CLOUD BASED LEARNING PLATFORM

Milestone 9 – Final Report

Grant # AID-OAA-F-13-00033

July 31 , 2015

Phase 4 (Endline evaluations and analysis) complete

All Phase 4 end-line evaluations and analysis activities have been completed. The following tasks were carried out:

- Exit Interviews with Students
- Exit Interviews with Teachers
- Exit Interviews with Parents
- Student Focus Groups
- Measure Operational Success
- Measure Educational Impact
- Deliver Final evaluation Report on Project Implementation

Summary of project implementation noting which activities occurred as planned and where the project experienced challenges

All project implementation activities were executed successfully. The key activities that were carried out included: 1) Development of content mapped to grades 3 – 5 of the CBSE curriculum with the added ability to support any educational standard; 2) Development of the cloud based learning platform; 3) Development of the Math Whiz adaptive learning applications; 4) Rollout of Math Whiz to two schools in Punjab – one using CBSE curriculum standard and one using Punjab Board standard; 5) Monitoring and evaluation of the intervention.

The key activities where challenges were encountered included:

1) Developing content for grades 1 – 6 as originally planned. We focused on content for grades 3 – 5 given time constraints and will develop remaining content for grades 1 – 6 during the scale-up period;

2) Utilizing advertising as a source of revenue. We experimented with embedding appropriate Advertisements in the Math Whiz application and found the experience to be distracting for students. We believe an app store version of the application which utilizes micro payments will be successful in generating revenue;

3) We experienced delays in rolling out the intervention at the National Public School due to unavailability of internet access. Since then, we have experimented with portable routers and cellular connectivity to bypass connectivity issues due to landline Internet Service Providers.

4) We had instances where tablets were not utilized for certain topics due to content not been available for all topics or administrative issues at schools. Both of these issues have been resolved.

Our key partners for this intervention have been faculty at Columbia University and University of Pennsylvania, who have helped design the instruments to evaluate and assess the efficacy of the Pilots;

the Jameel Poverty Action Lab (JPAL), which has provided on-the-ground operational support for the evaluation; and Micromax, India's largest tablet manufacturer, which has supplied the devices used for deploying Math Whiz and the technical support to ensure their smooth operation.

The response from the two pilot schools has been overwhelmingly positive from students, teachers, and the administrators. Given an environment where neither teachers nor parents expect children to do homework, our approach has drastically boosted the amount of practice students get in solving math problems. We have also received critical feedback from the schools during the intervention which has allowed us implement enhancements to the platform and also extend the range of content.

Project Impact & Evaluation

As in the previous analyses for the intervention, the final analysis of the results of the first year utilized a difference in differences approach, combining both pilot schools and data from the current (2014) and previous (2013) year. The progress of non-treated sections is used as a counterfactual for the progress of the treated ones. The sample is comprised of a balanced panel of students in grades 2-7 at the two schools. The identifying assumption is that the 149 Treated students would have experienced the same trend as the 348 Control students from last year to this year in the absence of the intervention.

Intuitively, the difference-in-differences estimates tell us how much outcomes for the treated students improved from last year to this year, relative to the other students. We include exams from all terms in the regressions below to give an overall picture of the results to date.

IMPACT OF CONTROLS

We begin by assessing the impact of the treatment and its robustness to the inclusion of relevant control variables.

Table 1: Estimated Treatment Effects of Tablet Intervention, Full Year

Dependent variable: Exam Scores (in standard deviations)

	(1) Full Sample	(2) Full Sample	(3) Full Sample
Treated classes x Post implementation	0.219 (0.217)	0.217 (0.217)	0.148 (0.193)
Controls	None	School	Grade
Number of observations	2627	2627	2627
Number of students	497	497	497

Notes: This table shows difference-in-differences estimates of the effect of the tablet intervention on test scores including all three terms. The dependent variable is standardized exam scores. The base sample is comprised of a balanced (at least one observation in each year) two-year panel of students in grades 2-7 at the two pilot schools, for a total of 2627 test score observations for 497 students. All regressions include a treatment dummy and a fixed effect for post-implementation year (i.e. the 2014-15 academic year) as well as the displayed interaction term, which shows the estimated impact of the intervention on the treated students. Column (2) adds fixed effects to control for the school attended and Column (3) adds fixed effects to control for the student's grade level. Standard errors are clustered by class section, with 21 total clusters.

