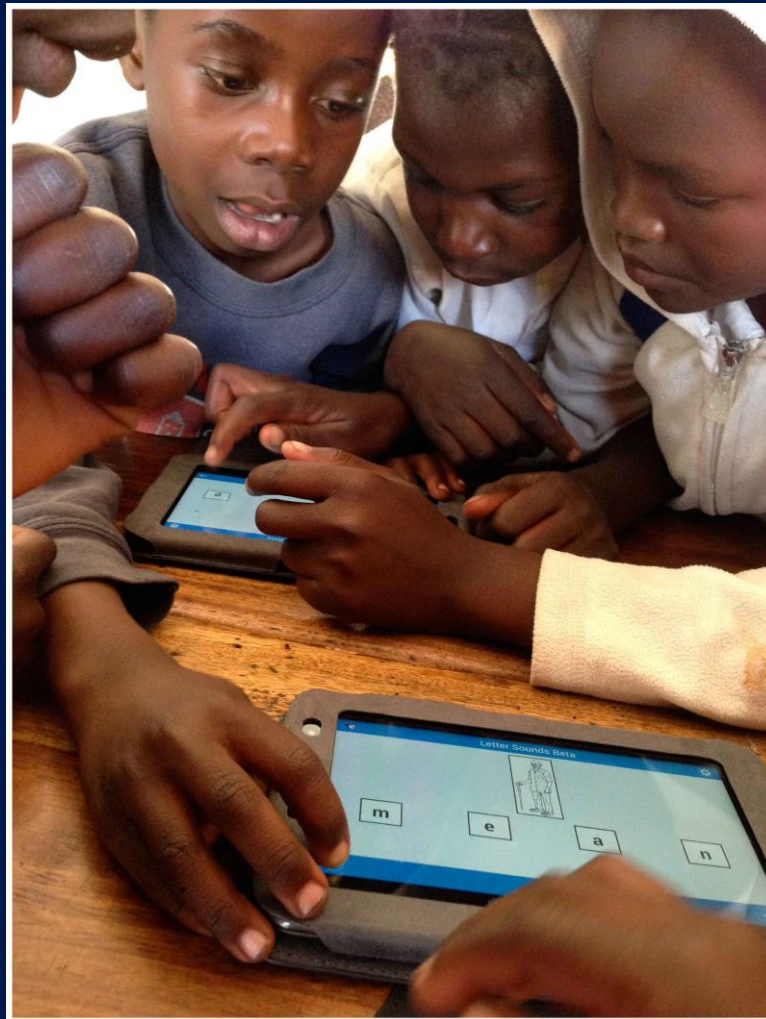




Vernacular Evaluation Report:

A Cost-Effectiveness Study of ICT in Zambian Community Schools

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EXECUTIVE SUMMARY

Vernacular is a set of reading activities that Zambian primary students can complete using android tablets. The software is designed to be customized with local language, artwork and sound recordings, at very little cost, so it can be rolled out in other Bantu languages within both Zambia and sub-Saharan Africa.



We have evaluated Vernacular in a randomized control trial involving 30 Cinyanja speaking community schools around Lusaka. The results show impressive learning gains for tablet users, over both control schools with no intervention and schools where the same activities were simulated in printed worksheets marked by the teacher. Not only did Vernacular users greatly outperform their peers in other groups, they also showed improvement in higher order literacy skills, such as passage fluency and comprehension, which were not explicitly practiced in the activity suite. This implies that the use of Vernacular was having cumulative effects on reading in a way that was not achieved by the worksheet intervention. In short, the whole effect of Vernacular was greater than the sum of its parts.

A recurring criticism of technology solutions is their cost. To investigate the cost effectiveness of Vernacular we analyzed the hardware costs for correlation with the learning gains they afforded. This unique addition to the study revealed that, when one considers falling device costs as well as the potential afforded by sharing devices across different classrooms, Vernacular is in fact more cost effective than printing student workbooks. That cost effectiveness will increase if the tablets are also used for other educational purposes, such as sharing teacher training and coaching materials.

Vernacular represents an excellent tool to improve literacy, as it provides learners with the opportunity to practice their reading skills, receive immediate feedback, and also watch their peers do the same, at low cost per user. Its design means that it can be easily and cheaply adapted into new languages, using only simple technical skills that are widely available in the Zambian marketplace. Vernacular represents an innovation in software design that allows the MOGE to create, with no further development assistance, a learning product with all the quality of an international solution but all the recognizable native attributes and retained local control of a home-grown product.

INTRODUCTION

This report discusses the context for and results of the Vernacular intervention and research study. First, we outline the implementation environments and conceptual framework that drove the Vernacular design decisions. Second, we describe the touch-screen activities that were created for learners to practice (within the conditions of a Zambian classroom) the component skills of literacy, and the simple steps required to animate the software into any local context. Third, we describe the study we completed both to measure Vernacular's learning impact and to analyze the true costs of this tablet intervention against a conventional literacy product. We conclude with some recommendations and points of discussion.

CONTEXT: EARLY LITERACY IN ZAMBIAN COMMUNITY SCHOOLS

The typical Zambian community school has been built by concerned parents who wish a quality education for their children, but who do not have access to a government school, either because they are too remote or because they are too poor to afford the hidden fees. These parents have been driven, by a combined spirit of enterprise and desperation, to take responsibility for their children's education in the only way they know how.



Both school structures and staff, though humble, are a function of the best means of the community. Buildings are simple, teachers are not typically trained. The most qualified community school teachers are grade 12 graduates themselves, though many more have not reached that level of education. Some are paid a subsistence level salary by the community, others are paid in kind with food or labor in their fields, and others still are true volunteers. Teaching skill levels are low, teacher attrition rates are high, class sizes are large. Yet, remarkably, the community school system works at the most basic level: teachers teach, children learn, and exam scores are surprisingly high.

Reading scores, however, are not. In 2012, the Time to Learn baseline assessment of community school students discovered that 68% of Grade 2 students could not correctly sound a single letter, and 94% of them could not read a single word. Indeed, teaching complex skills like reading is particularly challenging in community school conditions. Teaching reading requires a very specific instructional skill set that community teachers lack, a text-rich environment that is not found in their schools, and extended opportunities for individual student practice and feedback that the large class sizes and the low skills/low text environment mitigate against.

So how could these challenges be met? Inputs must match needs. Helping community schools to provide a higher quality of education means providing technical support that responds to their unique operational conditions. If a community teacher is to be trained, that training must be designed to benefit her replacement, as well, as the reality is she will likely not remain a teacher long. If materials are to be provided, they must be more robust and reusable than normal, as they will not be replaced soon. And if interventions are to be designed, they must account for the reduced attention each learner will receive due to the large class sizes and the low teacher skill. These were the needs we wanted to address when we designed Vernacular. The research study was intended to determine the extent to which we had been successful, both in terms of product-related outcomes and in terms of costs.

STUDY PURPOSE

The purpose of this study was to evaluate the Vernacular literacy software package and assess the impact it has on reading in a community school context. Our primary intention was to investigate whether our design of Vernacular was successful in addressing many of the challenges that hamper literacy instruction in community schools.

Secondarily, we also wished to investigate the common belief that while technology offers powerful tools, it also raises costs. We therefore compared Vernacular with a worksheet-based simulation of the same reading activities, in order to isolate the cost associated with ICT and the impact that technology affords, when compared with the costs and impact of a nearly-identical paper intervention.

The questions we sought to answer fell into three categories:

1. EFFECTIVENESS

- What literacy gains are achieved through the use of Vernacular, or the use of a worksheet-based Vernacular simulation, over conventional reading instruction in community schools?

2. COST-EFFECTIVENESS

- What is the cost-effectiveness of the ICT intervention (Vernacular) when compared to the paper based intervention (worksheets)?

