comprehensive early learning solution in response to the 617 million children and adolescents worldwide – six out of ten – who are not reaching minimum proficiency levels in reading and mathematics. Kitkit School, as the Global Learning XPRIZE co-winner, is designed as a comprehensive learning platform with game-based Kitkit Learning App, library of books, videos, and songs, and collection of learning tools for support and self-expression. The Kitkit Learning App is composed of interactive educational activities, which allow children to be exposed to high-quality, user-centered educational materials. Currently, Enuma offers Kitkit School in English and Swahili versions, with plans for new languages and contextualization ahead.

The Enuma team created Kitkit School to bring high-quality learning experiences to the children who need them most around the globe. With the needs of children, including those with special needs or without access to resources, at the core of their work, the Enuma team uses user experience and accessible design to engage early learners to gain confidence in early literacy and math. The name Enuma comes from the world enumerate, or to name one by one, to demonstrate the team's dedication to individual and independent learning experience for children.

Findings from the field

FINDING 1. Baseline reveals very low level of English literacy skills, even in P3

Since paper-pencil assessment may be difficult for children with insufficient literacy skills, a random sample of students 37 in grad 1, 31 in grad 2 and 34 in grade 3 out of 684 enrolled students were orally tested for their reading skills using Early Grade Reading Assessment (EGRA) and Early Grade Mathematics Assessment (EGMA).

In table 1, scores for each subtask have been transformed to be out of 100 total points. This indicates that in terms of literacy subtasks even grade 3 students score less than 20 points out of 100, implicating students are not fully skilled even in basic skills like alphabetic recognition, phonics and decoding. This highlights the need for supplementary education for English comprehension.

Starkly contrasting baseline scores for literacy and mathematics evidence the challenges before students, particularly those in P3, when the language of instruction is English. As seen from the baseline data, student scores reveal much lower literacy proficiency in comparison to the overall baseline scores for math. Scores demonstrate that Grade3 students marked 1.62% to 18.3 % of correct answer on literacy in comparison to their math score of 25.6% ~ 87.6%.

Without appropriate, effective intervention to support concurrent English acquisition as part of students’ literacy development, baseline averages worsen by grade leaving students ill-prepared for the transition to English in P4. Among students tested in P3, there were many children who do not know the alphabet, with comprehension showing a score average of nearly zero. This baseline finding speaks to the urgent and imperative need for improved learner supports for basic English in lower primary grades as well as the challenges facing Rwandan students that contribute to poor completion and high drop-out rates once the language of instruction changes to English in P4.

Table 1 Baseline Averages by Grade on Oral Literacy and Math tests

Sub-tests		Grade 1	Grade 2	Grade 3
Literacy	Letter Name	0.056	1.97	1.62
	Familiar Words	0.357	1.94	9.18
	Invented Words	2.41	6.33	18.4
	Oral Reading Passage	0.178	1.29	10.0
	Reading Comprehension	35.3	1.61	6.62
Mathematics	Number Discrimination Part A	50.3	70.0	87.6
	Number Discrimination Part B	37.6	20.6	75.9
	Addition Level 1	30.3	53.7	71.6
	Subtraction Level 1	28.5	40.5	53.1
	Missing Number	18.4	68.5	45.3
	Addition Level 2	10.6	24.2	42.1
	Subtraction Level 2	10.0	21.9	25.6

FINDING 2.
Students demonstrated significant learning gains (Pre-/Post-Assessment Overall Results)

Table 2 Difference between Endline and Baseline Oral Literacy and Math Tests by Grade
(T-test significance shown as * p < 0.10, ** p < 0.05, *** p < 0.01)

