INCREASING STUDENT ENGAGEMENT IN MATH: THE STUDY OF AN INTEL FUNDED PILOT PROGRAM IN CHILE

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Executive Summary

Khan Academy is an online platform offering educational videos and exercises in various content areas. As a free online learning resource, Khan Academy 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. For three years, Intel® has been supporting a pilot project using Khan Academy to teach math in Chile. The pilot is overseen by the Centro Costadigital at the Pontificia Universidad Católica de Valparaíso. With support from Intel, the Education Development Center (EDC) investigated how those educators in Chile are using Khan Academy with their students. Researchers spent two weeks observing how teachers are using Khan as part of an Intel-funded program to promote the use of technology in classrooms.

Educational policy makers around the globe often talk about Khan Academy with great expectations for deeply transforming teaching and learning, citing the concept of "flipping the classroom," where students receive direct instruction via video outside school and then work with the teacher doing math in the classroom. What we found in this developing-country context was something less "radical," than flipping the classroom but just as beneficial for students' math skills. We found teachers and students using Khan problem sets to practice and reinforce math skills.

Khan Academy

Khan Academy is best known for short videos of its founder, Salman Khan, explaining key concepts or skills, but the website also has other features. Most notably, the site offers an endless bank of interactive exercises on core math skills as well as other content areas. 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 solves five consecutive problems correctly, they have reached the first level in that skill. If the learner gets the fifth problem wrong, the count starts over and they must get another five correct without an error. The site also has game-like elements where learners earn points for completing the exercises, and points for the rate at which they solve problems. Both teachers and student can access all the data generated by the system.

In the five Chilean schools we observed, the preferred model of using Khan was to dedicate at least one class period a week to using Khan Academy in a computer lab. Of the principal components described, the exercises were by far the most commonly used Khan resources. The video component of Khan Academy was not as highly utilized or valued by the teachers or students.

Chilean Schools

We conducted exploratory case studies of teachers in five schools to learn about how they are embedding Khan Academy resources into teaching and learning. We worked with five schools in Santiago over a two-week period. Through interviews, focus groups, school walk-throughs, and classroom observations, EDC's goal was to document the types of teaching and learning practices developing around this popular new learning platform as a means to better understand the tool's role in an emerging market context.

The schools were carefully selected in collaboration with Costadigital to identify educators who were carefully and thoughtfully integrating Khan Academy into their teaching so that we could learn from their experiences and reflections. Four of the schools are part of a school network called *Sociedad de Instrucción Primaria* (SIP) that is run by a philanthropic foundation. The fifth school, Juan Moya Morales is a municipal K–8 school that serves the local student population.

Findings

Our research sought to explore the degree to which teachers blended the Khan Academy resources and online learning practices with existing resources and practices in Chile and how this might change what students learn math. Beyond supporting student's procedural fluency, working with Khan Academy changed their roles. While working on Khan, students took on more responsibility and control of their own learning process. To be successful, they had to learn how to oversee their own learning process and become more self-regulating. Khan also created opportunities for students to work together to solve math problems and find solutions.

Students are doing more math The Khan Academy site allows students to have increased exposure to math problems. In a traditional class, 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 have to do the work on their own. They cannot peer over a classmate's shoulder to get the answer because that person will be working on a completely different problem

Students are more engaged in math The elements of gamification on the site served to motivate many students to do more math exercises. Most of the students we spoke with described Khan Academy as fun. But it is the immediate feedback feature and access to just-in-time assistance that help keep students engaged with math and completing more exercises. Students do not need to wait for a teacher's assistance—they can get help from peers or from the Khan platform. There is no longer a bottleneck of information transfer, with the teacher trying to help all students in one class period; there are two additional pathways for students to get support.

Self-regulated math learning is a motivator Research has long suggested a connection between self-regulated learning and academic achievement (Zimmerman, 1990), particularly in math (Dignath, Buettner, & Langfeldt, 2008). There are aspects of students' experience with Khan Academy that suggest its classrooms use might encourage self-regulation. Once inside the Khan platform, students take control over much of their own learning. This ownership is at the heart of what makes Khan'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 encourage self-regulation: 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 A key component of developing self-regulation is metacognition: the ability to reflect on your own learning and know when to seek help (Zimmerman & Tsikalas, 2005). With Khan Academy, students know immediately if the answer is wrong. When students come up against an exercise they do not understand, they have to decide how to proceed: get a hint, watch a video, ask a friend, ask the teacher, or simply try again. 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, glanced at, and forgotten.

Students are 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 classes supported a certain type of student-to-student interaction. Khan Academy does not support collaboration, because the activities are individual. But, students do turn to each other for help. In traditional paper exercises, when students turn to a peer for help it 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 happening frequently in the Khan Academy sessions.

Students work on tasks appropriate to their level The way Khan Academy functions lets faster students advance more quickly while allowing other students to take time to grapple with the math skills they find challenging. Some students need more practice to solidify their operational ability, others need to work with the teacher to clear up a misconception, and others can move on to more advanced skills by themselves, but now they all have the time and opportunities to do any of those things.

Students are mastering more math skills As students do more math problems, and are more engaged in learning math content, it is not surprising that their skill level also would increase. Teachers, students, and the SIP leadership all feel that the students who are using Khan are learning more math content.

Students perceive themselves as a math learners Students felt more confident in their math skills when using Khan Academy because they could “see” their learning through points, badges, and charts. Similarly, students say that when they are forced to stop and get help, they can see that that getting 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 were learning, achieving, and mastering a subject.

Teachers are using more facilitation along with direct instruction 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. In part this is because the resources can be used in ways that easily blends into the teachers' current pedagogical approaches. Asking students to do Khan Academy exercises made sense to teachers and fits into a common practice of assigning math homework. But, the introduction of Khan Academy pushed teachers to play a different role while in the lab with their students, supporting and facilitating students' learning rather than practicing a more traditional method of direct instruction. Instead of the teachers being the sole providers of knowledge as students observe them doing math exercises, the students are the ones "doing math" non-stop for 30–40 minutes.

Conclusion

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 makes it a more inviting and universally adaptable tool across different types of teachers, classrooms, and countries. The fact that it does not diverge much from what math teachers already do with their students makes its adoption less intimidating and its integration more feasible.

However, the use of Khan Academy may plant the seeds of deeper pedagogical changes, such as mastery learning or differentiated instruction and allowing more student autonomy as well as improving students' math skills.

Table of Contents

Introduction 1
  Intel Chile, student-centered learning, and Khan Academy 1
  Khan Academy overview 2
    Videos 2
    Math exercises 2
    Gamification and data 3
  Research questions 3
The Chilean Schools 4
  Description of schools 5
  The typical school day in Chile 5
  Math class in Chile without Khan Academy 6
Khan Academy in Chilean Schools 6
  Why administrators choose Khan Academy for their schools 7
  Why teachers are integrating Khan Academy into their instruction 7
  A typical math class in Chile with Khan 9
Teacher and Student Use of Khan 10
  Doing practice exercises 10
  Using videos 13
  Using data 14
  Out-of-class use 15
Discussion 16
  Teachers are changing instructional practices and beliefs 16
    Teachers are using more facilitation along with direct instruction 17
    Teachers are changing their beliefs about assessment 18
  Students are doing more math 18
  Students are more engaged in math 19
    Self-regulated math learning is a motivator 19
    Just-in-time help supports metacognition 19
    Students are encouraged to tutor each other 20
    Students work on tasks appropriate to their level 20
  Students are mastering more math skills 20
  Students perceive themselves as a math learners 20
Conclusion 21
References 22
Appendix A: School Sampling 24
Appendix B: The Khan Academy Platform 25
  Videos 26
  Math Exercises 26
  Data 27
  Community 28

Introduction

Khan Academy is an online platform offering educational videos and exercises in various content areas and has become a worldwide education phenomenon in just a few years. As a free online learning resource, Khan Academy 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. The little research that exists around Khan Academy is focused on developed countries (Bernatek, Cohen, Hanlon, & Wilka, 2012; Kronholz, 2012; Wilka & Cohen, 2013), yet there is great interest among developing counties to access this free resource. For three years, Intel® has been supporting a pilot project using Khan Academy in Chile. With support from Intel, we sought to investigate how those educators in Chile are using Khan Academy with their students. Researchers spent two weeks observing how teachers are using Khan as part of an Intel-funded program to promote the use of technology in classrooms.

