

Khan Academy in Rural Classrooms: Effects on the Mathematical Performance of Basic Education Students

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ABSTRACT:

Artificial intelligence and assistive technologies are becoming increasingly visible in special education through adaptive learning platforms, automated assessment tools, communication aids, progress monitoring systems, and AI-supported instructional planning. These technologies have the potential to improve access to learning, personalized learning and participation for learners with disabilities, but present significant concerns related to special education. As AI becomes more prevalent, there can be concerns about job security, job autonomy, and the role of human judgment and decision-making in disability-sensitive classrooms. The aim of this article is to explore fear of automation, psychological stress, job security and use of AI among special educators in special and inclusive education environments. The article employs a qualitative interpretive review to examine the implications that AI and assistive technologies have for teachers' identity, workload, emotional wellbeing and perceived sense of professional security. The discussion emphasizes that special educators might not be against AI itself, but about how it is used in a replacement mode, lack of transparency, and demean of empathy-based education support. The article suggests that AI should be used as a supporting tool for teaching and not as a replacement for human knowledge and expertise. To promote the sustainable use of AI in special education, it is essential to have transparent systems, ethical safeguards, ongoing training, institutional support, and protection of the relational aspects of inclusive practice.

Keywords: Special Education; Artificial Intelligence; Assistive

1. Introduction

Modernity is configured as a scenario of accelerated transformations and constant appropriations, where technological development emerges as a disruptive element that influences various social spheres, including education. This reality has driven a progressive adaptation of curricular designs to capitalize on the advantages offered by technological progress (Amar-Rodríguez, 2021). In this framework, the incorporation of Information and Communication Technologies (ICT) in student life acquires special relevance, evidencing a clear trend towards the acquisition of smart devices that facilitate connectivity to social networks and other digital spaces of interest. This dynamic is reflected in the exponential growth of equipment such as personal computers, smartphones and tablets, whose demand is increasing by up to six million per year (Crespo et al., 2019).

In this context of educational transformation, open educational resources (OER) have become fundamental allies in breaking down barriers to learning. These tools not only make academic training more flexible, but also open the doors of knowledge to those who face economic obstacles or live in areas with limited traditional educational offerings (Santos-Hermosa, 2021). A clear example is Khan Academy, a platform that, by offering its content at no cost, allows students to progress at their own pace, reflecting deeply on the topics and building their learning in a meaningful way – a principle that fully coincides with the fundamentals of formative assessment (Bendou, 2021). What makes this platform especially valuable is its ability to reach corners where face-to-face education is limited, perfectly embodying the democratizing spirit that characterizes the best OER (Gray & Holyoak, 2021). Fractions are still that math hurdle that so many students find difficult to overcome, especially when it comes to performing basic operations with them

(Purnomo et al., 2022). The key is to help them build this knowledge step by step, connecting it with what they already know and allowing them to learn autonomously (García-Peñalvo, 2020). Platforms such as Khan Academy, with their visual and interactive approach, have become indispensable allies, not only to understand fractions, but also to develop those self-learning skills that young people need today more than ever (Delgado y Ruiz, 2021). This study employed a quantitative, quasi-experimental design to compare learning outcomes between two groups: a control group, which received traditional instruction, and an experimental group (Hernández Sampieri, 2018), which used Khan Academy's fraction modules. Carried out in a rural school in Ecuador, the research sought to answer the following question: How does the use of the Khan Academy platform influence the learning of fraction addition and subtraction operations in students in rural areas? The hypothesis posed that the experimental group would show a significantly greater improvement in fraction operations compared to the control group, thanks to the interactive and student-centered design of the platform.

This study is based on contemporary theoretical frameworks that explain effective digital learning. On the one hand, the theory of multimedia learning (Mayer & Fiorella, 2022) destaca How visual and interactive resources improve conceptual retention when designed under clear pedagogical principles. On the other, the theory of adaptive cognitive load (Kalyuga, 2023) explains how digital platforms can optimize mental effort during learning complex content.

Methodologically, pre- and post-tests were applied to both groups, analyzing the data using descriptive and inferential statistics. The results revealed a statistically significant improvement in the performance of the experimental group, supporting the hypothesis. These findings contribute to the literature on the effectiveness

of OER and highlight the potential of Khan Academy to reduce educational disparities in rural contexts.

