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Examining the Effectiveness of Khan Academy as an Instructional Tool in a Highschool Mathematics Course

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EXAMINING THE EFFECTIVENESS OF KHAN ACADEMY AS AN INSTRUCTIONAL TOOL IN A HIGHSCHOOL MATHEMATICS COURSE

A Master's Thesis

Presented to

The Graduate College of

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In Partial Fulfillment

Of the Requirements for the Degree

Master of Science in Education, Educational Technology

By

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ABSTRACT

With the many educational resources available to today's educators, it is critical that educators utilize the best options to maximize instructional time and resources. With the widespread use of Khan Academy, it is worthwhile to examine if its most well-known attribute, its math program, is effective in improving student outcomes. This study examined if the use of a Khan Academy in a high school math course would improve participating student scores over the course of a quarter marking period. The researcher anticipated that participating students would experience higher math scores and increased confidence in their ability to handle covered mathematical concepts.

KEYWORDS: Khan Academy, educational technology, educational resource, mathematics education, academic performance, high school mathematics

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INTRODUCTION

In the world of modern K-12 teaching, there is a wealth of resources available to educators, though this can sometimes pose an issue in terms of determining the best options available so as to maximize one's instructional time. Out of the many resources that could be used by a high school math instructor, few have the pedigree of Khan Academy, which has become one of the most widely utilized online educational resources due to the extensiveness and quality of its many built-in lessons and assessments (Schwartz, 2014). Thus, this researcher believed it was worthwhile to examine the efficacy of Khan Academy in improving student math scores, which in the case of this study was determined by looking at student math scores from the start to the end of a marking period.

Statement of the Problem

K-12 instructors only have so much instructional time with which to teach their students, which also limits the number of tools that can be successfully integrated into one's teaching practices. This makes it necessary to determine which available tools are the most effective in improving student outcomes.

Purpose of the Study

The purpose of this study was to determine the efficacy of Khan Academy in improving student math scores over the course of a quarter marking period, which was approximately 45 days over the course of around 9 weeks. The study tracked improvement in student math scores via data obtained from Khan Academy regarding the level of student participation by way of

number of minutes spent on learning activities and the number of skills improved throughout the trial quarter marking period. This data was then analyzed in order to make a determination as to the efficacy of Khan Academy in a K-12 math classroom so this researcher and other math teachers can make a more informed decision as to its value as an instructional tool. The efficacy of Khan Academy as a math intervention was measured through the use of a pretest and posttest to determine the students' beginning and ending mastery of predetermined mathematical concepts.

Research Question

Does the use of Khan Academy impact math scores among high school students?

Research Hypothesis

The researcher predicted that the focused implementation of Khan Academy would improve the math scores of participating students.

Significance of the Study

A study into the efficacy of Khan Academy is needed for a number of reasons. First, the fact that the use of Khan Academy is so widespread means that there is much instructor and student time being invested into learning content using the program, so research to determine if the time spent is efficacious is of importance. Second, if it is found that the use of Khan Academy is efficacious in the improvement of students' math ability, then this would mean that more instructors and students would likely benefit from the use of the program, making a push for expanding the use of the program important. Third, if Khan Academy is found to be an effective tool for improving students' math ability, this would be a further demonstration of the

value of digital educational tools and highlight the importance of investing in the infrastructure to support the use of such tools as the district, state, and federal level.

Assumptions

1. The participants will take the pre and posttest seriously and perform at the best of their ability.
2. The sample population will be representative of a typical suburban high school classroom.

Limitations

1. This study took place in a small, suburban private school, so the results may not generalize to different populations or geographic locations.
2. Student activity will largely be independent and self-directed.
3. Not all of the participants in this study are native speakers of English, which may impact their responses.

Definition of Terms

1. Digital educational tool: Any online computer or electronic based program or hardware that is used to supplement a student's education.
2. Khan Academy: An online resource that contains a wide range of lessons and assessments on PreK through college level educational topics. Students are able to work on teacher-assigned lessons or work on concepts at their own pace using site-structured topic sections.
3. Suburban: for the purposes of this study, a lower density area that separate residential and commercial areas; either part of a city or urban area, or exist as a separate residential community within a commuting distance from a city (Tennessee Department of Health, n.d.).

What follows next is a review of the current and related literature on the use of Khan Academy in a K-12 math classroom setting.

LITERATURE REVIEW

Many educational technology resources exist for teacher use, but it is important to determine which will lead to the optimal use of educator and student time. To determine whether or not Khan Academy is an effective resource, it is important to examine the existing literature on the subject of Khan Academy improving student math scores as a part of this study.