We find that the estimated overall impact of the treatment is 0.22 standard deviations. Although the effect is not precisely estimated and should be interpreted with caution given the relatively small sample, this effect is relatively large in the education literature, where an impact of 0.1 SD is typical (McEwan 2014).

Controls should, in theory, have little impact on the estimated impact beyond improving precision. However, we conduct an additional robustness check including school and grade controls to provide reassurance that the observed changes are not the result of other critical factors which could be imbalanced in a small sample. As can be seen in Columns (2) and (3), the positive and economically meaningful coefficient is resilient to controlling for School and Grade.

HETEROGENITY BY GENDER

Girls often suffer from a greater lack of educational inputs and opportunity. Access to the Mathwhiz software may help young girls to overcome some of these initial disadvantages via personalized content and increased practice, reducing the gap between male and female achievement. To examine whether girls disproportionally benefit from the intervention we decompose the overall impact of the intervention by gender.

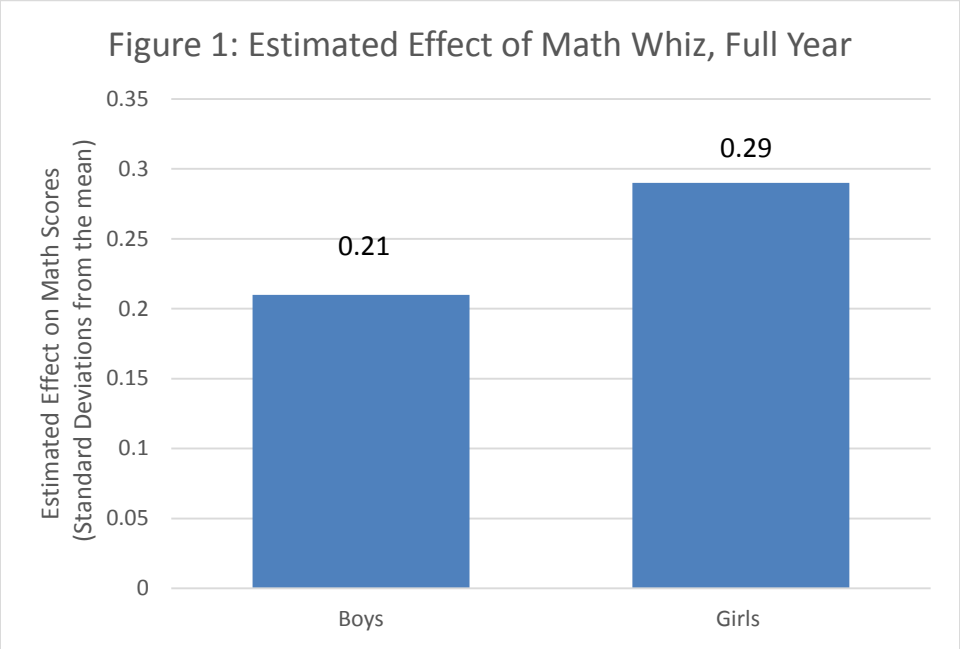
Table 2: Estimated Treatment Effects of Tablet Intervention, By Gender

Dependent variable: Exam Scores (in standard deviations)

	(1) Boys	(2) Girls
Treated classes x Post implementation	0.210 (0.225)	0.289 (0.235)
Number of observations	1461	869
Number of students	273	163

Notes: This table shows difference-in-differences estimates of the effect of the tablet intervention on test scores including all three terms. The dependent variable is standardized exam scores. The base sample is comprised of a balanced two-year panel of students in grades 2-7 at the two pilot schools, for a total of 1461 male (869 female) test score observations for 273 male (163 female) students. The slightly smaller total sample is caused by missing gender data for a small number of students. This data is being collected and will be included in future results. All regressions include a treatment dummy and a fixed effect for post-implementation year (i.e. the 2014-15 academic year) as well as the displayed interaction term, which shows the estimated impact of the intervention on the treated students. Column (1) presents the impact of the treatment among male students and Column (2) presents the impact of treatment among female

students. Standard errors are clustered by class section, with 21 total clusters.



