Five years of Khan Academy in Brazil, impact and lessons learned

April 2018

FUNDAÇÃO Lemann

KHANACADEMY

Index

1. Khan Academy in Brazil

Founded in 2006 by North-American educator Salman Khan, Khan Academy is one the most widely used educational tools in the world. Initially focused on math content, the tool currently has exercises and video lessons on many other subjects such as science, history, economics and others.

As an adaptive tool, Khan Academy adjusts content for different users according to their previous knowledge and level of development as they use the tool. In their first contact with Khan Academy, as part of their math mission, students perform an initial test to assess their level of knowledge and receive recommendations of videos and exercises suitable for each one. Use frequency and students' learning performance are rewarded with points, medals and gaming components to promote use and engagement.

The Lemann Foundation started a partnership with Khan Academy in 2012 to promote the use of Khan Academy in Brazil with an emphasis on math education. The translation of the content into Portuguese and its adaptation for the Brazilian context enabled over 2.6 million Brazilian students to register in the platform to use Khan Academy for their studies from 2012 to 2017.

As part of the efforts to expand access to the tool, the Lemann Foundation created "Khan Academy nas Escolas" (Khan Academy in Schools), a program made for Brazilian public schools. In 2015 this program expanded and became "Inovação nas Ecolas" (Innovation in Schools), which aims at promoting not only Khan Academy, but other technology resources focused on learning.

From a Khan Academy perspective, Inovação nas Escolas provides a four-hour face-to-face training program for teachers so they can realize the full potential of Khan Academy resources with their students in the classroom. Furthermore, teachers and school managers receive real-time reports on students' difficulties and strides, which allow them to better monitor the learning progress and target their teaching strategies.

From 2013 to 2017, Inovação nas Escolas reached more than 60 Brazilian cities. Thanks to the program, the Lemann Foundation introduced Khan Academy to more than 200,000 students in over 1,000 public schools all over Brazil.

In order to understand the impact Khan Academy had in the lives of teachers and students, Lemann conducted four surveys in 2015 and 2016. These studies included schools that participated in Inovação nas Escolas between 2014 and 2016 in six Brazilian states: Ceara. Bahia, Sao Paulo, Parana, Santa Catarina and Rio Grande do Sul. Additionally, Lemann analyzed students' mathematics performance on the 2015 Prova Brasil to determine how students performed using Khan Academy compared to students not using Khan Academy.

One of the objectives was to measure Khan Academy students' math performance through an impact evaluation. The surveys also aimed at understanding how they use the tool and what can be improved. An analysis was conducted based on questionnaires answered by students, teachers and school managers about the use of Khan Academy. This analysis was followed by two in-depth surveys conducted in an interview format. Both surveys produced very positive results. The details are as follows.

2. Impacts of Khan Academy in school performance

To identify the **causal effects** of Khan Academy on students' learning, the Lemann Foundation conducted an impact evaluation in 2016, using a quasi-experimental design[1]. The objective was to determine if schools that had access to Khan Academy through Inovação nas Escolas in 2014 and 2015 had superior math performance compared to schools that did not participate in the program during the same period of time.

The **results were positive**; fifth graders in schools that used Khan Academy for at least once a week for math classes had a better performance when compared to those who did not. On average, their performance was **four points higher** than the students from a matched comparison group of schools that did not use Khan Academy when they took the Prova Brasil 2015[2]. This four-point gain represents **30% of the learning expected of a school year in Elementary School**[3]. The learning gains were even larger (math average 5.8 points higher) among students in schools that used the platform since 2014 - in other words, students that worked with Khan Academy for longer - than students that worked with the tool in 2015 alone (math average 2.97 points higher).

Out of the 143 Brazilian public schools that used Khan Academy between April 2014 and October 2015 with fifth graders, 137 (96%) met the requirements for inclusion in the

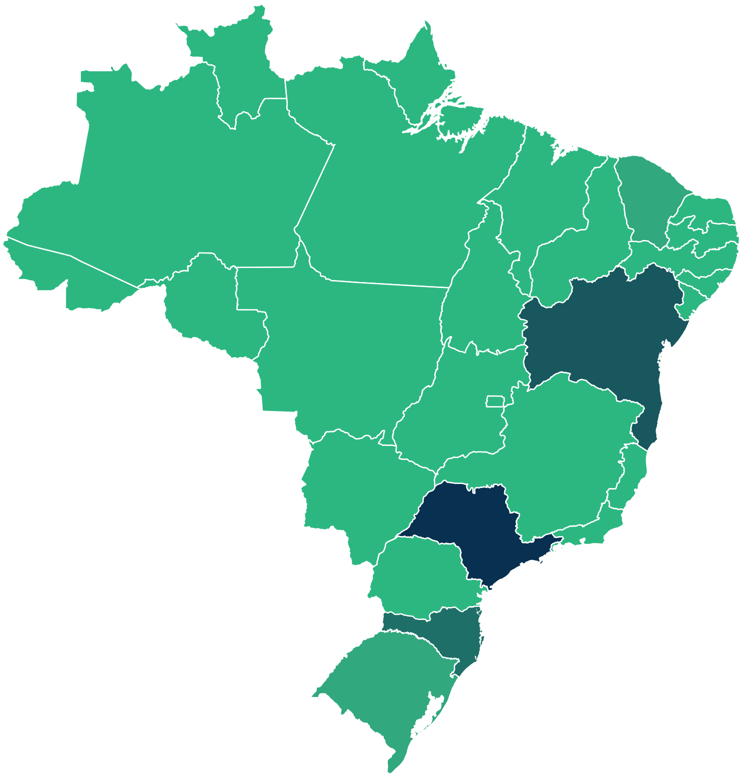
1 An impact evaluation was conducted to find out what would have happened with the schools that used Khan Academy (treatment group) had they not used the platform. Pinpointing the causal effect of Khan Academy in math grades presented yet another challenge; there was no randomization of schools between the treatment group and the control group (schools that did not use Khan Academy) before beginning the program. We tried to mitigate that through the most suitable and rigorous method possible for this case: a quasi-experimental, Difference-in-Differences and pairing method. This method entailed calculating the difference in math grades between schools from the treatment group and schools from the control group, before and after the Inovação nas Escolas program took place. In turn, pairing ensures that schools from the treatment group are compared to the control group, comprised by schools that are as similar as possible (see Appendix 1 for further details).