Efficacy of Khan Academy in Improving Student Math Ability

There have been numerous studies that have examined the efficacy of Khan Academy as a tool for the improvement of student math ability. Zengin (2017) examined specifically the use of Khan Academy and other free, open-source software in a flipped classroom setting. In that study a double integral achievement test and an opened-ended questionnaire were used to determine the results of the study, and it was found that the flipped classroom approach that incorporated Khan Academy resulted in enhanced student understanding and retention of math concepts (Zengin, 2017). Kelly and Rutherford (2017) designed a study to examine the use of Khan Academy as a mathematics intervention with a group of seventh grade students over the course of four weeks, one of whom utilized Khan Academy as a resource and a second group which did not. The researchers in this study then examined test scores from both groups and determined that there was no association between the use of Khan Academy and a difference in the math test scores (Kelly & Rutherford, 2017). Kelly and Rutherford (2017) noted that it was possible that numerous Khan Academy metrics, such as minutes spent using the resource, which topics were mastered, and so on, may be valuable predictors of student achievement, and that the outcome may have been the result of a general lack of structure in math enrichment classes like the one in which the study was delivered. A study funded by the New England Board of Higher

Education, led by Chan et al. (2016), looked into the use of Khan Academy in numerous community college remedial math courses to examine potential outcomes of the program's use. The researchers determined that core outcomes included "most students [taking] ownership of their own learning by completing Coach Recommendations and working towards Mastery of topics"; (p. 8) that a majority of students worked consistently towards the goal of competing Pre-Algebra and Algebra missions; and that numerous students decided to independently form cooperative study groups (Chan et al., 2016). Additionally, Chan et al. stated that the takeaways from the study were that while Khan Academy was not a "silver bullet" (p. 8) for math instruction, it proved to be motivational for student and instructor alike and that when used effectively, Khan Academy could result in assisting developmental math students find success in their remedial math course and beyond.

Light and Pierson (2014) found that Khan Academy was particularly effective at leading to performance increases in mathematical procedural skills rather than deeper conceptual skills. Bender (2017) noted that many students are so highly motivated to use Khan Academy that outside work is often done beyond teacher assignments and results in improved mathematical ability. Rueda and Serrano (2019) found that the use of Khan Academy led to increased levels of performance among students who put in the most time on the resource, and that when allowed to engage in self-directed use of the program, that most students spent much more time working through sample exercises than on watching the resource's videos. Sahlman and Kind (2012) determined that some of the greatest value-added properties of Khan Academy is in terms of the immediate feedback that students received after inputting their answers on the program's exercises. It was also found that providing teachers with a constant flow of data allowing them to modify and guide instruction to best accommodate student needs based on their progress in Khan

Academy (Sahlman & Kind, 2012). Additionally, in reporting on a pilot program that used Khan Academy heavily with a fifth and seventh grade class, it was noted by Sahlman and Kind (2012) that the use of Khan Academy in the fifth-grade pilot class resulted in slightly yet not significantly higher performance on standardized tests while the seventh-grade pilot class showed a significant increase in performance as most students moved from "below basic" to "proficient."

It was also found in a number of studies that the use of Khan Academy resulted in positive perceptions from the students who utilized it. Arnavut, Bicen, and Nuri (2019) found in the study's concluding survey that most students had positive reflections about their use of Khan Academy. Blacer-Bacolod and Bacolod (2020) determined that the students who had utilized Khan Academy were positive towards the use of the tool, particularly regarding the tool's personalized nature and the overall learning experience. Bender (2017) noted that teachers and students alike responded very positively to using Khan Academy as an educational resource, and that many students demonstrate an improved attitude towards mathematics and a greater sense of self-concept regarding their ability to solve math problems.

Efficacy of Khan Academy in Improving Student Ability in Other Subjects

Even though Khan Academy is primarily recognized as a tool for enhancing student math abilities, the tool has developed to include a wide range of resources in many other fields. San and Aykac (2020) examined the use of Khan Academy in the teaching of English grammar in a study of 67 students divided into an experimental and control group where the students in the experimental group were exposed to videos from Khan Academy on present, past, and future tense. It was determined by the end of the study that the experimental group had significantly

higher academic success than those students who did not receive the Khan Academy intervention (San & Aykac, 2020). Blacer-Bacolod and Bacolod (2020) discovered that among the non-STEM chemistry students who used Khan Academy, there was a discernible difference in test scores compared to those students who did not use the resource.

One area of possible concern regarding Khan Academy usage was discovered by Smith and Harvey (2014) in a study on Universal Design for Learning (UDL) principles in the resource's content across math, science, and history. The researchers determined that according to UDL principles, Khan Academy did not meet several key indicators and that this could result in Khan Academy being a less than ideal resource for students who require the benefits of certain UDL elements (Smith & Harvey, 2014).

Methods for Utilizing Khan Academy

With these studies on the effectiveness of Khan Academy in mind, it is also important to consider how Khan Academy could be best used to maximize any positive impact that the program can have. Cargile (2015) noted that four major instructional elements can improve an educator's use of Khan Academy: using formative assessment data to educate instruction and assignment of material; the setting of goals to keep students on track; the use of task lists to direct the pacing of student engagement with material; and the use of active and collaborative learning. Cargile (2015) also stated her belief that Khan Academy can be a very effective tool in a blended learning setting when these four tenets are followed by math educators. Gray and Lindstrom (2019) recommended that Khan Academy be introduced to students in a hands-on session before releasing students to attempt to use the resource independently, and to incorporate external motivation to encourage the use of the website. Further, Gray and Lindstrom (2019)

noted that pointing out learning benefits of Khan Academy to students, utilizing results from Khan Academy learning activities in in-person teaching activities, and considering how Khan Academy can be used as part of a broader educational toolkit could all lead the maximization of the resource's benefits.