As shown in Table 2 and Figure 1, the impact is not statistically differentiable between male and female students. However, the point estimate of the impact is roughly 1.5 as large for females as males, a result consistent with the hypothesis that female students may disproportionately benefit. We will continue to investigate gender-based heterogeneity in the impact of the intervention scales and estimates become more precise.

HETEROGENITY BY BASELINE TEST SCORES

The dynamically adaptive nature of the software is designed to promote achievement across the entire distribution of initial skill. However, it is possible that those individuals starting at the lowest levels of achievement may differentially benefit from content better suited to their current level of comprehension. We examine potential variability in impact by baseline levels of achievement by examining the impact of the intervention across terciles of initial achievement.

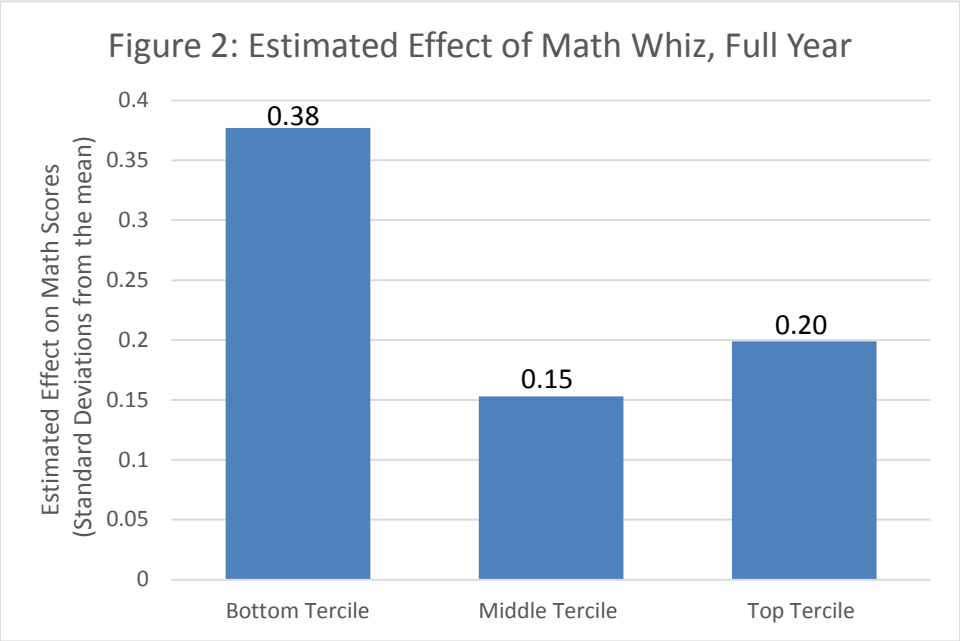
Initial achievement is measured as the average normalized test score in 2013, the baseline year in which no students were treated. Students are then split into the bottom tercile (scores less than 33rd percentile), the middle tercile (scores between the 33rd and 66th percentile) and the top tercile (scores above the 66th percentile). The impact of the tablet intervention is then estimated within each tercile.

Table 3: Estimated Treatment Effects of Tablet Intervention, By Initial Achievement

Dependent variable: Exam Scores (in standard deviations)

	(1) Bottom Tercile	(2) Middle Tercile	(3) Top Tercile
Treated classes x Post implementation	0.377 (0.261)	0.153 (0.201)	0.199 (0.202)
Number of observations	808	887	932
Number of students	155	167	175

Notes: This table shows difference-in-differences estimates of the effect of the tablet intervention on test scores including all three terms. The dependent variable is standardized exam scores. The base sample is comprised of a balanced two-year panel of students in grades 2-7 at the two pilot schools, for a total of 2627 test score observations for 497 students. All regressions include a treatment dummy and a fixed effect for post-implementation year (i.e. the 2014-15 academic year) as well as the displayed interaction term, which shows the estimated impact of the intervention on the treated students. Baseline test score tercile is calculated according to average performance on all exams in 2013, the baseline year. Column (1) presents the estimated treatment effect among students in the bottom tercile, or lowest 33%, in the baseline year. Column (2) contains results estimated among students in the middle tercile (33% to 66%), and Column (3) the estimated impact on students starting in the highest tercile (66% +). Standard errors are clustered by class section, with 21 total clusters.



