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Increasing Student Engagement in Math: The Use of Khan Academy in Chilean Classrooms

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ABSTRACT

Khan Academy, an online platform offering educational videos and exercises in different content areas, has awakened intense interest among foundations, multilateral organizations, policy makers, and educators about how this tool can help meet the educational challenges facing countries around the world. With support from Intel, Education Development Center (EDC) researchers sought to understand how this technology fits into the complex realities of schools in a developing country. In August of 2013, researchers traveled to Santiago, Chile to conduct research in five schools where teachers are using Khan Academy. We found that the way Khan Academy functions as a digital learning environment changes the ways and the degree to which students engage with and are engaged by the math content; it also changes the way teachers and students interact with each other. Even though the use of Khan Academy may plant the seeds of deeper pedagogical changes such as mastery learning or differentiated instruction, teachers did not need to change their entire teaching model to start using it. Khan Academy's straightforward approach of providing an endless bank of practice exercises makes it an inviting and universally adaptable tool across different types of teachers, classrooms, and countries.

Keywords*: Blended Learning; Khan Academy; Mathematics; Chile*

INTRODUCTION

For three years, Intel has been supporting a pilot project using the online learning platform, Khan Academy, in Chile. Khan Academy, a platform offering educational videos and exercises in different content areas, has become a worldwide education phenomenon in just a few years. As a free online learning resource that supports blended and personalized learning, Khan Academy has awakened intense interest among policy makers and educators about how this tool can help meet the educational challenges facing countries around the world. With support from Intel, the Education Development Center (EDC) was able conduct an initial set of case studies with Chilean teachers using Khan Academy. We spent two weeks observing their classrooms and interviewing them and their students about their experiences using Khan Academy.

As of February 2014, Khan Academy was being used in 200 countries, though 75% of its users reside in the United States. Although the Khan Academy name and brand are widely known (Ani, 2013; León & Reinah, 2013), research on the website and its use in schools is sparse. Much of what has been written is from Khan Academy itself (Khan, 2012; Koeniger, 2013; Maxwell, 2012; Schmitz & Perels, 2011), and is based on opinion (Izumi & Parisi, 2013; León & Reinah, 2013) or expert review of the resources (Ani, 2013; Kronholz, 2012; Strauss, 2012). On its website, Khan Academy has classroom case studies that offer videos, one-page briefs, and longer reports describing how Khan Academy is being used in classrooms around the world. These are not research but rather a space to showcase teacher and student experiences using the resources on the site. Nine of the showcases are schools in the US, two are from Europe (Ireland and Spain), and the one showcase from Latin America is a first person account of a staff developer's trip to Peru to train teachers on Khan Academy. However, there is no description of how teachers used Khan Academy in Peru.

There are two independent research studies of Khan Academy both of which were conducted in the United States. Khan Academy is one of the blended learning products explored in the *Blended Learning in Practice* Series (Bernatek, Cohen, Hanlon, & Wilka, 2012; Wilka & Cohen, 2013). In their case study on a California school, Bernatek and colleagues (2012) found that teachers used Khan Academy for students to do mathematics exercises. The other study is a two-year study of Khan Academy conducted in 20 United States schools from 2011-2013 (Murphy, Gallagher, Krumm, Mislevy, & Hafter, 2014). Researchers of this study found great variation in how Khan Academy resources are used across the schools. The researchers felt it was "methodologically unsound to conduct rigorous evaluation of Khan Academy's impact on learning" (p. 2) because the resources on the site are changing so frequently. Overall, they find that Khan Academy is used as a supplemental resource in mathematics. However, they were able to collect test data from two sites that suggest that students who spend more time on Khan Academy mathematics exercises do better on an end of year achievement test.

There is great interest in using Khan Academy as a tool to improve education in the developing world. However, there is a lack of research around the use of Khan Academy outside the United States. This study sought to explore the use of the site in a developing country context. Specifically, we wanted to better understand how teachers blended the Khan Academy resources with their existing resources and practices. We sought to document the strategies and practices of teachers who use Khan Academy. This report is an exploration of the ways in which Chilean teachers are integrating Khan Academy into their lessons and how that use is impacting teaching and learning.

RESEARCH QUESTION

We wanted to examine how Khan Academy is merging and blending with teachers' classroom practice by interviewing teachers about their use of Khan Academy resources and capturing their reflections on that use. According to Vygotsky's (1978) socio-cultural theory of learning, all learning is situated and embedded into a context. His theory envisions learning as a social process where students develop and grow intellectually in interaction with other people, and where *tools* play a fundamental role in this process. Our exploration of Khan Academy in Chile is grounded in these theories where ICTs represent new sets of tools that replace, displace, or combine with previous tools and strategies. Khan Academy, like any other new tool being integrated into a preexisting environment, may be used in new ways, or it may be spliced into old practices. Every digital resource, like Khan Academy, is a unique tool that may enable certain instructional practices just as it may impede others based on the functionality its creators build into it. With this in mind, our focus was on the use of Khan Academy and our findings may not necessary extend to other digital resources if their design features are different from Khan Academy.

