Migration Letters

Volume: 20, No: S11(2023), pp. 767-778

ISSN: 1741-8984 (Print) ISSN: 1741-8992 (Online)

www.migrationletters.com

Khan Academy Platform for Mathematics Teaching and Learning

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Abstract

Objective: To assess the impact of Khan Academy on the Mathematics educational process for UNDAC students and determine the relevance and efficacy of its content and strategies within the Mathematics-Physics program. Methodology: This research is framed within the positivist paradigm and takes on a quantitative approach. An experimental pre-experimental design was used with pretest and posttest in a single group. The study is applied in nature and is grounded in the contributions of expert researchers and methodologists on the subject. Analytical tools were developed with a reliability coefficient of 0.90, and the investigated population consisted of students from the Mathematics-Physics program at UNDAC. Results: Students who incorporated Khan Academy exhibited significant improvements in their mathematical performance. Persistence in using the platform led to significant enhancements in academic achievement. 70 % of the students reached high levels of mathematical skill development. The majority expressed high satisfaction with the platform. Conclusions: Khan Academy has a meaningful and positive impact on mathematics learning among university students at UNDAC. The platform not only promotes content mastery but also fosters learning autonomy. These findings advocate for the adoption of innovative educational technologies in teaching, especially within STEM disciplines.

Keywords: *Khan Academy; Mathematics Education; Learning Autonomy; Teaching-Learning; Higher Education Mathematics.*

1. Introduction

The future of education is glimpsed on a horizon where connectivity and technology converge with global educational goals. Information and Communication Technologies (ICTs), particularly through the internet, are redefining how we learn, regardless of geographical barriers. The recent transition from face-to-face university education to virtual modalities, driven by the COVID-19 pandemic, has been supported by regulatory frameworks such as Board of Directors Resolution No. 039-2020-SUNEDU-CD, Vice-

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Ministerial Resolution 087-2020-MINEDU, Supreme Decree No. 014-2021-MINEDU, Directive No. 006-2021-DPU/VRAC UNDAC and Directive No. 007-2021-DPU/VRAC. These guidelines reflect the joint effort to adapt to the new normal, underlining the importance of ICT in education. Thanks to the proactive participation of teachers and students, it is feasible to guarantee excellent professional training, even in challenging circumstances such as the current ones.

In this context, teaching and learning have undergone remarkable transformations in recent times, accentuated by unexpected events such as the COVID-19 pandemic. Thus, the closure of schools in Catalonia, implemented to curb the spread of the virus, posed significant challenges in adapting to a changing educational environment. Their study indicates that learning opportunities during confinement were influenced by socioeconomic and cultural factors, generating inequalities in educational access (Bonal Sarró & González, 2021).

Likewise, research based on the design of Teaching-Learning Sequences has been positioned as a trend in science teaching, it has been established as an essential resource to understand and optimize educational processes. The transition to digital platforms and the adoption of new pedagogical paradigms have been crucial in this approach to teaching (Guisasola et al., 2021).

1.1. Literature Review

Pérez Armijo (2021) makes a valuable contribution to the development of new didactic strategies for mathematics learning, a perspective that aligns with one of the central objectives of our research. The author concludes that, in the context of the pandemic and with the support of the Khan Academy (KA) platform, it is essential to innovate in didactic strategies, such as the flipped classroom. This proposal is especially relevant for students of the zeta generation, who are immersed in digital environments (Pérez Armijo, 2021). These strategies not only encourage meaningful learning and improve math skills, but also enhance social skills by allowing interaction and socialization of learning.

Recent research highlights the positive influence of the Khan Academy platform on mathematical learning, a point that coincides with the main objective of our research. The authors conclude that Khan Academy has reinvigorated students' interest in mathematics, moving them away from traditional approaches and promoting meaningful and innovative learning (Pacuruco-García et al., 2020). The platform has transformed content that was previously perceived as monotonous into dynamic learning experiences (p.418). Researchers highlight the advantages of Khan Academy, arguing that the platform, through its interactive videos, offers students direct and unrestricted access to study material (Santos & Santos, 2021). In this context, the role of the teacher is transformed, becoming a mediator in the processes and forms of teaching.