Sub-tests	Grade 1			Grade 2			Grade 3			
	Average (%)		Difference	Average (%)		Difference	Average (%)		Difference	
	Pre	Post		Pre	Post		Pre	Post		
Literacy	Letter Name	0.06	4.68	4.62***	1.97	10.32	8.35***	1.62	16.94	15.32***
	Familiar Words	0.35	3.59	3.24	1.94	14.13	12.19***	9.18	35.24	26.06***
	Invented Words	2.41	6.94	4.53	6.33	26.13	19.8***	18.35	47.24	28.88***
	Oral Reading Passage	0.18	1.69	1.52	7	16.57	15.28***	10.03	45.32	35.29***
	Reading Comprehension	n/a	n/a	n/a	1.61	39.63	38.01***	6.62	65.01	58.39
Mathematics	Number Discrimination Part A	50.29	74.12	23.82*	70	92.26	22.26***	87.65	98.53	10.88
	Number Discrimination Part B	37.65	65.29	27.65***	20.65	80	59.35***	75.88	89.41	13.53
	Addition Level 1	30.29	44.85	14.56	53.71	78.87	25.16***	71.62	92.65	21.03***
	Subtraction Level 1	28.53	40.29	11.76	40.48	61.94	21.45***	53.09	75.59	22.5***
	Missing Number	18.38	32.11	13.73	68.55	62.9	-5.65	45.34	79.17	33.82***
	Addition Level 2	10.59	53.87	8.82	24.19	53.87	29.68***	42.06	75.88	33.82***
Subtraction Level 2	10	17.06	7.06	21.94	48.06	26.13***	25.59	64.71	39.12***	

After the 3-month Kikit School extra-curricular session was provided, the same students who participated in EGRA and EGMA in the baseline were tested at the endline. Test result differences between the endline and baseline are shown in Table 2.

Scores from both baseline and endline are out of a total of 100 for each subtask. Thus, for example, 15.3 points increase for the letter name recognition indicates that on average, third grade students scored 15.3 points higher after participating in the Kitkit Session. Also, 35.3 points increase for underading the oral reading passage indicates that on average, third grade students scored 35.3 points higher after participating in Kitkit Session for 3 month. The statistical significance of the difference is represented at three levels, *** for 99% confidence level, ** for 95% and * for 90%. For most of the subtasks with statistically significant increases,

findings indicate that the improvement is statistically significant at 99% confidence level.

Letter name sub-test results improved for all three grades. Second and third grade students showed improvements for several sub-tests of literacy and math tests, including identifying familiar words and invented word, reading words from a reading passage, and addition and subtraction. However, first graders did better on number discrimination, which asked children to identify which number is bigger in a set of two (part A) and a set of four (part B) numbers. This implicates Grade 2 and 3 children are more ready to learn English as a second language while Grade 1 students need to focus more on learning Kinyarwanda as their mother tongue language. This provides lessons on proper designing of targeting for next intervention.

Kitkit School Activity Framework



As students progress through Kitkit School, they encounter over 2200 activities across literacy and numeracy. Each Egg Course contains up to 30 learning sessions and each session include 4-6 relevant, scaffolded activities. When children complete all the Egg Courses, Sessions, and Learning Activities in each Literacy and Numeracy Coop, they will have mastered the curricular content in the Kitkit School system, achieving a strong foundation in reading and math..

Kitkit School also provides embedded assessments. Each Course includes a Post-Test at the end of all sessions. These assessments ensure users have mastered the curricular content in the Course. If students succeed in each assessment, the creature associated with that Egg Course will get a crown, and the next Egg Course will be unlocked. These serve to inform users' progress through curriculum and to support each child's motivation and confidence.

FINDING 3.

Students spending more time engaged with Kitkit School, particularly students in 3rd grade, were more likely to pass to advanced stages in math and literacy.

On average, students used Kitkit Session for about 756 minutes, while the intended time use was 1230 minutes. The student who fully utilized the opportunity of Kitkit Session played for 2249 minutes.

As shown in Figure 1, second and third grade students' use was more evenly distributed than first grade students.