Light and Pierson (2014) recommended utilizing Khan Academy as an integrated tool alongside traditional in-person teaching to maximize the procedural skill development Khan Academy excels at with the deeper concept building that teachers could emphasize. Bender (2017) gave a wide range of steps for properly implementing Khan Academy in a math course, which starts with thorough teacher familiarization with what Khan Academy has to offer and then to spend time getting students signed into the program rather than trying to rely on students doing so themselves. The next set of recommendations was to use Khan Academy at least occasionally within the classroom to increase student familiarity with the program and to strengthen confidence in its use, the sharing of Khan Academy and what it has to offer with parents, and to use plenty of motivation to encourage outside work in the program (Bender, 2017). Sahlman and Kind (2012) noted that one avenue for effectively using Khan Academy was to place students into groups by starting ability level to provide a means for assigning relevant work as well as to provide individualized small group instruction while other groups worked on their appropriate work within Khan Academy.

Summary

The research covered in this section reveals several critical points regarding the data known about the use of Khan Academy in the classroom. Performance by students who utilized Khan Academy regularly ranged from being similar to significantly higher than students who did

not receive Khan Academy as an intervention, while the use of the program often led to reports of higher self-efficacy and self-concept regarding student math ability. Lastly, it is important to consider how Khan Academy is to be used within a classroom setting, as numerous factors and instructional decisions can improve or impede how effective the use of Khan Academy will be in practice. In the next section, the methodology used in this study will be presented.

METHODOLOGY

In conducting a study on the effectiveness of Khan Academy in improving student math scores, there are several important factors that must be considered. As this study examined how student math scores improved over the course of a 45-day marking quarter, it was necessary to design the study in a way that accounts for beginning student ability and how key math concepts improved by the end of the study period. The data obtained then needed to be analyzed in order to make a determination regarding how effective Khan Academy was as an instructional tool in a math classroom.

Research Design

This study utilized a quantitative research design in an attempt to determine how efficacious Khan Academy is as an instructional tool by placing participants in a quarter-long (approximately 45 school days) Math Enrichment course where students had in-school time to work on Khan Academy assignments. Participants in this study were administered a pretest to establish a baseline and determine what concepts they should have begun the course working on, then were administered a posttest at the conclusion of the course to determine how far the participants had advanced in their understanding of numerous mathematical concepts.

Site of the Study

This study took place at a K-12 private school in Northeastern Pennsylvania in the school's primary multimedia room. The township in which the school is located is rural-suburban of approximately 3,508 people and could be considered a suburb of the much larger

Wilkes-Barre/Scranton metropolitan area (US Census Bureau, 2010). The township's racial/ethnic composition is 97.89% White, 0.54% Hispanic/Latino, 0.51% Black, 0.31% American Indian, 0.23% Asian, 0.77% two or more races, and 0.29% who fall under "some other race" (US Census Bureau, 2010).

Participants

In conducting this study, the participants were 7-12th grade students from a private school in Northeastern Pennsylvania. The school is predominately composed of students from middle class White families but also has a sizeable number of students (approximately 10-15%) who are either Black, Hispanic, Asian, or multiracial, making it quite diverse when compared to the surrounding area. In terms of gender the school is split almost evenly between male and female students. Convenience sampling was used to recruit the participants for this study. Students were recruited from the school's 7th-12th grade student body, which was composed of 33 students as of November 2021.

Ethical Considerations

The author of this study ensured that numerous ethical considerations underlined the research process. First, the author obtained approval from Missouri State University's IRB Office (see Appendix A) prior to the recruiting of participants; the distribution of informed consent forms, surveys or assessment devices; or any other data that was collected. IRB approval was received on January 19, 2022, under study # IRB-FY2022-313; the approval letter can be found in Appendix A.

The author ensured that student participants received voluntary informed consent forms (see Appendix B) as well as their parents/guardians (see Appendix C) and that they were aware of the aims of the study and what would take place throughout the duration of the study. The privacy and confidentiality of all participants was fully protected by keeping student grades and performance in a password protected computer and on a Learning Management System with appropriate security protocols.

Any information involving participants' identity was kept strictly confidential through the use of fabricated ID numbers that were known only to this researcher. Any data presented or published was displayed in aggregate so no individual participant was identifiable.

The student participants were able to withdraw from the study at any time without consequences. Additionally, parents/guardians were able to withdraw their child from the study at any time without consequences. There are no known risks to participants.

Instrumentation and Data Collection

There were two specific instruments that were used to obtain data for this study: a pre-course assessment i.e., pretest (see Appendix D), and post-course assessment i.e., posttest (see Appendix E). The pre-course assessment determined which mathematical concepts each participant had mastered, was proficient in, and needed improvement in so as to provide a starting point for placement in Khan Academy i.e., establish baseline knowledge of the participants. The post-course assessment examined each students' final understanding and progress on identified mathematical concepts by the end of the course. The assessments were delivered physically and the data compiled via Microsoft Excel.