2 **Prova Brasil** is a national standardized exam given by the Brazilian Ministry of ion in odd-numbered years. This test assesses math and Portuguese knowledge of students from the fifth and ninth grades in Brazilian public schools.

3 This number was calculated based on the fact that, according to the Prova Brasil scale, the estimated difference between the grades of students in the fifth and ninth grades is 50 points. Thus, the evolution expected for one school year in the first years of Elementary is 12.5 points in the Prova Brasil scale. Therefore, the four-point impact measured in the assessment accounts for roughly 30% of that progress.

analyses. The requirements were as follows: schools had to have participated in Prova Brasil assessment in 2013 and 2015; schools had to have students enrolled in fifth grade in 2015 and/or in fourth grade in 2014 and have data regarding the variables considered in the statistical analysis. The 137 schools have 27,261 students enrolled.

Schools involved in the impact evaluation were located in 24 cities in 4 Brazilian states, most of which were situated in the Southeast, South and Northeast of the country (in that order). The map below shows the distribution of schools by state.



State	Number of schools
SP	98
BA	18
SC	12
PR	7
CE	1
RS	1

Map #1: Khan Academy schools considered for the impact evaluation.

The Lemann team conducted analyses based on Khan Academy platform usage data. Out of the 137 schools involved, 87% used Khan Academy for at least six months. Use of Khan Academy in the classroom - measured in minutes spent working on exercises and watching video lessons - was more intense as of May 2015 (at least 30 minutes per class each week) with an average of 37 minutes per class per week for the 2015 school year.

These schools' math performance in Prova Brasil, before and after Khan Academy use (2013 and 2015 results respectively) was compared to the performance of a group of schools with similar characteristics, in the same period, that did not use Khan Academy. Schools that did not use Khan Academy were matched to schools who used Khan Academy based on the following indicators: students' social and economic level; initial school performance (in 2009); school size; average hours of lessons per day; faculty characteristics; how much time teachers work in school; level of administrative complexity in the school; if the school is open for use in the weekends; if there is a library in the school; how predisposed the school is for participating in programs offered by

Lemann[1] and tech infrastructure (internet and number of computers for students).

Appendix 1 of this document provides a detailed methodological explanation of how the impact evaluation was conducted.

3. How Khan Academy helps students learn more: student, teacher and school managers perception

Three additional studies were conducted by the Lemann Foundation between 2015 and 2016 to understand how Khan Academy is used in Brazilian classrooms and how it can make math teaching more effective. The studies comprised interviews and perception questionnaires designed to assess four areas of interest:

- overall **impressions** of Khan Academy use in schools
- **the infrastructure necessary** for using the platform correctly
- teachers' and school managers' perceptions regarding the potential impact of Khan Academy on learning
- strategies adopted by schools and teaching networks to ensure that the platform is used effectively and continuously.

In 2015, the first study was conducted in five cities: Sao Jose dos Campos (Sao Paulo state), Ferraz de Vasconcelos (Sao Paulo state), Rolandia (Parana state) and Mucambo (Ceara state). In these cities, people from 25 different schools were interviewed including: 200 students, 75 teachers, 50 school managers and 5 school district superintendents. In the same year, another survey was carried out with 55 schools from different Brazilian states (Bahia, Ceara, Parana, Santa Catarina and Sao Paulo). In this survey, 1,788 students, 66 teachers and 37 school managers answered a structured questionnaire. Finally, in 2016, in the last stage of this series of studies, interviews were conducted in five schools in Pelotas (Rio Grande do Sul state), one school in Barueri (state of Sao Paulo) and one school in Lencois Paulista (Sao Paulo state). 15 teachers and 9 school managers participated.

Overall, the interview and survey findings showed a positive perception of Khan Academy and suggested that math learning became a more fun and interactive process; the platform seems to be connected to the students' reality and provide more autonomy for them.

We highlighted the main conclusions about Khan Academy use and the perceptions around it coming from surveys and interviews with students, teachers and school managers. The conclusions of this three-survey analysis are as follows:

1 In order to gauge different levels of engagement and motivation in schools, the control group was defined considering schools that did not participate in Inovação nas Escolas, but took part in other programs conducted by Lemann in 2016 (which is after the period of this analysis). The selection criteria for participating in these programs were the same criteria required for Khan Academy use (signing up via the selection process and having interviews with school managers).

3.1. Student use

Surveys show that students use Khan Academy mainly for individual activities (56%), accessing class subjects (49%), doing homework (42%) accessing new content recommended by the teacher (38%), revisiting class subjects (30%) and group activities (20%).

When asked about the time dedicated to Khan Academy, both in school and at home, most students (62%) said they use the tool for more than half an hour a week. Out of the 1,788 students **70% use the tool only in school**.

To some extent, the low rates of access out of school may be explained by the fact that, in some cities, few students own a personal computer. *"We had to teach them [...] nearly everything. We work with kids from rural areas that have no access [to computers]"*, says an informatics assistant from the city of Mucambo. Accordingly, proposing computer-related activities **brings students closer to technologies**. One of the technicians from the Ferraz School District said "The access promoted by Khan is a digital inclusion opportunity for children."