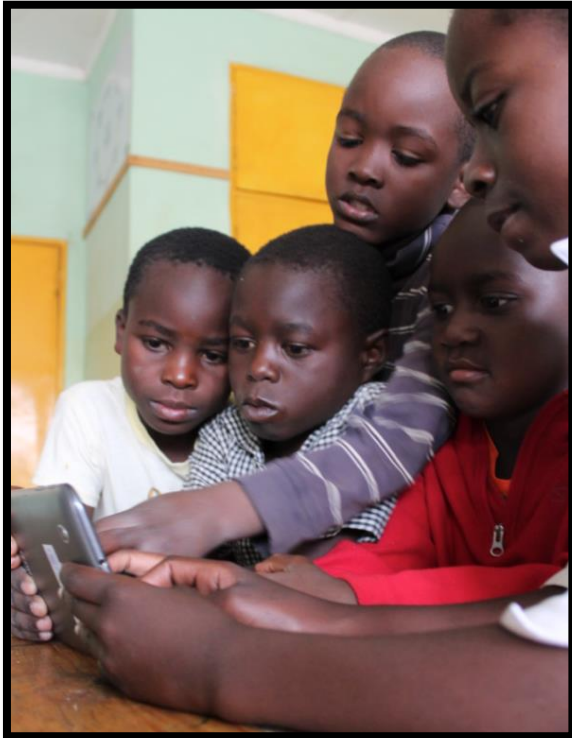
3. EFFICACY

- How well do the tablets endure the rigors of regular use in classrooms that have been given minimal technology training and maintenance and tech support?

THE USE OF ICT IN THE LEARNING PROCESS: AN ANALYTICAL FRAMEWORK

ICT based solutions have great potential to address educational challenges in Zambia. A well-designed tech intervention can supplement the skill set of the teacher and provide pedagogical structure for learning activities that a low-skills teacher may otherwise find difficult to design and implement. Technology can also be used to provide interactive

opportunities for students to practice new skills in a learning environment that, unfortunately, often remains teacher-centric and passive. Practice opportunities are made more powerful when the technology also provides immediate feedback to learners. Too often the large class sizes in some Zambian classrooms prevent teachers from providing students with individual guidance and encouragement. Delivering a three-part combination of strong pedagogy, interactive practice and immediate feedback is an attractive prospect in any learning environment, particularly in community schools. It is also a combination that has been historically hard to achieve through conventional materials and training techniques.



Despite these advantages, ICT solutions do not have a strong track record of success in Zambia. Software development is expensive and so are hardware inventories, maintenance and training. Tech devices can be fragile and unreliable. These constraints alone are enough to limit any educational impact.

However, attributing ICT intervention failures to cost and fragility actually masks a deeper problem. Technology solutions are too often externally developed and not grounded in the Zambian cultural or learning context. They do not represent the local curriculum, deliver content in the local language, allow for design input or control by local administrative bodies, or offer media that look and sound like the local environment. Often, as external, one size fits all solutions, they are so over generalized they do not

even address root educational problems. In short, they are device-centric rather than context-centric.

Until the Zambian educational ecosystem contains a core coding and instructional design skillset, technology solutions will always be an import instead of a native innovation. As such, they will look and feel wrong, they will be slow and expensive to adapt, and they will raise important questions related to ownership, control, adoption and validity, as the Bridge schools in Uganda¹ have. Proposed technology solutions will continue to miss the mark because they are not made by Zambians.

At Time to Learn, we do not see these authorship and cost challenges as insurmountable. Indeed, we feel that the potential of ICT to deliver the strong pedagogy, interactivity and

¹ <http://edition.cnn.com/2016/11/25/africa/uganda-schools-zuckerberg-gates/index.html>

reinforcement which are so difficult to deliver through conventional educational interventions is too great to ignore. Hardware costs are steadily falling, even as devices are developed that (with fewer moving parts and more intuitive interfaces) require less maintenance and user training. We thought it conceivable, therefore, that with the right design and hardware, a single software engine could be developed for simple local adaptation and rolled out into any number of Zambian languages, or even other Bantu languages across Sub-Saharan Africa. We recognized that while the initial design and development costs might be high, the recurring costs of local adaptation would be relatively low, and we believed that the benefits of this localized investment would be very high.

DESIGNING VERNACULAR FOR COMMUNITY SCHOOLS

Vernacular is a software platform designed for Android tablets that allows users to practice reading skills including phonemic awareness, phonological awareness and encoding. It has been created to enable children to complete interactive touch screen activities in their local language, and it provides levels of personal practice, feedback and correction that are normally difficult to achieve with low skilled teachers in over-crowded classrooms.

Vernacular contains three different activities: Letters, Sounds and Writing with Letters.

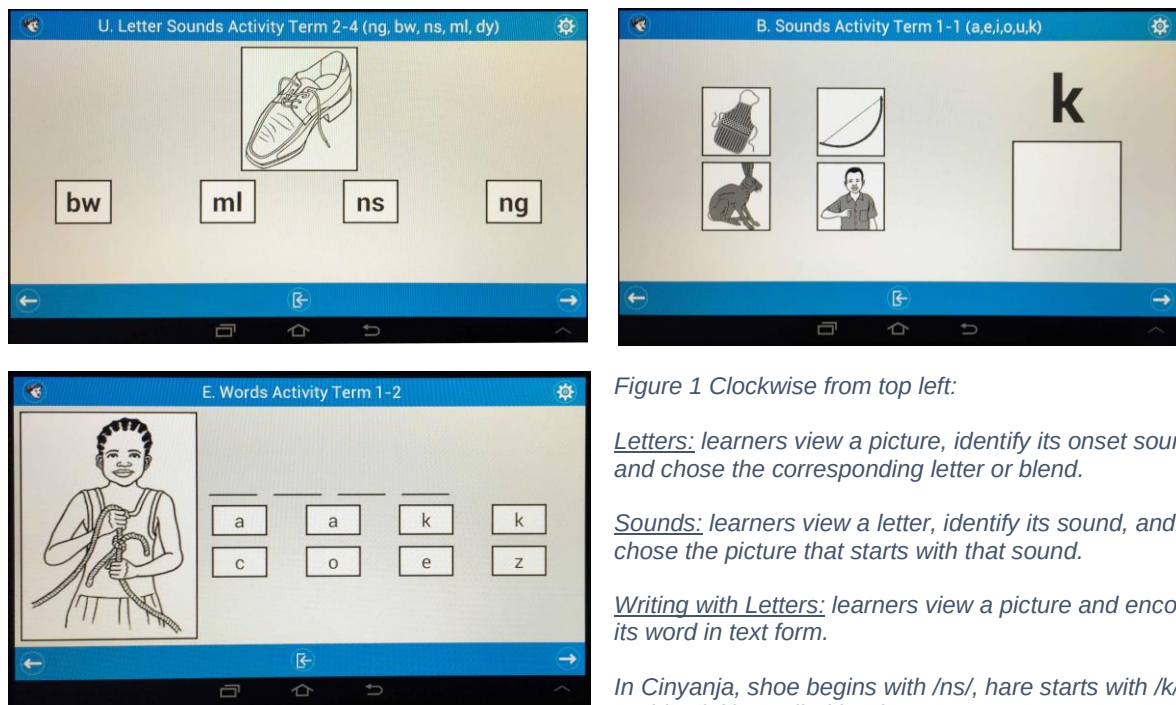


Figure 1 Clockwise from top left:

Letters: learners view a picture, identify its onset sound, and chose the corresponding letter or blend.

Sounds: learners view a letter, identify its sound, and chose the picture that starts with that sound.

Writing with Letters: learners view a picture and encode its word in text form.

In Cinyanja, shoe begins with /ns/, hare starts with /k/ and 'to tie' is spelled k-a-k-a.

A core set of principles informed our design. We sought to make Vernacular pedagogically generalizable rather than unique to one language, supplementary rather than directly instructional, iterative rather than finite, group-accessible rather than individualized, and graphically minimalist rather than visually rich.