This article is structured as follows: first, a review of the literature on OER, fraction learning, and rural education is presented. Then, the methodology is detailed, including the selection of participants and the design of instruments. The results are then discussed in relation to previous studies, followed by the implications for educational and teacher policies. The conclusion addresses limitations and future lines of research, emphasizing the need for scalable, technology-based solutions for underserved communities.

2. Materials and methods

The research adopted the positivist paradigm, using statistical tools to analyze observable data (Ramos, 2015). This approach is consistent with previous studies on digital platform evaluation, where quantitative measurement allows for

objective comparisons between groups (Hillmayr et al., 2020). Particularly in mathematics, quantitative research has proven to be effective in assessing the acquisition of specific competencies (Pellegrini et al., 2021).

Validation by experts, as presented in Table I, was carried out following the methodological protocols established in the specialized literature (Taherdoost, 2021), in order to ensure that the items adequately assessed competencies. It should be noted that the 10-item questionnaire on fractions demonstrated high reliability ($\alpha = 0.904$) (Sievert et al., 2019). As can be seen in Table II, these reliability values not only meet the required psychometric parameters, but also reflect the internal consistency of the instrument.

Table I: Validity of instruments by expert judgement

Criteria	Expert 1	Expert 2	Expert 3
Clarity	Yes	Yes	Yes
Relevance	Yes	Yes	Yes
Relevance	Yes	Yes	Yes
Methodology	Yes	Yes	Yes

Note. Adapted from methodologies for validating educational instruments (Torquemada & Loredó, 2021).

Table II: Case Processing Overview

Item Total Statistics	Scale if Deleted	Mean Scale Item Variance Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
In a fraction What is the numerator?	2,00	7,667	,695	-	,893
A fraction that cannot be simplified?	2,16	9,473	,049	-	,927
What are homogeneous fractions?	2,08	7,743	,739	-	,890
What are fractions with different denominators called?	2,04	7,623	,748	-	,889
What fraction does the figure represent?	2,08	7,743	,739	-	,890

Item Total Statistics	Scale if Deleted	Mean Scale Item Variance Item Deleted	Corrected Item- if Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
What sum represents the figures?	2,04	7,207	,939	-	,875
What is the correct answer for the next operation?	2,12	7,860	,743	-	,890
What is the result of subtracting the following fractions?	2,16	8,140	,678	-	,894
What is the answer to following addition of fractions?	2,00	7,250	,878	-	,879
What is the answer to the following fraction subtraction?	2,20	8,917	,353	-	,911

Note. Own elaboration (2025) with data processed in SPSS V.25

The sample included 49 eighth-grade students aged 12-13 years in a rural Ecuadorian educational institution. The selection of rural contexts responds to the need identified in recent literature to study the impact of educational technologies on populations with limited access to digital resources (Escueta et al., 2020). The sample size was determined by considering similar studies on technological interventions in mathematics (Cheung & Slavin, 2013).

The present study was based on a quasi-experimental cross-sectional design with two non-random groups, a methodology widely used in educational research to evaluate pedagogical interventions when random assignment is not feasible (Gopalan et al., 2020). The experimental group (n=25) used the Khan Academy platform as an open educational resource for fraction learning, while the control group (n=24) followed traditional methodology. This approach aligns with recent recommendations for edtech studies in real- world contexts (Means, 2022).

3. Results

The 4-week intervention with Khan Academy was designed considering recent findings on

optimal duration to evaluate the impact of educational technologies (Steenbergen-Hu et al., 2020). The specific selection of interactive videos was based on evidence about their effectiveness in teaching abstract mathematical concepts (Ofril et al., 2024). The use of non-parametric tests such as Mann- Whitney U was appropriate given the sample size and characteristics of the data, following current recommendations for analysis in educational sciences (Karch, 2021). This analytical approach has been consistently employed in comparative studies of pedagogical methods (Nehring & Schwichow, 2020).

3.1. Level of prior knowledge in operations with fractions

To measure the level of prior knowledge, an initial test (Pre-test) was applied to both groups. The results, which were classified according to the Ministry of Education's scale, showed that most students started out with a low command of the subject. In the control group, 70.8% of the 24 students remained at the NAR level (No Alcanza los Aprendizajes Requeridos), while, in the experimental group, 72% of the 25 students were also placed at this same level. Only one of the students in the experimental group managed

to reach the DAR level (Domina los Aprendizajes Requeridos), as detailed in Table III. These findings were in line with what he had

pointed out (Estrada, 2018), who mentioned that students usually have little prior knowledge when starting a curricular unit.