Sample Selection

The Intel-funded project worked with 48 schools around Chile. For the current study however, we decided to focus on schools from a non-profit school network called Sociedad de Instrucción Primaria (the Society for Primary Instruction, SIP). The SIP's mission is to provide high quality education for at-risk populations. The SIP network supports 18 K-12 schools serving 5,000 students from low-income families. In order to attend, students take an admissions test and families pay a small fee in the Chilean context, equivalent of $25USD a month per child. The SIP network was chosen because the mathematics teachers at the SIP schools are part of a professional community thinking about Khan Academy and we hoped to tap into that emerging knowledge base. The teachers who participated in the study were purposely selected in collaboration with the Centro Costadigital at the Pontificia Universidad Católica de Valparaíso

(Costadigital), to identify teachers who are thoughtfully integrating Khan Academy into their teaching so that we could learn from their experiences and reflections.

Four schools from the SIP network were selected, but a fifth municipal school that was not part of the initial design was added during the fieldwork phase. The public school was added to the sample because our Chilean colleagues from CostaDigital thought it was important to visit a municipal school. From our observations the level of resources available to the SIP schools were roughly equivalent to the municipal school, the primary difference was the level of professional support that the SIP teachers have because they are part of the SIP network. Mathematics teachers at the municipal school were working to integrate Khan Academy into their 5^{th}-8^{th} grade classes with support of a mathematics coach provided by a foundation, but the SIP teachers had access to pedagogical coaches and mathematics supervisors from the network. We conducted exploratory case studies of eight mathematics teachers in five Chilean schools to examine how they are embedding Khan Academy resources into teaching and learning. Since the Chilean schools are only using Khan Academy in mathematics, we limited our focus to math teachers.

The Chilean educators thought carefully about whether to use Khan Academy. For example, the SIP's Director of Mathematics and her department reviewed the Khan Academy resources. Upon reviewing the site, SIP decided that Khan Academy would be appropriate for their middle school curriculum. Becoming mathematically proficient has multiple components: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition (Cuoco, Goldenberg, & Mark, 1996; Kilpatrick, Swafford, & Findell, 2001). The SIP mathematics department believed that the elementary grades needed more hands on activities and manipulatives than a virtual environment would provide. The SIP leadership also felt that Khan Academy resources were not appropriate for supporting the more complex mathematical skills needed in high school math. However, they felt that Khan Academy would be an excellent resource supporting middle school students' need to develop procedural fluency (Kilpatrick et al., 2001) through increased practice. The SIP leadership also valued the Khan Academy platform as a sustainable choice because of its free, high quality exercises, and consistent online supports.

METHODOLOGY

The goal of this study was to document the types of teaching and learning practices that Chilean teachers are developing around this popular new learning platform as a means to better understand the tool's role in an emerging market context. We did this through interviews, focus groups with students, school walk-throughs, and classroom observations.

In total, we observed 25 math lessons both with and without using Khan Academy. None of the teachers had sufficient computer resources to use Khan Academy in their classroom, and all of the lessons observed with Khan Academy took place in computer labs. Classes ranged from 4^{th} to 12^{th} grade. We also conducted informal conversations with students during the observations to ask students about the exercises they were doing on Khan Academy. The researchers used an observation guide and recording sheet to capture the layout and set up of the classroom, as well as to document how teachers and students were interacting around the Khan Academy platform.

In addition to interviewing the eight teachers, we interviewed six school administrators, and 32 students. We used an interview protocol that asked questions around the use of Khan Academy in the classroom and for lesson planning, as well as impacts and challenges of the site. Administrators at each school worked with the teachers to pick students for the focus groups. We

asked administrators to select students with a range of abilities from classrooms of our focal teachers. The focus groups were organized by gender, and when possible, by ability. The focus group protocol focused on their use of various components of the site and any perceived impacts on their learning.

The research team also participated in meetings with the SIP leadership team and mathematics department, Intel, and Costadigital to better understand their roles in bringing Khan Academy into these schools and classrooms. In total, we interviewed 15 program staff from SIP, Intel, and Costadigital.

KHAN ACADEMY OVERVIEW

Khan Academy is an online learning platform started by a former hedge fund manager, Salman Khan, with the stated mission of "changing education for the better by providing a free world-class education for anyone, anywhere" (from the Khan Academy website: https://www.khanacademy.org/about). The site offers over 5,000 online instructional videos in an array of subject areas, an extensive repository of math exercises, and real-time data and analysis features (Koeniger, 2013).

There are three principal components of the Khan Academy website that we examined: videos, exercises, and data. These sections of the site work together to create what Khan Academy calls a "personalized, mastery-based, interactive and exploratory online learning environment" (Koeniger, 2013, p. 7). Though Khan Academy offers content in numerous subjects, by far its most comprehensive topic area is mathematics.

Intel and their Chilean education partner, the Centro Costadigital, selected and oversaw the translation of 650 math and biology videos into Spanish. The Chilean students have access to these videos in Spanish, but used the exercises in English. The Khan Academy platform is changing frequently. Right before we started the fieldwork, the site launched a full Spanish version that includes the exercises.