VERNACULAR IS PEDAGOGICALLY GENERALIZABLE

These basic literacy activities were designed because they represent a core selection of reading sub-skills. They are also suited to languages with predictive orthography, meaning they are suitable for all Bantu languages. “Letters” focuses on phonemic awareness and “Sounds” on phonological awareness, while ‘Writing with Letters’ covers both these skills in addition to encoding.

VERNACULAR IS SUPPLEMENTARY

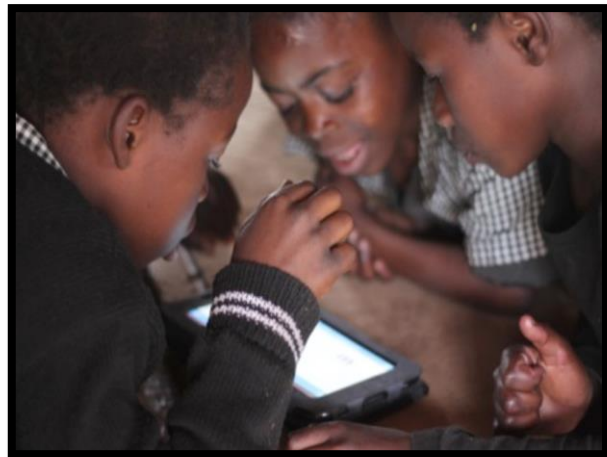
We expect the classroom teacher to be following the Zambian National Literacy Framework, and using the approaches and materials provided to Zambian schools by USAID’s literacy projects. Vernacular has not been designed to replace the teacher (indeed, doing so is neither possible nor desirable). Students will benefit most from Vernacular, therefore, if teachers have already taught them letter sounds and introduced age-appropriate vocabulary developed by MOGE. However, if the teacher has delivered this instruction effectively, Vernacular will quickly provide practice and feedback that clarifies and reinforces the core skills of reading. It will also guide self-reflective teachers who spend time observing students using Vernacular by reminding them of each letter sound and of how to identify the onset sounds of vocabulary words.

VERNACULAR IS ITERATIVE

Sounds in Vernacular are introduced in alignment with the schedule for each national language. Teachers are expected to introduce new sounds according to the schedule, so they progress from simple and common sounds to more complex and infrequent blends. Vernacular provides new weekly activities that follow this schedule, mixing the sounds or words that have been newly introduced that week with a review of earlier material.

VERNACULAR IS GROUP-ORIENTED

Children often learn best in groups, where slower learners benefit from watching their more advanced peers, and all students consolidate their understanding by explaining and demonstrating it to each other. Device costs are also much higher when provided on a one-to-one ratio than when purchased for group use. Vernacular was designed for use in groups of up to five students, both to improve learning and to reduce costs. Students are encouraged to watch and help each other as they wait for their turn to ‘drive’ the touchscreen.



VERNACULAR IS GRAPHICALLY MINIMALIST

Research has shown that graphic literacy is most easily developed with simple line drawings. While many Zambian learners will already have been exposed to multimedia experiences, it is

important that the software be accessible and intelligible to all students. We have therefore limited the stimulation and graphic complexity of the interface. Vernacular also rewards correct answers with color, to build on the natural human response to aesthetic stimuli. Black and white drawings turn to color when the correct answer is given.



Figure 2. A sample of Cinyanja vocabulary pictures for Grade 1 words: ana, duwa, nana, fulu, seka, ngwee, ota.

DESIGNING VERNACULAR FOR CONTEXT CUSTOMIZATION

Vernacular was created for simple ‘field’ assembly. New languages and activities can be added quickly and easily without the need for behind-the-scenes computer coding. Though our pilot study was conducted in Cinyanja, our local project staff could just have easily configured it to work in any other national language.

Simple context customization was made possible by breaking software production into its component parts. We identified four unique parties to be involved in the design: computer programmers, literacy specialists, language specialists, and artists. We then targeted their input appropriately to keep overall costs down.

Coders used java to compile Vernacular into an Android app. Their code framework supported content that was later added and packaged into coherent, interactive, touch screen activities. As a backend framework with frontend customization, the coding work, which was expensive, only needed to be done once.

The literacy specialist also represented a one-time investment cost. Our literacy TA designed the overall instructional methodology and the reading activities that Vernacular provides.

The language specialist was responsible for assembling and sequencing the component language sounds and their appropriate vocabulary words. Although language specialists are inexpensive, they represent a recurring cost needed for each new language development.

Finally the graphic and recording artists respectively draw and record all the vocabulary words and language sounds. They are normally found readily available either as government employees or in the local labor force, and represent the greatest share of the recurring costs.

The one-time expensive costs are represented as ‘Home Office’ skill sets in the diagram below. Field Office skill sets, required for developing the actual content and context, are equally as critical, although they are both cheaper and recurring.

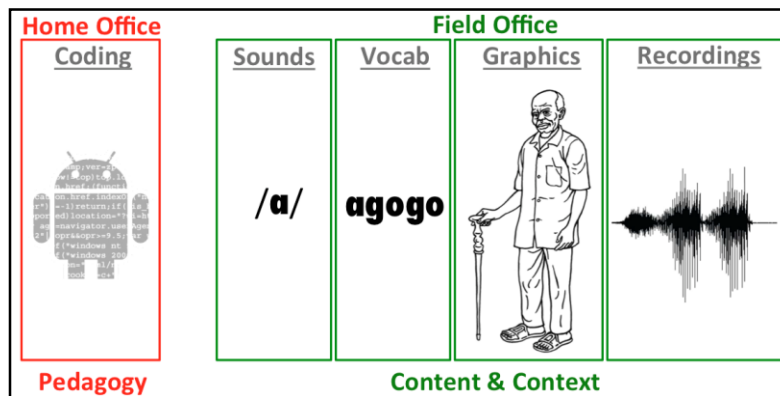


Figure 3 Vernacular's design isolates the expensive, one-time 'Home Office' costs from the small, crucial and recurring costs of customizing the software to local language and context.

After writing the Vernacular engine, the only ongoing costs relate to the two other skill sets: language specialists and local artists. MOGE retains internal capacity for both these needs. In our instance, CDC provided Language TA through Mr. Daka (the in house Cinyanja specialist) and DODE provided the recording services of their studios. We also hired an illustrator. The costs to the project for all three of these associated services was limited to a few thousand dollars. The future costs of developing Vernacular into each other Zambian languages will be limited to a similar figure.

With Vernacular we have inverted the traditional software development model and shown that coding doesn't need to be the final, cumulative act that compiles the contributions of others. In the Vernacular model the programming is done first. In consultation with our literacy specialists, our programmer has constructed a software framework that provides preset but 'hollow' reading activities. The three activities (Letters, Sounds, and Writing with Letters) are coded shells devoid of media. As such, they are a completed product that does not require recurring coding or literacy TA costs.

ASSEMBLING VERNACULAR IN THE FIELD

In keeping with our design aim, Vernacular was assembled in Lusaka by project staff who had no computer programming skills. Graphics were pulled from the Time to Learn literacy materials that were provided to community schools, all of which were drawn by a local artist.

Sound recordings, using a local voice actor, were completed at the Ministry of Education's studios. Project staff then loaded all media files into Vernacular's desktop authoring tool and sequenced them into weekly activities according to the language schedule. For details about the assembly process, please see Appendix A.

EVALUATING VERNACULAR

When the design and coding of Vernacular was complete, we had a product that did not require sophisticated coding skills to replicate into different languages. At this point we had achieved a major goal of producing a software platform that did not require large recurring costs to replicate in rich cultural detail in any number of local Zambian languages.

However, we still had two outstanding goals: to measure its impact on reading scores, and to measure its cost effectiveness when compared to a non-technology-based intervention. To achieve these two goals, we designed an impact evaluation of Vernacular.