This Chilean case study is part of a series of studies funded by Intel, exploring how teachers and schools in diverse contexts are blending information and communication technology (ICT) tools and practices into their classrooms (Light, 2010; Light & Pierson, 2012a, 2012b). The case study of Khan Academy in Chilean schools is the first in a series of studies focused on digital learning environments. In August 2013, researchers from EDC traveled to Santiago, Chile, to conduct research in schools where teachers are using Khan Academy with training and support from the Centro Costadigital at the Pontificia Universidad Católica de Valparaíso. In all of the schools, Khan Academy was being used exclusively to support mathematics.

Intel Chile, student-centered learning, and Khan Academy

Intel has long sought to contribute to the development of modern, high-quality educational systems worldwide by being a partner to national governments in helping to prepare young people for the 21st century. Intel offers national governments two flagship programs to support technology use: the Intel® Teach Program for teachers and the Intel® Learn Program for students. In Chile, Intel's local education manager works closely with the Chilean government to support particular local needs. One continuing challenge is promoting student use of ICT in school; the Chilean Ministry is not satisfied with the extent to which teachers are using ICT in the classroom with their students (Cancino & Donoso Díaz, 2004). Seeking to put technology directly into the hands of students, Intel Chile turned to Khan Academy as a learning tool for students.

The Khan Academy project grew out of Intel's response to the Chilean earthquake in 2010. Intel worked with schools devastated by the natural disaster, using the Assessment and Learning in Knowledge Spaces (ALEKS) program to support math learning. Although successful, the use of ALEKS was not scalable in Chile because of the cost, which Intel's Education Manager reported to be US$50 per student. For the next school year, Intel and their education partner, Centro Costadigital, began looking for other options that might be scalable, and they found Khan Academy.

Intel and Centro Costadigital mapped the Khan Academy resources to the Chilean curriculum to identify modules that would be best aligned to local needs. In collaboration with the Inter-American Development Bank, RELPE (Red Latinoamericana de Portales Educativos) and the Ministry of Education, Intel then funded the translation into Spanish of 650 videos—589 in math and 61 in biology. With Intel's support, Costadigital created the professional development course to use Khan Academy for math in 2011. The training familiarizes the teachers with the Khan Academy site and the curriculum map, and gives them time to develop plans and lessons using Khan Academy. But the training does not prescribe how teachers should use the Khan Academy platform.

Khan Academy overview

Khan Academy is an online learning platform started by former hedge fund manager Salman Khan, with the stated goal of "changing education for the better by providing a free world-class education for anyone, anywhere." The site offers over 5,000 online instructional videos in an array of subject areas (including math, science, economics, finance, history, and art), an extensive repository of math exercises, and real-time data and analysis features (Koeniger, 2013).

The Khan Academy platform provides resources for learners (or students) and for coaches (as teachers are called on Khan Academy). There are three principal components of the Khan website that support learning: videos, exercises, and data. These sections of the site work together to create what Khan calls a "personalized, mastery-based, interactive and exploratory online learning environment." Though Khan Academy offers content in numerous subjects, by far its most comprehensive topic area is mathematics.

Videos

The videos of the founder teaching various subjects are the best-known feature of Khan Academy. The site offers short videos organized in the disciplines of Math, Science, Economics, and Humanities, and then sub-divided by subjects such as Chemistry, World History, or Geometry. 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, it is in Math that Khan Academy offers a seemingly inexhaustible bank of online practice exercises connected to specific math skills. Students have access to a seemingly endless pool of problems. 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 solves five consecutive problems correctly, they have reached the first level in that skill. If the learner gets the fifth problem wrong, the count starts over and they must get another five correct without an error.

Khan Academy's exercise bank offers hints to help students. Users can get step-by-step hints through the solution, allowing students to realize on their own what step of the procedure they were missing, without simply giving them the answer. Each page also links to a video related to the skill they are practicing.

Learners earn points for completing the exercises, and points for the rate at which they solve problems.

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, which were solved correctly and which incorrectly, the amount of time spent on each exercise or video, the wrong answers given, and the hints used.

Teachers can track progress of a group of students or of an individual. They can look at progress by specific skills or topics. 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: Red indicates the student is having difficulty, while dark blue indicates topic mastery. (For a more detailed description, see Appendix B: The Khan Academy Platform.)

The Khan Academy platform is changing frequently, and experienced substantial changes both while we were visiting the schools and since then. One of the most profound changes was the full translation of the Khan website into Spanish. The Chilean Students had previously used the site in English, using a browser-based translator as needed. While we were in Chile, they had their first look at the site in Spanish. We realized that students had largely ignored many aspects of the site — personal goals, data, and community discussions — because they could not understand the language.

Research questions

We want to examine how Khan Academy is merging and blending with teachers' classroom practice. Since all learning is situated and embedded into a context, our exploration of Khan Academy in Chile is grounded in a socio-cultural theory of learning (Vygotsky, 1978) that 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. Tools are embedded in all classroom practice, shaping everything that happens. 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.

Access to educational tools and resources in the classroom is an important factor that influences the possibilities for creating engaging and supportive learning environments for students. Providing good educational resources is a concern for schools in all countries, but in developing countries the challenges of accessing resources is a fundamental aspect of schooling. They frequently lack many educational tools and resources that schools in wealthier countries take for granted. Therefore, we believe it is particularly important to understand how new resources, like Khan Academy, can be integrated into the context of a developing country.

The Chilean Schools

We conducted exploratory case studies of teachers in five Chilean schools to examine how they are embedding Khan Academy resources into teaching and learning. Since the Chilean schools are using Khan only in math, we limited our focus to math teachers. Through interviews, focus groups, school walk-throughs, and classroom observations, EDC's goal was to document the types of teaching and learning practices developing around this popular new learning platform as a means to better understand the tool's role in an emerging market context.

Over the course of two weeks, we worked with five schools in Santiago. These schools were not randomly selected, but were chosen in collaboration with Costadigital. We were looking for educators who were carefully and thoughtfully integrating Khan Academy into their teaching so that we could learn from their experiences and reflections. Four of the schools are part of a school network called *Sociedad de Instrucción Primaria* (SIP) that is run by a philanthropic foundation. The SIP's mission is to provide high-quality education for at-risk populations, and the schools are located in low-income neighborhoods. The SIP network supports 18 K–12 schools serving 18,000 students. In order to attend, students take an admissions test and families pay a small fee, equivalent to US $25 per month per child. The SIP network was chosen because, as a network of schools, the math 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. With help from *Costadigital*, EDC worked with administrators at SIP to choose the schools with the most established Khan programs, with teachers who were trained to use the tool and who were systematically integrating it into their practice. The schools selected include: Colegio Claudio Matte, Liceo Bicentenario Italia, José Agustín Alfonso, and Arturo Toro Amor (all girls).

The fifth school, Juan Moya Morales is a municipal K–8 school that serves the local student population. Their mission is to provide a free, secular, and high-quality education, and to prepare students for high school by helping them develop values and cultural skills that allow them to cultivate their own intellectual, emotional, and creative selves. The municipal school was added to the sample because the Chilean researchers thought it was important to visit a municipal school. Math teachers at this school also were working to strategically integrate Khan Academy into their 5th- to 8th-grade classes.