The results in Table 3 and Figure 2 suggest that although there are indeed gains across the entire distribution of test scores, the gains are concentrated among the students with the lowest levels of initial achievement. In particular, Column (1) shows an estimated gain of 0.37 standard deviations among the students in the lowest tercile of initial achievement. The middle (Column (2)) and top (Column (3)) terciles have smaller, but still positive gains of 0.15 and 0.20 standard deviations, respectively.

SUMMARY

Although the results presented are derived from a relatively small sample and hence should be interpreted with caution, they demonstrate significant promise for the Mathwhiz adaptive learning intervention. The estimated overall gain of 0.2 standard deviations is economically meaningful and relatively large compared to effects typically found in this literature. In addition, the largest gains appear to be concentrated among the most disadvantaged populations including girls and those with the lowest initial levels of achievement.

The randomized evaluation at sufficient scale to ensure balance across treatment and control groups and adequate power will provide more rigorous evidence of the overall impact and variation in that impact across sub-populations.

Assessment of the project's cost-effectiveness and financial viability

Overall, we are pleased with the project's cost effectiveness and financial viability. The key costs of the intervention consist of the following components:

1. Tablets
2. Internet Connectivity
3. Aide [Not required at scale]

The tablet cost for the intervention was $125 / tablet. The tablets for both schools were provided by Micormax, India's leading tablet manufacturer. Micromax either repaired or replaced any tablets with issues free of charge. The cost of the intervention during the evaluation phase is artificially inflated due to hiring of aides at each school location. This is necessary for the proof of concept to ensure operational excellence and to aid in the administration of the testing used to evaluate the efficacy of the program but will not be required at scale.

At scale, we expect the tablets to support content for grades 1 – 8 and expect the per tablet cost to decline to $80 / tablet with a depreciation of 3 years.

Per Student Cost for Proof of Concept

Tablet Cost: Each Tablet utilized by 3 students with a depreciation of 3 years - $125 / (3*3) = $13.88 / student. This will decline further at schools where we have multiple treatment sections.

Internet Cost: $300 / year - $300/ (3 grades * 30 students) = 3.33 / student

Aide Salary: $2,000 / year - $2,000 / (3 grades * 30 students) = 22.22 / student

Fully Loaded Cost per Student: $39.43 per student for proof of concept

Per Student Cost at Scale

At Scale, each tablet will support 8 students, with content for grades 1 – 8 and the cost of each tablet reduces to $80 / tablet with a depreciation of 3 years. An Aide will not be required at scale.

Tablet Cost: Each Tablet utilized by 8 students with a depreciation of 3 years - $80 / (8*3) = $3.33 / student

Internet Cost: $300 / year - $300 / (8 grades * 30 students) = $1.25 / student

Fully Loaded Cost per Student at scale: $4.58 per student per year

Financial Viability

We currently envision a school licensing fee of $5 - $10 USD per student, exclusive of the cost of the tablets. There are a number of models where the school purchases tablets from a third party, purchases outright via Pixatel, or we finance the purchase of the tablets. In any of these scenarios, our price points will enable the intervention to be financially viable at scale. Additional revenue streams from the app store add to the financial viability of the intervention. Based on market research, we believe this model will be competitive and enable us to achieve financial viability.