Figure 1. Number of Minutes on Kitkit Session by Grade

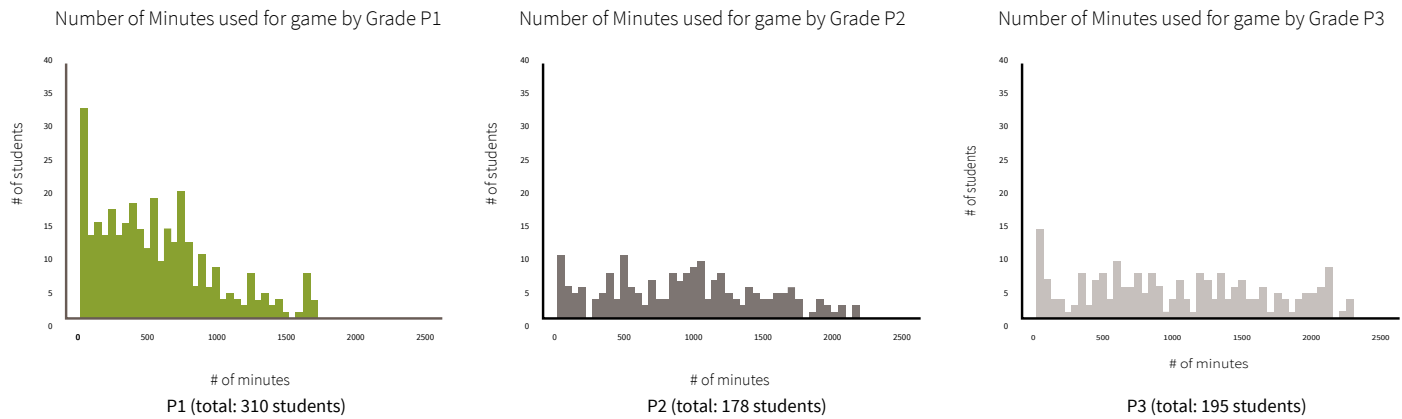
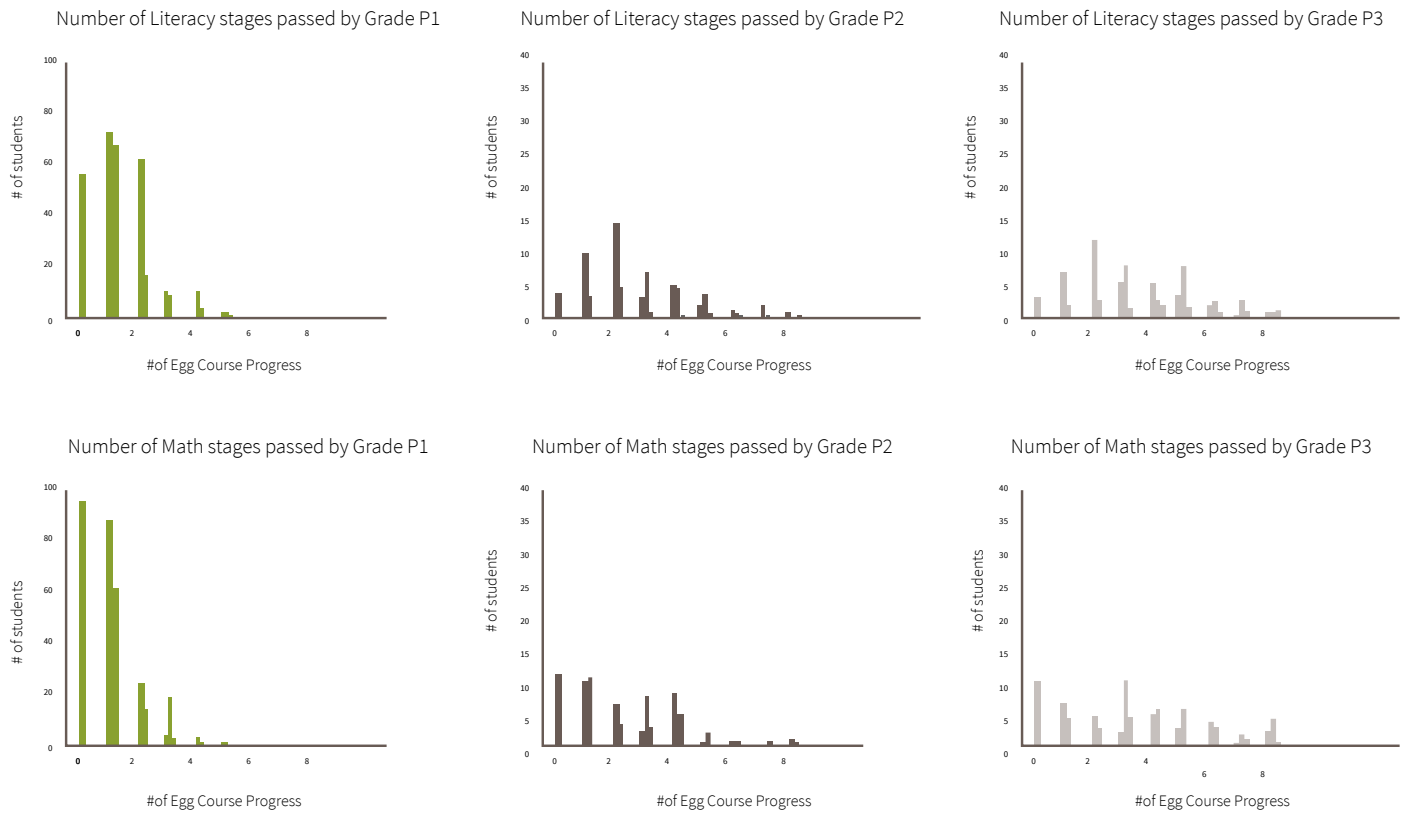