Across the five schools, we worked with 11 math teachers, conducting interviews and observing lessons. In total we observed 25 math lessons, both with and without the use of Khan Academy. The grades observed ranged from 4th to 12th grade. (See Appendix A). We also conducted informal conversations with students during the observations. In addition, we interviewed 6 school administrators, 32 students, and 15 program staff from SIP, Intel, and Costadigital. The EDC team also participated in meetings with the SIP leadership team and math department, Intel, and Costadigital to better understand their role in bringing Khan Academy into these schools and classrooms.

Description of schools

All five schools 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. Many of the schools have murals or student artwork on display in these open areas. The schools in the study were vibrant, organized, and orderly. The directors and teachers we spoke with were dedicated, hardworking, and hopeful that the Khan Academy platform could improve student learning.

The class sizes in the SIP schools ranged up to 40 students, and the municipal school had around 30 students per class. In the classrooms we visited, students sat at desks organized in rows facing the front of the room. There was very little technology in the classrooms for students, though teachers had a laptop and projector to use if needed. The classroom walls are mostly bare with an occasional world map, but very little student work on display.

All schools had at least one computer lab with sufficient computers for students to work individually. The SIP computer labs had about 40 computers set on desks in various configurations around the space. One school included laptops in their lab, but the other three schools had only desktop machines. Two of the four schools had interactive whiteboards in their labs. The municipal school had a small computer lab with 21 desktops.

The 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 in the classroom, it is important to keep the context of Chilean schooling in mind. Although every school has its own unique culture, there are some general patterns.

Unlike many developing countries, Chile has full-day schooling (at least 7 hours); students start the day around 8:00 a.m. and are in school until about 3:00 p.m. The students are together in the same classroom all day, and this cohort or *section* generally stays together from year to year as they move up. In elementary school, students have the same teacher for all subjects, but by 5th grade students start to have different teachers for each subject. The students stay in their classroom, and the different 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 would be 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/).

The infrastructure in classrooms can vary, of course, but there are some common patterns here as well. Most Chilean classrooms now have individual desks for students, the desks are not bolted to the floor and the configurations can be rearranged as needed. Chile has made substantial investments in technology for the classrooms and all of the classrooms we visited had either an interactive whiteboards (IWB) or a projector. And the teachers had laptops available to them.

Math class in Chile without Khan Academy

The typical math class without Khan Academy that we observed was not unlike lecture-based math classes elsewhere. For lessons when teachers are introducing new material, they work with the whole class, demonstrating a problem and a new concept on the whiteboard while students follow along in their workbook. At key moments, the teacher might ask students for suggestions or ask them 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. The teacher may verify the answer, or use questions to guide the student (and the class) to find the mistake and then solve the problem correctly.

After this presentation of new material, the teacher assigns a set of problems from the workbook in class, 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 worked in small groups, and their conversations were a mix of gossip and math. The teacher responded to any requests for help, but many students did not ask the teacher for help: Most asked their friends instead. Often, a request to a peer for help resulted 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 in mind these patterns of doing math in a classroom context, because the uses of Khan Academy that the Chilean teachers have developed intersect and begin to transform these processes.

Khan Academy in Chilean Schools

Intel and Costadigital promoted Khan Academy specifically for math. Although many learners come to Khan Academy on their own as individual learners, the schools we worked with were using Khan as part of their instruction. Thus, teachers were integrating it into their lessons, as well as encouraging students to use Khan on their own at home or after school. The preferred model of use that was emerging among these teachers was to dedicate at least one class period a week to using Khan Academy with their students. In all of these schools, this meant taking the students to a computer lab. These teachers did not use all of the features of the Khan website with the same frequency; of the four principal components described in the preceding section—videos, exercises, data, community—teachers and students in Chile utilized the exercises by far the most often.

Why administrators choose Khan Academy for their schools

According to the SIP leadership team, after Intel invited the school network to participate in the Khan Academy program, SIP's Director of Mathematics and her department reviewed the Khan 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). For pedagogical reasons, the SIP mathematics department felt that the elementary grades needed more hands-on activities and manipulatives than a virtual environment would provide. The SIP leadership also felt that Khan 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 felt that the interactive nature and game-like features of Khan Academy would help encourage students to do more math homework. This addresses a common complaint among SIP math teachers: that their students do not do enough homework. The SIP leadership also values the Khan Academy platform as a sustainable choice because of its low cost (free), high-quality exercises, and consistent online supports.

The municipal school came to Khan Academy through a different route. An external education consultant, funded by Fundación Telefónica, suggested the use of Khan Academy as one way to utilize the school's computer lab to help improve students' math knowledge. Unlike the SIP schools, at municipal school, Khan was being used by the elementary classroom teachers (3rd to 6th grades), as well as by the math teachers in the 7th and 8th grades.

Why teachers are integrating Khan Academy into their instruction

The group of Chilean educators we worked with had all carefully thought through how to integrate Khan Academy as a resource to support their teaching. Teachers in Latin American 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 for at least 45 minutes a week. The Khan Academy sessions were principally used for students to practice skills and develop procedural fluency, and not for direct instruction. The teachers all felt this was a worthwhile change because their students were doing substantially more math exercises. They also felt that the way Khan Academy features function promoted students' becoming more engaged in math and improved their performance.

Depending upon the availability of computing resources, teachers varied on whether they had students use Khan Academy during class time, for homework, or as an after-school activity. The students in the schools we observed did not have access to desktop or laptop computers in their classrooms; computers and the Internet were accessible solely in the computer lab. This would be considered a *Lab Rotation* model of blended learning (Ferdig, Cavanaugh, & Freidhoff, 2012), where students and teachers spent between 45 and 90 minutes per week in the computer lab.

In looking across the observations and interviews, four common objectives emerged. Teachers' main objectives were focused primarily on the exercises and on having students doing math, the videos were not a prime resource. The teachers had two main motives when using Khan with all students:

- *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.
- *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 often were tackling a wider range of skills, since Khan allows student to focus on any skills in which they are weak. Teachers felt 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."

But the teachers used Khan Academy to support the following two levels of personalization or differentiation:

- *Enrichment for more advanced students*. Teachers used Khan during elective math classes, as well as during after-school math clubs. The huge amount of content and exercises allows the most advanced students to access information beyond what is provided in the government textbook. Students can move through the site at their own speed, exploring new topic areas and more sophisticated exercise sets while using the teacher as a guide rather than as the primary mode of knowledge delivery.

- *Remediation for students falling behind*. The teachers felt that Khan Academy was able to adapt to the needs of struggling students by giving them an endless supply of problems to work on, and because the approach to mastery was based on getting five correct answers in a row, not on the percent of problems correct. Those students who needed more practice to master a procedure could continue working outside of class. Some schools also organized afterschool sessions with Khan Academy for students who needed extra support.

The practice of differentiation is not yet widespread in Chile, and it is an innovation for many teachers. The teachers interviewed were envisioning how Khan Academy could support the different learning needs of slower and faster students. The Chilean teachers talked about differentiating instruction in very careful ways. They all felt they had to keep students moving along the same path and at relatively similar pacing. Also, the government provides just one math textbook, so teachers have limited access to diverse curricula. One teacher commented that in the classroom they "to do everything the same" for all students. The extent to which teachers can vary the curricular resources for each student is limited.

When deciding which topics to assign students, the alignment with the Chilean curriculum was the most important factor. Most teachers made sure the actual exercises linked to the content they were currently teaching. A few teachers considered other criteria. At one school, the teachers observed that the exercises for some content areas increased in difficulty as children moved forward, while others maintained the same level of complexity. Although these teachers preferred to use the consistent exercises, this feature was not available for all skills.