Videos

The videos of the founder teaching different subjects are the best-known feature of Khan Academy. There are short videos organized by discipline. These videos are designed to be the primary content delivery mechanism used to teach facts and procedures via a simulated blackboard and the voice of the instructor explaining the steps.

Math Exercises

Though all subject areas have some exercises for learners to complete, Khan Academy offers a seemingly inexhaustible bank of online practice exercises in mathematics. Learners pick a skill and, as they finish each problem, they get a new problem.

The math problems are dynamically generated and no two students get the same problem at the same time. Progress is tracked with check marks (✔) or cross outs (✗). If a learner gets five problems correct in a row, they have reached the first level in that skill. If the learner gets the fifth problem wrong, the count starts over and they need to get another five correct in a row. Khan Academy's exercise bank offers hints to help students. Users can get step-by-step hints that reveal each step of the process allowing students to realize on their own what step of the procedure they were missing, but not just give the answer. Each page also links to a video related to the skill they are practicing.

Gamification and Data

The entire site is gamified in that students earn points and badges for doing exercises and watching videos. Access to real-time and accumulated data allows students and their teachers to track the number of videos watched, number of exercises attempted, including which ones were correct and which were incorrect, the amount of time spent on each exercise or video, the wrong answers given, and the number of hints used.

Teachers can track progress of a group of students or an individual. And they can track progress in the past or in real time. Data is color coded so that coaches can get a sense of progress quickly (e.g., red indicates the student is having difficulty while dark blue indicates topic mastery).

THE CHILEAN SCHOOLS

All five of the schools in the study are very similar in infrastructure and layout. The typical Chilean school layout provides a large open courtyard where students play and socialize before or after school and during recess. Classes in SIP schools reach about 40 students and the municipal school had around 30 students per class. In the classrooms, students sit at desks organized in rows facing the front of the room. There is very little technology in the classrooms for students, though teachers have a laptop and projector to use if needed. All schools have at least one computer lab. The SIP computer labs have about 40 computers set on desks in various configurations around the space. The municipal school has a computer lab with 21 desktop computers.

Typical School Day in Chile

Our case study of Khan Academy focuses on how that tool is incorporated into teaching and learning and embedded into teachers' and students' classroom practice. In order to fully understand the impact of Khan Academy in the classroom, it is important for readers to keep the context of Chilean schooling in mind. Unlike many developing countries, Chile has full day schooling (at least 7 hours) and students start around 8 A.M and finish about 3 P.M. The students are together in the same classroom all day. This cohort generally stays together from year to year as they move up. In elementary school, students have the same teacher for all subjects, but by 7^{th} grade students start to have different teachers for each subject. The students stay in their classroom and subject teachers rotate into that classroom. This means that content teachers do not have their own rooms with specialized teaching materials for their content areas. The only exceptions are the computer lab or when students need a science lab. Also, unlike many other developing countries, all Chilean students have their own textbooks or workbook for each subject provided by the Ministry of Education (See http://www.textosescolares.cl/).

Math Class in Chile without Khan Academy

The typical math class without Khan Academy that we observed is not unlike lecture-based math classes elsewhere. For lessons when they are introducing new material, the teachers work with the whole class demonstrating a problem and a new concept on the interactive whiteboard or standard whiteboard while students follow along in their workbooks. At key moments, the teacher might ask students for suggestions or to explain a procedure. After completing a demonstration

problem, the teacher might ask a student to do a problem on the board and then have the whole class review the procedure.

After presenting new material, the teacher assigns workbook problems which students do individually or in small groups while the teacher moves around the classroom helping. In our observations in the Chilean classrooms, students typically work in small groups and their conversations were a mix of math as well as gossip. The teachers respond to any request for help, but many students do not ask the teacher for help. Most students ask friends for help. Often, requests to a peer for help result in one student simply giving the answer. Once all students have completed the problems, the teacher might lead a review session, where a student might put up the solution to each problem on the board and review the procedure. In a 45-minute lesson, the class might do a total of 10 problems – some done as a whole class and the rest done in small groups – with the answers being checked at the end of the class. It is important to keep these patterns of doing math in a classroom context in mind, because the uses of Khan Academy that the Chilean teachers have developed intersect with and begin to transform these processes.

KHAN ACADEMY IN CHILEAN SCHOOLS

The Chilean teachers we worked with were selected specifically because they were integrating Khan Academy into their lessons. Teachers in Latin America often distinguish between theory classes and practice sessions. In math, the practice often comes as homework, but these teachers made decisions to dedicate part of their instructional time to having students use Khan Academy. The Khan Academy sessions were principally used for students to practice skills and develop procedural fluency and not for direct instruction. The teachers felt this was a worthwhile trade because their students were doing substantially more math exercises, but they also felt that aspects of how Khan Academy functions increased student engagement in mathematics and improved performance. These teachers did not use all of the features of the Khan website. Of the three key components (i.e., videos, exercises, and data), teachers and students in Chile utilized the exercises the most often.

