

The Effects of Online Homework in Mathematics

Kyle Ramstad

California State University, Northridge

May 2, 2017

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THE EFFECTS OF ONLINE HOMEWORK IN MATHEMATICS

Abstract

This study explores the use of the online computer-assisted instructional software Khan Academy for assigning students homework. Most students at Timber Creek School cannot receive help on their math homework from their parents, many of which never completed their formal education. Khan Academy allows students to receive tutoring at home through short instructional videos and guided practice problems. This study's goal was to determine if the use of these tools at home could help increase student achievement in mathematics at this school. While conducting a sample of 68 8th grade students, Khan Academy caused a decrease in student homework completion and scores. It was not found to increase overall student performance when compared to traditional paper and pencil homework. Online homework does not appear to positively impact student achievement levels for middle school students.

Introduction

Among other countries around the world, The United State of America is not the highest ranked in mathematics. The United States ranks 27th out of 104 in a measure performed found by the Program for International Student Assessment by The Organization for Economic Co-operation and Development (2012). American mathematics educators need to explore and study new ways of teaching mathematics.

Computer-assisted instructional (CAI) software is becoming increasingly popular in schools and colleges around the world. Websites such as Khan Academy, ALEKS, IXL, and Carnegie Learning Software have become widely known for their use of technology as a way of instructing students in mathematics. These services offer a wide range of tools that allow students to learn mathematics. Some of the services offer video tutorials or mini-lectures, while others offer more traditional text based learning from a digital math book. A key feature is that they offer students an individualized course through mathematics. This allows students to work at their own pace and at a level appropriate for them. It allows teachers to assign differentiated work easily based on data provided by the platform.

A study looking at using CAI software showed that they could increase mathematics achievement, especially for minority students (Brown, 2000). Further research has shown that using these technologies may be beneficial when used outside of the classroom for homework (Mendicino, Razzaq, & Heffernan, 2009).

At Timber Creek School, students have had struggles passing math courses and doing well on the new SBAC standardized tests. Many students fail math courses and are then enrolled into math tutorial courses. This study's goal was to determine if the use of CAI software at home could help increase student achievement in mathematics at this school. This study used the

website Khan Academy to assign students homework to verify the conclusions of Mendicino, Razzaq, & Heffernan, that the use of CAI software at home can improve student achievement. The results of students' homework scores, chapter assessment scores, and overall class grades were used to determine if this tool is beneficial to students. Homework completion rates were used to determine if student engagement increased when compared to traditional homework.

Literature Review

With the advent of online CAI software such as Khan Academy, ALEKS, and Carnegie Learning Software, students are able to effectively practice math concepts online at their own skill level. These online services offer teachers a suite of tools that allow them to assess and analyze students' skills and progress, help differentiate work assigned to students, and track students' knowledge over time. This study will use the Khan Academy service to assign students homework selected by the teacher. The purpose of this study is to compare students' learning outcomes when homework is assigned through an online service versus traditional paper and pencil homework. The hypothesis is that students who complete their homework online with assistance will have better test scores and overall grades than those who complete their homework on paper. Previous research on CAI has focused on cognitive tutoring, immediate feedback, skills tracking, differentiated instruction and remediation, and homework.

Cognitive Tutors

In an average class size of 30 students with only 60 minutes of class, teachers only have 2 minutes to work with each student one-on-one. One-on-one interaction with experienced human tutors has been shown to increase student achievement (Bloom, 1984). This would exclude any lectures or activities planned for a lesson. Realistically, teachers do not have enough time to work with every student one-on-one. Services such as Khan Academy, offer students one-on-one instruction much like human tutors provide. Cognitive tutors are CAI software that replaces human tutors. Khan Academy offers students guided instruction based on their individual skills. They also offer students step-by-step tutorials, immediate feedback, and problem hints. Khan Academy also allows teachers to track students' progress towards teacher created goals and assignments.

Cognitive tutors make instructors think about measuring the amount of interaction and the amount of assistance that will best help students. Withholding information, such as hints or tutorials, can allow students to discover knowledge on their own, while providing information and assistance provides scaffolding for students. Koedinger and Alevan (2007) found that the balance of information and assistance verses withholding information is one of the biggest questions that needs to be answered in educational technology. Their study reviewed the amount of interaction and assistance given by different technologies. Koedinger and Alevan ultimately concluded that there should be further study on interaction with technology that provides information and those that withhold information. Their study was not able to find under what conditions information should be withheld and when assistance is necessary. The software used in this study, Khan Academy, allows students to decide when they needed assistance.

A study conducted by Williams showed that providing students with online homework only affected students' homework grades (2012). It did not affect test scores or other grades. However, Williams study only used technology that provided information for students at all times. The software used, Aplia, does not withhold information while students work towards a goal.

Using Khan Academy in this study will explore this information withholding balance by providing students with assistance at a cost. When students ask the software for assistance, it does not count their correct answer towards their progress on an assignment (see Appendix B to see an example of how Khan Academy reports student progress). To complete an assignment, students must be able to correctly answer five questions without assistance. The trade-off between receiving assistance and starting the assignment over may provide students with the assistance and the self-efficacy these studies have been searching for.