METHODOLOGY

The study was designed to evaluate the effectiveness and the cost-effectiveness of the Vernacular intervention in improving reading outcomes of first grade community school students, relative to a comparable paper workbook intervention. Both the Vernacular and workbook groups were also compared to a control group that received only the standard Time to Learn material inputs (student readers and teacher instructional resources).² The two treatment groups were characterized by higher levels of student engagement and practice. The worksheet group allowed for both student engagement and practice, but provided only low level and delayed individual feedback in the form of teacher marks on the worksheets. The Vernacular group received engagement and practice opportunities combined with immediate feedback through the tablet activities.



Vernacular intervention group: students used tablets with instructional software that provided them with immediate feedback on their literacy work.

² Time to Learn resources include all material types needed to learn to read but, due to their prohibitive costs at volume, do not include materials for individual student consumption. Non-consumable student readers and teacher resources can be re-read by different students and used across school years.

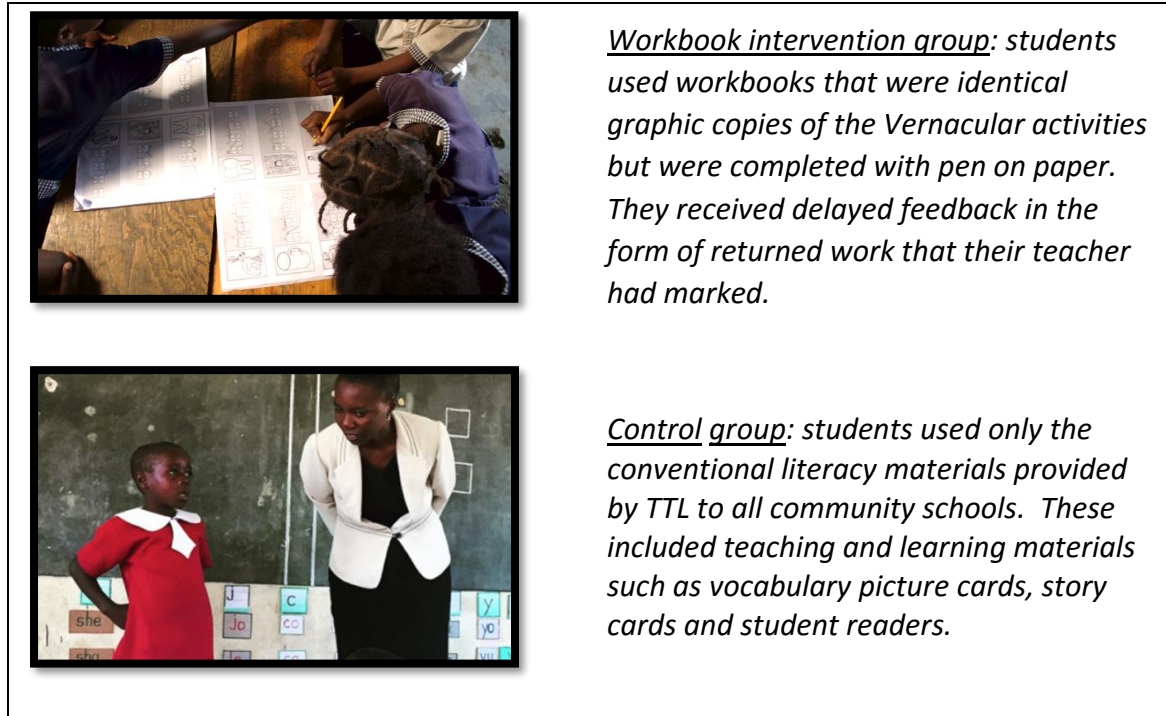


Figure 4. This study involved three groups. Through contrasting the similar interventions of Vernacular and workbooks, we attempted to isolate the greater levels of student engagement, practice and feedback that ICT interventions can provide.

Measuring Vernacular's Effectiveness

Outcomes of interest related to the effectiveness of Vernacular in improving early grade reading skills were rapid letter identification, fluency in decoding non-words, oral reading fluency of a grade-level passage, and oral reading comprehension. The standard Zambian version of the Early Grade Reading Assessment (EGRA) was used to measure these outcomes.

Measuring Vernacular's Cost Effectiveness

To investigate the extent to which the additional expense of procuring ICT for use in Zambian classrooms is justifiable in terms of return on investment, we employed the cost-effectiveness analysis method developed by Henry Levin (1995). Cost-effectiveness analysis is a decision-oriented method; it is designed to ascertain which means of attaining particular educational goals are most efficient when both costs and outcomes are taken into consideration.

The costs of an intervention are defined as the value of the resources that are given up by society to effect the result. These are referred to as the ingredients of the intervention, and it is the social value of those ingredients that constitute its overall cost. The ingredients method implies costing out all of the ingredients of the intervention, including implicit and explicit costs, and arriving at a comprehensive and detailed summary of the costs per unit of outcome. Cost-effectiveness analysis results in a ratio where the numerator is the total cost of the intervention and the denominator is the effect size of the outcome of interest.

When comparing multiple models for effecting desired educational outcomes, it is a reasonable and widely-practiced approach to exclude from the analysis elements of the delivery that are identical across the intervention, and focus the cost analysis on those

elements that are different. Since the intent of this cost analysis is to compare cost-effectiveness of the ICT versus Workbook interventions, only the marginal costs of those two interventions were included in the cost analysis.

Measuring Vernacular's Efficacy

We also explored the efficacy of implementing an ICT-based reading intervention in Zambian classrooms. The study looked at how well the tablets survived regular classroom use, and whether the software was simple enough for teachers and students to use without a continuous support system that might add dramatically to the cost.

ANALYSIS

The study used a randomized controlled trial design with two arms and a control group. The population of schools from which the study schools were selected and then randomly assigned to one of the three study groups was community schools within reasonable proximity to Lusaka. The sample, therefore, is not representative of the entire population of community schools in Zambia but rather of community schools in proximity to Lusaka.

The sampling approach followed a random clustered sampling method to obtain a nationally representative sample of non-private schools (public and government-aided schools only). The sample was determined based on the following assumptions:

- Type of analysis: logistic regression
- Alpha (probability of Type I error): $.05/4 = .0125$. Alpha is divided by four because four separate measures are used by the test (letter identification, decoding, fluency and comprehension)
- Power (probability of Type II error): 0.9, or 90 percent
- Expected effect size: 0.3 (moderate)
- Expected inter-class correlation (ICC, or roh): 0.05

Using Optimal Design cluster sampling software, the following sample size was computed:

- Total number of clusters (schools) = 30
- Cluster size (number of students in a school, per each grade, per each gender) = 20 students in each school.



Figure 5. A teacher orients his class to using the tablets.

Total sample size was 600 students, with 619 students actually tested and included in the study (221 students in the Vernacular study group, 201 in the workbook study group, and 197 in the control group).

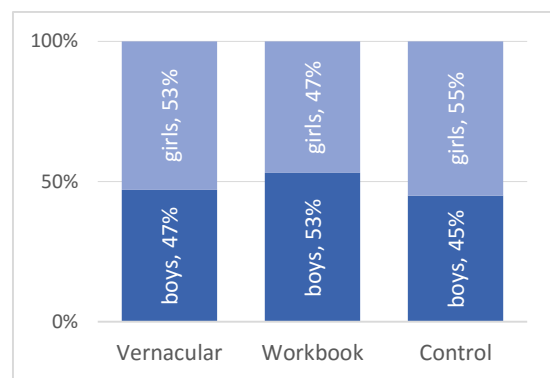
The study team tested students twice: the first time in May of 2015 school year, and again after four months of usage. The study design intended to track students longitudinally to establish the amount of growth each student experienced. However, not all students were present during the second testing, so those students who were missing were replaced with students with similar demographic characteristics, such as their gender and age. The rate of replacement was highest in the control group, at 27%, compared with 19% in the Vernacular group and 23% in the Workbook group. The median student age in the Vernacular group was 7 and in the other two groups it was 8. Finally, while gender was not a research consideration, the study overall had near gender parity (though the gender distribution in the three groups was not even - the Workbook group had somewhat more boys in the sample while the other two groups had more girls.)