Figure 2. Number of Literacy (top) and Math (bottom) Stages Passed by



In the case, how far students are able to advance in the Kitkit School curriculum for literacy and math lessons are shown in Figure 2. Stages range from 100 to 800, which is referred to as Egg Course 1 to 8 within the Kitkit curriculum. While first grade students do not pass beyond 500 (Egg Course 5) for both literacy and math lessons, fewer second and third grade students stayed in level 0 and greater number of second and third grade students reach level 800 (Egg Course 8). On average, first grade students remain in Egg Course 1 for both literacy and math, while second and third grade students reach Egg Course 2 for literacy and math.

As different level-progress data show, tablet-based 1:1 learning solution enables individualized learning path by reflecting each child’s unique learning capabilities and needs. For students learning English as a second language, there is still much to be considered when designing the intervention to provide the optimal level of accessibility and rigor for students at different levels of readiness. For example, first graders may need to be paced slowly while third graders could be on a faster track. This implicates the need for reconsideration on designing the intervention to target English learners.

FINDING 4. More improvement when students take-up intended use time

Students were divided into two groups, by using the intended time spent on Kitkit Session as the cutoff, 1230 minutes. For each set of boxplots in Figure 3 and 4, the left boxplot is based on the students who played the Kitkit less than the intended time, while the right boxplot is based on the students who used it more than the intended time. While the orange line indicates the median of the distribution of students’ scores on math

or literacy subtask, the blue line represents the average score. Among math subtasks, students who used Kitkit more than the cutoff time, scored 9 points higher on average (Figure 3). Among literacy subtasks, students improved most on identifying the letter name, scoring 30 points higher for those who used more than the cutoff time (Figure 4).