Comparison of Computer Assisted Learning (CAL) Programs

There exists very little rigorous evidence on the impact of computer assisted learning on educational outcomes, especially in India and other developing countries. One program in Gujarat in which students spent 2 hours a week playing math games on a shared computer raised test scores by 0.36 and 0.54 standard deviations in the first and second years, respectively (Banerjee et al. 2007). The program cost was $15.18 per student per year exclusive of software development costs (Banerjee et al. 2007).

Evaluations of other Indian CAL programs have found gains of 0.27 standard deviations in reading (He et al. 2008) and 0.28 standard deviations in math using the The Gyan Shala CAL program (Linden 2008), with larger gains for remedial students in the latter study. We have not been able to find hard dollar costs for the former program. The Gyan Shala CAL program had an estimated cost of $3.22 to $4.59 per tenth of a standard deviation gain. The computers used in this study were donated so the per student cost is an estimate.

Alternate Solutions

The most cost-efective intervention to date seems to be the Balsakhi program, which augmented teachers in the classroom with supplemental aides. The program trained and placed local village residents as assistant teachers in schools to provide remedial math education in India. The program only covered math and did not help non-remedial students. The program increased math scores among weak students at a cost of $2.25 per student per year, making the program one of the most cost-effective interventions that has been tried (Banerjee et al. 2007). This translates to a cost of about $0.67 per standard deviation gain of the Treatment group vs. the Comparison group.

We feel it's important to have these numbers in mind but we believe our solution is more scalable because it will deliver many subjects for the fixed cost of one tablet when it scales. In Balsakhi's case, covering more subjects would require additional teachers, which—combined with high teacher turnover and difficulty in monitoring quality—undermines the cost-effectiveness and scalability of this program. So we don't feel that we have to meet $2.25 per student per year cost because in the long run we can deliver more than this program.

Next steps to refine the solution and achieve the intended scale up plans

We are excited by the results-to-date of the DIV Stage I Math Whiz proof of concept. The DIV grant and the partnership of the DIV team have given us the opportunity to crystalize our vision, build out the technology platform, deploy the software in rural areas, iterate on field operations and solidify short-term focus areas.

In order to develop a scaling plan that can be operationalized and ensure we have the ability to scale Math Whiz, Pixatel and our partners have been planning, conducting field research, developing organizational capacity, and conducting mini proof of concepts. The following key activities have contributed significantly to developing this plan and bolstered our confidence in our ability to execute effectively:

We hired Jasjit Singh in 2014 to manage field implementation of the proof of concept and scale-up operations in 2015. Jasjit brings over a decade of international business experience, most recently having managed India operations for Datawind, the makers of the low cost Akaash tablet. Jasjit spent 70% of his time in India during 2014 and relocated to India in December 2014 to manage scale-up operations. He brings deep local connections to the team which will assist us in further scaling.

We hired Ganesh Rao and Jalnidh Kaur as a JPAL RAs to work with faculty at Columbia University and University of Pennsylvania to manage the monitoring and evaluation of the scale-up. Ganesh joined the team in July and Jalnidh joined the team in August.

Several members of Pixatel's management team, including Prabhjot Singh (CEO) and Jasmit Kochhar (CTO) have worked to understand and mitigate on the ground business and implementation challenges, develop and cultivate local partnerships, and oversee the set-up of operational scale-up.

Sidra Rehman, PhD candidate at Columbia University, joined our team in Nov 2014, and has been actively involved to optimize implementation protocols. She will be returning to Punjab in August 2015 to assist with scale-up activities.

Professors Supreet Kaur (Columbia University) and Heather Schofield (University of Pennsylvania) have worked in collaboration with the Pixatel team to monitor the intervention and advise on scale-up planning. Prof. Schofield and Prof. Kaur are increasing their commitment as we scale up operations by leveraging graduate students, university networks, and sources of additional funding (currently $95,000) to support our scale-up. We are currently in the process of enhancing Math Whiz based on Pilot feedback from students and teachers.