3.2. Student perception

Nearly 70% of students agree that Khan Academy allows them to autonomously choose study content. Over 80% of students like using computers for studying, while 90% consider Khan's content interesting and say it helps them **learn more easily**. *"Sometimes we don't learn something from the text book, but we learn it after the first try with Khan."*

Surveys suggest that students are more willing to study math and can learn more because they feel enthusiastic about it. *"We learn more because we're doing something cool"*, says a student from Ferraz de Vasconcelos (Sao Paulo state). The ludic platform helps challenge students – they earn points and medals, which also fosters friendly competition. *"I ask my friends how many points they got"*, says a student from Sao Jose dos Campos (Sao Paulo state). *"I always want to be the best!"*

3.3. Teacher perception

Out of the 66 teachers surveyed, over 80% report that Khan Academy has a **positive impact on students' overall classroom performance**. When it comes to external assessments, such as Enem (The National High-School Exam) or Prova Brasil, 90% of teachers perceive Khan Academy's impact on students' outcome as positive. It's worth mentioning that 97% believe this impact reaches high-performing students, while 81% believe it impacts low-performing students.

More than 90% of teachers believe that Khan Academy promotes student autonomy and classroom engagement by fostering a positive "competition for knowledge" and making lessons more dynamic. A teacher from Ferraz de Vasconcelos (Sao Paulo state) said *"students become protagonists and teachers become mediators."*

Other benefits were mentioned, such as developing reasoning by mental calculation, expanding vocabulary and improving text interpretation, the last two being related to interpreting exercise premises. According to teachers from Rolandia, *"[Khan Academy] promotes text interpretation by working on concentration and attention to exercises."* This opinion is echoed by school managers and district technicians. A pedagogical coordinator from the city of Mucambo (Ceara state) said *"[students] are more dynamic and take their time to reason."* According to a technician from the Ferraz de Vasconcelos (Sao Paulo state) school district, *"students are learning to think mathematically."*

From a teachers' perspective, even though Khan Academy is perceived positively, less than 50% of teachers use it on a weekly basis in their lesson plans. This can be related to the schools' technology situation (such as lack of computer maintenance and unstable internet connection), but it can also suggest a need to create supportive strategies to help secure teachers' engagement with Khan Academy and encourage them to use it continuously in their lesson plans.

Although not all teachers use Khan Academy to plan their lessons every week, over 90% of them stated that the reports made by the Lemann Foundation about student time spent using different aspects of Khan Academy (doing exercises or watching videos lessons) have helped them get a deeper understanding about their students' difficulties.

Another factor suggested by the surveys is that using technology in the classroom is challenging for some teachers. Teachers that feel apprehensive about using Khan Academy also don't feel comfortable using any other type of technology in the classroom.

3.4. School managers perception

Out of 37 principals and pedagogical coordinators surveyed, over 90% believe Khan Academy **streamlines teachers' lessons**, making **classes more appealing** and developing new skills in students. Although more than half of teachers report that they are not integrating Khan Academy activities in their lesson plan every week, 73% of managers said they encourage teachers to integrate Khan Academy in their lesson plans and propose complementary or reinforcement activities.

On the other hand, only a little more than half the managers encourage teachers to use Khan Academy to assess students' learning progress to then identify and further support students with low performance in math.

The survey results also highlighted how essential it is for teachers to oversee and support students' use of Khan Academy. In at least two cities (Santo Andre and Mucambo), Khan Academy lessons are overseen by only one informatics assistant without a math teacher present. Assistants help students with computer-related issues, but they're not expected to guide them through any specific math teaching.

This factor was considered adverse to Khan Academy engagement and its continuous use, not only by students from these cities who complain about lack of support by the assistants, but also school managers. According to a Digital Inclusion manager from the Santo Andre school district, informatics assistants are technicians, they are not trained to teach students.

Furthermore, school managers and teachers stressed the **importance of training** for using Khan Academy effectively. Training contributes by making a coherent introduction of Khan Academy to the school's pedagogical plan and ensuring continuous use in the classroom.

3.5. Teacher training

The teacher's role is crucial for Khan Academy to help students learn. Khan Academy's aim is to support teachers and enable a more customized lesson for each student's development. "Students are not all the same, their difficulties vary", says a teacher from Santo Andre (Sao Paulo state).

In this context, the teacher training and ongoing follow-up provided by the Inovação nas Escolas program is really important to help teachers make good use of Khan Academy with their students. However, despite the support, **there are still challenges**. Teachers are struggling to master all functionalities of the tool. *"I'd be lying if I said I know all the resources*", admitted a teacher from Santo Andre (Sao Paulo state). So, in the interest of continuously improving Inovação nas Escolas and expanding Khan Academy's qualified use, we have to address the teachers' need for training and guidance. We already began to put this into practice in 2017. We produced tutorials and how-to videos to help teachers manage the platform daily, created a direct communication chanel between teacher and trainer through Whatsapp and guaranteed a moment when we remind teachers how to use Khan Academy ensuring pedagogical allignement.

Having well-trained people conducting the project inside the schools is paramount, whether they are math teachers, pedagogical coordinators or assistants. They are in a position to ensure success and enthusiasm for students using Khan Academy.

A good example happened in a Sa nto Andre school which took part in a teacher training pilot project that was close to optimal. The implementation was closely monitored; the trainers and Lemann Foundation staff held weekly Q&A sessions. *"We went to Sao Paulo and had training sessions at the Lemann Foundation; later on we had weekly meetings with the trainers who came here and talked to us*", said one of the teachers from Santo Andre. The principal confirmed; *"Trainers would sit with teachers for an hour during Phys Ed to help them with the platform."*

3.6. Infrastructure in schools

The minimum infrastructure for a good use of Khan Academy in schools includes at least one computer for every two students, at least 0.5MB of internet connection per computer – the speed required for running the Khan Academy platform – and a large space with proper ventilation.

However, the ideal use of Khan Academy requires one computer per student for adapting and customizing content. Several schools have experienced a **lesser impact** on Khan Academy use because usually there are not enough computers available in the informatics lab for every student, so they have to share them with one or two other classmates. It's worth mentioning that a poor lab structure impacts not only the Khan Academy platform, but any technology platform used in a school.