Feedback

Homework can be assigned and function as a formative assessment. Formative assessments are commonly used to help teachers find student errors and to use them to further student learning through scaffolded questioning or remediation (Bransford et al., 1999). Although teachers gain information from the use of formative assessments, students should also use the information themselves. Feedback on student performance during formative assessments needs to be shared with students so they can monitor their own strengths and weaknesses. It allows them to know what expectations they need to meet to be successful (Bransford et al., 1999). A study done by Sadler (1989) showed that quality work examples and high quality work created by the teacher helps students learn what is expected of them and the quality of work they should produce. The online service used in this study offers this kind of feedback along with examples through the use of hints and video tutorials. Khan Academy provides students with immediate and detailed feedback that students can use to monitor and adjust their work.

Feedback should also offer a way for students to learn or progress. It is only useful when it allows students to move toward a specific goal (Sadler, 1989). Giving students feedback about their progress within a specific topic can greatly increase their ability to self-monitor and progress academically. Khan Academy awards students badges for completing different levels of mastery in a specific skill. The feedback offered by awarding students badges can help them progress through a learning goal.

Online CAI software can also offer students immediate feedback. Feedback that is given in a timely manner helps students to correct misconceptions and errors before they become problems (Falter Thomas & Sondergeld, 2015). Without timely feedback, students could develop a math skill incorrectly and have difficulty learning the skill correctly at a later time.

Falter Tomas and Sondergeld (1989) found that feedback needs to be specific and given in a timely manner in order for students to respond positively to it. Students that received this timely feedback were more likely to say that they felt it helped them learn. Other CAI software, such as ALEKS, provides feedback after students have answered a question wrong. Khan Academy allows students to request help during a problem. Additionally, the CAI software Math Blaster is a game that only provides students with feedback that informs the students if they were correct or not. Khan Academy provides students with more detailed feedback that instructs a student how to successfully complete a problem type.

A study of the use of homework as instructional tool has shown that immediate feedback given online has been just as effective as delayed feedback given by a teacher during class (Singh et al., 2011). However, this research did not study whether online homework can completely replace homework review during class. Although the results of the study were unexpected, the researchers suggest that online homework can allow teachers to spend less time in class discussing homework and instead teach new concepts. Saving five to ten minutes each lesson can add up to approximately 30 more hours of instruction during a regular 180-day school year. This is a considerable amount of time considering the small amount of time saved each day. The goal of this study is to determine if homework review in class is beneficial to students when compared to the feedback students are provided through an online CAI software platform. Homework review in class will not be given when online homework is assigned in this study.

Skills Tracking

Online CAI software not only informs students on the correctness of their answers but it also informs them about their mastery of specific topics and standards. It has been shown that students can improve their skills by monitoring their progress (Sadler, 1989). Khan Academy

provides students with a skill progress tracker so that they understand what skills need to be improved and practiced. This allows students to begin to self-monitor their learning. Although many students are successful without self-monitoring, Sadler's (1989) study showed that students that make the transition from teacher-feedback learners to self-monitoring learners may be more successful. Giving students the ability to track and analyze their own learning is an important step in that transition. However, another study found that allowing students to choose their own mathematics topics using an online tool did not benefit their learning outcomes (Bartelet, 2016). It is clear that teachers still need to play an active part in how the data are used to help students advance their own learning. In this study, the students were assigned their homework based on the needs of each student.

Teachers can better provide feedback, differentiation, and remediation if student data is clear and can direct teachers to resources. Almost all teachers have access to student data, but about two-thirds are not satisfied with the data or tools they have available to them (*“Teachers Know Best”*, 2015). Online CAI software allows teachers to track student progress and get data about specific math concepts and standards. Khan academy allows teachers to view and assess the areas that each student needs improvement in (see Appendix C to view the skill tracking dashboard from Khan Academy). This kind of specific skill tracking is what teachers need to provide better learning experiences for students while in the classroom. According to Verbert, et al. (2013), learning dashboards can help teachers create student specific learning goals to advance student achievement.

Differentiated Instruction

Differentiated instruction is a method of providing all students with the learning material they need to succeed based on their specific learning needs. The idea of differentiated instruction

most closely relates to the Zone of Proximal Development (ZPD) (Vygotsky, 1978). According to Vygotsky's work, a student learns best when they are presented with material that is slightly more difficult than the student can do on their own. Vygotsky suggests that students need to be provided with the scaffolds or assistance needed to reach the material. For a teacher, providing appropriate scaffolds can be difficult because every student has a different ZPD. Differentiated material allows a teacher to provide each student with work that is in their own ZPD so that they can learn. Cognitive tutors like Khan Academy provide practice and lessons that can be made to fit the needs of each student.

All classes are made up of students with mixed ability levels. Low-level students are in need of remediation while high-level students are not challenged enough to be engaged with the material (Konstantinou-Katzi et al., 2013). Differentiated instruction is needed to allow students to learn in the Zone of Proximal Development. Konstantinou-Katzi et al. (2013) noted that because of the wide range of student readiness, traditional methods of teaching are usually ineffective. Differentiated instruction provides tools for all students based on their specific needs in the topic area. Their study found that the use of differentiated mathematics instruction positively affected students' learning.

One method of differentiating is to use small group instruction. It involves categorizing students' needs and instructing them separately in homogeneous groups. Small instructional groups allow a teacher to provide specific help that subsets of a classroom may need. Small group instruction has been shown to be effective at raising student achievement in mathematics (James, 2013). James' study suggests that further research into different differentiation strategies and methodologies is needed. Small group instruction is just one way of providing students with differentiated material. This current study will take this idea one step further and instruct

students individually at home through the use of Khan Academy. The goal of this study is to research the effectiveness of individual mathematics study to support student learning in the classroom.