Table III: Pre-test results (frequencies and percentages by learning levels).

Qualitative Levels	Quantitative Scale	Control Group Frequency	Control Group Percentage (%)	Experimental Group Frequency	Experimental Group Percentage (%)
DAR	9,00–10,00	0	0%	1	4%
AAR	7,00–8,99	3	12,5%	4	16%
PAR	4,01–6,99	4	16,7%	2	8%
NAR	≤ 4	17	70,8%	18	72%
TOTAL OF STUDENTS		24	100%	25	100%

Note. - Own elaboration (2025) based on information taken from (Ministerio de Educación del Ecuador, 2016)

A detailed analysis of the responses in Table IV revealed that questions related to fraction simplification and addition/subtraction of homogeneous and heterogeneous fractions were the most complex for students. For example, in

the control group, only 6 students answered question 1 correctly, and 4 answered question 10 correctly. These data confirm that the initial level of knowledge in fraction operations was low in both groups.

Table III: Pre-test results for the control group and the experimental group

Question	Control Group Correct	Control Group Incorrect	Experimental Group Correct	Experimental Group Incorrect
P1	6	18	8	17
P2	5	19	4	21
P3	6	18	6	19
P4	5	19	7	18
P5	5	19	5	19
P6	7	17	7	18
P7	4	20	5	20
P8	3	21	4	21
P9	5	19	8	17
P10	4	20	3	22

Note. - Own elaboration (2025)

3.2 Inferential Analysis and Normality Testing

A normality test (Shapiro-Wilk) was performed to determine if the data followed a normal distribution. The results (Table IV) showed that the Pre-test and Post-test scores in both groups

did not come from a normal distribution ($p < 0.05$), except in the Post-test of the control group ($p = 0.02$). Because of this, the nonparametric Mann-Whitney U test was used to compare the groups.

Table IV: Normality Test Results

Normality test	Shapiro-Wilk	Statistic	gl	24 Say.
CALPREEXP	,754	24	,000	
CALPOSEX	,519	24	,000	
CALPRECON	,682	24	,000	
CALPOSCON	,898	24	,020	

The Mann-Whitney U test in Tables V and VI showed no significant differences between the groups in the Pre- test ($p = 0.457 > 0.05$), confirming that both groups had a similar level of initial knowledge. This supports what has been stated by (Rodríguez et al., 2020), who indicate that prior knowledge is usually homogeneous in comparable groups.

Table V: Mann-Whitney test ranges (Pre-test).

Group	Mean Rank	Sum of Ranks
Control	26.44	634.50
Experimental	23.62	590.50

Table VI: Mann-Whitney test statistics (Pre-test).

Statistic	Value
Mann–Whitney U	265.50
Wilcoxon W	590.50
Z	-0.743
Asymptotic Sig. (2-tailed)	0.457
Exact Sig. [$2 \times$ (1-tailed Sig.)]	0.100

3.3 Course Design at Khan Academy

The course at Khan Academy was structured around seven themes, using resources such as videos, exercises, and quizzes. Table VII shows that 65% of the resources were videos, followed by exercises (22%) and tests (13%). The criteria for selecting the videos (Table VIII) included clarity in explanation, use of appropriate mathematical language, and adaptation to the students' available time.

Table VII: Number and type of resources used in the course.

Resources used	Quantity	Percentage
Videos	35	65%
Exercises	12	22%
Testing	7	13%

Table VIII: Selection criteria for videos.

Resource Type	Present on the Platform	Selected Videos	Selection Criteria
Videos	12	3	Establish the meaning and use of fractions.
	5	2	Performs fraction simplification.
	4	1	Identify homogeneous fractions.
	4	1	Identify heterogeneous fractions.
	4	1	Performs the reading and graphic representation of fractions.
	1	1	Performs the reading and graphic representation of the sum of fractions of equal denominator.
	1	1	Performs the addition of homogeneous fractions.