Looking across the observations and interviews, four instructional objectives emerge: two general objectives and two objectives around differentiation. All of these objectives are focused primarily on the exercises and “doing math.” Except for enrichment, the videos are presented to students as helping aids if they are lost or confused on how to do a procedure. The teachers we observed use Khan Academy for two main reasons:

1. Practicing and reinforcing recently learned skills. This was the most common goal we saw. As in the typical session described above, students would go to the computer lab, log on, and start doing math exercises.
2. Revisiting or refreshing previously learned content for test preparation. In particular, some of 8th grade students we observed were using Khan Academy to review a range of math topics to prepare for the national exam, which is given in 8th grade. In these sessions, the students were often tackling wider ranges of skills, since Khan Academy allows student to focus on whatever skills they are weakest. Teachers feel this was a clear benefit of Khan Academy. One teacher explained, “Khan saves time when reviewing old material or refreshing students’ memories on specific content. It does not save time when teaching new things. Students still need to practice that in the classroom.”

In Chile, the extent to which teachers can vary the curricular resources for each student is limited. The teachers report that they are expected to keep students moving along at a similar pace. Also, the government provides one math textbook, so teachers have limited access to diverse curricula. One teacher commented that in the classroom they “do every thing the same” for all students.

However, with Khan Academy, teachers are envisioning ways to support the learning needs of slower and faster students. The Chilean teachers use Khan Academy to support two levels of personalization.

1. Enrichment for more advanced students. Teachers used Khan Academy during elective math classes as well as during afterschool math clubs. The huge amount of content allows the most advanced students to access information beyond what is in the textbook. Students can move through the site at their own speed, exploring new topic areas and exercises with the teacher as a guide rather than the primary mode of knowledge delivery.
2. Remediation for students falling behind. According to the Chilean teachers, Khan Academy adapts to the needs of struggling students by giving them an endless supply of problems to work on, and because success is based on getting five-in-a-row and not on the percent of problems correct. Those students who need more practice to master a procedure can do more exercises in class and continue working outside of class.

When deciding which topics to assign students, the alignment with the Chilean curriculum is most important. Most teachers made sure the actual exercises linked to the content they were currently teaching.

Typical Math Class in Chile with Khan Academy

Across observations, the math classes using Khan Academy share common patterns of teacher and student practices. The classes without Khan Academy also share common practices. However, the classes with and without Khan Academy were quite different from each other.

First, in the labs, most of the students sat at individual machines. By far, the most common practice was for teachers to have their students complete exercises. Only in two observations did teachers assign video in addition to exercises. In those classes, most students either had the video running in another window while they did exercises, or said they would watch the video later.

Most of the teachers assigned students the goal of reaching the practice level (i.e., getting five-in-a-row) by a certain date. We observed teachers assigning anywhere from one to five skills in a single class. One teacher we observed started her students on five math skills during a computer lab session mid-week and they had until the following Monday to do five-in-a-row for each skill. Once a learner successfully completes five-in-a-row, he or she moved on to the next skill.

After an initial introduction, all students started working individually doing math exercises, each with different sets of problems. In some classes, the students were working on different skills. Students were mostly quiet and focused on their computer screens – most doing math problems. In the Khan Academy sessions, the students were visibly asking the teacher for help more frequently than in the traditional classes. The teachers never stopped going from student to student answering questions or providing support. A number of teachers commented that since using Khan Academy, their students are more comfortable asking questions.

The students talked with their neighbors while working on the computer. As in the non-Khan Academy math class, the conversations were a mix of gossip and math. But in the lab, when a student asked a friend for help, the friend could not simply give the answer because each student had a unique problem in front of him. What we observed however were students trying to explain the math procedures.

In two of the classes we observed, there were also student mentors walking around helping their peers. The teachers explained that a common strategy in Chile is to choose a few more advanced students in a specific class to be mentors to their peers.

TEACHER AND STUDENT USE OF THE KHAN ACADEMY

This section is organized around the three main components of the Khan Academy website: exercises, videos, and data. This section details the degree to which these teachers are using each component, the specifics of how those resources are being integrated into teachers' instruction, and how their use is changing students' learning activities.

Doing Practice Exercises

At first glance, doing exercises in Khan Academy might not appear to be drastically divergent from completing problem sets from the back of a textbook. However, the interactive, web-based mechanics behind the Khan Academy exercises differentiate it from paper-based problems sets. Given how Chilean teachers are using Khan Academy during class time, seven features emerge as potentially important to creating an enhanced learning environment for their students. Khan Academy:

1. offers a workbook with an infinite number of problems;
2. generates individualized problem sets: in math, problems are randomly generated which means students are never working on the same problem;
3. gives the user immediate feedback after each answer is submitted;
4. provides hints and video lessons if needed;
5. uses multiple rewards systems to motivate students;
6. utilizes a mastery approach to advancing users through the material: the teachers used the five-in-a-row level built into Khan Academy as the indicator of successful mastery of the skill;
7. illustrates complex concepts some of which are difficult to show on a conventional one-dimensional black or whiteboard.