Role of the Researcher

During the course of this study, the researcher was responsible for developing the research question and hypothesis that served as the foundation of the research to be conducted. The researcher was also responsible for obtaining Institutional Review Board (IRB) approval, as well as creating, distributing, and collecting all required consent forms. The researcher also implemented appropriate privacy and confidentiality guidelines for the protection of all participants.

Once the study began, the researcher was responsible for administering the pretest to all participants, for working with students during the first week of the program to determine academic placement in the appropriate Khan Academy subject areas, and for administering the program's posttest at the conclusion of the program. The researcher then needed to compile all relevant data obtained throughout the course of the study. In the next section is the analysis of collected data and discussion of the results.

RESULTS

Data Collection

As the purpose of the study was to determine whether or not the use of Khan Academy as an intervention would improve student performance with preidentified mathematical concepts, 31 students were enrolled in a Math Enrichment course where Khan Academy was the primary mode of instruction both inside and outside of the school environment. All students were enrolled in a Math Enrichment course in the Khan Academy platform, where they were then placed in the program's Pre-Algebra curriculum of materials. Students were assigned four math units to focus on, which were Factors and Multiples, Ratios and Rates, Percentages, and Exponents Intro and Order of Operations.

After registering students in the Math Enrichment course in Khan Academy, the first class session was conducted and the goals of the course were explained to all participating students. Each student was then administered the pretest (see Appendix D) with questions primarily taken from the four Khan Academy units noted earlier in this section, which the students then completed and submitted to the researcher. As students worked in Khan Academy, their performance was tracked by the researcher to determine how much time each student was spending in Khan Academy and how many/which concepts were worked on by each student.

At the conclusion of the marking period, the participating students were administered a posttest (see Appendix E), the results of which were compiled in an Excel spreadsheet for analysis.

Data Analysis

Table 1 indicates each student's overall results on the pretest. Table 2 shows each student's pretest accuracy rates. Table 3 indicates each student's overall results on the posttest. Table 4 shows each student's posttest accuracy rates.

Table 1. Pretest Results from Students

Students	Test score
# 1	93%
# 2	75%
# 3	50%
# 4	68%
# 5	61%
# 6	96%
# 7	57%
# 8	50%
# 9	71%
# 10	61%
# 11	82%
# 12	61%
# 13	89%
# 14	89%
# 15	54%
# 16	75%
# 17	29%
# 18	82%
# 19	50%
# 20	32%
# 21	82%
# 22	68%
# 23	18%
# 24	100%
# 25	82%
# 26	54%
# 27	29%
# 28	57%
# 29	89%
# 30	82%
# 31	61%

Table 2. Pretest Results Accuracy Rate

Question	Accuracy Rate
# 1	71%
# 2	74%
# 3	68%
# 4	58%
# 5	90%
# 6	71%
# 7	90%
# 8	74%
# 9	87%
# 10	74%
# 11	74%
# 12	81%
# 13	81%
# 14	42%
# 15	48%
# 16	16%
# 17	36%
# 18	84%
# 19	100%
# 20	61%
# 21	16%
# 22	68%
# 23	77%
# 24	65%
# 25	42%
# 26	94%
# 27	74%
# 28	36%
Average	66%

There were four students who performed at a higher level of performance (90% or better) on the pretest, including one who obtained a score of 100%. Excluding this single student who demonstrated mastery with the identified mathematical concepts, the fact that the overall class average on the pretest was 66% indicated that there was significant progress that could be made by the participating students in the identified mathematical concepts. Examining individual

Table 3. Posttest Results from Students

Students	Test score	% of Improvement
# 1	93%	0%
# 2	89%	14%
# 3	54%	4%
# 4	57%	-11%
# 5	64%	3%
# 6	100%	4%
# 7	86%	29%
# 8	64%	14%
# 9	96%	25%
# 10	64%	3%
# 11	96%	14%
# 12	61%	0%
# 13	93%	4%
# 14	100%	11%
# 15	82%	28%
# 16	93%	18%
# 17	64%	35%
# 18	82%	0%
# 19	50%	0%
# 20	50%	18%
# 21	75%	-7%
# 22	79%	11%
# 23	18%	0%
# 24	96%	-4%
# 25	89%	7%
# 26	82%	28%
# 27	64%	28%
# 28	Excluded	Excluded
# 29	96%	7%
# 30	86%	4%
# 31	86%	25%

questions from the pretest, performance was quite divergent from one question to the next, with only one question (Question 19) receiving perfect marks from the students and the lowest scoring two questions (Questions 16 and 21) receiving only a 76.97% correct rate. Overall, the results of the pretest indicated that almost all of the students participating, regardless of their

grade level, could demonstrate an increase in their posttest scores, assuming that working on the identified mathematical concepts in Khan Academy was conducive to an improved understanding of the material.