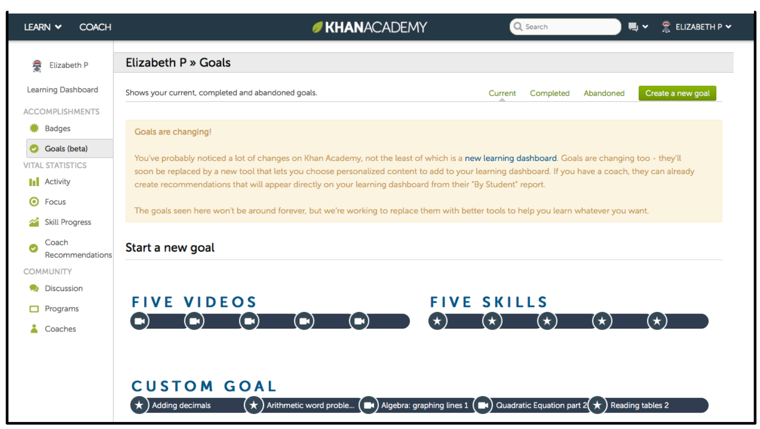
A typical math class in Chile with Khan

The particularities of how teachers used Khan Academy resources and how students interacted with the site emerged in conversations and in closer observation of individual students working on problems. Across observations, the math classes using Khan shared common patterns of teacher and student practices; all the classes without Khan shared common practices, as well. However, the classes with and without Khan were quite different from each other.

First, in the labs, most of the students are seated at individual machines—only in the municipal school do a few students share a machine. By far the most common practice was for teachers to have their students complete exercises on the Kahn Academy site. Only in two observations did teachers assign video in addition to exercises, and 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.

To direct the students' activities during class, all the teachers told students what exercises to do. Two teachers handed out a paper instructing students where to go on the website. But most teachers gave verbal instructions on what topics to do, either having students navigate through the "Knowledge Map" or using the "Goals" functions built into the site (see Appendix B for more information on the Knowledge Map). Most of the teachers assigned students the goal of reaching the practice level (i.e., getting five correct answers in a row) by a certain date. One teacher we observed started her students on five math skills during a computer lab session mid-week and gave them until the following Monday to do five-in-a-row for each skill. Students used the search box to find the assigned topics. Once students located the topic, they added it to their skill list (Figure 1). We observed teachers assigning anywhere from one to five skills in a single class. Once a learner successfully completed five-in-a-row, he or she moved on to the next skill.

Figure 1: Image of Goals page



After an initial introduction, all students started working individually doing math exercises, each with different sets of problems and, in some classes, each working on different skills. Students were mostly quiet and focused on their computer screens—in some schools students wore headphones and listened to music as they did exercises. In the Khan sessions observed, the students were seen 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 were talking with their neighbors while working on the computer and, as in the *non-Khan* math class, the conversations were a mix of gossip and math. But in the lab, when a student asks a friend for help, the friend cannot give the specific answer because every student has a unique problem on their screen. What we observed were students trying to explain the math procedures.

In most classes, students kept working until the end of the 45-minute class period, but in a few classes the teachers did bring students together to review common problems they were having or do some other closing activity before the end of class. 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, and we saw this practice in two of the classes we observed.

Teacher and Student Use of Khan

This section is organized around the four main components of the Khan Academy website: exercises, videos, data, and community. It describes the degree to which each component is being used, the specifics of how those resources are being integrated into teachers' instruction, and how their use is changing students' learning activities. The use of Khan outside of school hours is also discussed.

Doing practice exercises

Exercises were by far the most frequently used component of the Khan Academy website. In all of the observations, students were completing exercises. On its face, doing exercises in Khan Academy might not appear to be a 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 were using Khan Academy during class time, seven features emerged as 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—teachers used the five-in-a-row level built into Khan Academy as the indicator of successful mastery of the skill; and
(7) illustrates complex concepts, some of which are difficult to show on a conventional one-dimensional blackboard or whiteboard.

When students were working on Khan Academy in the computer labs, these features combined to transform how students engaged with math and developed 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 had their own set of problems to work on during the class appeared to increase the number of problems they did and allowed students to work on problems at their current skill level. In the classrooms we observed without Khan, teachers generally used a combination of whole-class instruction and individual seatwork as the whole class moved through the same set of problems. In interviews, the teachers commented that in the classroom (without Khan) they target instruction at the middle level. Slower students often fall behind, more advanced students disengage. In total, students might go through ten problems during the class, but it was uncertain whether individual students actually did the problems, simply got answers from peers, or went through the motions while copying from the teacher. When the students were on the Khan Academy website in the computer labs, all the students were engaged in doing problems and teachers walked around the room offering help. Khan enabled students to move at a pace that was more appropriate to their learning needs. Students who understood the material had to complete only five exercises before moving on, while individuals who needed more practice could complete as many exercises as necessary to learn the content.

One teacher said she used to prepare extra problem sets for the fastest and slowest students, but she could never create 40 separate problem sets. The teachers felt that students who are using Khan are doing more math problems than they would in a standard classroom, and that as they do these problems they are practicing and perfecting procedural skills that will help them as the content becomes more complex.

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 changed the way students engaged with the math content. Instead of completing ten problems and going over them in class only to find there was a misunderstanding from the first problem, students on Khan Academy know immediately if they are right or wrong after each exercise. They get immediate feedback, and students who understand the procedure quickly reach the goal of five-in-a-row.

If students get the answer wrong, they must 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 did observe a few students persist with the same, incorrect strategy for a problem or two, but since they continued getting ✗'s, they soon sought help. Since Khan Academy never runs out of math problems, students can keep practicing. Additionally, since mastery on an assignment was five-in-a-row, not total percent correct, students were motivated to keep trying. A few mistaken attempts did not ruin their grade, as it would have on a pencil-and-paper set of problems. One teacher commented that she now has more students getting full credit for their homework.

Increased pathways for getting help. As mentioned above, students knew immediately if they were doing something wrong. Having students use Khan Academy during class time created a need to seek help, while also providing multiple pathways to get help. The platform offers hints and relevant videos built into each exercise. But, since the Chilean students were using Khan at school, they also had access to teachers, peers, and notebooks. One teacher said, "Teachers can be assured that if students encounter a problem when they are on Khan, they will not stay frustrated."

In Chile we observed that even though students had the imbedded supports, they preferred turning to peers and teachers. When a student could not complete a problem, the most common first step we observed, was for the student to ask a more math-savvy peer for help. Because each student has unique problems, Khan actually transforms the typical peer-to-peer interaction from the exchange of correct answers to one of facilitation and guidance. Unless a student is willing to do the math problem for her friend, students cannot just give the answer or copy it. Students are forced to work through the problem together, and are 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, whom they saw as a more trusted and accurate resource. Asking the teacher is the safest option, because students do not want to make a mistake and be forced to accrue check marks again. Some students used their notebooks not only as a physical scratchpad to work out solutions, but also as a reference guide for lists of prime numbers, square roots, times tables, or the value of pi. They also referred back to notes they took during a classroom lecture to help them figure out how to solve a problem.

There are a number of reasons that students utilized the imbedded support features less frequently than other sources of help. First, some students were wary of using the imbedded hints for assistance because it meant they would not earn points for that exercise. Once a student clicks on the "I'd like a hint" button, they automatically received a red ✗ in their tally. This would interrupt their accumulation of ✔ marks and require them to rebuild back towards five-in-a-row. In contrast, one student who described herself as "timid and shy" preferred hints because she could hide the fact that she did not know something. She could review a concept through the hints, and neither her peers nor the teacher would ever know she was struggling. During our observations, students rarely used the videos because of the aforementioned language and technical barriers.