When students are on Khan Academy in the computer labs, these features combine to transform how students engage with math and develop procedural fluency. The following section describes some of the key differences between using Khan Academy or traditional paper-based exercises based on teacher reflections and what we observed in the classrooms.

Self-paced and individualized. The fact that each student has his or her own set of problems to work on during the class appears to increase the number of problems they do and has allowed students to work on problems at their current skill level. In the typical classrooms we observed, teachers generally used a combination of whole class instruction and individual seatwork as the whole class moves through the same set of problems. In total, students might go through 10 problems during the class, but it is uncertain whether individual students actually do the problems, simply get answers from peers, or go through the motions while copying from the teacher. When the students were on Khan Academy in the computer labs, all the students were engaged in doing problems and teachers floated around the room. Khan Academy enabled students to move at a pace that is more appropriate to their learning needs. Students who understood the material quickly moved on while others completed as many exercises as needed to learn the content. The teachers reported that students are doing more math problems than they would in a standard classroom.

Re-conceptualizing mastery through immediate feedback and endless opportunities to try. The possibility for infinite practice to reach mastery and the immediate feedback of the website changes the way students engage with the math content. Instead of completing ten problems and going over them in class only to find there is a misunderstanding on the first problem, with Khan Academy students know immediately if they are right or wrong on each exercise.

If students get the answer wrong, they need to decide how to proceed: recheck their work, review the procedure, get a hint, watch a video lesson, ask a friend, or ask the teacher. We observed a few students who continued with the same strategy for a problem or two. However, since they continued getting answers wrong, they soon sought help. Since Khan Academy never runs out of math problems, students can keep practicing. Additionally, since mastery on an assignment is five correct in a row not the total percent correct, students were motivated to keep trying because a few wrong answers do not ruin their grade. One teacher commented that she now has more students getting full credit for their homework.

Increased pathways for getting help*.* Having students use Khan Academy during class time creates a need to seek help while also providing multiple pathways to get help. The platform offers hints and relevant videos for each exercise. But, since the Chilean students were using Khan Academy at school, they also had access to teachers, peers, and notebooks. In Chile, we observed that even though students had the imbedded supports, they preferred turning to peers and teachers. The most common first step we observed was to ask a more math-savvy peer for help. Because each student had unique problems, Khan Academy transformed the typical peer-to-peer interaction from the exchange of correct answers to one of facilitation and guidance. Students were forced to work through the problem together, and were more likely to share procedural advice than actual solutions. Peers became facilitators rather than answer sheets.

Other students still preferred to get help from the teacher who they saw as a more trusted and accurate resource. Asking the teacher was the safest option because students do not want to make a mistake and be forced to accrue check marks again.

Students utilized the embedded support features less frequently. Some students were wary of using the embedded hints for assistance because it meant they would not earn points for that exercise. Once a student clicks on the "hint" button, they automatically receive an ✗. This interrupts their accumulation of ✔ marks and requires them to rebuild back towards five-in-a-row.

Gamification of learning as a motivator*.* It is clear from talking with students that getting immediate feedback and seeing the ✔marks build up is motivating and gave them a sense that they are mastering different procedures. But, Khan Academy also has other reward systems built into it. Because of incentives like points, avatars, and badges, some students saw Khan Academy as a place to play as well as a place to learn. Students called the site "fun," "dynamic," "motivating," and "game-like." Though not universal, many of the students we talked to were motivated to complete math problems in order to accumulate energy points and earn new badges. But the motivation was not always to accumulate points: with points one can buy more interesting avatars. There are also a few students who saw the points as proof they were getting better at math.

The teachers and administrators of the SIP also used the points to motivate students. Both at the individual school level as well as the SIP network level, contests were used as an additional motivation for students to complete more problems. Winners were tallied at the end of a given

period (weekly or monthly) to earn prizes such as homework credit, technology devices, or simple bragging rights.

More in-depth ways to explore math content. Khan Academy also gives teachers and students access to graphics and illustrations that are hard to replicate at the blackboard. These visualizations are built into certain exercises. Figure 1 shows an example of a math problem with an interactive, graphic of the concept being assessed. In the Solid Geometry example, students can see full three-dimensional images that turn as they mouse-over the figure. One teacher spoke of using this feature instead of trying to draw the images on a whiteboard for each class period. Using this tool, students have access to a higher quality and dynamic image right in front of them.