Resource Type	Present on the Platform	Selected Videos	Selection Criteria
	1	1	Performs the subtraction of homogeneous fractions.
	1	1	Performs fraction simplification.
	2	2	Performs the subtraction of heterogeneous fractions.
TOTAL	35	14	

The exercises (Table IX) and tests (Table X) were chosen to promote specific competencies, such as simplifying fractions and solving operations with homogeneous and heterogeneous fractions.

Table IX: Mann-Whitney test statistics (Pre-test).

Resource Type	Present on the platform	Practical exercises chosen	Selection criteria
	3	3	Establish the meaning, and use of fractions.
	1	1	Performs fraction simplification.
	1	1	Identify homogeneous fractions.
	1	1	Identify heterogeneous fractions.
Exercises	1	1	Performs the reading and graphic representation of fractions.
Practical	1	1	Performs the reading and graphic representation of the sum of fractions of equal denominator.
	1	1	It performs the addition of homogeneous fractions.
	1	1	It performs the subtraction of homogeneous fractions.
	1	1	Performs fraction simplification.
	1	1	It subtracts heterogeneous fractions.
TOTAL	12	12	

Table X: Selection criteria for the tests.

Resource Type	Present on the Platform	Selected Tests	Unit Selection Criteria
1	1	1	Establish the meaning and use of fractions.
1	1	1	Performs fraction simplification.
1	1	1	Identify homogeneous fractions.
1	1	1	Identify heterogeneous fractions.

Resource Type	Present on Platform	the Selected Tests	Unit Selection Criteria
1	0	0	Performs the reading and graphic representation of fractions.
1	0	0	Performs the reading and graphic representation of the sum of fractions of equal denominator.
0	0	0	Performs the addition of homogeneous fractions.
0	0	0	Performs the subtraction of homogeneous fractions.
0	0	0	Performs fraction simplification.
1	1	1	Performs the subtraction of heterogeneous fractions.
TOTAL	7	5	

3.4 Post-test Results and Group Comparison

After the intervention, a Post-test was applied to both groups. The results (Table XI) showed a significant improvement in the experimental

group: 88% reached the DAR level, while only 25% of the control group achieved this level. In addition, the average of the experimental group was 9.63/10, compared to 6.04/10 of the control group (Figure I).

Table XI: Post-test results (frequencies and percentages by learning levels).

QUALITATIVE LEVELS	QUANTITATIVE SCALE	Control Group		Experimental Group	
		FREQUENCIES	PERCENTAGE	FREQUENCIES	PERCENTAGE
DAR	9.00 -10.00	6	25%	22	88%
AAR	7.00 - 8.99	5	21%	3	12%
PAR	4.01 - 6.99	13	54%	0	0%
NAR	<=4	0	0%	0	0%
TOTAL NUMBER OF STUDENTS		24	100%	25	100%

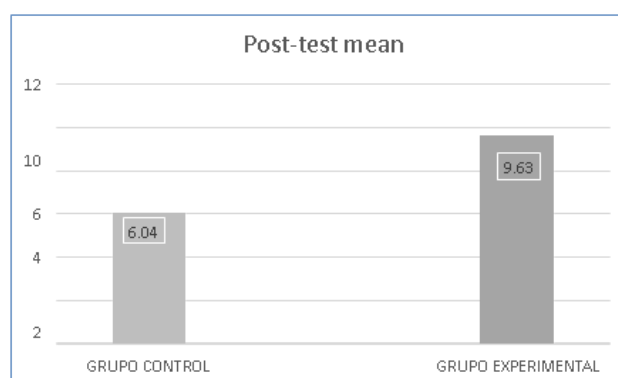


Figure I: Average of the Post-test (control vs. experimental group).

The Mann-Whitney test (Tables XII and XIII) confirmed that the differences between the groups were statistically significant ($p = 0.000 < 0.05$), which allowed us to reject the null hypothesis (H_0) and accept that the use of Khan

Academy generated significant learning. These findings coincide with (Vivar-Espinoza y Erazo-Álvarez, 2021), who emphasize that the platform motivates students and transforms learning into a dynamic process.

Table XII: Mann-Whitney test ranges (Post-test).

Ranks				
Rating Post-test	Students Group Experimental	N Range	Average	Sum of ranks
	Control Group	25	34,10	818,50
	EXPERIMENTAL CONTROL	24	16,26	406,50
	Total	49		

Table XIII: Mann-Whitney test statistics (Post-test).