Even in schools located in Sao Jose dos Campos (Sao Paulo state) – which, out of the entire network assessed, had the best informatics lab, the highest number of computers and a good maintenance of the space – there were only 15 computers for an average number of 25 to 30 students per classroom. In some places, like Sao Paulo, students have access to tablets, but these devices don't have enough processing capacity to run Khan Academy properly.

Santo Andre (Sao Paulo state) and Rolandia (Parana state) have an average of 8 to 15 working computers in the schools. *"Computers just turn off by themselves, they go down and the screen turns to black"*, said a teacher at Rolandia. In Ferraz de Vasconcelos (Sao Paulo state) there's an average of 15 to 30 computers, but only half of them work. *"Seeing students disperse due to the lack of computers is sad"*, said a teacher from the city. Mucambo (Ceara state) has the worst infrastructure and classes are conducted in inadequate spaces.

Other difficulty observed is that problems arise with equipment during class and **maintenance takes a long time**. Usually the delay in maintenance occurs because some cities don't have enough staff to oversee the informatics lab. In addition, many technicians don't know how to use the operating system installed in some computers, which makes it difficult to hire these professionals, as told by a school manager in the city of Rolandia (Parana state). *"Computers run on Linux, which makes it harder to hire technicians because most of them are not knowledgeable about this system."*

In most cities, **the internet connection is slow** and connecting several computers at once is nearly impossible. The connection speed drops as more devices connect via Wi-Fi. *"Sometimes it just goes down. You perform an activity and can't count your points because the internet crashes"*, complained a student from Sao Jose dos Campos (Sao Paulo state). Rolandia (Parana state) is the exception, with a decent 0.5MB connection per computer.

In some cases schools also have issues in their physical infrastructure. Although some schools in the Inovação nas Escolas program have good informatics labs, many of them have small or inadequate spaces with poor ventilation and maintenance problems with computers and the internet.

3.7. Suggested improvements

Respondents provided valuable suggestions of improvement points for Khan Academy and Inovação nas Escolas.

Suggestions related to **Khan Academy** include making it even more ludic; creating a search guide to help find certain contents quicker[1]; creating more contests and different prizes; using more images, graphs and illustrations to make the platform more didactical; including audio in the exercises to help students who struggle with reading; promoting more interaction between students by creating an online chat tool. *"It would be cool to have a chat inside Khan to talk to my friends and ask questions."*

Access to Khan Academy would be easier if it were possible off-line, considering that many schools have limited internet access. As a matter of fact, another suggestion to mitigate that problem was already put in practice; creating a mobile app, since many families don't own a computer but have smart phones.

From a **content** perspective, people requested subjects other than math with content in line with Brazilian assessments such as Enem and Prova Brasil. *"Currently, there is a link for exclusive Enem items in Khan. Here in the state of Ceara we're always preparing for these tests, it's essential to have something for Prova Brasil"* said a trainer from Sobral (Ceara state).

The poor **structure** of schools and informatics labs had a very negative effect in the Khan Academy implementation as part of the Inovação nas Escolas program. Schools need support for equipping their informatics labs, as well as good maintenance and internet connection. Ideally, for respondents, there should be notebooks in the classroom and better internet. *"Mobile devices are on the rise, we don't need to be stuck to a physical room"*, said a Digital Inclusion manager from the Santo Andre district.

Additionally, people suggested that Khan's managerial reports, which are sent to the school district on a weekly basis, should also be sent to the schools[2]. This would help improve monitoring of platform use thanks to the high level of detail provided in the reports.

1 It's possible to look for content relatively quickly in class, even though it's difficult to find some content due to the difference in terminology between Portuguese and the translation from English.

2 While schools receive weekly reports on the average time classrooms spend using the tool, the reports sent to the district indicate the average level of Khan use in the school network considering the average period of time and the number of students active in that week.

4. Recommendations for good use of Khan Academy in schools

Some key elements were identified to enable Khan Academy use within Inovação na Escolas. A **suitable technology infrastructure** is critical. Minimum technology requirements include 0.5MB internet speed per computer and a student-computer device ratio no greater than 2:1 – that is, a maximum of two students per computer – though 1:1 is ideal. In order to solve infrastructure-related problems quickly, we underscore the importance of engagement with the school district, even for technical issues (internet connection and computer maintenance). Furthermore, it's important to continuously monitor and provide technical support for schools to solve potential problems and difficulties with the equipment and Khan Academy.

There are several contributing factors to promote qualified and continuous student use. The goal is to have most students using the tool for at least one math class per week throughout the school year. We underscore the importance of the following actions in helping to achieve this goal: having a teacher or assistant present, someone who is responsible for Khan Academy in the school in partnership with the math teachers; recommending the tool as part of the teachers' lesson plan; encouraging use by promoting contests between students; engaging teachers with the platform and balancing traditional math classes with Khan Academy lessons.

Therefore, a successful Khan Academy implementation requires **one computer per student** so everyone can access the platform at the same time; **the math teacher should be present** with an assistant providing computer-related support. Additionally, **students may use laptops** in the classroom (or in informatics labs that are larger and better equipped) and it's necessary to have **good internet connection via Wi-Fi**.

Initial and continuous training is also pivotal so teachers can learn how to use Khan Academy and be able to include it in their pedagogical plan. Ideally, training should be conducted with a diverse group of educators, including coordinators and assistants, as well as math teachers. An effective training should focus on identifying the teachers' main needs.

We also identified the need of clearing teachers' doubts about Khan Academy by providing tutorials and how-to videos. Disseminating **good practices** of Khan Academy in schools was pointed out as a productive initiative.

In addition, it was suggested to designate "Khan Academy Ambassadors" within the schools. Ambassadors could be employees or students knowledgeable in Khan Academy. Their role would be to promote Khan Academy engagement in every class and to help out by answering questions about its use whenever necessary. An Ambassador initiative would help improving the quality and intensity of Khan Academy use in schools.