The study used gain score analysis (also known as the difference-in-difference method) to compare gains over the baseline in each of the study groups. The effect sizes of the changes between the baseline and the endline were computed and statistically compared.

In addition to the student learning assessment, data collection included a student context survey and a teacher survey at both baseline and endline. These surveys were designed to provide information about the context of implementation.

The study team also collected fidelity of implementation data throughout the four months of the intervention implementation. The data from the assessments, fidelity monitoring and the surveys were included in the analysis.

Figure 6. Gender distribution in the study groups



GENERALIZABILITY AND LIMITATIONS

The 30 schools selected for the RCT were selected non-randomly. As a result, it is unknown to what extent the findings from the present study can be generalized onto the entire population of the community schools in Zambia. Additionally, the attendance data and the fidelity of implementation data were found to be incomplete for most schools, which prevented any analysis of time-on-task. Finally, despite the random assignment of schools to each group, the balance test revealed that the Vernacular intervention schools showed significantly better results at the baseline compared with the other two groups, and the control schools were found to be performing the worst of the three groups. Since the pattern of growth in education outcomes is rarely linear, it is unknown to which extent the difference

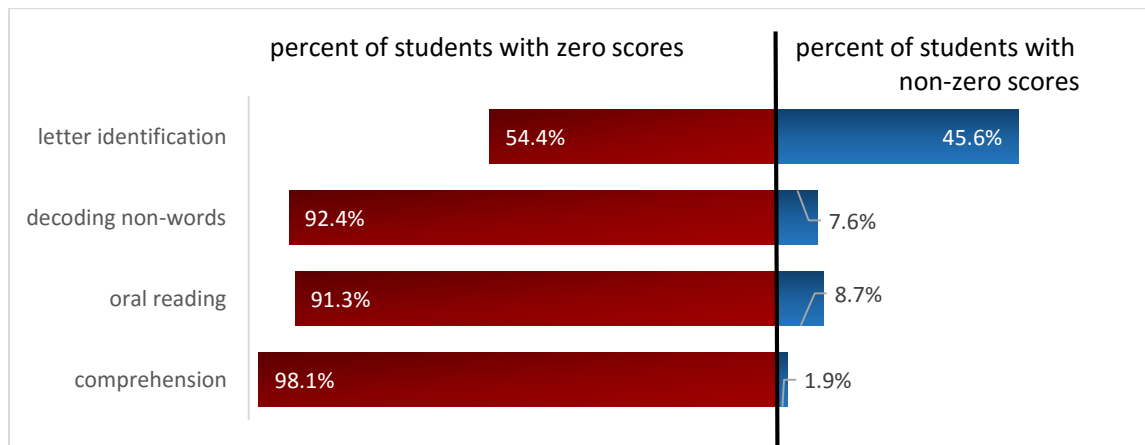
in achievement at baseline is indicative of other characteristics that predisposed those schools to a higher improvement rate, comparing to the control schools. Additional studies with larger samples representative of the entire population of Zambian schools would be necessary to fully determine efficacy of implementation of the Vernacular intervention.

FINDINGS

CHANGES IN READING SCORES

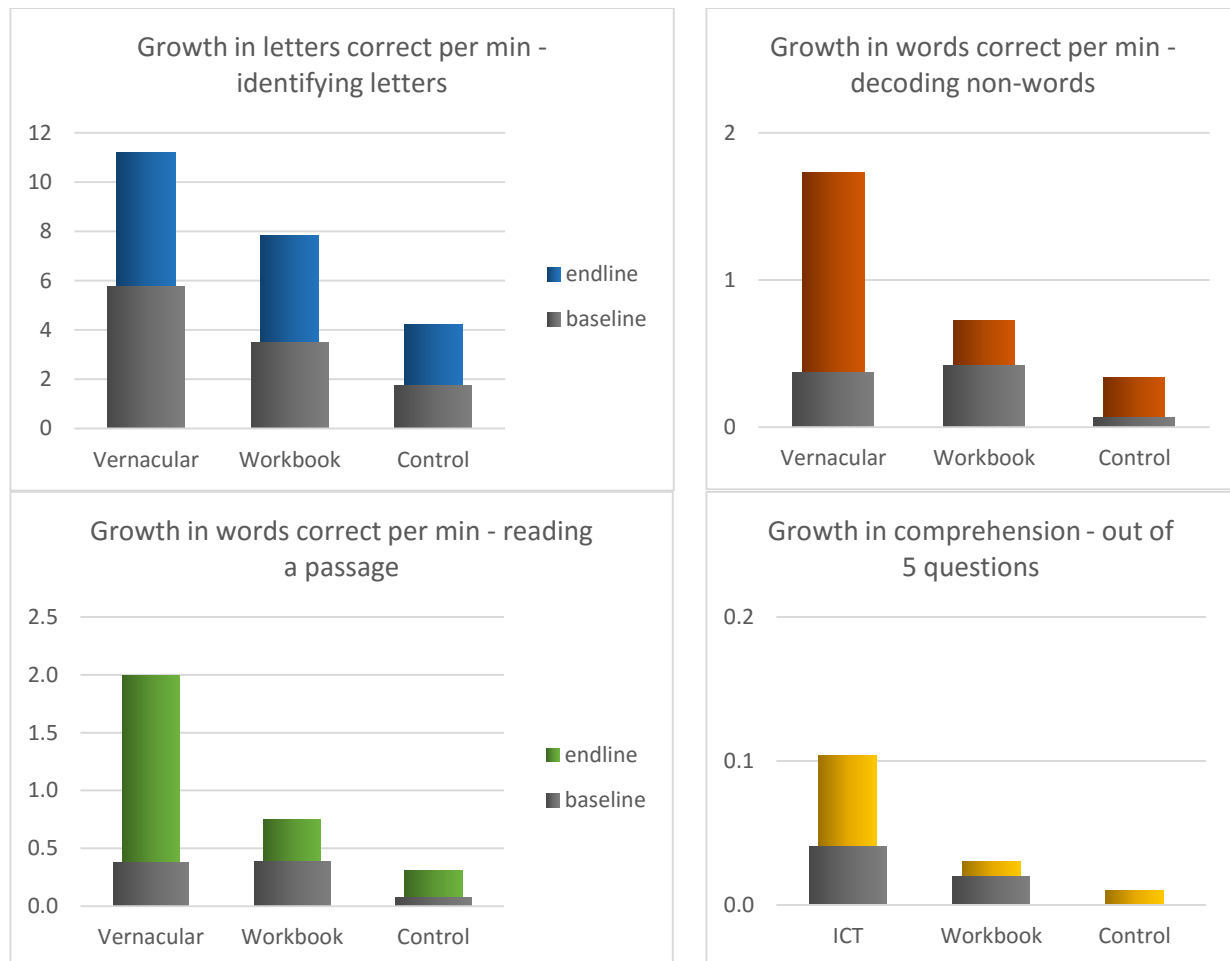
The first question we sought to answer was what literacy gains could be achieved through the use of Vernacular, or the use of a worksheet-based Vernacular simulation, over control schools. The baseline assessment found overall very low levels of reading among all tested students. More than half of all tested students could not identify a single letter at the beginning of the first grade, and over 90% could not read a single word.