Gamfication of learning as a motivator. It was clear from talking with students that getting immediate feedback and seeing the ✔ marks build up was motivating and gave them a sense that they were mastering different procedures. But, Khan Academy also has other reward systems built into it. Because of incentives such as points, avatars, and badges, some students see Khan Academy as much as a place to play 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 more math problems in order to accumulate energy points and earn new badges. With points, one can buy more interesting avatars, which was a motivation for some of the girls we spoke with. There also were a few students who saw the points as proof they were getting better at math. Many of the students in our focus groups knew exactly how many points they had earned, a clue as to the high value they placed on those numbers. But the motivation was not always the accumulation of points.

The teachers and administrators of the SIP also used the points to motivate students. Both at the individual school level and the SIP network level, contests were used as an additional motivation for students to complete more problems and increase their energy points. 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 visualization are built into certain exercises. Figure 2 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. On the website, students have access to a higher quality and dynamic image right in front of them.

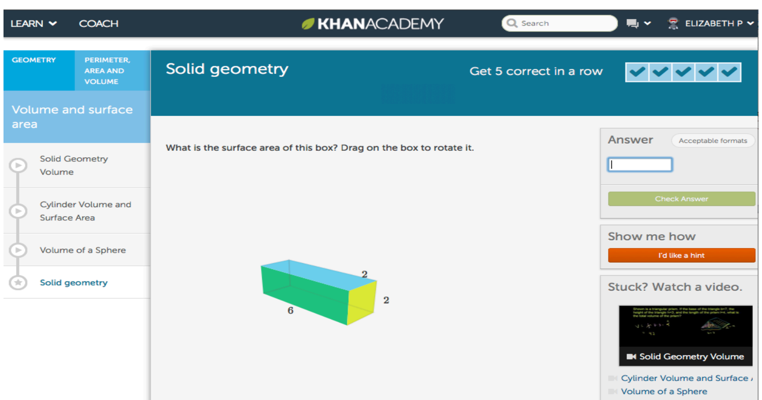


Figure 2: Demonstrating concepts through Khan graphics

Using videos

The video component of Khan Academy was not as highly utilized or valued as the exercises. On the rare occasion that a teacher would recommend a video to a student, it would be for extra help, reinforcement, or clarification; it was never used as the primary mode of instruction. At one school, the girls understood that they had to watch the videos in order to increase their points and earn certain badges; it wasn't clear to what extent these students were following through with this tactic.

As mentioned above, teachers sometime assigned videos along with exercises, and in those instances we observed students running the video in the background while doing exercises. We observed, and students later confirmed, that when they watch (and focus on) videos during class, it was usually with the volume off or just watching the equations move across the screen. The researchers observed a few students with their own headphones, but it was not a common practice. The headphones were sometimes connected to a video, and other times were playing music. Other students used subtitles if they wanted to know what the speaker was saying.

There were a number of reasons that teachers did not frequently assign video. The first reason was the insufficient bandwidth at the schools. Teachers and students already complained of slow connections when all of the machines were being utilized. Streaming 30+ videos would have overloaded the system and made viewing nearly impossible.

Second, the videos were not always available in Spanish. At the time of our visit, videos that had been translated from English were not accessible directly from the Khan Academy site, students had to go through a YouTube site. The English videos with Spanish subtitles were also problematic because videos require the student to read subtitles while also watching someone write out math equations. The subtitles also frequently contain unfamiliar terms and new words that present a reading challenge to the student.

Finally, students and teachers agreed that content delivered through 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 felt the videos were too long to be really feasible for classroom use.

Using data

The Khan platform generates a good deal of data on the users. Though not all teachers utilized the built-in data analysis tool on the Khan website, many Chilean teachers were using the data in five different ways.

Tracking energy points. The most common use of data is to track the number of energy points students have earned. Students earn points for doing math problems and watching videos, and teachers were tracking and posting student scores to foster motivation, engagement, and excitement around doing math. Most students and the schools we observed were engaged in at least one tournament, either among their immediate classmates, across the entire grade at the school, or against other students in the SIP network.

Assigning a grade for Khan. Some of the teachers we observed gave students grades for their work on Khan Academy and teachers used the data to verify student work and assign a final grade Most teachers required students to correctly complete five problems in a row (i.e., complete the practice level). Students who reached five-in-a-row got full credit, and 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). Teachers also kept track of the number of skills mastered and the level of those skills to assign grades. For example, if a student earned a certain number of extra points for relevant skills in a week, he or she would receive a homework credit in the grade book. Teachers sometimes discounted points earned for skills that are way below the level of the student to ensure that students did not simply accumulate points for simple skills (i.e. telling time or one-digit addition)

Tracking student progress. The other main use of data was to monitor student progress through the material. Through the charts and graphs generated on Khan, teachers can see how much time students spend on the site or on a specific topic, and who is on the site at what time of day. One teacher said he uses the Khan Academy app on his phone to monitor student progress. Teachers could more easily distinguish which students should 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; 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 very interesting use of the "Real Time" data function to monitor student progress during the class. Teachers would project a chart that shows each students progress on a set of math skills (see Appendix B: Figure 8) 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 also could see how much students were working. Even though Khan Academy is self-paced, some students still need a little oversight. In one session, the teacher reviewed the Khan data 20 minutes into the class and called out two students who had attempted only two problems, while she highlighted others who had done many more, and one student who had already completed five skills (i.e., more than 25 problems).

Using data to identify instructional needs. The data also helped teachers see if there might a topic that was troubling a large portion of the students so they could re-teach that concept. In two of the lab sessions, we saw teachers ask the whole class to stop and focus on the whiteboard to explain a concept with which many students were struggling. One teacher used data from Khan 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 Khan every Sunday night. He can 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, these 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, and 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 data was available.

Out-of-class use

Because Khan is based in the cloud, students can access their accounts and practice math anytime and anywhere they have access to the Internet. Not surprisingly, since access to computers and Internet varied by student, the use of Khan Academy at home also varied. Teachers rarely assigned Khan as homework, but students understood that if they were unable to complete all the exercises during the allotted class period, they would have to find time during recess, between classes, after school, or on weekends to finish the work. All five schools understood that these technologies were not yet ubiquitous in the homes of their students, and therefor offered access to the computer lab during recess and various after-school programs. Teachers reported students "flooding" the lab during these times to finish homework, practice for a test, or simply amass points in their Khan account.

Students who did have Internet in their homes visited the site to complete assignments, to prepare for standardized tests, such as the 8th-grade Education Quality Measurement System (Sistema de Medición de la Calidad de la Educación; SIMCE) and University Selection Test (Prueba de Selección Universitaria: PCU), and to share it with family members. Some students also logged on for fun. One student commented that Khan Academy was the only site her parents let her use at home. Another student talked about showing Khan Academy to her parents and her little brother.

Discussion

Our research sought to explore the degree to which teachers blended the Khan Academy resources and online learning practices with existing resources and practices in Chile. To that end, this report has described in detail the specific ways in which teachers and students in Chile used the various features of Khan Academy. 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. Additionally, Intel has clearly achieved their initial goal of getting more technology into the hands of students.

Figure 3 depicts the cycle of impacts on students who are using Khan Academy in their math classes. What we observed in Chile is that Khan Academy, most basically, provides 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. In theory, the impact cycle continues to perpetuate itself because as students are more engaged, they are doing more math, and as they are doing more math, they should be able to learn and retain more math skills.