The involvement of the School District during the implementation of the Project is another important factor to ensure quality use of Khan Academy. The incentive generated by the district and its openness to support schools in solving technical problems impacts the project's feasibility and continuity.

5. Closing remarks

Khan Academy proved to be quite essential in assisting students with math learning in Brazilian public schools. Besides being **considered excellent** by students and teachers, the impact evaluation conducted by the Lemann Foundation took into account Prova Brasil results from 2015 and identified a **positive effect on math performance** of schools that used Khan Academy continuously between 2014 and 2015 as part of the Inovação nas Escolas program.

Besides **getting students enthusiastic and impacting math learning, Khan Academy is also a digital inclusion opportunity** for many students. Teachers and school managers realize Khan Academy **promotes logical thinking** through mental calculation, expands vocabulary and improves text interpretation via exercise premises. Math **teachers** play a **pivotal role** in ensuring Khan Academy use in schools; in order for them to include the platform in their pedagogical plan, it's helpful to provide initial training. Teachers also feel more comfortable including the platform in their students' routine if they receive initial training.

However, most schools need to enhance their **infrastructure** in order to ensure good and functioning use of educational technologies. We still need to provide better internet connection and a sufficient number of computers for students. Furthermore, school districts should provide a sufficient number of staff to quickly meet demands related to equipment maintenance so these issues don't affect students' education.

Appendix

Methodological observations about the Impact Evaluation

Ideally, to assess the causal impact of Khan Academy on math achievement among fifth graders in the 137 schools evaluated[1], it would be necessary to know what would have happened had these schools not implemented Khan Academy. Answering this question is no trivial matter, since it's not possible to know what would actually happen in these schools had they not participated in the program – this is what is known as non-observed counterfactual[2].

Selection bias is another factor that needs to be addressed as part of an impact evaluation. Selection bias occurs when the reason for schools to participate in the program is potentially correlated to its outcome. In other words, it's possible that schools with better math performance are more prone to using Khan Academy and participating in Inovação nas Escolas in the first place. This bias presents an additional challenge to assess the true impact of Khan Academy in the grades of students who participated.

Furthermore, since implementing Khan Academy is a voluntary initiative, it's likely that the decision is also related to teacher and students' motivation and the level of engagement of the school staff. These non-observable (and non-measurable) characteristics further exacerbate the issue of selection bias.

In this way, our hypothesis is that the selection bias for Khan Academy use in schools can be explained by non-observable attributes (such as the school's motivation and engagement level compared to its level of participation in educational projects), as well as observable characteristics (school administration, teacher and student management).

A statistical solution to solve the non-observed counterfactual issue and to mitigate the selection bias problem is to identify a matched comparison group of schools (which did not use Khan Academy) to replace the non-observed counterfactual. The schools in the comparison group should be similar to those of the treatment group (Khan Academy users).

To this end, we conducted a quasi-experimental impact evaluation. To identify the control group more appropriate, we used propensity score matching to pair schools that used Khan Academy (treatment group) with schools that did not use Khan Academy but that were otherwise similar in terms of observable characteristics. This pairing method matches schools based on their estimated propensity score (i.e., the conditional probability of participating in the treatment, given a set of observed characteristics).

The **Difference-in-Differences** method was then used to assess relative differences on math achievement between the treatment group (Khan Academy users) and the control group (non-Khan Academy users). The Difference-in-Differences method helps one understand what changed with the treatment group due to Khan Academy use. This method reaffirms the analysis credibility since it separates the effect of Khan Academy use from the non-observable characteristics effect (such as love for math and motivation, which tend to be invariable through time).

1 Out of the 143 schools, 137 had enough information to be considered in the impact evaluation.
2 Counterfactual: hypothetical situation or event, what could have happened.

The combination of both methods helps solve the selection bias problem and provides more credibility to pinpoint the Khan Academy effect on math results. This means that, by adjusting the differences between the treatment group and the comparison group using pre-treatment observable variables and the Difference-in-Differences method, we can eliminate the bias of simply comparing both groups.

In order to create the best control group possible, treatment schools were compared to:

Control group #1: public schools in Brazil with infrastructure suitable to use Khan Academy according to the School Census data (informatics lab, bandwidth internet and at least 14 working computers for students).

Control group #2: public schools in Brazil that participated in other Lemann Foundation projects between the second semester of 2015 and 2016 and possess adequate infrastructure for using Khan Academy (informatics lab, bandwidth internet and at least 14 working computers for students).

Schools in the treatment group were paired with schools in each the control group based on a propensity score calculated through the following variables: the Basic Education Development Index (2009)[1]; students' social economic indicator[2]; the teacher training indicator[3]; level of complexity in the administrative structure[4]; average hours of classes per day; number of students per classroom, number of students enrolled in the fifth grade; the teacher attendance indicator[5].

Table #1 shows descriptive statistics of the main variables for schools that used Khan Academy and for schools that comprise both comparison groups (before pairing).

1 Basic Education Development Index (Portuguese acronym is IDEB): indicator ranging from 0 to 10 comprised by math and reading grades and school approval data.

2 Social economic indicator: ranging from 1 to 7, this indicator takes into account information about the family's assets, hiring services of a housekeeper, family income and parents' educational level.

3 Teacher training indicator: 1 represents the most exemplary educational background (teachers with a degree in the subject they teach or a bachelor's degree in the same subject complemented by a pedagogy course) and 5 represents the least suitable background (teachers with no higher learning).

4 Complex administrative structure index: ranges from 1 to 6. The lowest level of complexity (schools with less than 50 students enrolled, teaching only one period and a single stage, highest level is grade school) is represented by 1. The most complex level (schools with over 500 students enrolled, teaching three periods with four or more stages, highest level is adult education) is represented by 6.

5 Teacher attendance indicator: assesses teacher attendance in schools for the five previous years. Scores close to 0 indicate a more inconsistent faculty, scores closer to 5 indicate a more consistent faculty.