Current remote education shows that platforms such as Khan Academy promote innovative teaching strategies, such as the flipped classroom, to strengthen mathematical competencies. It is essential to adapt to this reality and take advantage of technological resources as pedagogical tools. Khan Academy as an organization that grew out of one man's initiative to help his nieces and nephews and now has a diverse team of more than 150 professionals committed to providing free quality education globally. This platform incorporates theories such as connectivism and meaningful learning, leveraging technology for teaching mathematics (Khan Academy, 2023).

The Flipped Classroom is understood as a pedagogical approach that inverts the traditional teaching process and shows an innovative and useful way for learning management (Reynosa Navarro et al., 2020). Students prepare beforehand at home and the most complex topics are addressed in class. The aim of this methodology is to optimise time in the classroom, attending to the individual needs of students and

encouraging collaborative work. In this model, the teacher acts as a guide and advisor, providing resources and feedback.

Mathematics is an inexhaustible source of problems that defy intuition. However, facing these challenges prepares the individual to solve similar situations in daily life, even if they present themselves in more sophisticated ways (Paenza, 2012). The mathematical contents are based on the Curriculum 2017, Mathematics-Physics syllabus (Universidad Nacional Daniel Alcides Carrión, 2017). The methodology used is problem-solving, supported by recent research emphasizing the importance of problem solving as a means of improving mathematical learning outcomes (Kul & Çelik, 2020).

Khan Academy is an educational platform that provides a wide variety of resources, including videos, articles, and exercises in mathematics, allowing users from all over the world to learn at their own pace. Although it encompasses areas such as economics, computer science, physics, biology and chemistry, our main focus is the Mathematics. This tool is especially relevant for students of the Mathematics-Physics study program at the Universidad Nacional Daniel Alcides Carrión (UNDAC). Given the university's transition from face-to-face to virtual education, Khan Academy becomes an essential resource in achieving the program's goals. The platform is free, available in Spanish, and only requires an internet connection to access. For ease of use, Khan Academy offers a detailed manual (Khan Academy, 2023).

The research aimed to explain the influence of Khan Academy on the teaching-learning process of Mathematics for UNDAC students. The aim was to validate the contents and strategies of the platform to improve the teaching of Mathematics. In addition, research instruments were designed and validated to determine the impact of this tool in areas such as formative research, university social responsibility and mathematical training in the Mathematics-Physics curriculum.

2. Materials and methods

2.1. Design

The research is framed in the positivist paradigm, responds to a quantitative approach, with a pre-experimental experimental design with pretest and posttest in a single group (Ñaupas Paitán et al., 2014). It was of an applied type, based on the contributions of researchers and methodologists who are experts in the field (Carrasco, 2016; Quesada Lucio, 2015).

2.2. Population and sample

The study population was composed of 78 students of the Mathematics-Physics program of the Daniel Alcides Carrión National University, located in Cerro de Pasco, during the year 2021. From this group, a non-probabilistic sample of 19 students of the VI semester of the subject of didactics of Mathematics-Physics was selected. The research stood out for working with a sample of 19 students out of a total population of 78. 10 learning sessions, both synchronous and asynchronous, of four hours each were conducted over ten weeks, exclusively using the Khan Academy platform. Content and strategies of the platform that coincided with those of the subject and that responded to the needs and interests of the students were selected and validated. Finally, the results of the pretest and posttest applied to the research group were compared. Scientific, experimental, statistical, inductive, descriptive and deductive methods were also used. Data collection techniques included surveys and observations, using questionnaires, pretest and posttest as instruments.

2.3. Data Processing

The items were designed based on the operationalization of the investigated variables. The validity of the instruments was determined by expert judgment, and their reliability was established with Cronbach's alpha, using SPSS version 27 software, obtaining a reliability coefficient of 0.90.

2.4. Methodological sequence applied to the development of the learning sessions

Figure 1 Learning session model (in methodological sequence format) used during the study. In original Spanish language.