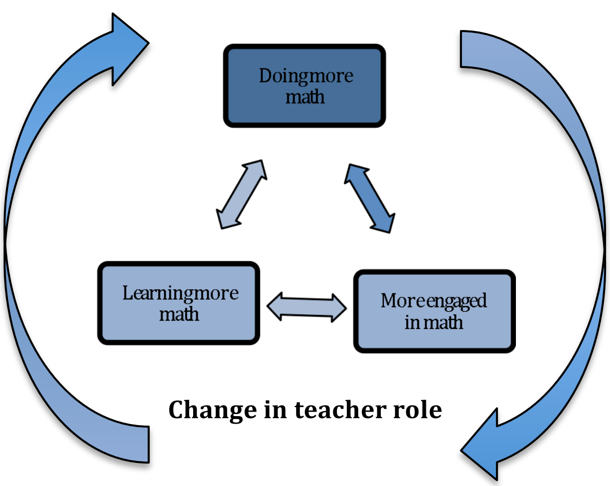


Figure 3: Impact Cycle

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. In part this is because the resources can be used in ways that easily blends into the teachers' current pedagogical approaches. All of these math teachers typically assigned homework from the textbook, and Intel had provided maps connecting the resources to the Chilean curricula, so asking students to do Khan Academy exercises made sense to teachers and fits into a common practice. The initial change that these teachers made was the decision to dedicate class time to using Khan Academy instead of "teaching".

However, the easy fit between Khan Academy and these teachers' prior instructional practices does not mean that nothing was changing. During classroom observations when Khan was not in use, we observed teachers maintaining many of their traditional instructional practices and they integrated Khan at deliberate and specific moments. It was while they were in the lab with their students that changes in their practice became apparent.

Teachers are using 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, supporting and facilitating students' learning rather than practicing a more traditional method of direct instruction. Instead of the teachers being the sole providers of knowledge as students observe them doing math exercises, the students are the ones "doing math" non-stop for 30–40 minutes. One teacher explained, "I feel much more like a guide. Before I was the person that knew everything, now I can help students where they are; I am more of a tutor." The Khan platform changes the teacher's role in the learning process by increasing classroom efficiency and enabling her to become more of a facilitator (at least while in the computer lab).

As the teacher steps out of her traditional role, students take on more control of their own learning experience. When using Khan, students are empowered to make more decisions for themselves about their learning path and to become more self-sufficient learners. Students have more resources to help support their own learning needs, allowing them to act more independently from the teacher. One teacher said, "I have 35 students, I can't divide myself in 35 pieces to help all of them. They now have the autonomy to help each other." Khan shifts some control to the students because it is each student's responsibility to complete the exercises. At least two teachers talked about the value of Khan to teach students skills such as responsibility and self-discipline. One teacher does not dictate how much time students should spend on Khan at home, he leaves it up to them to decide. This is his way of teaching them responsibility

Teachers' use of classroom time also changes with Khan, because they do not need to develop their own problem sets and are able to spend less time worrying about classroom resource management and logistics. The teacher does not need to spend precious class time drawing precise mathematical formulas and figures on the board, just to have them marked up for the next class, when she has to take time to draw them again. Khan provides various interactive images and graphics that help students visualize complex concepts in multiple dimensions. Teachers are not spending as much time creating worksheets, because Khan provides an endless bank of practice questions. They can use that time to help struggling students or to plan more engaging lessons.

Teachers are changing their beliefs about assessment

There are elements of a mastery learning approach emerging in the way these Chilean teachers are using Khan Academy. Mastery learning is a complex and effective pedagogical strategy (Guskey, 2010; Hattie, 2009) based on the idea that when 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 of its core features were present: numerous feedback loops on small, well-defined chunks of content, and variability in time allowed to reach the goal. An important variable is that, while learning goals are constant for all children, time is adaptable to individual needs.

Moving from valuing the percent of correct exercises to achieving five-in-a-row shifts students and teachers to a mastery-based view of success. This increases student motivation to persist until they master the skill and demonstrate fluency. One teacher reported that many more of her students are getting 100% on their homework. Another teacher said that Khan works best with his students who struggle the most, because it gives them a chance to succeed. Instead of quitting, the students who most need it are more likely to struggle on until they master the skill. It is more difficult for students to slide through the system, because teachers can track student progress and see how much work they are doing and where they are struggling.

Students are doing more math

In addition to supporting shifts in the teacher's role, the use of Khan Academy also impacts students and their interactions with math. Basically, the Khan Academy site allows students to have increased exposure to math problems. In a traditional class, 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. Teachers also acknowledged that students did not always do their homework, and sometimes copied answers from peers. Khan Academy fundamentally changes that dynamic. Through an infinite bank of unique exercises, students have to do the work on their own. They cannot peer over a classmate's shoulder to get the answer because that person will be working on a completely different problem. Similarly, students cannot 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 immediate feedback feature and access to just-in-time assistance that help keep students engaged with math and completing more exercises. Students do not need to wait for a teacher's assistance—they can get help from peers or from the Khan platform. There is no longer a bottleneck of information transfer, with the teacher trying to help all students in one class period; there are two additional pathways for students to get support, allowing more students to move through more material more quickly. Additionally, because students can access the Khan platform wherever they have an Internet connection, they can work on problems during recess, after school, and at home. Learning is not confined to the 45-minute class period.

Students are more engaged in math

The elements of gamification on the site served to motivate many 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, other students just wanted to earn points to gain access to a new avatar. But there were also students who saw the points as proof they were mastering each skill. The points, which allow teachers to use the platform to compare students, introduce a competitiveness to math. The SIP schools were even engaged in a Khan-related tournament.

Self-regulated math learning is a motivator

Research has long suggested a connection between self-regulated learning and academic achievement (Zimmerman, 1990), particularly in math (Dignath, Buettner, & Langfeldt, 2008). There are aspects of students' experience with Khan Academy that suggest its classrooms 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 Khan Academy 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'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

A key component of developing self-regulation is metacognition: 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, they 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. If they continue using the same strategies, they continue getting ✗'s, so they quickly learn to seek help. 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, glanced at, and forgotten.

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

Students are 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 classes supported a certain type of student-to-student interaction. Khan Academy does not support collaboration, because the activities are individual. But, students do turn to each other for help. In traditional paper exercises, when students turn to a peer for help it 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 happening frequently in the Khan Academy sessions.

Peers are seen as a valuable and useful resource in the Khan classroom; students are not chastised for talking to their friends. In fact, teachers see a benefit to peers helping each other because it frees up their time to attend to the neediest students. Almost all of the peer interactions observed by researchers took place in the computer lab as opposed to the classroom. When students spoke with each other in the classroom they were quieted by the teacher; in the lab, they were free to engage with each other. Most, though not all, of the observed interactions in the lab were related to the math task at hand.

Students work 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 helps create a more equitable learning environment and reduces frustration and boredom. Some students need more practice to solidify their operational ability, others need to work with the teacher to clear up a misconception, and others can move on to more advanced skills by themselves, but now they all have the time and opportunities to do any of those things.

Students are mastering more math skills

As students do more math problems, and are more engaged in learning math content, it is not surprising that their skill level also would increase. Teachers, students, and the SIP leadership all feel that the students who are using Khan are learning more math content. At least two girls we interviewed said that Khan has made them better at math. Another student noted that Khan has improved his mental calculation skills and, as a result, he is faster at completing problems. One teacher reported that many more of her students are getting 100% on their homework. Students also report doing better on the practice college entrance exams.

Students perceive themselves as a math learners

Students felt more confident in their math skills when using Khan Academy because they could "see" their learning through points, badges, and charts. Similarly, students say that when they are forced to stop and get help, they can see that that getting 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 were learning, achieving, and mastering a subject. Two young women talked about how Khan has helped them understand the value of math in their daily lives. One girl, whose confidence in math has increased since Khan, 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, citing the concept of "flipping the classroom," where students receive direct instruction via video outside school and then work with the teacher doing math in the classroom. What we found in this developing-country context was something less "radical," at least in the context of math. In these Chilean schools we found Khan Academy being used in ways that probably improves students' math skills, but not by flipping the classroom.

Beyond supporting student's procedural fluency, working with Khan Academy changed their roles. While working on Khan, students took on more responsibility and control of their own learning process. To be successful, they had to learn how to oversee their own learning process and become more self-regulating. Khan also created opportunities for students to work together to solve math problems and find solutions.