Math Remediation

It is important to screen all students for potential math difficulties and provide them with interventions through the practice of math skills and problem solving exercises (Kingsborough, 2011). Basic math skills are a prerequisite for more advanced abstract topics covered in middle and high school math courses (Bartelet, 2016). The use of online services allows teachers to assign students relevant remediation material while still learning new content. Students that may be behind in the math skills may never catch up by the time they finish high school. Many basic mathematical skills can be enhanced with the use of online mathematics practice (Tienken & Wilson, 2007). These skills can help student achievement in relevant grade level content.

According to the National Center for Education Statistics (2013), around 20% of students entering their first year of college have to enroll in remedial courses in English and mathematics. Early remediation of basic math skills can help students save time and money when enrolling in postsecondary schools. Remediation in mathematics needs to be proactively addressing the needs of students as early as possible (Kingsborough, 2011). The use of CAI software may help struggling students that would otherwise never catch up because it addresses this remediation.

Homework

Traditionally, homework is one assignment given to all students to complete using a pencil and paper. This homework may not meet the needs of many students. Work that is too challenging for struggling students, or not challenging enough for gifted students, may not provide them with a way of learning that is engaging enough (Konstantinou-Katzi et al., 2013).

Some educators are starting to advocate for getting rid of homework for this reason (Boesveld, 2014). Assigning homework online may be able to help teachers provide homework with purpose. It may be easier to help students that are struggling and challenge students that are otherwise not engaged.

Recent research (Mendicino, Razzaq, & Heffernan, 2009) has shown that assigning homework online can improve achievement for 4th grade students. Another study has shown that these results can be reproduced in middle school students (Singh et al., 2011). However, neither study looked at the effect that online homework has on homework completion rates. One of this study's goals is to measure the difference in homework completion rate between online homework and traditional paper and pencil homework. Assigning online homework may not benefit all students if it does not increase engagement with mathematics while students are at home.

According to Mendicino, Razzaq, & Heffernan (2009), online homework systems have some disadvantages for teachers. It is not possible to review the steps students take to arrive at an answer. The use of the systems also makes it easier for students to cheat. The use of other sites such as Wolframalpha can give students answers to nearly all math questions. Although some students may cheat, Wolframalpha and other services also provide students with step-by-step instructions. Teachers should not assume their students are cheating because an online service is being used to assist in their learning. Assessing students' ability to explain their work and assessing their math skills during class following the assigned homework can easily help determine if students are cheating on their homework. Allowing students to use technology and the Internet to broaden their knowledge of mathematics is an important step in students growing as self-monitoring learners.

Conclusion

Online CAI software such as Khan Academy provide the feedback, differentiated instruction, remediation, and skills tracking that these studies have shown help students advance their math skills. The timely feedback Khan Academy provides allows students time to correct their misconceptions and errors. The data and skill tracking it provides allows students and teachers to differentiate instruction on an individual basis. Cognitive tutors offer advice to students that are struggling to grasp basic standards.

Although the services provided by Khan Academy are supported by the literature, research in this area can be furthered. These studies have shown that the use of online CAI software platforms can have a moderate effect on student learning when compare to face-to-face only instruction (Cargile, 2015). These moderate improvements in learning outcomes suggest that more research into its effectiveness is needed. This study's goal is to add to the current research and show that an online mathematics tool can be used to increase student achievement through the use of feedback, differentiated instruction, remediation, and skills tracking.

Methods

This action research project looked at the effectiveness of assigning mathematics homework through Khan Academy. The study looked at whether or not this method of assigning homework increases students' homework completion rates, assessment results, and overall course grades. This study expected that learning outcomes would improve due to the immediate feedback, differentiation, cognitive tutoring, and skills tracking that the online CAI software platform provided.

Selection of Instructional Software

Khan Academy was chosen for this study because of the large selection of features it offers and its cost. Its reporting features allow the tracking of students' individual skills. This allows for easy analysis of remediation needed for each student. The tutorial videos provide students' without help at home to receive information from an expert instructor (see Appendix D for a sample tutorial video). Khan Academy provides all of its features for free for all students and teachers. This was an important factor in the selection process due to the financial restrictions of Timber Creek School and student population. Khan Academy also has an Android and iOS app that allows easier access for students with smart phone access.

This service was also selected due to its grading of assignments. It balances information and assistance with accountability of student learning. Khan Academy allows students to ask for hints or view a video tutorial. However, when assistance is needed, progress towards completing the assignment is reset. Students are asked to complete five problems correctly in a row without assistance.

Participants

This study followed two math 8 courses during the 2016-2017 school year at Timber Creek School. About 85% of students are Hispanic, 3% African American, 3% Filipino, 2% White, 2% Asian, <1% Pacific Islander, and <1% Native American/Alaska Native. Around 23% of students are English Learners. About 90% of students qualify for free or reduced lunch.

One course was a gifted class with many high achieving students while the other was not. Due to the limited amount of courses available for this study, these two classes had to be chosen. Because of the differences in students' achievement levels, this study did not create a separate control group and experimental group. Therefore, good comparison groups could not be created. This causes limitations in the application of the results of this study. The homework assigned through Khan Academy was given during two chapters that may be considered harder or more complex for students that did not do well with the material at the beginning of the semester. The lack of a comparable control group may limit this study's ability to make conclusions about any learning gains.

All students were given the same paper homework assignments to measure the effectiveness of the implementation of Khan Academy. Students that did not have internet and computer access at home were provided with access before and after school, in class, and in the school's library. Students that completed their work on campus were not provided additional human assistance with their Khan Academy work as to properly measure any affect from the online software only.