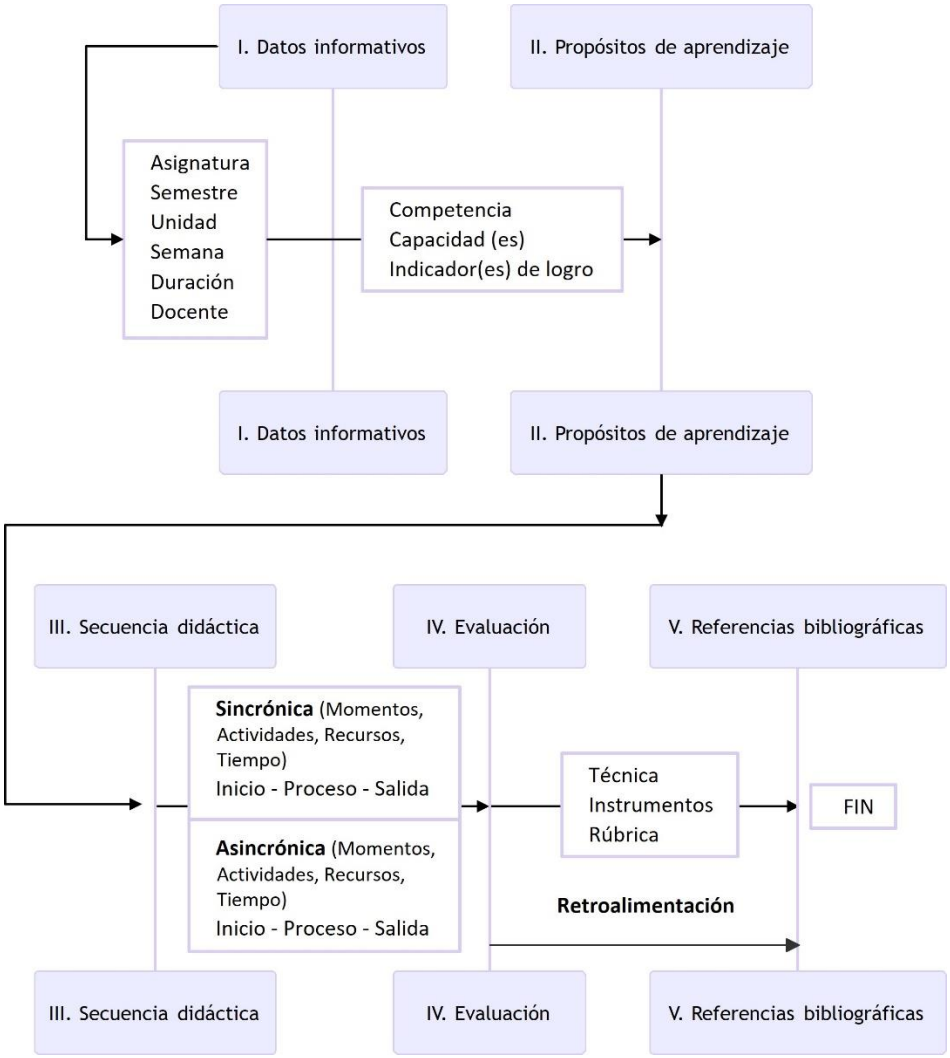


Figure 1 standardizes a detailed outline of the Methodological Sequence, designed to structure and optimize the educational process, transcending beyond a simple session model. This sequence is structured by "Informational Facts", which provide essential context about the subject, the semester, the unit, the week, the duration and the teacher in charge. Next, the "Learning Purposes" are outlined, which define the competencies, capabilities, and achievement indicators that students must achieve. The "Didactic Sequence" is bifurcated into synchronous and asynchronous components, detailing the associated moments, activities, resources, and times. It is crucial to note that this sequence is evaluated on an ongoing basis, allowing constant feedback with the aim of corroborating the effective transfer of knowledge. Subsequently, the "Assessment" section outlines the techniques and instruments that will be used to measure student progress and understanding. Finally, the model concludes with a list of "Bibliographic References", ensuring academic integrity and proper attribution. This visual