Table 4. Posttest Results Accuracy Rate

Question	Accuracy Rate
# 1	86%
# 2	79%
# 3	93%
# 4	82%
# 5	89%
# 6	86%
# 7	96%
# 8	82%
# 9	82%
# 10	75%
# 11	75%
# 12	96%
# 13	93%
# 14	25%
# 15	79%
# 16	57%
# 17	43%
# 18	89%
# 19	93%
# 20	61%
# 21	50%
# 22	89%
# 23	89%
# 24	89%
# 25	71%
# 26	93%
# 27	71%
# 28	36%
Average	76.97%

The posttest scores indicated minimal-to-high rates of improvement from the pretest, with an average of an 10.40% improvement from the pretest to the posttest. The range of improvement was from -11% to 35% from the beginning of the intervention to the end of the quarter when the posttest was given to the participating students. Out of the participating students, three received a lower score, four received the same score, 23 received a higher score, and one was excluded since the student transferred to a different school and did not complete the study. Higher rates of participation in the Khan Academy platform generally resulted in higher rates of improvement, with an average of 11.2% improvement among the top five users by minutes spent compared to an average of 4.2% improvement among the five users who spent the least amount of time on Khan Academy.

What follows next is a discussion of these findings, recommendations for future research, and conclusions.

DISCUSSION

Summary

This study was conducted to determine the efficacy of Khan Academy in improving student math scores over the course of a quarter marking period, which was approximately 45 days over the course of around nine weeks. The study tracked student performance in the Khan Academy platform, including how long each student spent in Khan Academy and how many skills were mastered throughout the trial quarter marking period. A pretest was given at the beginning of the Khan Academy program, with students receiving an average score of 66% with a range of scores from 18% to a 100%. At the end of the program, a posttest was given to the participating students with an average score of 76.97%, with the vast majority of students having experienced some degree of improvement from their pretest score.

Discussion

As was found in the Literature Review conducted earlier in this study, most of the existing research on the efficacy of Khan Academy in improving student outcomes indicates that Khan Academy is at least somewhat effective in doing so. The majority of the studies indicated that other factors, such as the structure of the class in which Khan Academy is implemented, the amount of time students spend on the platform, etc., all influence the extent to which the intervention can improve student outcomes.

This study indicated that for the students who participated in the Khan Academy program, around 77% experienced a positive outcome in the form of a higher posttest score, which this researcher believes was a result of the learning that took place through the Khan

Academy platform and supports the research hypothesis. The results of this study align with much of the existing research that has been conducted involving Khan Academy and K-12 students, particularly regarding the use of the tool as a math intervention. Additionally, the 11% average improvement rate of this study aligns with some of the more dramatic findings of studies like the one conducted by Sahlman and Kind (2012) where most of their 7th-grade pilot students moved from below basic to proficient on their standardized tests.

By combining the average rate of improvement among the participating students from the beginning to end of the program (with the fact that most students experienced some degree of improvement), along with these results corroborating much of the existing research on this topic, this author believes the results of this study support the use of Khan Academy as a mathematics intervention for K-12 students, per the research question that served as the foundation of this study.

Recommendations for Future Research

While this study demonstrated that the use of Khan Academy can result in improved student performance on identified math concepts over a relatively short period of time, there are a number of ways that future research could expand upon these findings. For example, a longer-term study taking place over the course of a half or even a full school year could help determine if these results would be replicated over a longer period.

Another potentially useful variable would be to use a larger pool of participating students, perhaps from several different schools, which could help generate more generalizable results and provide insight into whether different groups of students under different educators would display similar outcomes. Additionally, greater structure in a future Khan Academy intervention which

included weekly assignments that carried enough academic weight and/or other motivations to increase student participation and buy-in, as well as more formative assessment, would likely result in more discriminating and accurate determination of how much Khan Academy can improve student mastery of identified mathematical concepts.

Lastly, a study that utilized an experimental research design whereby there would be a control group of students who did not receive a Khan Academy intervention and an experimental group that did could be useful in verifying whether or not improvements in student performance were largely or exclusively the result of the use of Khan Academy. This study nonetheless should provide insights into how such a study could be designed to deliver a Khan Academy intervention to a group of students, given that the students in this study did appear to benefit from the Khan Academy intervention due to the higher performance of participating students on the posttest.

Conclusions

After comparing pretest and posttest scores of the students who participated in the Khan Academy intervention, an 11% improvement in test scores was demonstrated, indicating that the students did benefit from the use of Khan Academy in a largely independent setting which relied on students working at home or during free time throughout the school day. As Khan Academy is a versatile program that can be used by students in and outside of the classroom, it gives teachers numerous avenues for implementation. Based on the results from the studies mentioned in the Literature Review, along with the results of this study, Khan Academy appears to be an effective mathematics intervention which educators should consider implementing in their classrooms.