Table #1: Treatment groups and control groups BEFORE pairing: Average and standard deviation of the variables analyzed

Variable	Treatment group (schools that used Khan Academy 2014/2015)			Control group 1 with adequate infrastructure (informatics lab + bandwidth internet + >14 computers)			Control group 2 (schools that participated in Lemann projects) + adequate infrastructure		
	Obs.	Average	Stand. Dev.	Obs.	Average	Stand. Dev.	Obs.	Average	Stand. Dev.
student math performance	124	221.83	20.20	11,397	214.94	23.27	280	211.26	22.77
student math performance 2013	132	222.63	19.29	12,209	217	24.87	290	212.84	23.52
student math performance 2015	137	233.85	18.54	12,209	223.09	22.19	290	220.19	22.02
Ideb 2009 fifth grade	125	5.09	0.88	11,504	5	0.97	270	4.83	1.04
Ideb 2011 fifth grade	124	5.46	0.84	11,396	5.20	0.96	280	5.06	1.06
Ideb 2013 fifth grade	132	5.64	0.82	12,209	5	1.01	290	5.21	1.06
Ideb 2015 fifth grade	137	6.16	0.76	12,209	5.70	0.97	290	5.55	1.05
social economic level (1-7)	141	5.15	0.66	12,158	5	0.93	290	4.57	0.91
teacher training indicator 2013	142	72.39	16.88	12,195	66.09	23.06	290	72.49	18.37
teacher training indicator 2015	142	76.95	15.65	12,205	69	22.18	290	76.37	17.14
average # of students/classroom 2013	142	25.39	4.48	12,209	24.06	3.88	290	24.24	3.46

average # of students/classroom 2015	142	25.35	4.31	12,209	24	3.85	290	23.96	3.36
administrative complexity indicator 2013 (1-6)	144	3.44	1.33	12,209	3.67	1.42	290	3.81	1.55
administrative complexity indicator 2015 (1-6)	144	3.39	1.36	12,209	4	1.41	290	3.69	1.58
average hours of class per day 2013	142	4.87	1.02	12,209	4.50	0.93	290	4.49	0.77
average hours of class per day 2015	142	4.85	0.99	12,209	5	1.07	290	4.66	1.13
# of students who took the test	142	197.18	146.02	12,158	185	126.72	290	214.17	191.54
teacher attendance 2013 (0-5)	134	2.93	0.62	12,009	3.08	0.56	282	3.06	0.55
teacher attendance 2015	142	2.85	0.65	12,139	3	0.55	287	3.10	0.51

Source: Analysis done by our staff based on INEP data (National Institute of Educational Studies and Surveys) – Ministry of Education.

According to this data one can verify that, before pairing schools by the estimated propensity score, the average math grade in Prova Brasil of schools that used Khan Academy between 2014 and 2015 was higher than schools that did not use Khan Academy.

Table #2 shows the average differences of every variable before pairing. The differences between the treatment group and the comparison group are statistically significant in almost every variable analyzed. In other words, we noticed that schools that use Khan Academy are significantly different in almost every characteristic considered compared to schools that don't use Khan Academy. That suggests how important it is to consider such characteristics to estimate the effect of Khan Academy in students' education.

Table #2: Difference in average BEFORE pairing

Variable	Average difference test (T - C1)		Average difference test (T - C2)	
student math performance 2011	6.89	***	10.57	***
student math performance 2013	5.91	**	9.79	***
student math performance 2015	10.76	***	13.66	***
Ideb 2009 fifth grade	0.20	**	0.26	**
Ideb 2011 fifth grade	0.27	***	0.40	***
Ideb 2013 fifth grade	0.25	**	0.43	***
Ideb 2015 fifth grade	0.46	***	0.60	***
social economic level (1-7)	0.44	***	0.58	***
teacher training indicator 2013	6.30	***	-0.11	ns
teacher training indicator 2015	7.82	***	0.57	ns
average # of students per classroom 2013	1.32	***	1.15	***
average # of students per classroom 2015	1.56	***	1.39	***
administrative complexity index 2013 (1-6)	-0.22	*	-0.36	**
administrative complexity index 2015 (1-6)	-0.17	ns	-0.30	*
average hours of class per day 2013	0.38	***	0.39	***
average hours of class per day 2015	0.27	***	0.19	ns
social economic level indicator (1-7)	0.44	***	0.58	***
# of students who took the test	12.37	ns	-16.99	ns
teacher attendance 2013 (0-5)	-0.15	***	-0.13	***
teacher attendance 2015 (0-5)	-0.24	***	-0.24	**

Source: Analysis done by our staff. *:p<0.10; **: p<.05; ***: p<.01.;ns = non-significant.

However, as seen on table #3, after pairing between the treatment group and the comparison groups according to the closest neighbor method (1:3)[1], the difference in almost every variable is no longer statistically significant.

Table #3: Treatment group and control groups AFTER pairing - Average and standard deviation of the variables analyzed