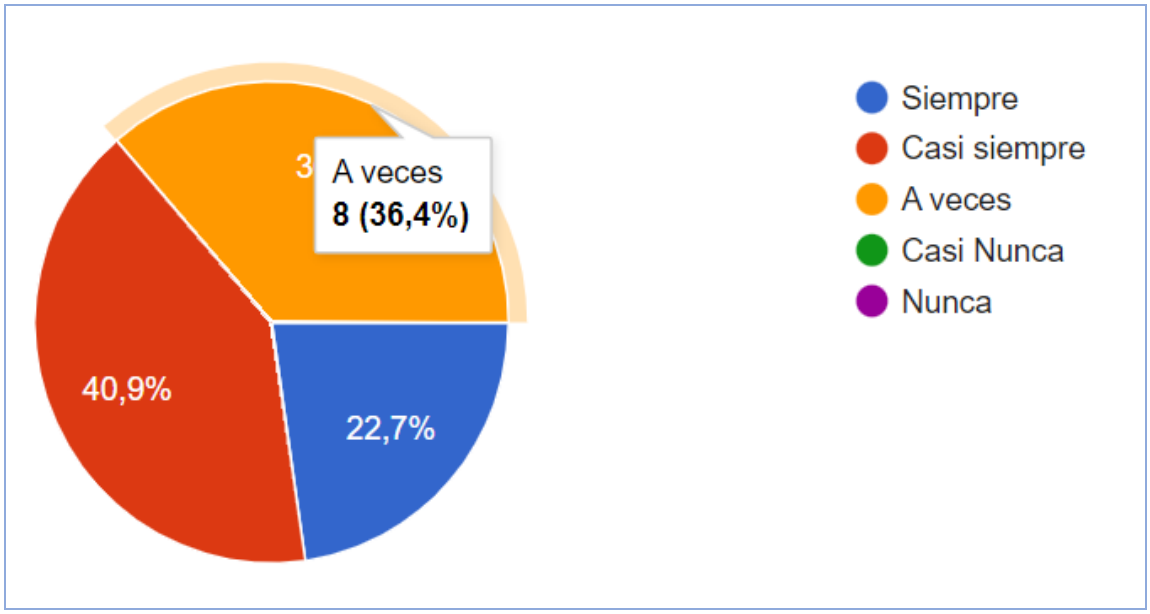
representation serves as a guide for educators, while also underscoring the depth and rigor of the pedagogical approach adopted in this study.

2.5. Ethical Considerations

The ethical considerations of this study are based on the fundamental principles set out in the Declaration of Helsinki and the Nuremberg Code. All participants provided informed consent before being included in the research, ensuring their voluntariness and understanding of the purpose and procedures of the study. The privacy and confidentiality of the information collected was ensured, respecting at all times the integrity, autonomy and human rights of the participants. In addition, care was taken to minimise any risk or discomfort associated with the intervention, committing to transparency and sharing the findings in a comprehensive and truthful manner (Carlson et al., 2004; Merz, 2018).

3. Results

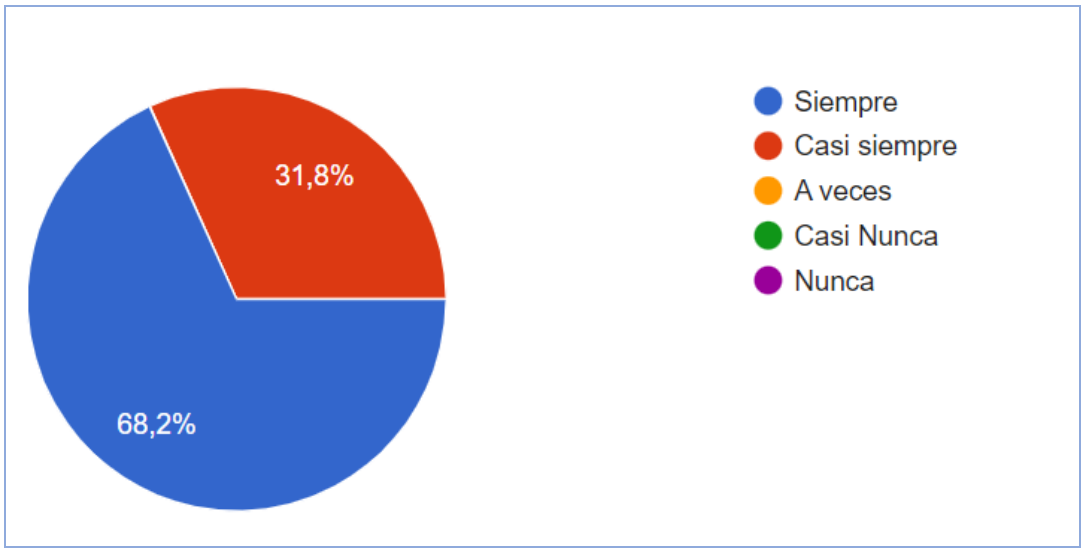
Figure 2 Use of the Khan Academy platform in the teaching and learning of Mathematics-Physics. In original Spanish language.