Figure 7. Overall levels of reading proficiency at baseline, grade 1 (n=619)



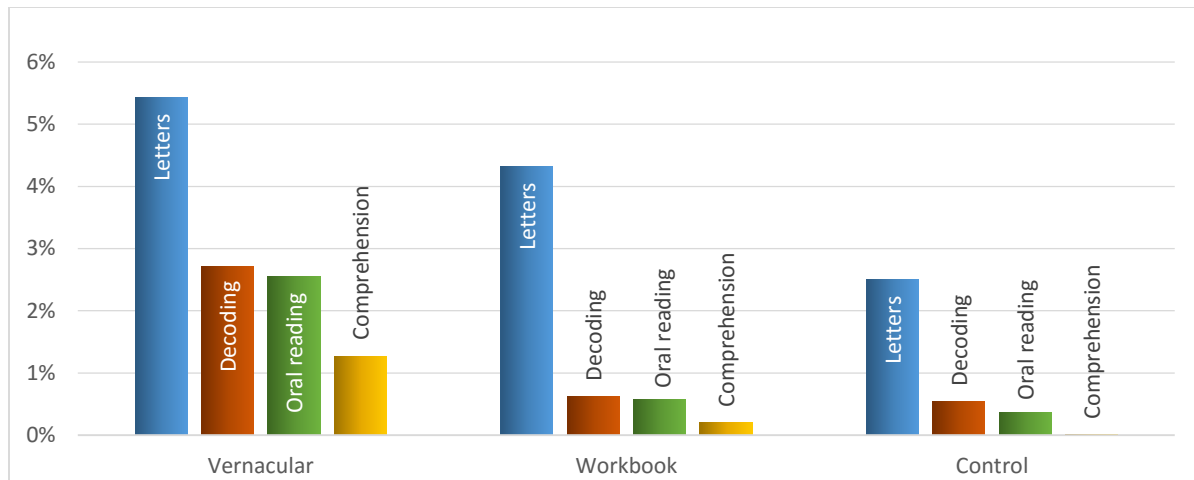
The Vernacular intervention group showed the greatest gains between the baseline and the endline, followed by the Workbook group. The control group showed the least improvement between the baseline and the endline. The figure below shows the average scores of students in the three study groups.

Figure 8. Average growth between baseline and endline.



The following figure shows average gains between baseline and endline for the three study groups. The letter identification subtest showed the largest gains. While our incomplete fidelity data does not permit us to state this conclusively, anecdotal evidence suggests this is due to the fact that the teachers focused most of their reading instruction on this basic foundational competency.

Figure 9. Gains in percent correct between the baseline and endline.



Calculations of effect sizes demonstrated that the Vernacular intervention group significantly surpassed the Workbook intervention group in gains over the control group, with the average effect size³ of .36 in the Vernacular group and .08 in the Workbook group. Table One presents the effect sizes for each of the subtests, over the control group.

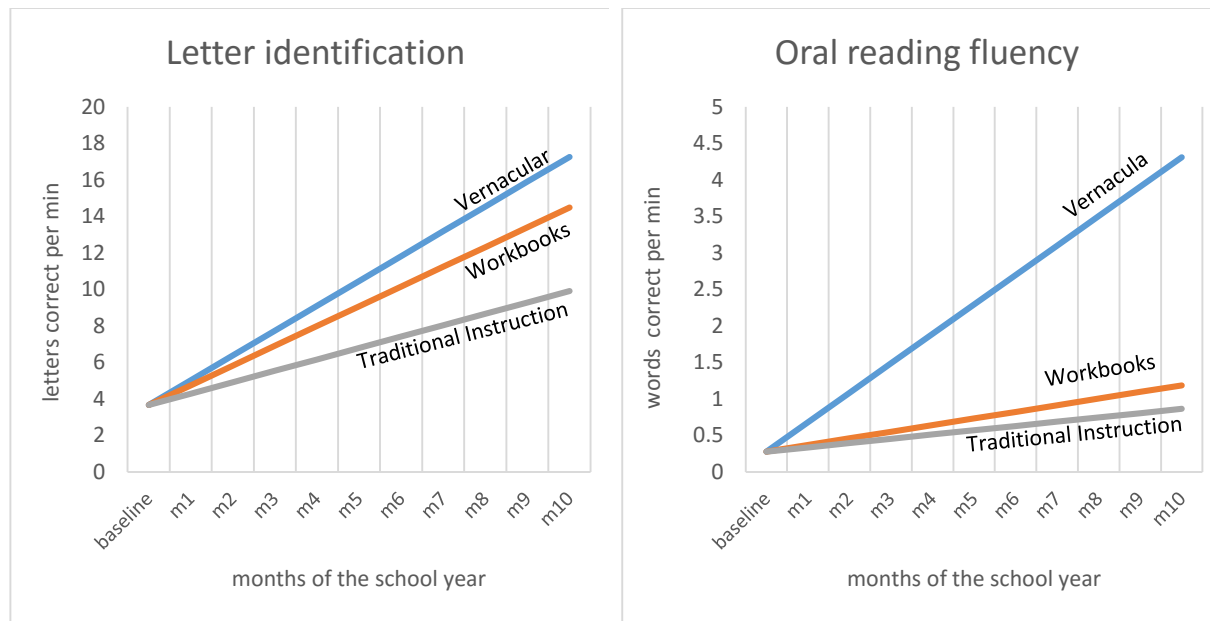
Table 1. Effect sizes of gains in the intervention groups over the control group

SUBTESTS	Effect size of Vernacular over control	Effect size of Workbook over control
Letter identification, correct per minute	0.35	0.21
Decoding non-words, correct per min	0.37	0.02
Reading a passage, words correct per min	0.42	0.06
Oral reading comprehension, pct correct	0.25	0.00

Based on the data from the three study groups, we estimated the growth trajectory of the two studied interventions and compared them to the control group. To enable the comparison of growth trends over the course of the entire school year, we created a single starting point for the three groups by averaging the existing baseline data, and constructed the growth trend by projecting the rate of improvement to the full school year, based on the data for the first four months of the year.

³ Lipsey and Wilson (1993), Vernez and Zimmer (2007), and Hill, Bloom, Black and Lipsey (2007) suggest the following interpretation of effect sizes in education: 0.25+ as large, 0.15 as medium, and 0.05 to 0.10 as small.

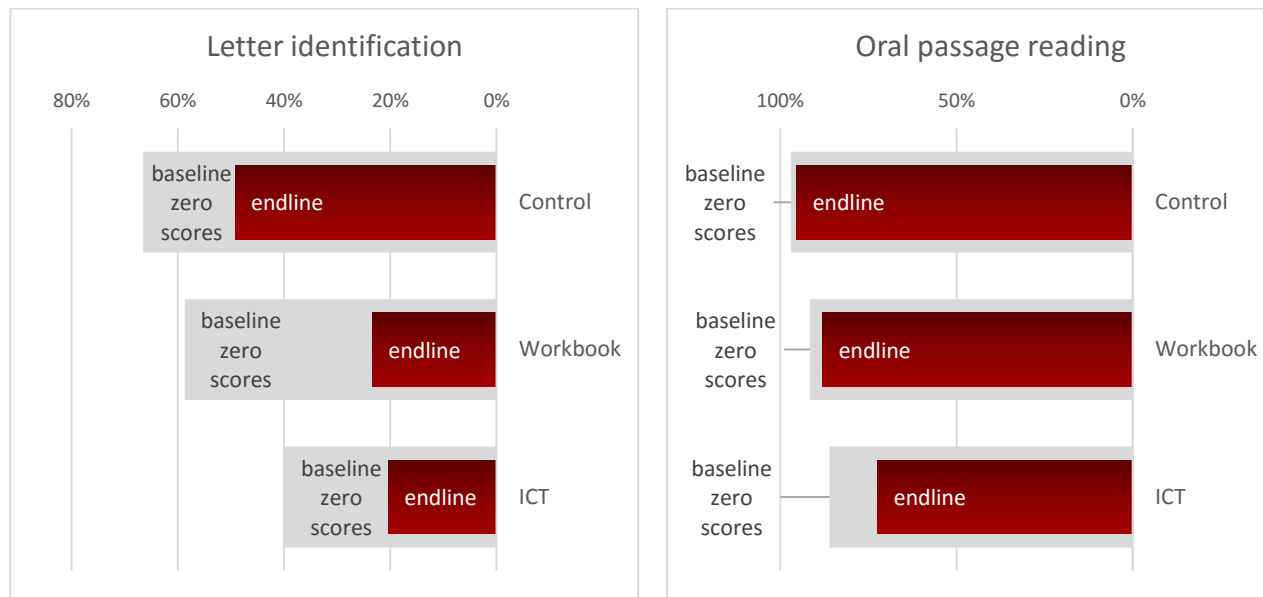
Figure 10. Growth trends over one school year for the two interventions and the control group. (n=619)