During scale-up, we will make further significant enhancements to improve the Math Whiz solution and deliver even greater impact. One of the key functionalities that will be added to the software is to make it adaptive across grade levels. This means that if a child in Grade 3 doesn't have the ability to add or subtract 3 digit numbers, which is the requirement for 3rd grade math, the software will step the student down to 2 digit numbers, which the curriculum for 2nd grade. We are also in the process of adding descriptive solutions for each question, which will help students understand why right answers are correct and the methodology of getting to the correct answers. We are in the process of filing a provisional patent on this invention and expect to file in Q4 2015.

The above inputs have enabled us to develop a three year scale-up plan for Math Whiz with the following objectives:

1. Demonstrate large scale causal improvements in math learning outcomes
2. Develop multiple routes to market for delivering Math Whiz
3. Achieve financial sustainability

Goal 1: Demonstrate large scale impact on math learning outcomes

Columbia University and University of Pennsylvania have agreed to continue partnering during scale-up to evaluate the effectiveness of Math Whiz in improving math outcomes. The scale-up activities began in April 2015, overlapping with the last three months of our DIV Phase I grant.

During this scale up phase, we will conduct a rigorous randomized control trial to establish the effectiveness of the Math Whiz intervention.

During the 2015 school year, we plan to deploy the Pixatel Learning platform at 10 schools across grades. This will give us the opportunity to develop infrastructure for larger-scale operations, enhance the curriculum by addressing variations across different schools, refine deployment and monitoring protocols, and further build out our technology platform.

Pixatel is in the process of setting up an office in Chandigarh, the capital of Punjab and Haryana. The office will provide us a base of operations to manage scale-up and also provide us with proximity to two state governments. The office will be operational in Feb 2015.

During the 2016 school year, we will scale the intervention to 25 schools. In total, the scale-up would cover 5 grades in 25 schools, with multiple sections per grade in many schools) This would provide evidence of our ability to scale the implementation of Math Whiz, and lay the operational foundation for achieving scale in private and public settings.

During the 2017 school year, we will continue the intervention at 50 schools across grades 1 – 6. We will analyze results of the previous three years and present our findings at academic, development and education events. We will also host a funder conference to disseminate results to date and share the significance of our findings.

Evaluation

The randomized control trial will enable us to proffer evidence to governments and private institutions regarding the effectiveness of the intervention. Punjab government's minister of education has expressed support of the Math Whiz intervention and requested such evidence for deploying the solution widely.

To evaluate the impact of the intervention, we will randomize class sections into receiving Math Whiz (treatment group) and receiving traditional instruction (control group). The randomization design will be as follows. Randomization will be stratified by school, with half of the grades in each school assigned to the treatment group and the other half to the control group. In addition, using a Latin Squares design, we will ensure that across schools, in each grade, exactly half of the class sections are in treatment and control, respectively. With approximately 500 classroom sections, we will have ample statistical power to examine treatment effects on learning outcomes.

This design has several benefits. It ensures the treatment is given to half of the sample within each school and in each grade across schools, respectively. This will improve statistical power, enabling us to control for school fixed effects and grade fixed effects in the analysis. In addition, for political feasibility, we have decided that within a school, all sections of a given grade will receive the treatment. This randomization design is similar to that used by Banerjee et al. (*Quarterly Journal of Economics*, 2007). Conversations with school principals have indicated that such a design should not create political issues for schools or raise equity concerns among parents.

The initial Pilot has enabled us to develop the testing and survey instruments that will be used to assess impact. Specifically, we will measure learning outcomes using 4 sets of paper and pencil testing instruments, which will be given to both the treatment and control groups:

- Baseline tests: Each student will be given a mathematics test at baseline to enable us to assess baseline mastery. This will improve power and be useful in assessing heterogeneous effects to better understand which children benefit the most.

- End of semester cumulative final exams: These will be standard final exams administered to all students at the end of each term.

- Monthly tests: Under the CBSE standards, all teachers are required to test their students monthly and maintain a record of the results. We will obtain the schools' cooperation to enable us to provide questions for these tests, enabling us to compare treatment and control sections.

- Topic-wise practice exercises: We have created short 10-question practice sheets for each topic in the CBSE curriculum; these closely follow the content in CBSE textbooks and are representative of the type of practice problems and homework assigned by teachers. We will provide these practice sheets to all treatment and control teachers in the schools, giving them the option to utilize them in their schools. This will provide extremely detailed, topic-wise performance metrics for treatment and control students.