There were also changes in the teachers' role. After reviewing the resources and piloting them for many months, the administrators and teachers at SIP felt that Khan Academy is useful for improving mechanical skills but not necessarily at promoting deeper math learning or teaching difficult concepts; face-to-face teachers are still the best at that. It was unrealistic to expect students from these low-income families to have home computers and Internet access, which also meant it was unrealistic to assign Khan Academy for homework. Instead, these teachers dedicated one lesson period a week to using Khan in the labs. Teachers were still providing direct instruction in their classroom, but were now taking on new roles in the labs. And this also changed how students engaged 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, teachers did not need to change their entire teaching model to start using it. 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 imbedding Khan 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 makes it a more inviting and universally adaptable tool across different types of teachers, classrooms, and countries. The fact that it does not diverge much from what math teachers already do with their students makes its adoption less intimidating and its integration more feasible.

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Appendix A: School Sampling

Across the five schools, researchers interviewed and observed multiple lessons of 11 unique math teachers. We interviewed seven of those observed teachers, and one teacher whose class we did not observe. In addition, we interviewed six school administrators, 32 students, and 15 program staff from SIP, Intel, and CostaDigital. We observed 25 classes taught by 11 unique teachers. Classes ranged from 4th to 12th grade, along with a number of electives courses. All but one of those classes was in the subject of math (see Table 1, below). We also engaged in informal conversations with students during their observations; these are not included in the table. The EDC team also participated in meetings with research partners, including SIP, Intel, and CostaDigital, to better understand their role in bringing Khan into these schools and classrooms (see Table 2, below).

Table 1: School Visits

School	Days in School*	Subjects Interviewed			Classroom Observations	
		School Leaders	Teachers	Students	Classroom	Computer Lab
Toro Amor	2	1	2	9	1	3
Claudio Matte	1	1	1	0	0	3
Agustin Alfonso	2	1	1	20	2	5
Bicentenario Italia	2	2	3	3	3	4
Juan Moya Morales	1	1	1	0	1	3
Total	**--**	**6**	**8**	**32**	**7**	**18**

* Note: Researchers were split into two teams so school visits could take place simultaneously.

Table 2: Interviews with Affiliated Program Staff

	Program Staff	Subjects Interviewed
SIP Administrators	General Manager	1
	Pedagogical Director	1
	Mathematics Director	1
	Evaluation Director	1
	Head of Planning	1
	Communications Director	1
	Mathematics Coach	3
	Mathematics Teacher	2
Intel	General Manager, Intel Chile	1
Centro CostaDigital	Head of Regional Training for Intel	1
	Head of Technical Support	1
	Head of Assessment	1
Total		**15**

Appendix B: The Khan Academy Platform

The Khan Academy platform was originally designed as an individual-driven experience, with the learner in complete control of what, when, why, and how they learned. As Khan has become increasingly popular as a part of formal instruction and as an in-school learning tool, the designers have begun to develop ways for teachers to assign (or at least suggest) activities to learners.

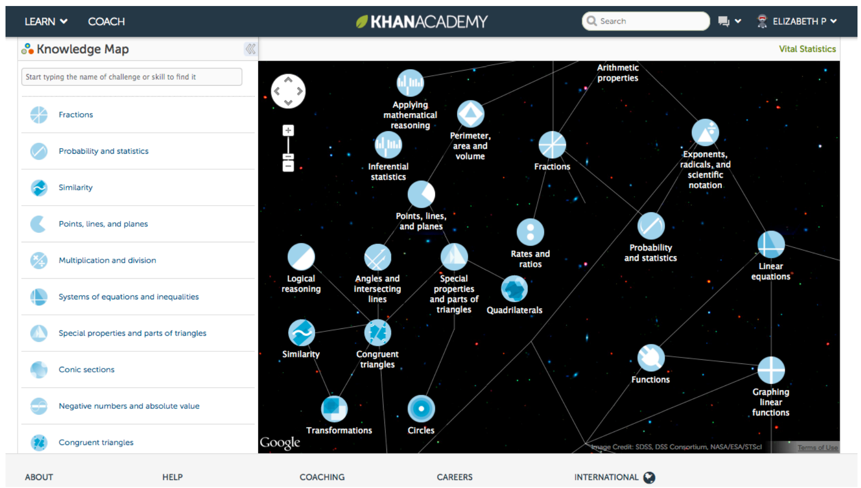


Figure 4: Knowledge map

The math content is searchable by grade level, something that is not available in any other topic area. Math also provides the most robust collection of practice exercises, and it incorporates a "Knowledge Map" to help users navigate through the interconnected topic areas. Figure 4 shows the knowledge map, where users can trace how different math concepts are related to each other. Teachers in Chile used the Knowledge Map to help guide their students to the specific topics they were teaching.

Logging into the site brings the user to the "Learning Dashboard" (Figure 5). Students can see their progress in the "World of Math," they can see how many points and badges they have earned, they can take a mastery test, practice particular skills, review their accomplishments, analyze their vital statistics, or engage in the wider Khan community. The lighter the square, the more practice must be done. Gray squares indicate a topic that has not yet been visited by the user.

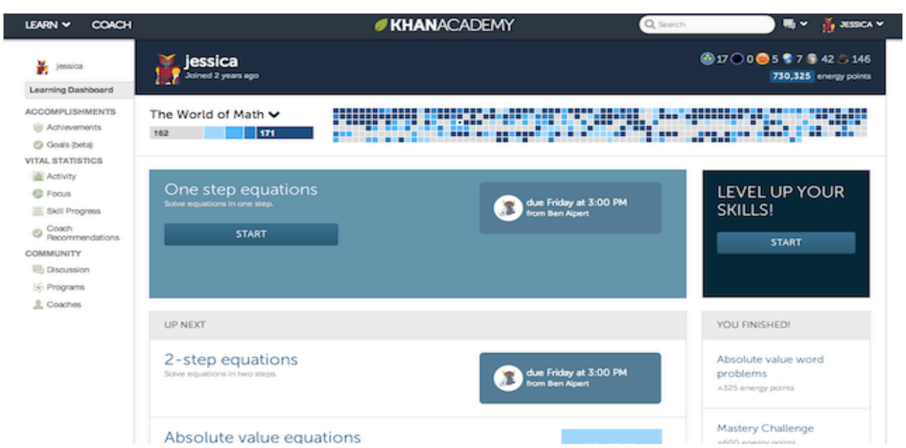


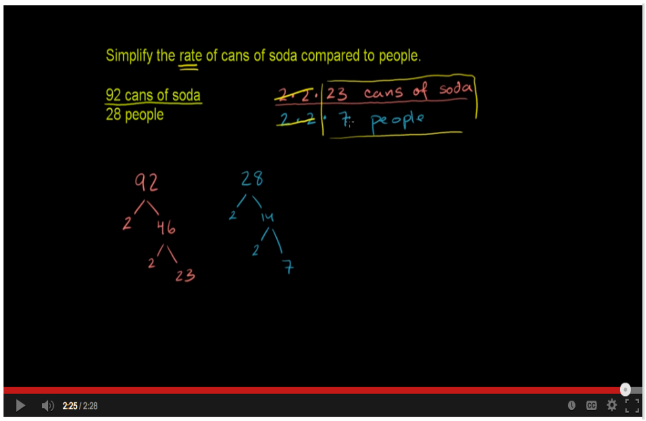
Figure 5: Personalized learning dashboard

Khan Academy also is a gamified site, where learners can earn points and win badges by watching videos, doing practice exercises, taking tests, or displaying mastery in various ways.

Videos

The videos of the founder teaching various subjects are the best-known feature of Khan Academy. There are short videos for every topic area offered on the site. 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 (see Image 1). The videos are organized in disciplines of math, science, economics, and humanities, and then subdivided by areas such as chemistry, world history, or geometry. A drop-down menu on the site allows users to search for videos by discipline and content area. From a content area, the user chooses a subtopic, and clicks on a video. In math, the videos drill down to very specific subtopics, such as "converting percents to decimals" or "derivative intuition."