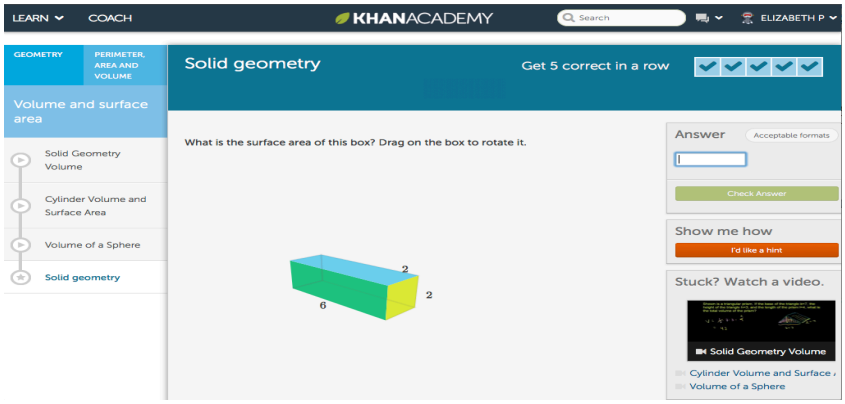

Figure 1: *Demonstrating Concepts through Khan Academy Graphics*

Using videos. Similar to case studies in the United States (See Bernatek et al., 2012), the video component of Khan Academy is not as highly utilized or valued as the exercises. As mentioned above, teachers sometime assign videos along with exercises and in those instances we observed students running the video in the background while doing exercises.

There are a number of reasons that teachers do not frequently assign video. One reason was the insufficient bandwidth at the schools. Teachers and students complained of slow connections when all of the machines were being utilized. Streaming 30+ videos would overload the system and make viewing nearly impossible.

Next, the videos are not always available in Spanish. At the time of our visit, translated videos were not stored on the Khan Academy site. Rather students had to go to YouTube where subtitles were available. The English videos with Spanish subtitles were also problematic because they require students to read subtitles while also watching someone write out math equations. The subtitles also frequently contained unfamiliar terms and new words that presented a reading challenge to the student.

Students and teachers agreed that instruction delivered by their own teacher was better than any video. Students preferred to listen to their own teacher lecture in their own language than listen to a stranger on a screen. One student explained, “The teacher can teach me more than the video.” Some teachers also reported that the videos were too long to be really feasible for classroom use.

Using Data

The Khan Academy platform generates a lot of data on the users. These Chilean teachers were using the data in five different ways.

Tracking energy points. The most common use of data was to track the number of points students earn. Teachers tracked and posted student scores to foster motivation, engagement, and excitement around doing math.

Assigning a grade for Khan Academy work. Teachers also used the data to verify student work and assign grades. Most teachers required students to complete five problems correct in a row and students who reached five got full credit, or partial credit if they did not reach five. However, a few teachers required that students earn a minimum number of points during each class period (1,000).

Tracking student progress. The other main use of data was to monitor student progress through the material. One teacher said he used the Khan Academy app on his phone to monitor student progress. Teachers could more easily distinguish which students needed to be spending their class time more productively, and who was doing extra work over the weekends. The monitoring process also helped teachers create student homework assignments because students who did not complete all of their assigned goals during the class period, would be expected to finish the rest for homework.

Monitoring student work during class. Three of the teachers we observed made interesting use of the real time data function to monitor student progress during the class. Teachers would project the data so students could compare their own progress to their peers as a way to motivate students and to generate a level of competition. The teachers could also see how much students are working. Even though, Khan Academy is self-paced, some students still needed a little oversight. In one session, the teacher reviewed the data 20 minutes into the class and called out students who had only attempted two problems, while highlighted others who had done many more.

Using data to identify instructional needs. The data also helped teachers see if there was a topic troubling a large portion of the students so that they could re-teach that concept. In two of the lab sessions, we saw teachers bring the class together to focus on the whiteboard while they explained a concept. One teacher used data from Khan Academy to help formulate groups either pairing students with similar abilities, or matching more advanced students with struggling peers. Another teacher said he checks students' progress on the platform every Sunday night to see what mistakes students are making and what topics they are struggling with. That information then feeds back into his instructional decisions around what to teach and what videos to assign.

Student use of data. Although many students kept track of their points and badges, the students rarely looked at any other data or statistics about their progress. However, this may be because the students had not had a chance to explore the full site in Spanish. The Spanish version of Khan Academy launched while we were in Chile. We did observe students being surprised that the site had vital statistics and other data. This suggests that perhaps the students simply did know what the data was.

DISCUSSION

Our research sought to explore the nature of how teachers blend the Khan Academy resources and online learning practices with existing resources and practices in Chile. The way these teachers were using Khan Academy as a digital learning environment changed the ways and the degree to which these Chilean students engaged *with* and were engaged *by* mathematics content. It also changed the way teachers and students interacted with each other. These findings are similar to what research around the use of Khan Academy in U.S. schools have found (Bernatek et al., 2012; Murphy et al., 2014; Wilka & Cohen, 2013). In Chile, we observed that Khan Academy provided the opportunity for students to do more math through having contact with more math exercises. This increased interaction with math impacts both student engagement and learning.

Teachers Are Changing Instructional Practices and Beliefs

From the observations and interviews, it was clear that the Khan Academy math resources have been quickly and deeply integrated into these Chilean teachers' math instruction. The major change that these teachers made was to dedicate class time to using Khan Academy in the computer labs. During classroom observations, we observed teachers maintaining many of their traditional instructional practices while integrating Khan Academy at specific moments where its use aligns with the traditional practice of having students do exercises. However, the easy fit between Khan Academy and these teachers' prior instructional practices does not mean that nothing is changing. The observations and interviews suggest that these teachers changed their practice while using Khan Academy with their students.