	Treatment Group (common support)			Control group #1			Control group #2			Average difference test			
	n. obs.	Mean	DP	n. obs.	Mean	DP	n. obs.	Mean	DP	dif (T-C1)		dif (T-C2)	
Math grade 2015	109	232.99	18.40	293	229.85	22.21	102	232.01	23.47	3.13	*	0.97	ns
Math grade 2013	109	222.92	19.41	293	221.22	24.13	102	226.04	19.86	1.70	ns	-3.12	ns
Math grade 2011	109	223.79	19.73	293	223.07	23.16	102	226.97	22.07	0.73	ns	-3.18	ns
Math grade 2009	109	212.90	20.29	293	210.46	23.98	102	214.79	19.39	2.44	ns	-1.89	ns
Math grade 2007	99	201.95	15.32	276	201.87	22.39	94	199.45	16.92	0.08	ns	2.51	ns
Math grade 2005	91	189.78	16.23	230	189.97	17.83	68	186.68	14.05	-0.19	ns	3.10	ns
Ideb 2015	109	6.11	0.75	293	5.96	0.99	102	6.11	0.92	0.15	*	0.00	ns
Ideb 2013	109	5.63	0.81	293	5.55	1.02	102	5.75	0.89	0.07	ns	-0.12	ns
Ideb 2011	109	5.53	0.81	293	5.51	0.97	102	5.70	0.83	0.02	ns	-0.17	*
Ideb 2009	109	5.09	0.88	293	5.02	0.99	102	5.15	0.76	0.07	ns	-0.06	ns
Ideb 2007	99	4.71	0.89	276	4.71	0.95	94	4.63	0.75	0.00	ns	0.08	ns
Ideb 2005	91	4.44	0.89	230	4.39	0.92	68	4.26	0.65	0.05	ns	0.18	ns
social eco-nomic level (1-7)	109	5.12	0.66	293	5.12	0.86	102	5.27	0.70	0.00	ns	-0.15	*
teacher training indicator 2015	109	77.67	15.10	293	73.97	19.48	102	81.19	14.74	3.71	**	-3.52	ns
teacher training indicator 2013	109	73.36	17.07	293	71.75	20.67	102	75.11	14.35	1.61	ns	-1.74	ns
Average # of students per class-room 2015	109	25.82	4.17	293	25.28	3.61	102	23.32	3.86	0.54	ns	2.50	***

1 Closest neighbor method (1:3): methodological procedure which estimates for every school the conditional probability of participating in a program according to relevant observable characteristics. For every school in the treatment group we selected the three neighbors (with replacement) with similar estimated probabilities for participating in the program.

Average # of students per class-room 2013	109	25.83	4.53	293	25.99	3.59	102	23.93	3.86	-0.16	ns	1.90	***
school admin-istrative complexity 2015	109	3.52	1.42	293	3.37	1.35	102	3.15	1.38	0.15	ns	0.37	*
school admin-istrative complexity 2013	109	3.55	1.38	293	3.61	1.41	102	3.33	1.43	-0.06	ns	0.22	ns
average hours of class per day 2015	109	4.77	0.83	293	4.73	0.93	102	4.81	0.90	0.04	ns	-0.04	ns
average hours of class per day 2013	109	4.76	0.81	293	4.71	0.89	102	4.73	0.80	0.05	ns	0.03	ns
teacher attendance 2015	109	2.91	0.64	293	2.99	0.59	102	2.96	0.46	-0.08	ns	-0.05	ns
teacher attendance 2013	109	2.99	0.59	293	2.94	0.60	102	2.95	0.47	0.05	ns	0.04	ns
school open on weekends	109	0.18	0.39	293	0.13	0.34	102	0.17	0.38	0.05	ns	0.01	ns
schools with cycles (grade, elementar, etc.)	109	0.89	0.31	293	0.87	0.34	102	0.87	0.34	0.02	ns	0.02	ns
has a library	109	0.28	0.45	293	0.32	0.47	102	0.33	0.47	-0.03	ns	-0.04	ns
has a read-ing room	109	0.53	0.50	293	0.50	0.50	102	0.49	0.50	0.03	ns	0.04	ns
# of stu-dents test	109	215.13	154.34	293	194.61	127.42	102	190.74	128.92	20.52	ns	24.38	Ns

Source: Analysis done by our staff. *:p<0.10; **: p<.05; ***: p<.01.;ns = non-significant.

Before pairing, it was noticeable that schools that used Khan Academy had more advantageous characteristics than schools that did not use it. However, after pairing the propensity score, these differences were greatly reduced. (Table #3)

It's worth pointing out that, in order for the Difference-in-Differences method to be valid, schools' observable characteristics should follow a trajectory of parallel trends; especially in the result variable (math grade) in the previous treatment periods. We ran a test to determine if the difference in math and reading grades between the treatment group and the control group are consistent through time (from 2005 to 2013). We observed that, in fact, the difference between schools is around 6 points compared to control group #1. Regarding control group #2, the difference is roughly 9 points. This was observed in both subjects in every year analyzed, except for 2009.

For some reason, in 2009, these differences dropped to 2 and 5 points respectively. As of 2011, however, the differences resumed the previous trend. Therefore, in an attempt to bring back parallel trends, we included math and reading grades from 2009 as an explanatory variable of the models. The following session provides more detail about the results.

Detailed results of the impact evaluation

The results of the impact evaluation indicate that Khan Academy contributes significantly to students' education. Fifth graders in schools that used Khan Academy performed an average of four points higher in Prova Brasil (2015) than students in schools that did not use Khan Academy. The impact in grades accounts for 30% of the learning expected in a school year during the first years of Elementary.

Table #4 shows the results of different econometric methods used to verify if Khan Academy had an impact on the average performance of fifth graders in the treatment group. The most rigorous model is the one combining pairing with Difference-in-Differences. As stated before, it's a two-stage model; first we pair schools according to their likelihood of participating in a program based on observable variables. Afterwards, through the Difference-in-Differences method, we control non-observable variables that are consistent through time.

Table #4 – Estimated effect on average math grades (Prova Brasil 2015)

	(a) Control group #1 (informatics lab + bandwidth + 15 computers for students)			(b) Control group #2 (schools in Lemann projects + adequate IT infrastructure)		
	OLS	Diff-Diff	Diff-Diff and Pairing	OLS	Diff-Diff	Diff-Diff and Pairing
Average effect (ATT)	4.59***	2.72**	4.19***	4.86**	3.63**	3.92**
	(1.24)	(1.17)	(1.37)	(1.92)	(1.71)	(1.74)
N. obs.	11.581	11.578	430	387	384	224
R2	0.528	0.670	0.688	0.608	0.702	0.744

Analysis done by ourselves. We used the closest neighbor method (1:3) top air the estimated propensity score with the replacement. The results obtained by the kernel pairing method led to similar conclusions. Diff-Diff: Difference-in-Differences. OLS: Ordinary Least Squares. N. obs: Number of observations. **: $p<.05$ ***: $p<.01$.