Test statisticians

Post-test Rating of the Control Group - Experimental

U de Mann-Whitney 81,500

W de Wilcoxon 406,500

Z -4,665

Asymptotic sig. (bilateral) ,000

a. Grouping variable: Student Experimental Group and Control Group

3.5 Comparativa Pre-test vs. Post-test

In the control group (Table XIV and Figure II), although there was an improvement (25% in ARD vs. 0% initial), the results were less

impressive than in the experimental group. This reinforces the conclusion that Khan Academy is more effective than traditional methods for teaching fraction operations.

Table XIV: Pre-test and Post-test comparison of the control group.

CONTROL GROUP		PRE-TEST		POST -TEST	
QUALITATIV	QUANTITATIV	STUDENTS	PERCENTAG	STUDENT	PERCENTAG
E LEVELS	E SCALE		E %	S	E %
DAR	9.00 -10.00	0	0%	6	25%
AAR	7.00 - 8.99	3	12,5%	5	21%
PAR	4.01 - 6.99	4	16,7%	13	54%
NAR	<=4	17	70,8%	0	0%
TOTAL NUMBER OF STUDENTS		24	100%	24	100%

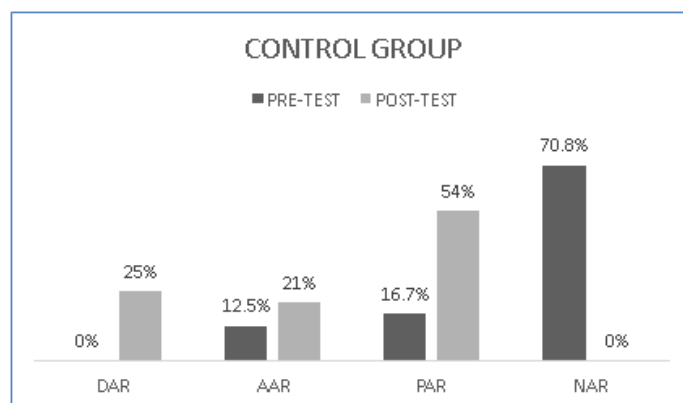


Figure II: Qualitative percentage distribution of the control group (Pre-test vs. Post-test).

Research demonstrates that Khan Academy's platform serves as a powerful instrument to improve understanding of operations involving fractions among students in rural settings. The performance metrics of the experimental cohort were markedly higher than those of the control cohort, which corroborates the hypothesis that open educational resources can facilitate more impactful and engaging learning experiences. These results have important ramifications for the incorporation of educational technologies in contexts limited by limited resources.

Discussions

The findings derived from this research provide compelling evidence on the effectiveness of the Khan Academy platform as an open educational resource (OER) aimed at improving understanding of operations involving fractions among eighth-graders residing in rural regions. The results indicate that the experimental cohort, using the platform, achieved 88% proficiency in required learning outcomes (DAR), in contrast to only 25% proficiency observed in the control group that adhered to traditional pedagogical methods (see Table XI). This remarkable disparity ($p = 0.000$, see Table XIII) corroborates the proposition that open educational resources can effectively transcend the limitations associated with conventional methodologies in resource-limited settings, as postulated by the Faculty of Educational Resources. Farfán-Pimentel et al. (2022), who underline the transformative potential of such tools to make the educational experience more dynamic and engaging.

One of the main contributions of this research is the foundation of a pedagogical framework based on systematically organized digital resources, in which video content constituted 65% of the materials used (Table VIII). The meticulous selection of these resources, which emphasizes explanatory accuracy and alignment with individual learning speeds (Table IX), aligns with the statements by Mayer (2014) on the fundamental role of multimedia design in the understanding of complex concepts. In addition, the incorporation of interactive exercises (22%) and self-assessment assessments (13%) reinforces the premise that immediate feedback is essential for meaningful learning outcomes (Hattie & Timperley, 2007), particularly in contexts where access to specialized educators is limited.

From a methodological point of view, this research demonstrates its robustness by employing nonparametric statistical analyses (Mann-Whitney U) to evaluate groups characterized by non-normative distributions (Table IV). a methodology supported by Field (2018) in the context of research with limited sample sizes. The findings not only corroborate the initial homogeneity observed between the groups (p

$= 0.457$ in the pre-test, table 10), but also shed light on the different effects of the technological intervention, thus corroborating previous research, such as that carried out by Gray & Holyoak (2021) on the consistency of prior knowledge in analogous contexts.