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APPENDICES

Appendix A: Institutional Review Board (IRB) Approval

IRB-FY2022-313 - Initial: Initial Approval

D do-not-reply@cayuse.com <do-not-reply@cayuse.com>
1/19/2022 4:15 PM

To: Chang, Ching-Wen; Kreller, Shane C

Missouri State University

To:
Ching-Wen Chang
Reading Foundations & Tech

RE: Notice of IRB Approval
Submission Type: Initial
Study #: IRB-FY2022-313
Study Title: Examining the Effectiveness of Khan Academy as an Instructional Tool in a Highschool Mathematics Course
Decision: Approved

Approval Date: January 19, 2022

This submission has been approved by the Missouri State University Institutional Review Board (IRB). You are required to obtain IRB approval for any changes to any aspect of this study before they can be implemented. Should any adverse event or unanticipated problem involving risks to subjects or others occur it must be reported immediately to the IRB.

This study was reviewed in accordance with federal regulations governing human subjects research, including those found at 45 CFR 46 (Common Rule), 45 CFR 164 (HIPAA), 21 CFR 50 & 56 (FDA), and 40 CFR 26 (EPA), where applicable.

Researchers Associated with this Project:
PI: Ching-Wen Chang
Co-PI:
Primary Contact: Shane Kreller
Other Investigators:

Appendix B: Informed Consent for Student

You are being invited to participate in a Master's research study titled **Examining the Effectiveness of Khan Academy as an Instructional Tool in a Highschool Mathematics Course**. This study is being conducted by Mr. Shane Kreller in the Master of Educational Technology program at Missouri State University.

There are no known risks if you decide to participate in this study. There are no costs for your participation in this study. The information gathered will form the basis for future research, improvements in the classrooms, and may be used in scholarly publications. The information collected may or may not benefit you directly. The information gathered in this study should provide more general benefits to educators.

The information gathered from the research instrument is confidential. No one will know whether or not you participated in the study. Individuals from the Institutional Review Board may inspect these records. Should the data be published, it will be used in aggregate; individual participants cannot be identified.

Your participation in this study is completely voluntary. All data collection or observations will be conducted during normal classroom time as part of the Math Enrichment course you will participate in if you decide to do so. If you are willing to participate in the study, it would be greatly appreciated. By signing this form, you are voluntarily agreeing to participation.

If you have questions regarding the research, you may contact the researcher, Mr. Shane Kreller the research advisor, Dr. Ching-Wen Chang, or the Office for Research Administration at MSU whose contact information is provided below.

If you are willing to participate in the research, you must sign below. Thank you for your consideration, it is greatly appreciated.

Mr. Shane C. Kreller (570) 472-1810 sck1995@missouristate.edu	Dr. Ching-Wen Chang (417) 836-5353 cchang@missouristate.edu	Office for Research Administration 417-836-5972

_____

Student Name - Printed Student - Signature Date

Appendix C: Informed Consent for Parent/Guardian

Your child is being invited to participate in a Master's research project titled **Examining the Effectiveness of Khan Academy as an Instructional Tool in a Highschool Mathematics Course**. This study is being conducted by Mr. Shane Kreller in the Master of Educational Technology program at Missouri State University.

There are no known risks if you decide to allow your child to participate in this study. There are no costs for your child's participation in this study. The information gathered will form the basis for future research, improvements in the classrooms, and may be used in scholarly publications. The information collected may or may not benefit you and your child directly. The information gathered in this study should provide more general benefits to educator.

The information gathered from the research instrument is confidential. No one will know whether or not your child participated in the study. Individuals from the Institutional Review Board may inspect these records. Should the data be published, it will be used in aggregate; individual participants cannot be identified.

Your child's participation in this study is completely voluntary. No additional time will be required of you or your child in order to participate. All data collection or observations will be conducted during normal classroom time as part of the Math Enrichment course your child will participate in if you decide to allow their participation. If you are willing to allow your child to participate in the study, it would be greatly appreciated. By signing this form, you and your child are voluntarily agreeing to participation.

If you have questions regarding the research, you may contact the researcher, Mr. Shane Kreller the research advisor, Dr. Ching-Wen Chang, or the Office for Research Administration at MSU whose contact information is provided below.

If you are willing to have your child participate in the research, both you and your child must sign below. Thank you for your consideration, it is greatly appreciated.

Mr. Shane C. Kreller (570) 472-1810 sck1995@missouristate.edu	Dr. Ching-Wen Chang (417) 836-5353 cchang@missouristate.edu	Office for Research Administration 417-836-5972

_____

Parent/Guardian Name - Printed Parent/Guardian – Signature Date

_____

Your Child's Name – Printed

Appendix D: Khan Academy Program Pretest

Name:_____

This test is only meant to determine your starting point in terms of proficiency with the mathematical concepts that will be targeted by the Khan Academy study. Your performance on this exam has no effect on your grade or anything else whatsoever, so please relax and just do your very best!

1.) Which of the following are factor pairs for 49? Mark all that apply.

- ☐ 3 & 13
- ☐ 7 & 7
- ☐ 2 & 23
- ☐ 1 & 49
- ☐ 4 & 11

2.) Which of the following are factor pairs for 66? Mark all that apply.

- ☐ 3 & 22
- ☐ 2 & 33
- ☐ 6 & 11
- ☐ 4 & 16
- ☐ 1 & 66

3.) A rectangle has an area of 20 square centimeters. Which of the following could be the rectangle's length and width? (Area = length * width). Mark all that apply.