Instruments or Materials

At the beginning of the study, the students were given a technology and home environment survey (see Appendix E to view the complete survey). This survey asked students

whether they have access to the internet at home. It asked what device(s) they have access to (cell phone, laptop, desktop, etc.) and if they feel comfortable asking their parents for help with math homework. The survey was used to determine the overall home environment of the students for the use of Khan Academy.

Khan Academy allows teachers to assign individual assignments to students and tracks their progress through the Common Core State Standards for Mathematics. The service's main purpose is to provide students with tutorial videos and sample questions for students to practice mathematics. When homework was assigned, students were asked to complete five consecutive questions correctly. If students got a question wrong, requested a hint, or watched an instructional video for help, the question counter reset. This requirement was part of the Khan Academy platform and was set by default. Since this study was conducted, Khan Academy now allows the instructor to set the question amount. Students were not graded down on their assignment if the use of hints or videos helped them complete the questions.

The students were also tested before (formative; not graded), halfway through, and at the end of the chapters. There were no differences made to the assessments because of this study. They were already apart of the course curriculum. All assessments were used to measure the mathematical understanding of the students. Two chapters were covered during the course of this study.

Lastly, an end of semester survey (see Appendix E to view the survey) was given to determine the students' thoughts about how they were assigned homework and how they perceived its effects on their work.

Procedures

The technology and home survey was given on the first day of instruction of the 2016-2017 school year. Students were expected to return the survey by the end of the first week of school. After classes were selected for the study, all students were given an in-class tutorial on how to navigate and use the Khan Academy website.

Homework began to be assigned during the second week of the school year and continued throughout the study. Assignments were due by the following class session. As homework was completed through Khan Academy, this study used individual student reports to assign remediation work for students that were under performing in the topics currently being taught in class. These assignments were also due by the following class session. The traditional pencil and paper homework that was assigned at the beginning of the study had around 10 questions for each assignment. These questions were similar in difficulty level and contained questions that pertain to different math topics. Homework review was conducted for around 5-10 minutes during lessons after paper homework was assigned. This homework review was not conducted while online homework was assigned due to the differentiated nature of the work that was assigned.

All students were given the same paper classwork, projects, and assessments to complete as part of their normal course curriculum.

Data Analysis Method

A qualitative analysis was based on the technology and home survey and the end of semester survey. The data from the technology survey was used to create a profile of the students' learning environments at home. The end of semester survey was used to determine the

attitudes of students and how they felt Khan Academy helped or hindered them when compared to traditional homework.

A quantitative analysis was based on completion rates of homework, chapter assessment scores, and overall class grades. Paired T-tests will be used to determine the significance of the data.

Results

The following data results are reported from two math 8 courses collectively. There were no experimental or control groups in this study. The data will be compared based on when it was collected. Data from the traditional homework phase of this study was compared to the data collected from the online Khan Academy homework.

Technology Survey

The technology survey was given to all 68 students before the study began. The survey found that 95% of students had Internet access with about 2 devices ($M=2.26$ $SD=1.06$) to access Khan Academy with. To accommodate the students without Internet access, laptops were provided before, during, and after school. The survey also found that most students (71%) do not ask their parents or family members for help with their math homework. When asked to rate how comfortable they felt when asking for help from parents or family members on homework, students rated an average of 3.0 ($SD=1.45$) on a scale from 1 to 5 (1 represents “not comfortable at all” and 5 represents “very comfortable”).

Scores and Grades

Homework Scores and Completion Rates. Six traditional paper homework and eight Khan Academy homework assignments were given during this study. The scores of the traditional homework are typical when compared to scores from previous years in the same courses. Paper and online homework was graded on correctness and completion. A percentage grade was given on each assignment.

Homework scores dropped significantly after using Khan Academy (see table 1). Scores dropped an average of 43.13%. This difference is statistically significant ($t(67)=10.86$; $p<0.0001$). Khan Academy negatively affected the homework scores of most students (90%).

Completion rates of homework also showed a large change (see table 1). The 49% difference in homework completion rates is statistically significant ($t(67)=11.82$; $p<0.0001$). Khan Academy negatively affected the homework completion rate of 90% of students.

Table 1

Comparison of homework scores and completion rates before and after the use of Khan Academy

	Homework Score (N=68)	Homework Completion Rate (N=68)
Before Khan Academy Mean (SD)	85.78% (15.34%)	92.40% (13.03%)
After Khan Academy Mean (SD)	42.65% (36.35%)	42.65% (36.35%)
Difference	-43.13%	-49.75%

Chapter Assessment and Class Grades. Chapter assessment scores were analyzed before and after the use of Khan Academy (see table 2). The average chapter assessment score went down 3.95%. Although this is a statistically significant difference ($t(67)=1.76$; $p=0.041$), the mathematics taught during and after the use of Khan Academy was more complex and may have contributed to this difference. Two chapters were covered during the course of this study. The subjects of the chapter were different. Therefore, the comparison may not be due to the use of Khan Academy.

Overall class grades increased 1.09% from the beginning to the end of this study (see table 2). This increase in overall class grade is not statistically significant ($t(67)=-1.18$; $p=0.12$). To account for the increase in overall grade, an additional paired t-test was conducted on

classwork assignments. This showed an average classwork grade increase of 4.78%. This increase is significant ($t(67) = -3.54$; $p < 0.0004$).