Image 1: Screen shot of math video on simplifying fractions



Math Exercises

Though all subject areas have some exercises for learners to complete, it is in math that Khan Academy offers a seemingly inexhaustible bank of online practice exercises connected to specific math skills (i.e., "simplifying fractions" or "prime factorization"). Through an adaptive software platform, Khan Academy gives users access to an ever-growing pool of equations, word problems, geometric shapes, graphs, charts, expressions, matrices, statistics, vectors, functions, lines, logarithms, angles, theorems, and formulas.

Learners pick a topic and the platform gives them a problem to solve. 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. Figure 6 (below) shows an example of the exercise interface and how its various components function. Progress is tracked at the top right-hand corner of the screen, with check marks (✔) or cross outs (✗). The example shows how ✔s and ✗s accumulate as users attempt each new problem. If a learner gets five problems in a row correct, they have reached the first level in that skill. If the learner gets the fifth problem wrong, the count starts over and they must get another five in a row correct.

Khan Academy's exercise bank offers various supports to help students. First, a "scratchpad" allows a learner to write directly on the screen as they are working through a problem. Second, users can get step-by-step hints. (See hint in Figure 6: "Make sure the decimals are lined up.") The hints are intended to reveal each step of the process, allowing students to realize on their own what step of the procedure they were missing, rather than just giving them the answer. Finally, each page links to a video related to the skill they are practicing. The suggested video walks students through completing a similar type of problem. Students then can apply that knowledge to the exercise in front of them.

Learners earn points for completing the exercises, and points for the rate at which they solve problems. Learners will get an ✗ if they use the hints to solve a problem, but using a video for help does not impact their point accumulation.

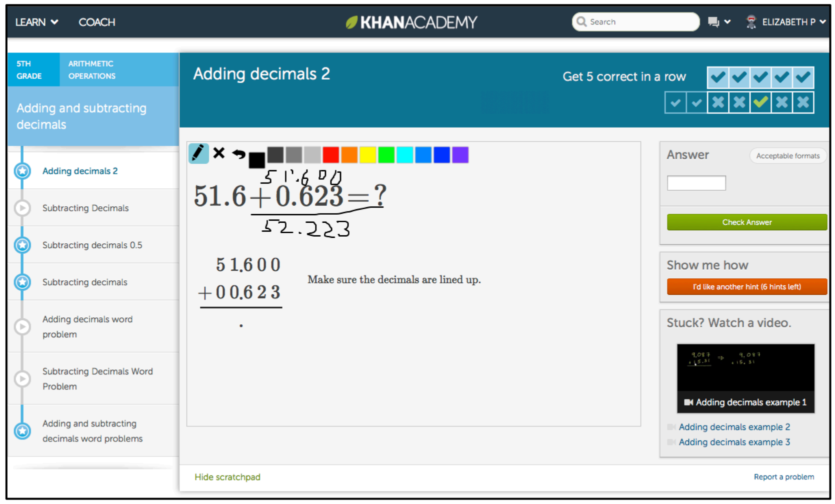
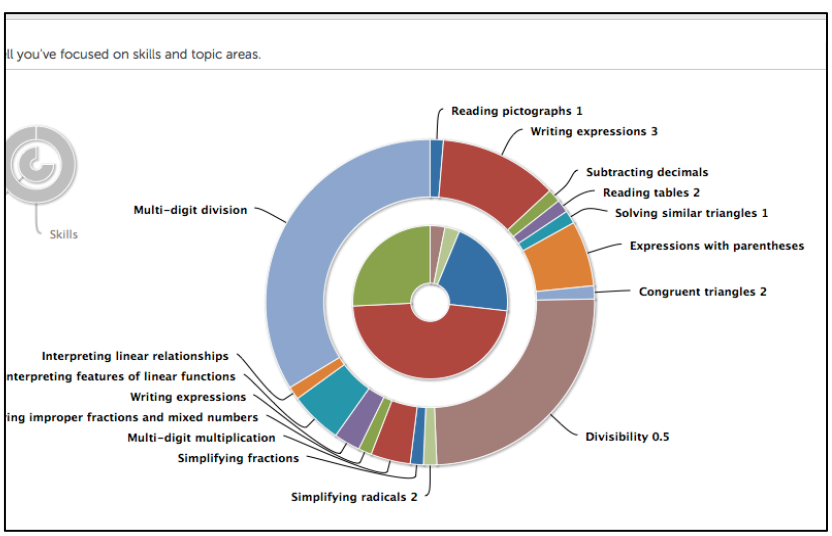


Figure 6: Example of Khan Academy exercise bank

Data

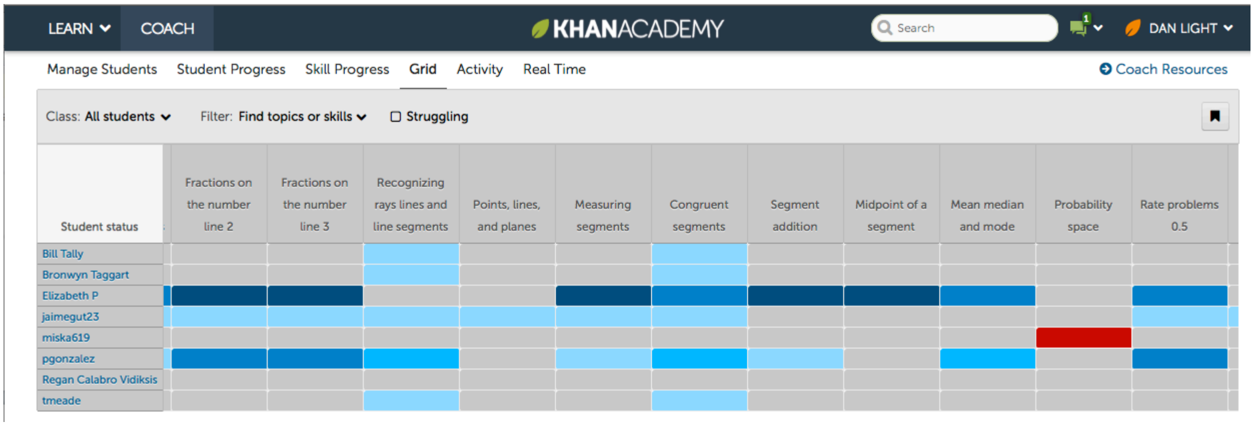
Khan Academy also offers data for learners and coaches about the use of Khan resources in all subject areas. Access to real-time and accumulated data allows students and their teachers to track the number of videos watched, number of exercises attempted, which ones were correct and which incorrect, the amount of time spent on each exercise or video, the wrong answers given, and hints used. These data allow students and teachers to track use, analyze misunderstandings, and chart progress. Under the "Vital Statistics" heading in the left-hand scrolling window, learners can monitor their own progress on the site. Figure 7 shows how individual users can track their own activity over the course of a certain time period to see how much work they are doing each day. The "Focus" link creates a graph for students to see how they are spending their time around both videos and exercises.

Figure 5: Image of focus graph



Teachers can track progress of a group of students or of an individual. They can look at progress by individual students or by specific skills or topics. 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; red indicates the student is having difficulty, while dark blue indicates topic mastery. The “Student Activity Over Time” chart indicates when a student did work, and how much time they spent and on which topics. Figure 6 shows the “grid” view of student progress that allows coaches to review student-level data.

Figure 6: Coach view of student data



Community

Khan Academy also provides a community space where members can post questions and answers and share comments about the website or what they are learning. As a Khan Academy community member, any learner can pose questions, give answers, provide tips, and comment freely on all of the videos and other resources available on the site. Users can then track their participation from their dashboard.