In the future, this research proposes several

avenues for further research. First, it would be beneficial to examine the scalability of the model across various educational levels or STEM domains, as Lin & Powell (2022) They clarify that foundational math skills are indicative of success in scientific fields. In addition, the fusion of Khan Academy with gamification (Triantafyllou et al., 2025) or artificial intelligence (Luckin et al., 2016) It has the potential to improve the personalization of learning experiences, particularly among populations characterized by linguistic or cultural heterogeneity. Another interesting avenue of exploration involves examining hybrid models that integrate resource-enhanced activities (OER) with educator-led, face-to-

face instructional sessions. This approach is consistent with the conceptualization of Hamilton et al. (2016) of the SAMR framework, in which technology not only supplants but also transforms pedagogical methodologies. In addition, longitudinal research could assess the sustained effects on student retention and achievement metrics on standardized assessments, addressing a shortcoming noted by Okoye et al. (2023) in its analyses of the REA in the context of Latin America.

Ultimately, this study underscores the imperative for public policies that promote the professional development of educators in the use of Open Educational Resources (OER) and the establishment of localized repositories adapted to regional curriculum standards, as recommended by the UNESCO (2019) in its framework of inclusive education. Effective technology integration, when executed with a robust pedagogical framework, has the potential to serve as a conduit for educational equity; however, it needs institutional structures that guarantee its long-term viability.

Conclusions and Recommendations

The following general conclusions can be drawn from the exhaustive body of research carried out: After passing the exam prior to the start of the curricular unit on fractions, eighth-grade students enrolled in

Basic General Education had considerable difficulties in acquiring the skills related to the addition and subtraction of homogeneous and heterogeneous fractions. In essence, the students did not achieve the required learning outcomes, as evidenced by the performance of the control group, 71%, and that of the experimental group, 72%. Consequently, it is imperative to identify an alternative solution through a pedagogical intervention that incorporates various educational technological resources, with the aim of improving the academic performance of students.

The implementation of the Khan Academy platform facilitated the improvement of learning in the fractional operations unit for eighth-grade students residing in rural areas, specifically those in the experimental group, who obtained better academic results compared to the control group. This statement is supported by the findings derived from inferential statistics; therefore, the null hypothesis is rejected, while the alternative hypothesis is affirmed, which indicates that the use of the Khan Academy platform as an open educational resource generates significant learning about the operations of addition and subtraction of fractions among students in rural contexts.

Khan Academy's platform allowed students to cultivate confidence, resolve, encouragement, and motivation throughout their teaching-learning process within the fraction unit, while fostering essential learning skills such as comprehension, identification, calculation, and interpretation. In other words, it offers substantial support for students' educational development, as well as facilitating the teacher's role as a coordinator of collaborative efforts.

Students who participated in the experimental group reaped the benefits associated with utilizing Khan Academy's platform, as the educator can monitor interactions through various means, such as watching instructional videos, conducting hands-on exercises, or administering unit assessments. All these

activities are facilitated by the reports generated by the platform, which serve to implement feedback mechanisms and academic reinforcement strategies. Educational establishments can consider the Khan Academy platform as a valuable resource and support mechanism to facilitate students' understanding of mathematics. In the same way, the integration of mathematical skills in the management documentation within the framework of the Institutional Educational Project (PEI) is taken into account; These competencies allow students to gain a deeper understanding of mathematical challenges and consequently solve them in a simple and practical way depending on the different contexts.

Educators from various disciplines and educational levels are encouraged to employ this

tool using various organizational methodologies, either individually, in pairs, or within groups, to serve as a framework to foster collaborative efforts among students, thereby cultivating the competencies needed to address mathematical challenges, particularly fundamental arithmetic operations, which form the essential basis for tackling any type of mathematical problem.

Administrators of educational institutions should organize training sessions and seminars to effectively integrate Khan Academy into their pedagogical practices, taking into account students' academic achievements, developmental progress, and instructional methodologies. This is imperative, as the four core learning competencies are the main pillars in mathematics, and the impact of Khan Academy on the achievement of these competencies has been demonstrated.

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