Table 2

Comparison of chapter assessment scores and overall class grades before and after the use of Khan Academy

	Chapter Assessment Score (n=68)	Overall Class Grade (n=68)
Before Khan Academy Mean (SD)	77.10% (10.10%)	77.28% (8.98%)
After Khan Academy Mean (SD)	73.15% (20.22%)	78.37% (11.40%)
Difference	-3.95%	+1.09%

End of Semester Survey

The end of semester survey was given to all 68 students that took part in the study. Students were asked to rate how they felt Khan Academy helped them in their math class and how much the hints and videos on Khan Academy helped them complete their homework (see figure 1). About half (51%) of all students felt that the use of Khan Academy helped them in their math class at least “somewhat”. Most students (53%) also felt that the hints and videos in Khan Academy helped them complete their homework at least “somewhat”. These questions were used to determine if students perceived any difference in their ability to complete their work and learn from using Khan Academy.

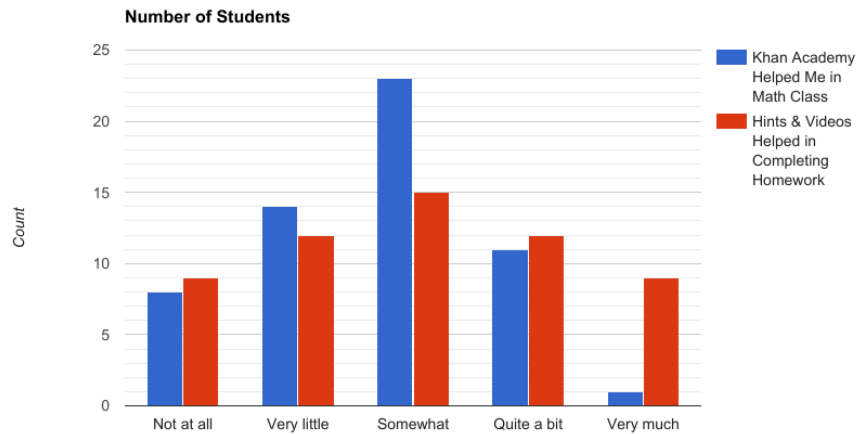


Figure 1. Rating of how much Khan Academy helped in students’ math class and with completing homework

Students were also asked to rate the difficulty of the homework they completed online and on paper. This was asked to help determine why students may not have completed their homework. Almost half (47%) of students found that the paper and pencil homework was “easy” or “very easy” compared to 21% for Khan Academy homework (see figure 2).

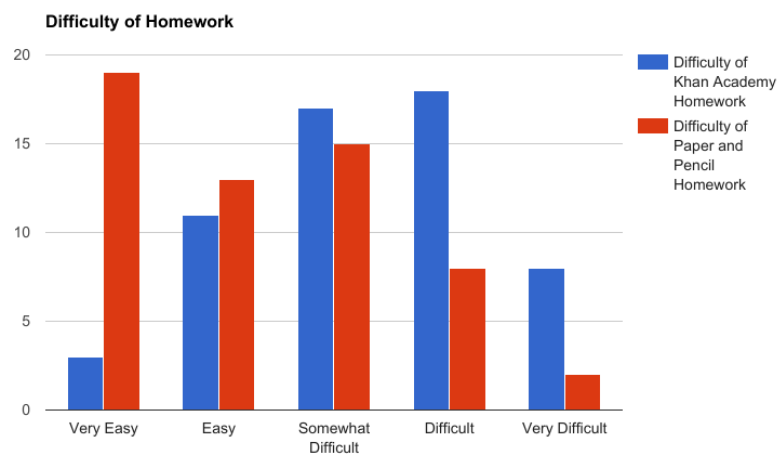


Figure 2. Difficulty level of Khan Academy and Paper and Pencil Homework

Student thoughts. Students were asked to provide their thoughts and feelings about using Khan Academy. Figure 3 shows that nearly 75% of students prefer to have paper and pencil homework. The most common (17 students) reason that paper homework was preferred was that they found Khan Academy too difficult to complete. One student commented, “it was extremely frustrating that I had to start all over by answering 1 answer wrong.” Another student said, “It took way too long to complete because I had to keep starting over.” All 17 of these students remarked on having frustration with trying to complete five correct questions in a row. This is a requirement that Khan Academy set for the assignments automatically. Seven students preferred paper homework due to technology issues they had with the website. Three students commented that the website was too confusing to use and three students said that paper homework allowed them to better show their work (see figure 4).

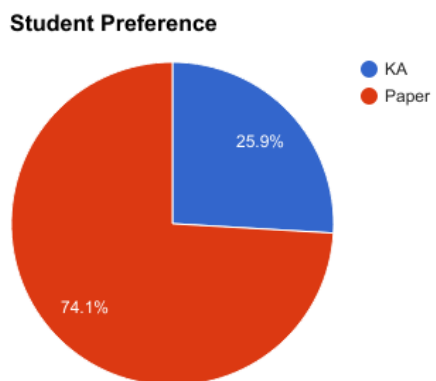


Figure 3. *Student preference for completing homework.*

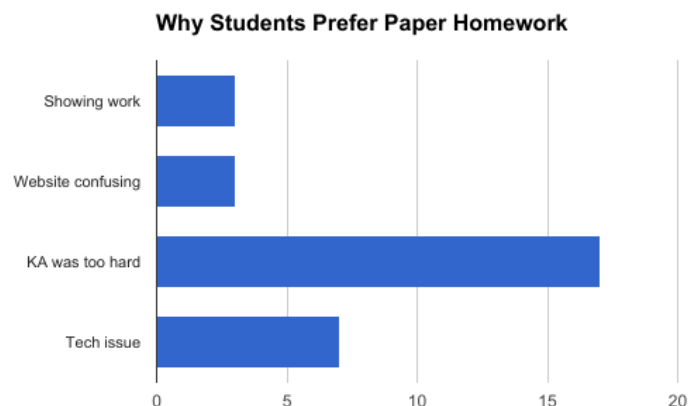


Figure 4. *Student explanations as to why they preferred paper homework.*

Many students made the decision not to attempt or complete their homework when it was assigned through Khan Academy. Students were not very forthcoming about why they made this

decision. Many thought that it helped them learn math but that they did not like using it. One student explained it the following way:

It helped me in my math class because the hints gave me an understanding of some things I learned in math. I did not enjoy using Khan Academy for homework. The work was usually easy and it was rarely hard. It was only hard a few times. I did not have trouble getting to Khan Academy. The website was easy to use. I would want to have homework on paper rather than online.

Student did not like using the website even though they believed it helped them. Learning mathematics at home is not something most students do and may make them uncomfortable. These students may not be digital natives like most people believe that millennial are. Using technology to complete assignments that they are used to doing on paper may also make them feel uncomfortable completing their work.

Summary of Results

Most students reported that they not ask for help for homework from their parents or family members. Khan Academy was used to provide help to the students digitally. About half of students found that it did in fact help them somewhat with their homework and with the material in their math class.

However, completing homework online through Khan Academy had a negative impact on students' homework scores, homework completion rates, and chapter assessment scores. It was not found to affect their overall class grade in any significant way though. Overall class grades actually went up slightly. Students said they would prefer to complete paper homework mainly due to Khan Academy's difficulty and Internet connectivity issues they experienced.

Conclusions

Purpose

At Timber Creek School, many students have to retake math courses. Hundreds of students are also enrolled into intervention math courses. When students are given homework in these courses, they often do not have a parent or family members that can help them. This study measured the effectiveness of using the online CAI software Khan Academy when it is assigned as homework. This service was chosen because it provides students with video tutorials and hints for problems that students may not otherwise get while at home.

The literature reviewed in this study has shown that assigning homework online with Khan Academy may lead students to higher achievement in their math course. Cargile (2015) found that online learning platforms can have positive effects on student learning. A study by Medicino, Razzaq, and Heffernen (2009) found that online homework could improve achievement for elementary school students. This study sought to find if an online CAI software platform could improve student achievement when assigned as homework to middle school students.

Sixty-eight students were assigned to complete math problems using Khan Academy for their homework. These students were also assigned traditional paper homework in the weeks leading up to this study. The effects on homework scores and completion rates, assessment scores, and overall grades were evaluated to determine if Khan Academy improved student achievement.

Findings and Implications

The use of Khan Academy negatively affected students' homework grades. It has been shown that homework can have a positive effect on student achievement (Cooper, 1989; Cooper, Robinson, & Patall, 2006). The same study also found that too much homework (a total of 90 minutes or more) has a negative effect on achievement. From the end of semester survey, many students stated that the homework took too much time to complete and that it was too difficult because Khan Academy required them to complete five questions in a row without hints or mistakes. Students in this study spent an average of 13.5 minutes on each assignment. It is unknown how much homework they were also assigned from different classes. This result has implications for teaching. Teachers need to ensure that when homework is assigned, it is limited by how much time it will take to complete. This needs to be thought through carefully since every student may take a different amounts of time based on their skill level with a topic.

Students' overall grades increased slightly due to increased classwork grades. This may also be because homework grades can only account for up to 10% of a students overall grade. This is a limitation given by the school's administration. However, this may instead suggest that decreasing the amount of homework completed by students increases their ability to successfully complete classwork assignments. Increased classwork grades could have also been caused by the extra time given to lessons because homework review was not given when Khan Academy was assigned. Further study on the correlation between homework grades and completion to classwork grades needs to be conducted for this reason.

Students of this generation are often described as growing up understanding technology. However, the survey conducted in this study showed that students feel more comfortable doing work on paper while at home. When considering methods for which students can submit their

work, teachers may want to give students the option to complete work online or on paper. Future study will be needed to determine if giving students this choice benefits their learning.

Limitations

This study is limited by its narrow sample. This study only had a sample size of 68 students. It was only comprised of two math 8 courses. Because of the sample size, it is difficult to determine whether the implications of this study can be applied to other courses, schools, and students. Further study on this topic should include a larger sample size.

The questions on assignments given by the Khan Academy website were not created by myself. Although I tried to create similar homework on paper, differences in teaching styles on the assigned topics may have created important differences in the way questions were created and asked. Different question styles could have resulted in different assignment grades.

This study was also limited by its design. It was not an experimental study. It was an implementation study that tried to look for changes in student performance over time. As students were being asked to complete their homework online, they were also being given more complicated topics that relied on their previous knowledge of past topics. The nature of mathematics is that it builds on itself. That also means that the topics may have become harder for students as the semester progressed. To counter this effect, a future study should implement an experimental design.

Thoughts on the Future

This study has shown that online homework can have a negative affect on math 8 students' homework grades. However, it is not completely clear as to why their grades in the course were not affected. Most students did not complete or attempt this work. Classwork scores increased while students were assigned online homework. From this study, it is unclear as to why

students that failed to complete their homework did better on their classwork. It may be due to a decrease in stress from schoolwork or because of extra time saved in class from not having homework review. Further experimental study needs to be done to help answer this question. I would also like to extend the data collected in this study to include future results of state testing. I would hope to find that students that used Khan Academy more often also did better on state testing.