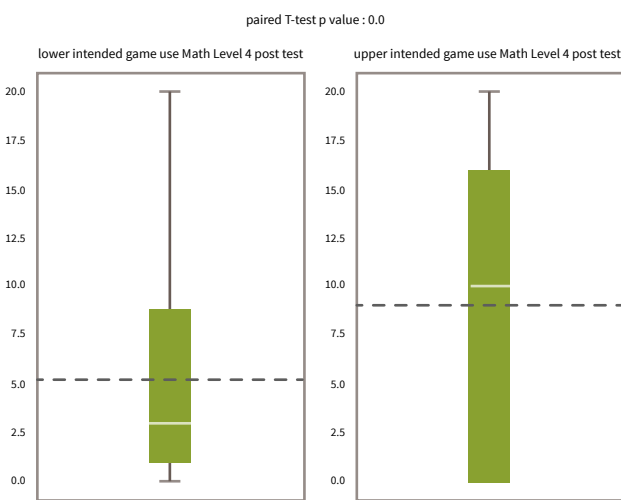


Figure 3. Boxplot of Score Improvement on Math Subtask Missing Number

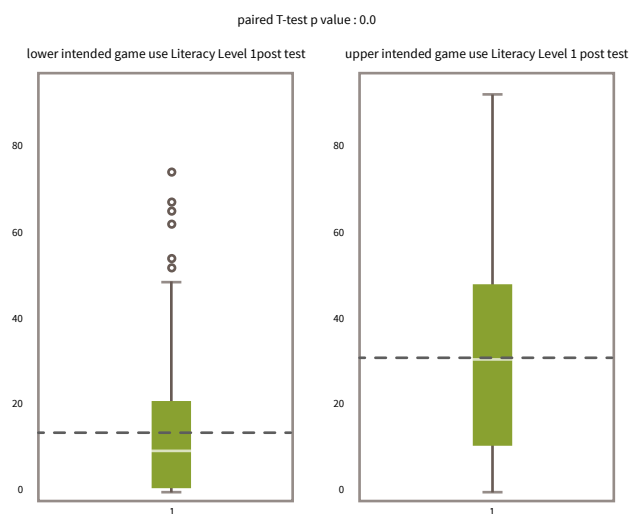


Figure 4. Boxplot of Score Improvement on Literacy Subtask Letter Name

Summary & Recommendations

THE POTENTIAL OF DIGITAL INTERVENTIONS TO SUPPORT SIGNIFICANT LEARNING GAINS AND IMPROVED ACCESS AND ENGAGEMENT FOR STUDENT

Whether digital learning solutions, beyond the provision of digital educational hardware, can deliver improved education experiences for children in low-resource settings is a practical and urgent challenge to be addressed to achieve sustainable development.

Although Kitkit Session was provided as a voluntary extra-curricular activity, it is promising that students actually used it to learn literacy and math skills. Beyond engagement, playtime is considered one of the indicators of children's level of motivation to learn as participation was voluntary-based in the project. As observed, students in higher grades seem to be more engaged with the solution; while third grade students played Kitkit School for 1003 minutes on average, second grade students used it for 905 minutes on average and first grade students for 515 minutes. First grade students spent the least amount of time on Kitkit Session, indicating that it might be too early to actively learn a second language for them. Additionally, the limitations of the available space in the school and related 2-3 hours waiting time to join Kitkit Session might provide an explanation. For young learners in first grade, the wait for this voluntary program may have hindered maximum participation. If GN and Enuma are

interested in a second round of the trial, analyzing peer effects of using Kitkit School and the role of facilitators and teachers in the implementation of Kitkit School may be also useful to better understand why there are such differences across grades. Better understanding of any social, cultural, or institutional barriers for participation also needs more attention.

Moreover, EGRA and EGMA oral I test results indicate that second and third grade students improve on many English literacy and math subtasks. Whether these improvements are correlated with specific games within Kitkit School tasks will also be helpful so that teachers have students repeat tasks they need practice in. Going forward, it will be worthwhile to study the relationship between the participation and degree of Kitkit School use on school academic achievement outcomes.

Additionally, it should also be stated that results provided here are limited to process evaluation, due to the absence of a comparison group. For future plans to scale up this project, it is recommended that the partners utilize a phase-in design to assign treatment and comparison groups of students.

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