Teachers used more facilitation along with direct instruction. The introduction of Khan Academy pushed teachers to play a different role while in the lab with their students compared to the classroom. While using Khan Academy to support students' mathematics practice, the teachers in this study were clearly facilitating students learning rather than using a more traditional method of direct instruction. When a class of students entered the computer lab to work on Khan Academy, the power dynamics shifted. Instead of the teacher standing in front of the class "doing math", the students were the ones "doing math" non-stop for 30-40 minutes. The teacher's role was in support of the students.

As the teacher stepped out of her traditional role, students took on more control of their own learning experience. When using Khan Academy resources, students had to make more decisions for themselves about their learning path and became more self-sufficient learners. Students had more resources to help support their own learning needs allowing them to act more independently from the teacher. At least two teachers in the study talked about the value of Khan Academy to teach students skills such as responsibility and self-discipline. One teacher reported that he did not dictate how much time students should spend on Khan Academy at home rather he left it up to them to decide. This was his way of teaching them responsibility for later in life.

Teachers' use of classroom time also changed with Khan Academy use because they no longer needed to develop problem sets and spend less time worrying about classroom resources and logistics. The teacher did not need to spend precious class time drawing precise mathematical formulas and figures on the board each time they were needed.

Teachers are changing their beliefs about assessment. There are elements of a mastery learning approach emerging in the way these Chilean teachers were using Khan Academy. Mastery learning is a complex and effective pedagogical strategy (Guskey, 2010; Hattie, 2009) built on the idea that, given sufficient support and resources, all children can master the material. Although mastery learning has more key elements than we saw with Khan Academy, two core

features were present: numerous feedback loops on small, well-defined chunks of content and variability in time allowed to reach the goal.

Students in the study were doing more mathematics because they had more opportunities to succeed at math because Khan Academy changed the criteria of success. Moving from valuing the percent of correct exercises to achieving five-in-a-row was shifting students and teachers to a mastery-based view of success. This increased students' motivation to persist until they mastered the skill and demonstrated fluency. One teacher reported that Khan Academy worked best with his students who struggle the most because it gave them a chance to succeed. The students who most needed it got more chances. It is more difficult for students to slide through the system because teachers and students can track individual progress and see how much work they are doing and where they are struggling.

Students Are Doing More Mathematics

The Khan Academy site allows students to have increased access to mathematics exercises. In traditional classes we observed, students might see 10 to 15 exercises; but the teacher could never be certain how many students actually engaged in doing the exercises or how many copied the answers. Khan Academy fundamentally changes that dynamic. Through an infinite bank of unique exercises, students had to do the work on their own. They could not peer over a classmate's shoulder to get the answer because, undoubtedly, that person was working on a different problem. Similarly, students could not haphazardly fill out a worksheet with incorrect answers just to say they completed it. With Khan Academy, the user is required to input the correct answer before moving on.

But it is the features of immediate feedback and access to just-in-time assistance that help keep students engaged with math and completing more exercises. Students did not need to wait for a teacher's assistance; they could get help from peers or from the Khan Academy platform. There was no longer a bottleneck of information transfer with the teacher trying to help all students in one class period; there were two additional pathways for students to get support, allowing more students to move through more material more quickly. Additionally, because students could access the Khan platform wherever they have an Internet connection, they could work on problems during recess, after school, and at home. Learning was not confined to the 47-minute class period.

Students were more engaged in math. Some research has found that gamification can increase student engagement (See Plass et al., 2013). The elements of gamification on the site appeared to motivate many Chilean students to do more math exercises. Most of the students we spoke with described Khan Academy as fun and made references to the game-like elements. However, the points and badges appeared to motivate in different ways. Some students clearly wanted to earn as many points as possible, while other students just wanted to earn points to gain access to a new avatar. There were also students who saw the points as proof they were mastering each skill.

Self-regulated math learning was a motivator. Research has long suggested a connection between self-regulated learning and academic achievement (Zimmerman, 1990) and particularly in math (Dignath, Buettner, & Langfeldt, 2008). There are aspects of students' experience with Khan Academy that suggest classroom use might encourage self-regulation. Self-regulated learners "plan, set goals, organize, self-monitor and self-evaluate at various points during the process of acquisition" of knowledge or skills (Zimmerman, 1990, pp. 4-5).

While teachers manage students' entry into the system (through assigning skills and tasks), once they are there, students take control over much of their own learning. This ownership is at the heart of what makes Khan Academy's math exercises so engaging for students. First, students are able to move at their own pace and choose in which order they want to complete the assigned skills. Next, Khan Academy provides two types of feedback that might serve as a "self-oriented feedback" loop that theorists believe is fundamental to self-regulation (Zimmerman, 1990, p. 6). One feedback comes from the immediate response after each exercise; but students are also constantly monitoring overall progress through ✔ marks, points, and badges. Both of these feedback systems invite the learner to monitor their own progress and learning methods.