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Appendix A

Informed Consent Form

Kyle Ramstad, Teacher
Timber Creek School

Dear Parent/Guardian:

Your child's math 8 class will be participating in a research study on using the online mathematics service Khan Academy. The study is part of my studies in the Master's in Educational Technology program at the California State University, Northridge. As part of the study, your student may be asked to complete their math homework online at khanacademy.org. As part of the study I will be giving the students a survey about their access to the Internet at home. Per university guidelines, I need your permission to include your child in this study. The survey and study results will be anonymous and no students' names will appear in the report. There will be no impact on your child's grade in class for participating or not in the study. Agreeing to participate will increase the quality of the data for this project.

Please sign and return this form to Mr. Ramstad.

If you have any questions about this project you can contact me at kyle.ramstad@lausd.net

Student Name _____

Please check one:

I DO give permission for my child to take part in this study

I DO NOT give permission for my child to take part in this study

Name of parent/guardian _____ Signature _____ Date _____

Appendix B

Khan Academy screenshots

Combine the like terms to make a simpler expression:

$$-4q - (-8q) + 10$$

1 / 2 Combine the q terms:

$$\begin{aligned} -4q - (-8q) + 10 &= (-4 + 8)q + 10 \\ &= 4q + 10 \end{aligned}$$

2 / 2 The simplified expression is $4q + 10$.

Stuck? These things might help.

Don't worry, you won't lose your streak.



Combining like terms challenge problem

Scratchpad



[Report a mistake](#)

No more hints



Check answer

Khan Academy showing hints for a problem. When all hints are used, the problem is recorded as incorrect.

Combine the like terms to make a simpler expression:

$$-5j + (-2j) + 3$$

Stuck? These things might help.

Don't worry, you won't lose your streak.



Combining like terms challenge problem

Scratchpad



[Report a mistake](#)

Get a hint

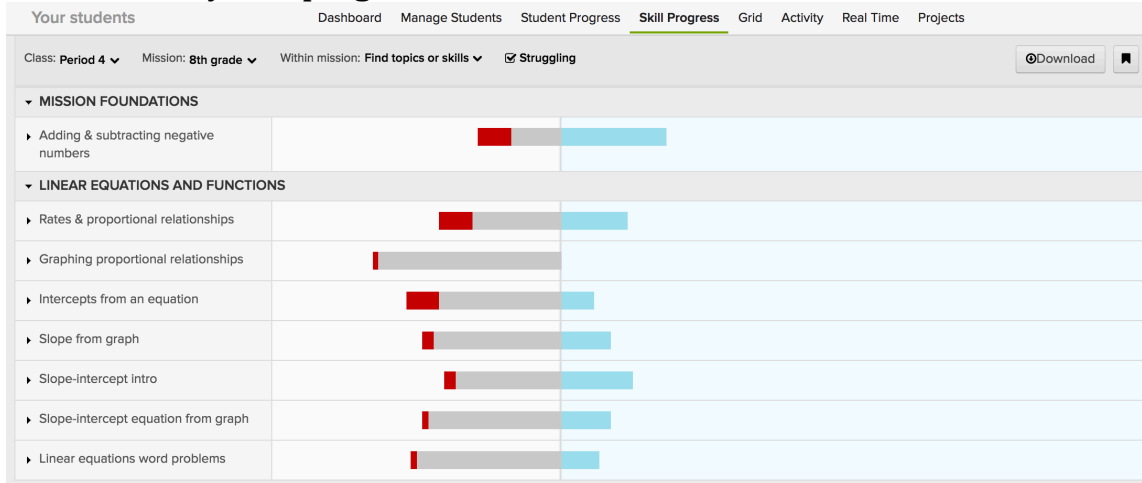


Check answer

When a limited number of hints are used, the problem is correct but not counted towards the goal of getting five questions correct in a row.