We anticipated that one of the results would be a significant reduction in the percent of students with zero scores. Indeed, the *t* test showed that the reduction in the percent of students with zero scores on both letter identification and oral passage reading subtests was statistically significant for the Workbook intervention group ($p < .01$ for the letter identification subtest and $p < .05$ for the oral passage reading subtest). The analysis also found a highly statistically significant difference in a reduction of zero scores on the oral passage reading in the Vernacular intervention group, compared to the traditional group ($p < .001$), but not in the letter identification subtest.

The following figure demonstrates changes in the percent of students with zero scores on the letter identification and oral passage reading subtests.

Figure 11. Percent of students with zero scores at baseline and endline (n=619)



Overall, despite significant improvements seen in the intervention groups, the proportion of students with zero scores was found to still be extremely high after the four months of classroom instruction.

COST-EFFECTIVENESS OF VERNACULAR VERSUS THE WORKBOOK INTERVENTION

The second aim of our study was to discover the cost effectiveness of Vernacular, compared to a traditional, non-ICT intervention. The development costs of the Vernacular back end were excluded from this study because they are one-time costs and will not be incurred again.

The following table summarizes the ingredients that were included in the cost analysis of the two intervention models, compared to the traditional model.

Table 2. Ingredients included in the cost-effectiveness analysis

INGREDIENTS	Control	Vernacular intervention	Workbook intervention	Included in cost analysis?
Labor costs	same	same	same	No
Facilities	same	same	same	No
Teacher training	none	same	same	No
Standard materials	same	same	same	No
Intervention materials	none	Tablets, \$250/4 learners = \$62.5 per learner	Paper workbooks, \$0.88 per learner	Yes

Computations of cost-effectiveness of the two studied interventions that used data from an intervention period of 4 months resulted in the following findings:

Table 3. Cost-effectiveness of Vernacular versus Worksheet interventions, \$250 per tablet

INGREDIENTS	Vernacular intervention: actual cost per outcome*	Workbook intervention: cost per outcome**
Letter identification, correct per minute	\$179	\$4.2
Decoding non-words, correct per min	\$169	\$44.0
Reading a passage, words correct per min	\$149	\$14.6
Oral reading comprehension, pct correct	\$250	n/a

*computed as follows: the actual cost per learner (\$62.5) divided by the effect size (Table 1)

**computed as follows: the actual cost per learner (\$.88) divided by the effect size (Table 1)

A true understanding of costs involves a close examination of parameters and assumptions involved in the cost analysis. The present study utilized tablets that were locally procured and were not the best value. Tablet costs have also fallen since the study. An analysis of the tablet market conducted subsequently showed that comparable tablets could be procured for as little as \$40 each, dramatically changing the cost-effectiveness computations:

Table 4. Cost-effectiveness of Vernacular versus Worksheet interventions simulations, \$40 per tablet

INGREDIENTS	Vernacular intervention: cost per outcome* - \$40 tablets	Workbook intervention: cost per outcome**
Letter identification, correct per minute	\$29	\$4.2
Decoding non-words, correct per min	\$27	\$44.0
Reading a passage, words correct per min	\$24	\$14.6
Oral reading comprehension, pct correct	\$40	n/a

*computed as follows: the cost per learner (\$10) divided by the effect size (Table 1)

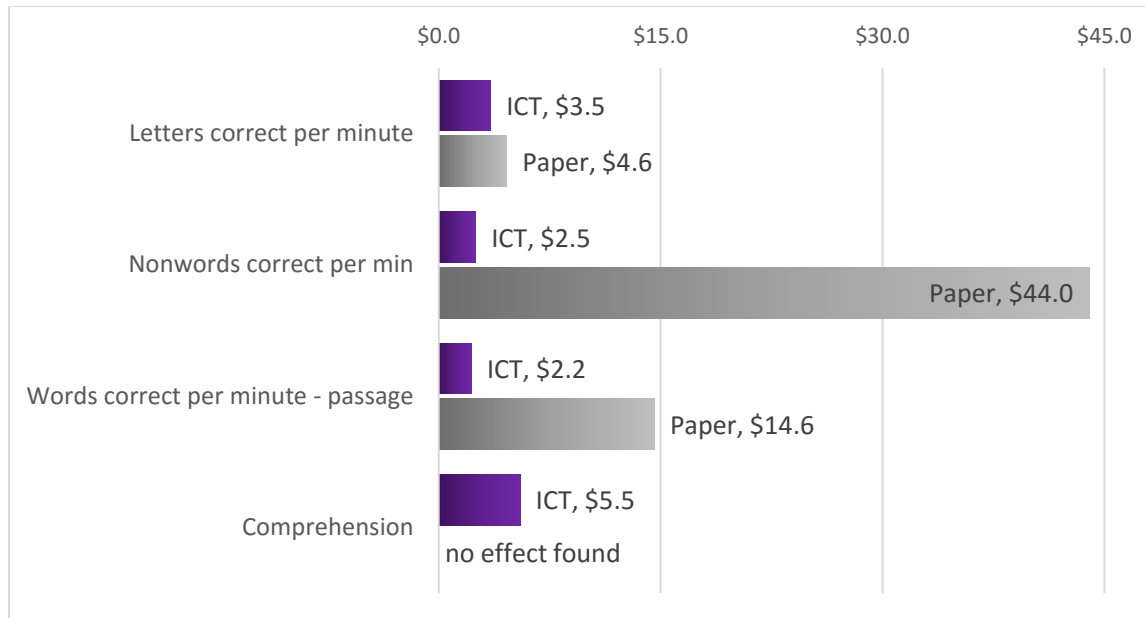
**computed as follows: the actual cost per learner (\$.88) divided by the effect size (Table 1)

Finally, the present study only examined the use of tablets with one class over the course of four months during a school year. One of the main advantages of the ICT approach as opposed to paper is its ability to be transferable as it is not a consumable product. We have computed estimates for cost-effectiveness of the two interventions with an assumption that tablets are shared across 4 different classes and are used for 3 years, with 15% replacement rate in Year 2 and 25% replacement rate in Year 3⁴. The resulting calculations, shown below,

⁴ Replacement rate estimates are based on five years of EDC experience with using tablets around the world in instruction and in digital data collection.

demonstrate that ICT can indeed be a cost-effective solution compared to an identical paper-based intervention.

Figure 12. Cost-Effectiveness of Vernacular versus Worksheet, when \$40 tablets are used with 4 classes, 4 students per tablet, projections for 3 years of use (15% replacement in Y2, 25% replacement in Y3)



EFFICACY OF TABLET USE IN COMMUNITY SCHOOLS

The third research question of our study focused on the durability of tablets and both their security and sustained usage in community schools. During the course of the study all schools were monitored regularly, and issues logs were kept on matters related to these factors. The research period was surprisingly non-eventful, with few notable findings.



Figure 13. Mobilock was installed so users could only access Vernacular.

Training

Training teachers to use both tablets and worksheets was limited to 7 hours each. This time was sufficient to cover the basics of usage, and no issues arose from the short training duration.