The first model presented for every control group is the Ordinary Least Squares (OLS). We assume there is a linear ratio between treated schools and control schools, but the selection is based on invariable and non-observable characteristics (such as motivation and engagement to look for projects that improve math learning). Therefore, this method can be considered simpler, but it signals a positive correlation between Khan Academy use and math grades.

The analysis indicates that fifth graders in schools using Khan Academy had an average math performance 4.59 points higher than control group #1. Regarding control group #2, the difference was 4.86 points. Both estimates are statistically different from zero; the probabilities are 99% and 95% respectively.

On the other hand, the Difference-in-Differences method (diff-diff) eliminates the influence of non-observed characteristics fixed in time. However, the method compares schools that use Khan Academy to all schools in the comparison group, irrespective of their likelihood of participating in Khan Academy based on observable characteristics. By employing this method, the effects of Khan Academy on math grades drop to 2.7 and 3.6 in control group #1 and control group #2 respectively. Both results were statistically significant. The decrease on estimated impact suggests that part of the effect estimated by the OLS method is explained by non-observable characteristics, thus indicating that the Difference-in-Differences method is relevant.

A more solid methodology is comparing treatment schools to control schools that have the same probability of participating in the program based on observable characteristics. That's the objective when using the Difference-in-Differences method combined with pairing based on the propensity score. As stated earlier, despite having different characteristics in the base line from a statistics perspective, most schools turn out to have the same results after pairing.

According to this model, the average effect on students' education after using the platform ranges between 4.19 and 3.92 points, depending on the control group analyzed. This means that fifth graders in schools that use Khan Academy attained results approximately four points higher (21% of the standard deviation between school grades) than students in schools that did not use Khan Academy between April 2014 and October 2015.

Another way to interpret this result is evaluating what it means in terms of expected grade development during Elementary school. It is known that the difference between the grades of fifth and ninth graders should be around 50 points in the Prova Brasil scale. Considering a linear development in the four years between 5th and 9th grade, it is expected that student learning be equivalent to 12.5 points per year in Brazil. Accordingly, the impact observed in Prova Brasil, which is about four points higher in average math performance in schools that used Khan Academy, accounts for 30% or more than the learning expected of fifth grade students in one year in Brazil.

We also identified that the Khan Academy effect varies according to the number of months the tool was used. According to the most rigorous estimation method (Difference-in-Differences and pairing), the learning gains were even larger (5.48 points) in the group that started using Khan in 2014, compared to the group that started using Khan in 2015 (2.6 points) considering comparison group #1. Considering comparison group #2, the average estimated effect was 2.97 points between the schools with less exposure. The following table presents the results of estimated effects comparing to both control groups.

Table #5 – Heterogenic effects of Khan Academy according to time of exposure to treatment

	(a) Control group #1 (informatics lab + bandwidth + 15 computers for students)		(b) Control group #2 (schools in Lemann projects + adequate IT infrastructure for Khan)	
	Less exposure	More exposure	Less exposure	More exposure
Average effect (ATT)	2.61*	5.48**	2.97*	5.80**
	(1.39)	(2.23)	(1.82)	(2.71)
N. obs	289	142	147	95
R2	0.677	0.619	0.750	0.681

Source: Analysis done by our staff. Estimates done based on difference-in-differences after pairing per estimated propensity score – closest neighbor (1:3). *p<0.10; ** p<.05. ***: p<.01.

The following table provides some descriptive statistics that relate Khan Academy use data and exposure to the platform (number of months that schools used Khan Academy) between the treatment schools. We noticed that students spend more time working on Khan Academy exercises in schools that use the platform since 2014. Considering that a math class lasts for an average of 40 minutes in Brazil, the total time devoted to Khan Academy accounts for 860 class-hours in schools with more time of exposure and 400 class-hours in schools with less time of exposure[1].

Table #6: Schools that used Khan Academy – platform use data

	Khan Academy: Less time of exposure	Khan Academy: More time of exposure
# of schools	95	48
% months using Khan	26.1%	38.7%
average # of months using Khan	4.96	7.35
% schools that started in 2014	24.0%	75.0%
total average of minutes using Khan	15,995.0	34,331.9
# of class-hours with Khan	399.9	858.3

Source: Analysis done by us based on Khan Academy administrative data.

It's worth pointing out that the average estimated impact of Khan Academy proved to be solid in every single specification and pairing method test.
We also conducted a robustness test with the same methodology to assess the program's impact on a population that was not directly exposed to treatment, but was related to the group that received it. For this purpose, we used the Portuguese grades of fifth graders in schools that used Khan Academy in the 2007 Prova Brasil. These students

1 In Brazil, a school year in Elementary school is comprised by 800 hours.

were not directly exposed to treatment; they would be in high school by 2015. We didn't expect to see any impact since it would suggest that the selection bias problem was not solved. As expected, the coefficient estimated for the interest variable was not statistically significant. This indicates that the effect on Portuguese grades in 2007 is nil, thus validating the methodology and the results found in 5th grade math.
It's important to stress that, in order to further attest Khan Academy's importance for students' learning, the Lemann Foundation, in partnership with the Getulio Vargas Foundation (FGV), Regional Centers for Learning on Evaluation and Results (Clear) and Abdul Latif Jameel Poverty Action Lab (J-PAL) conducted an impact evaluation with an experimental design in 2016 and 2017. We randomly selected classes of students from 150 public schools to use Khan Academy in one math class per week and other classes to be in the control group. Based on the 2017 Prova Brasil exam, we will evaluate the impacts of Khan Academy on students' performance, intrinsic motivation and math engagement (the last two are non-cognitive skills that will be captured by a tool designed specifically for this purpose). The results of this evaluation should be available for consultation in the second semester of 2018.

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