In addition to these testing instruments, we will also have the rich Math Whiz performance data for treatment students. This will enable us to see how treatment students advance through content, and correlate this with the outcomes in the paper and pencil tests above.

We will also look at other behavioral outcomes, such as attendance and disruptive behavior.

Examining heterogeneity in effects – for example, by baseline ability and by gender – will enable us to better understand which groups of individuals are being helped by the intervention.

Finally, the evaluation will also incorporate a substantial research component, described in the Academic Research Questions section below.

Goal 2: Develop multiple routes to market for delivering Math Whiz

We seek to scale Math Whiz via a three pronged approach that relies on 1) licensed revenue, 2) support from donors, governments, and corporations, NGOs, and 3) distribution via app stores. Our plan for each of these approaches is as follows:

Private Sector Revenue

- We expect to establish channel partners in India to sell Math Whiz to schools. We are currently in discussions with DLP India Edutech Pvt. Ltd. In New Delhi to onboard them as our first channel partner. We have also initiated dialogue with Google Education in India with the aim to developing a path to them licensing Math Whiz for their private deployments.
- Both the pilot schools during the DIV Phase I grant will be continuing the intervention and will become paying customers at the conclusion of the RCT.
- We are currently working with Private School networks such as Akal Academy to include one of their schools in our scale up in 2015 to provide evidence on the effectiveness of the intervention to get buy-in for larger scale deployments.
- Pixatel will set-up our own Sales and Marketing organization in India to more aggressively sell the Math Whiz solution in private schools through partners in year 2 and directly in year 3.

Support from donors, governments, and corporations, non-profits

In addition to seeking scale up support from USAID DIV, we plan to work with other public and private donors.

- Micromax remains enthusiastic about our partnership and will continue to provide tablets for our scaleup.
- We plan to be opportunistic in deploying Math Whiz in partnership with partner NGOs and donor funded schools.
- Google has committed $100,000 in Hosting Credits to help us scale-up the intervention.

- We plan on developing partnership with organizations such as READ (Rural Education and Development) Global to test if utilizing their infrastructure to deploy Math Whiz can be an additional channel for distribution.
- We are in process of submitting grant applications to the following funders, who have demonstrated interest in supporting scale-up:
    - Columbia University SIPA (Application submitted)
    - Columbia Roads Grant (Application submitted)
    - Unorthodox Philanthropy (LOI Submitted)
    - Spencer research Awards
    - Columbia President's Global Innovation Fund

Distribution of Math Whiz via App stores

App Stores represent the route to market that has the greatest potential of impacting students. Given that India's 875MM+ mobile devices will soon have the ability to support apps (Telecom Regulatory Authority of India, 2013), focusing on this channel can be immensely rewarding for Pixatel by generating broad distribution of the product.

Currently no adaptive learning math application exists for India's CBSE curriculum on Google Play or the Apple App Store. By making the application free to download and charging nominal sub $1 USD micro-payments for curriculum sections, we expect to generate a steady revenue stream for Math Whiz.

To ensure that the application is competitive in the marketplace we are also enhancing the user experience by enhancing the visual effects and incorporating appropriate themes to make the application more enticing, friendly, and effective.

An additional benefit of rolling out the app store versions will be to give us visibility into usage patterns and performance for a large set of students. We will be able to analyze the data to improve our adaptive learning algorithms for greater effectiveness.

Goal 3: Attain Financial Sustainability for Math Whiz

We expect to attain financial sustainability for Math Whiz during the scale up period. We will achieve core business sustainability through license revenue generated by paid deployments in private schools and through revenue from in-app purchases in our Android and iOS applications.

At the same time, we plan to generate revenue by deploying Math Whiz in rural areas and to underserved populations through funding from donors, partners, and governments. The large scale RCT will help us demonstrate impact to large funders and governments to enable us to go after large customers like the Government of Punjab, which has shown interest in math Whiz and requested proof points for validation.