Just-in-time help supports metacognition. Since the Chilean teachers used Khan Academy with their students in a lab, the students had access to multiple supports and, in particular, help from their teachers. A key component of developing self-regulation is metacognition, which is the ability to reflect on your own learning and know when to seek help (Zimmerman & Tsikalas, 2005). When students come up against a procedure they do not understand, students have to decide how to proceed: get a hint, watch a video, ask a friend, ask the teacher, or simply try again. With Khan Academy, students know immediately if the answer is wrong. Students are required to reflect on their procedural choices and problem-solving approaches in the moment, not days later when a paper worksheet would be graded and returned.

In fact, getting help when they need it means students were more likely to stay engaged and on task instead of getting distracted while waiting for the one teacher to finish assisting other students. Because students were able to get help from multiple sources, as mentioned above, the teacher could spend more time with the struggling students who most needed her attention; this prevented that vulnerable group of students from falling further behind and potentially disengaging all together.

Students were encouraged to tutor each other. There was much more student discussion in the Khan Academy sessions than in the regular class, and the conversations were notably different. The way Khan Academy was used in these Chilean classes supported a certain type of student-to-student interactions. Since the activities were individual, Khan Academy did not support collaboration, per se. But, students did turn to each other for help. In traditional paper exercises, students also turn to a peer for help but this often means copying their answer. Since students on Khan Academy all have different exercises, they cannot share answers. The only option is to explain the process, which we observed frequently in the Khan Academy sessions.

Students worked on tasks appropriate to their level. The way Khan Academy functions in letting faster students advance more quickly while allowing other students to take time to grapple with the math skills they find challenging helped create a more equitable learning environment and reduced frustration and boredom. Some students needed more practice to solidify their operational ability, others needed to work with the teacher to clear up a misconception, and others wanted to move on to more advanced skills by themselves. Now, they all have the time and opportunities to do that.

Students are mastering more math skills. As students did more math problems and were more engaged in learning math content, it is not surprising that their skill level would also increase. Teachers, students, and the SIP leadership all felt that the students who were using Khan Academy were learning more mathematic content. Most of the students we spoke with liked math class. Some student said that this was a change for them. A few directly attributed Khan Academy for this shift. For example, two girls we interviewed felt that Khan Academy made them better at math. Another student believed that using Khan Academy improved his mental calculation skills. One teacher reported that many more of her students were getting 100% on their homework. Other students also reported doing better on the practice college entrance

exams. Although we were not able to analyze pre or post-test results in this study, other studies have found a connection between Khan Academy exercises and improved scores on basic mathematics (Murphy et al., 2014)

Students perceived themselves as math learners. Students felt more confident in their math skills from using Khan Academy because they could *see* their learning through points, badges, and charts. Similarly, when students are forced to stop and get help, they saw that getting that support actually works. Because Khan Academy provides infinite opportunities to practice problems and get things right, students have many opportunities to feel successful in their learning. They also noted that, with practice, they could learn, achieve, and master something. Some of the students also felt that Khan Academy had helped them value math. For example, two young women talked about how Khan Academy has helped them understand the value of math in their daily lives. One girl, whose confidence in math has increased since working with Khan Academy, works at the market with her father where she is now better able to use her math skills to help sell products.

CONCLUSION

Educational policy makers around the globe often talk about Khan Academy with great expectations for deeply transforming teaching and learning, with the concept of "flipping the classroom" where students receive direct instruction via video outside the classroom and then work with the teacher doing math in the classroom. What we found in this developing country context was something quite different at least in the context of mathematics. Similar to other studies (Murphy et al, 2014; Wilka & Cohen, 2013), in these Chilean schools we found Khan Academy being used in ways that improves students' math skills, but it is not by flipping the classroom.

After reviewing the resources and piloting them for many months, the administrators at SIP and their teachers felt that Khan Academy was useful for improving the procedural skills but not necessarily at promoting deeper mathematics learning or teaching difficult concepts; face-to-face teachers are still the best at that. Expecting students from these low-income families to have home computers and Internet access also means it is unrealistic to assign Khan Academy for home use. Instead, these teachers dedicated one lesson period a week to using Khan Academy in school computer labs. Teachers still provided direct instruction in their classroom, but teachers were taking on new roles in the labs. This also changed how students engage with math in powerful ways.

Even though the use of Khan Academy may plant the seeds of deeper pedagogical changes such as mastery learning or differentiated instruction, our findings suggest that teachers do not need to change their entire teaching model to start using this tool. Teachers assign exercises and students complete them; the practice appears the same as in the days of workbooks. Khan Academy does not require teachers to embrace a complex or novel view of teaching for them to make it useful and worthwhile. We observed teachers embedding Khan Academy resources within their traditional instructional practices and creating a decidedly non-traditional – yet improved – learning environment.

While some critics might emphasize its lack of reform approach as a fault, Khan Academy's straightforward approach of providing an endless bank of practice exercises may make it a more universally adaptable tool across different types of teachers, classrooms, and countries. The fact

that it does not diverge much from what mathematics teachers already want to be doing with their students makes its adaption less intimidating and integration more feasible.

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