Appendix C

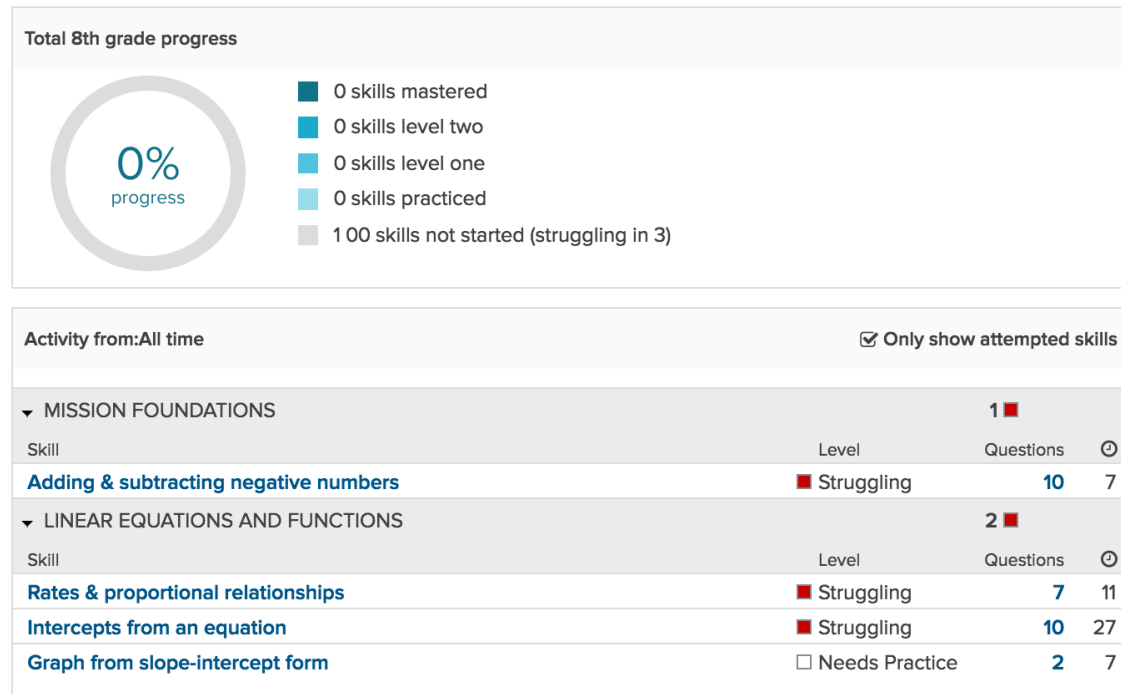
Khan Academy skill progress dashboards



Teachers and students can view struggling skills that they need to continue working on.

[+ Make a recommendation](#)

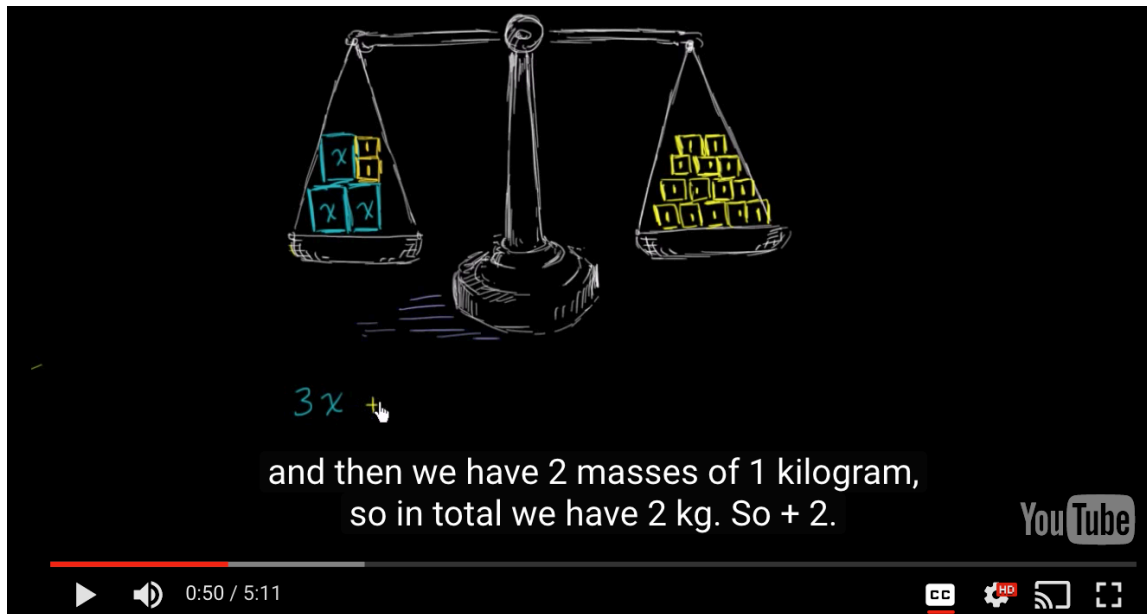
Skills Recommendations Videos Badges Activity Focus



Teachers and students can view more specific data about skills needing review. Students can then find recommended practice, videos, and topics that may help advance their learning.

Appendix D

Khan Academy tutorial video



A sample of a Khan Academy tutorial video. They often include drawings to help explain complex ideas and concepts. All videos have transcripts and closed captioning available.

Link to this video: <https://www.khanacademy.org/math/algebra/one-variable-linear-equations/alg1-two-steps-equations-intro/v/why-we-do-the-same-thing-to-both-sides-two-step-equations>.

Appendix E

Surveys

Technology Survey

* Required

Name *

Choose

Do you have internet access at home? *

It can be on any device, including desktops, laptops, tablets/ipads, cell phone, etc.

- Yes
- No
- Other:

What internet connected devices do you have access to at home? *

- Tablet / iPad
- Smart Phone / iPhone
- Desktop Computer
- Laptop
- Chromebook
- Other: _____

Do you have a quiet/safe place to complete homework at home?

*

Yes

No

How comfortable do you feel asking your parents/family members for help with math homework? *

1

2

3

4

5

Not
Comfortable

Extremely
Comfortable

Do you ever ask your parents/family members for help with math homework?

Yes

No

End of Study Survey

* Required

Name *

Choose

Give a rating for each *

Not at all Very little Somewhat Quite a bit Very much

Kahn Academy helped you in your math class.

The hints and tutorial videos Khan Academy provided helped you complete your homework.

Give a rating for each *

Very Easy Easy Somewhat Difficult Difficult Very Difficult

How difficult you found Khan Academy homework to be.

How difficult you found paper and pencil homework to be.

How do you feel about completing homework online using Khan Academy? *

How did it help you in your math class? Did you enjoy using it? Was it easy/difficult work? Did you have trouble getting access to it? Was the website easy to use? Do you prefer homework online or on paper?