- ☐ 3 cm & 8 cm
- ☐ 4 cm & 5 cm
- ☐ 2 cm & 10 cm
- ☐ 1 cm & 20 cm

4.) A rectangle has an area of 81 square centimeters. Which of the following could be the rectangle's length and width? (Area = length * width). Mark all that apply.

- ☐ 9 cm & 9 cm
- ☐ 7 cm & 12 cm
- ☐ 1 cm & 81 cm
- ☐ 3 cm & 27 cm

5.) List all the factors of 24. Mark only one choice.

- ☐ 24, 48, 73, 96
- ☐ 1, 2, 4, 6, 8, 10, 12, 24
- ☐ 1, 2, 3, 4, 6, 8, 12, 24

6.) List all the factors of 56. Mark only one choice.

- 1, 2, 3, 6, 14, 28, 56
- 1, 28, 56, 112
- 1, 2, 4, 7, 8, 14, 28, 56

7.) Which of the following numbers is a multiple of 9? Mark only one choice.

- 77
- 18
- 46
- 39

8.) Which of these numbers is prime? Mark only one choice.

- 5
- 10
- 75
- 85
- 91

9.) Which of these numbers is prime? Mark only one choice.

- 11
- 15
- 21
- 56
- 57

10.) Which of these numbers is composite? Mark only one choice.

- 4
- 7
- 23
- 29
- 41

11.) Which of these numbers is composite? Mark only one choice.

- 11
- 15
- 19
- 41
- 83

12.) Erin loves to play sports! She has earned 3 tennis trophies, 4 basketball trophies, 7 soccer trophies, and 1 volleyball trophy. What is the ratio of Erin's tennis trophies to soccer trophies? Mark only one choice.

- 3 : 7
- 4 : 7
- 7 : 4
- 3 : 12

13.) Quinn has a large family. She has 4 cousins who live in Texas, 3 cousins who live in Nebraska, and 9 cousins who live in Michigan. What is the ratio of Quinn's cousins who live in Texas to her cousins who live in Michigan? Mark only one choice.

- 4 to 3
- 3 to 4
- 4 to 9
- 4 to 12

14.) Select three ratios that are equivalent to 4 : 3. Mark all that apply.

- 8 : 6
- 9 : 12
- 20 : 15
- 32: 24
- 36 : 28

15.) Select three ratios that are equivalent to 5 : 2. Mark all that apply.

- 2 : 5
- 10 : 4
- 20 : 50
- 35 : 14
- 55 : 22

16.) A box of 15 cookies costs $9. What is the cost for 1 cookie?

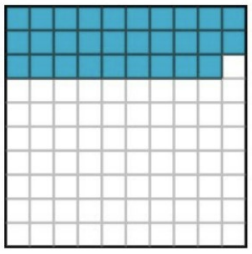
_____

17.) Celia bought a bag of 12 goldfish for $3. What is the cost for 1 goldfish?

_____

18.) Answer the question below.

The square below represents one whole.

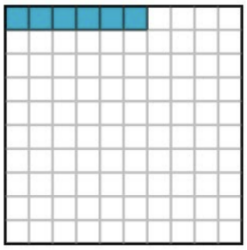


What percent is represented by the shaded area?

_____ %

19.) Answer the question below.

The square below represents one whole.

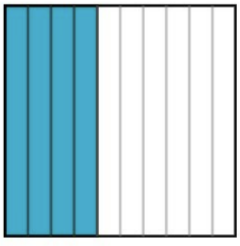


What percent is represented by the shaded area?

_____ %

20.) Answer the question below.

The square below represents one whole.

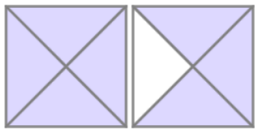


What percent is represented by the shaded area?

_____ %

21.) Answer the question below.

Each square below represents one whole.



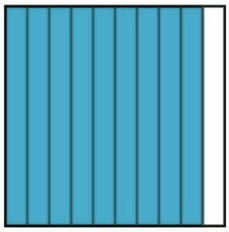
What percent is represented by the shaded area?

_____ %

22.) Answer the question below.

The square below represents one whole.

Express the shaded area as a fraction, a decimal, and a percent of the whole.



Fraction: _____

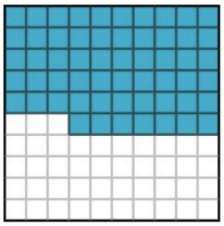
Decimal: _____

Percent: _____ %

23.) Answer the question below.

The square below represents one whole.

Express the shaded area as a fraction, a decimal, and a percent of the whole.



Fraction: _____

Decimal: _____

Percent: _____ %

24.) Evaluate 0^5.

_____

25.) Evaluate 3^4.

_____

26.) Evaluate the following expression. 9 * 10 + 3

_____

27.) Evaluate the following expression. (4 + 3) * 5 – 4

_____

28.) Evaluate the following expression. 2^2 + (8 / 2) * 15

_____

Appendix E: Khan Academy Program Posttest

Name:_____

This test is only meant to determine potential improvement in terms of proficiency with the mathematical concepts that were be targeted by the Khan Academy study. Your performance on this exam has no effect on your grade or anything else whatsoever, so please relax and just do your very best!