Maintenance

There were no notable maintenance issues, either in the form of tech support or broken devices. All tablets were provided in a case that offered some level of protection from rough handling. Tablets were also locked down using Mobilock, so access to all features apart from Vernacular was restricted. Early field testing showed this was a critical step to avoid device tampering and abuse.

Security

All thirty schools in the sample were preselected partly because they had a lockable room for tablet storage. There were no lost or stolen devices in 9 of the 10 Vernacular schools. However, the entire set of tablets was stolen during an evening break-in to the secure room of one school. Interviews with school officials and local police revealed that they believe the thief was looking for school funds that were sometimes kept in the strong room, and when no money was present the thief took the tablets instead. Because they were restricted to only use Vernacular, the thief was not likely able to profit from their resale. The project replaced the tablets and the school completed the study with no further incident.



Figure 14. A teacher learns Vernacular.

CONCLUSIONS

VERNACULAR'S EFFECTIVENESS

This study was designed to isolate the effect of the delivery model from the effect of the intervention itself. This design demonstrated that, indeed, intervention delivery via a tablet can be both more effective and more cost-effective than a more traditional paper-based delivery.

Vernacular users showed significant improvement over the workbook schools. They also registered the greatest effect sizes: on all four different reading sub-skills that were tested Vernacular effect registered as large against the Workbook's medium effect sizes. While the study was only four months long, projections for gains achieved show Vernacular learners on a trend line that steadily pulls ahead of the other groups.



Figure 15. Vernacular was designed to harness the social nature of learning.

It is also worth noting how Vernacular improved reading comprehension, which is a difficult accomplishment. A similar impact was measured on non-word reading, another sub-skill in which Vernacular, in its current version, does not provide practice. This is particularly interesting because Vernacular does not contain any comprehension skill-building activities – it is focused on phonics, phonemics and encoding. Comprehension is a higher-level literacy skill that builds in part on

these foundations. It is likely, and encouraging, that the literacy foundation being laid by Vernacular is strong enough to see gains in areas that extend beyond the scope of its activities.

This ‘carry on’ effect was somewhat similar for the workbooks, but more limited. The workbook group also saw an improvement in non-word reading ($r = 0.06$), though it wasn’t as large ($r = 0.42$). However, there were no comprehension gains in the workbook group, while Vernacular users still showed a large effect size ($r = 0.25$). This further highlights the positive impact of Vernacular relative to workbooks, and underscores the argument that the levels of interactivity provided by ICT stimulate deeper levels of learning that are hard to measure.

VERNACULAR’S COST-EFFECTIVENESS

The cost-effectiveness of Vernacular, under the conditions we tested (\$250 per tablet, used as a single-class set) showed that the effect size ‘purchased’ by an investment in worksheets was larger. However, this study did not investigate the reusable nature of tablets, and it did not use the most economic hardware available. By substituting a \$40 device and by assuming the class set can be shared over time within a school, Vernacular’s cost effectiveness surpassed that of a paper intervention. When effect size is held constant in these conditions, an investment of \$14.60 in worksheets returned the same learning gains as a \$2.20 investment in tablets.

VERNACULAR’S EFFICACY

We did not have any hardware problems of note. There were no major support or breakage issues with the devices, even after minimal training. In most places theft was also not a concern, perhaps because we removed the market value of each device by restricting it to only use Vernacular. While one set was stolen from a school, its replacement set was not.

Despite the fact that the ICT intervention clearly wins over the Workbook intervention and both produce better results than business-as-usual, the rate of improvement is still unacceptably low. Vernacular shows evidence of being an effective tool, but not a silver bullet.



DISCUSSION

This study raises several questions that are worth further discussion. What would further research discover if:

- The study period was expanded beyond four months?
- The schools were selected outside a peri-urban area?
- Activities were developed to practice other reading sub-skills?
- Tablets held other resources in addition to Vernacular?
- Vernacular was used in smaller class sets?

These questions are discussed below.

Expanding the Research Period

While we projected the trend line for learning gains 8 months beyond the study, we would prefer to repeat this research across a full school year. Reading gains are not normally linear and many students experience a ‘breakthrough’ when reading sub-skills crystalize and their reading speed improves dramatically.

We do not have verifiable data about the lifespan of each device. We estimated a three-year lifespan with escalating replacement rates each year when we completed the cost



effectiveness calculation. A longer study would allow us to confirm these assumptions.

Expanding the Research Site

We restricted this initial study of Vernacular to sites around Lusaka intentionally to take advantage of grid power. We wanted to research the impact of the software and the usability of tablets in classroom settings, and didn't want to compromise this research by introducing the further variable of solar power. However, solar panels are easily available to charge tablets, and although they would increase the cost they would not be difficult to provide or maintain.

Using solar power would allow us to evaluate Vernacular in more remote locations that could uncover new learning about the training and maintenance needs among a rural population.

Introducing New Reading Activities

In its current version, Vernacular is limited to three activity types that focus on phonics, phonemics and encoding. With further investment in the code base, activities for other reading skills (such as decoding, fluency, comprehension and writing) can be added. Multiple activity types for each skill can also be developed.

Vernacular also focuses on activities instead of games. Although more complexities arise in game development, the same design principle of allowing for media and language contextualization can be followed. Reading games are likely to raise literacy further, as children stay more engaged.

While both expanding the activity base and introducing games would increase the up-front investment costs in Vernacular, they would not add to the cost of each class set of tablets. Therefore, the cost effectiveness of Vernacular will increase further, partly because the print costs of additional workbooks to match would go up, and partly because it is reasonable to assume that the more advanced levels of interactivity would broaden the effect size gap Vernacular currently enjoys.

Introducing Other Tablet Resources

Tablets can be used for many things other than providing reading practice. Activities can be developed in other subjects following the same design principles as employed in Vernacular. Tablets can also be used for other important, but non-instructional activities, such as testing or teacher training. Adding these additional tools would make it more complicated to share tablets within a school, but they would not increase the hardware costs of providing them to each school. The breadth of impact would increase, and the cost effectiveness of the ICT intervention would improve even further.

Reducing the Class Set

Our early investigation into the ideal ratio of device to student discovered that 1:5 was unwieldy for the teacher, as children became impatient and disruptive during the long space between their turns. Ratios of both 1:4 and 1:3 were workable, though 1:2 was the favorite of both teachers and students. Interestingly, teachers disliked the ratio of 1:1 as they were quickly overwhelmed by simultaneous questions from students who didn't have a partner to problem-solve with. While this investigation informed our eventual choice of 1:4 for this study, we do not know what learning gains could have been achieved with each of the other ratios.

We also do not know if learners would benefit from a differentiated system in which Vernacular was used either as a remedial activity for struggling learners or as tool for advanced learners to forge ahead with new skills. It may even be possible to accomplish some modest gains with as few as 2 or 3 tablets per classroom. These questions have large implications for the costs associated with expanding Vernacular among a wider range of schools.



RECOMMENDATIONS

In light of the findings of this study, and the discussion points above, there are a few recommendations to note.

1. Vernacular should be expanded to provide more literacy activities and to introduce reading games. This would likely increase impact.
2. Other ‘field-assembled’ tools like Vernacular should be developed to address different school challenges. If added to the Stepping Stone platform, they would expand the utility and further improve the cost effectiveness of tablets in schools.
3. Vernacular’s use as a single-classroom support device should be investigated to provide options where a scale-up ratio of 1:4 (device to student) is not economical.
4. Vernacular should be tested further among expanded conditions such as:
 - a. across a full school year to measure it’s reading impact after sustained use
 - b. shared among several classrooms to provide an expanded picture of device breakage
 - c. in off-grid schools to investigate its cost effectiveness with a solar power solution

We look forward to an opportunity in future to apply these recommendations to an improved version of Vernacular.



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