1.)Which of the following are factor pairs for 63? Mark all that apply.

- □ 4 & 13
- □ 7 & 9
- □ 4 & 23
- □ 1 & 63
- □ 21 & 3

2.)Which of the following are factor pairs for 42? Mark all that apply.

- □ 3 & 22
- □ 2 & 21
- □ 14 & 3
- □ 4 & 16
- □ 1 & 42

3.)A rectangle has an area of 35 square centimeters. Which of the following could be the rectangle's length and width? (Area = length * width). Mark all that apply.

- □ 4 cm & 8 cm
- □ 5 cm & 7 cm
- □ 1 cm & 35 cm
- □ 3 cm & 11 cm

4.)A rectangle has an area of 104 square centimeters. Which of the following could be the rectangle's length and width? (Area = length * width). Mark all that apply.

- □ 9 cm & 12 cm
- □ 4 cm & 26 cm
- □ 2 cm & 52 cm
- □ 6 cm & 17 cm

5.)List all the factors of 18. Mark only one choice.

- □ 18, 36, 54, 72
- □ 1, 2, 3, 4, 6, 10, 9, 18
- □ 1, 2, 3, 6, 9, 18

6.)List all the factors of 64. Mark only one choice.

- 1, 2, 4, 8, 16, 32, 64
- 1, 32, 64, 128
- 1, 2, 4, 6, 8, 14, 28, 64

7.)Which of the following numbers is a multiple of 12? Mark only one choice.

- 77
- 18
- 48
- 39

8.)Which of these numbers is prime? Mark only one choice.

- 10
- 75
- 11
- 85
- 91

9.)Which of these numbers is prime? Mark only one choice.

- 15
- 21
- 56
- 17
- 57

10.)Which of these numbers is composite? Mark only one choice.

- 7
- 23
- 10
- 29
- 41

11.)Which of these numbers is composite? Mark only one choice.

- 11
- 19
- 41
- 83
- 24

12.)Erin loves to play sports! She has earned 9 tennis trophies, 2 basketball trophies, 8 soccer trophies, and 1 volleyball trophy. What is the ratio of Erin's tennis trophies to soccer trophies? Mark only one choice.

- 9 : 8
- 2 : 9
- 1 : 2
- 8 : 9

13.)Quinn has a large family. She has 6 cousins who live in Texas, 2 cousins who live in Nebraska, and 11 cousins who live in Michigan. What is the ratio of Quinn's cousins who live in Texas to her cousins who live in Michigan? Mark only one choice.

- 11 to 6
- 6 to 2
- 6 to 11
- 11 to 2

14.)Select three ratios that are equivalent to 8 : 2. Mark all that apply.

- 12 : 4
- 4 : 12
- 4 : 1
- 16: 4
- 12 : 3

15.)Select three ratios that are equivalent to 2 : 3. Mark all that apply.

- 2 : 5
- 20 : 30
- 10 : 15
- 35 : 14
- 4 : 6

16.)A box of 30 cookies costs $15. What is the cost for 1 cookie?

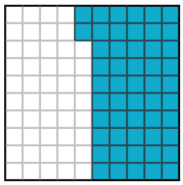
_____

17.)Celia bought a bag of 30 goldfish for $5. What is the cost for 1 goldfish?

_____

18.) Answer the question below.

The square below represents one whole.

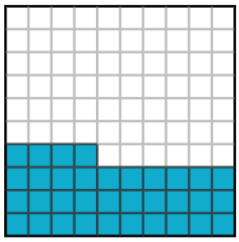


What percent is represented by the shaded area?

%

19.) Answer the question below.

The square below represents one whole.



What percent is represented by the shaded area?

%

20.) Answer the question below.

The large rectangle below represents one whole.

What percent is represented by the shaded area?

%

21.) Answer the question below.

Each square below represents one whole.

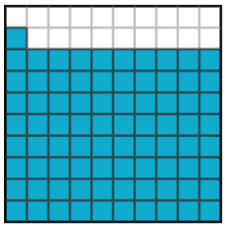
What percent is represented by the shaded area?

_____ %

22.)Answer the question below.

The square below represents one whole.

Express the shaded area as a fraction, a decimal, and a percent of the whole.



Fraction: _____

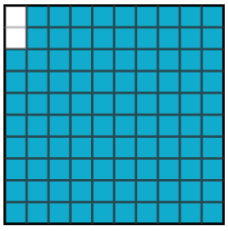
Decimal: _____

Percent: _____ %

23.)Answer the question below.

The square below represents one whole.

Express the shaded area as a fraction, a decimal, and a percent of the whole.



Fraction: _____

Decimal: _____

Percent: _____ %

24.)Evaluate 0^8.

_____

25.)Evaluate 4^3.

_____

26.)Evaluate the following expression. 10 * 3 + 4

_____

27.)Evaluate the following expression. (2 + 5) * 9 – 2

_____

28.)Evaluate the following expression. 5^2 + (6 / 2) * 11

_____