Source: Questionnaire on the use of the Khan Academy platform applied to students. Archive of the group of researchers

Figure 2 shows that approximately 64% of respondents use the Khan Academy platform for mathematics teaching and learning, while 36% use it occasionally.

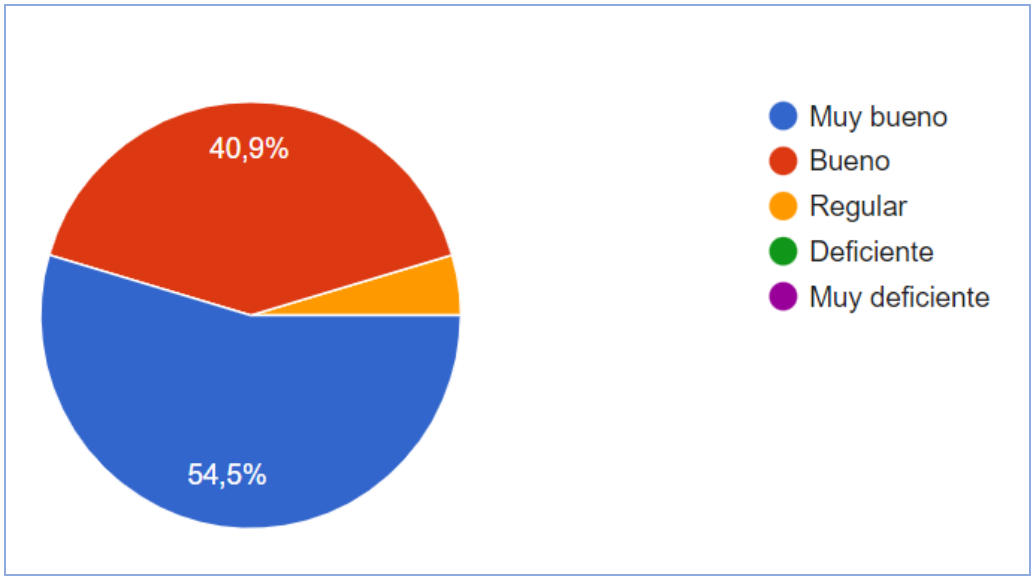
Figure 3 Influence of the use of the Khan Academy platform on the teaching and learning of Mathematics-Physics. In original Spanish language.



Source: Questionnaire on the use of the Khan Academy platform applied to students. Archive of the group of researchers

Figure 3 shows that 68% of students consider that the use of the Khan Academy platform always has a positive influence on the teaching and learning of mathematics and physics.

Figure 4 Appreciation of the Khan Academy platform by the students who used it. In original Spanish language.



Source: Questionnaire on the use of the Khan Academy platform applied to students. Archive of the group of researchers

The figure shows that 95% of students rate the use of the Khan Academy platform as good or very good. In addition, these same students recommend its use for their classmates in the Mathematics-Physics study program of the Daniel Alcides Carrión National University.

Table 1 Basic pretest and posttest statistics

Statistical		Pretest	Postest
N	Valid	19	19
	Lost	0	0
Stocking		11,16	17,89
Median		12,00	20,00
Fashion		14	20
Standard deviation		3,420	5,174
Variance		11,696	26,766
Asymmetry		-,970	-2,849
Standard Asymmetry Error		,524	,524
Kurtosis		1,219	8,270
Standard Kurtosis Error		1,014	1,014
Minimal		2	0
Maximum		16	20
Percentiles	25	8,00	20,00
	50	12,00	20,00
	75	14,00	20,00

Source: Pre- and post-test tests carried out by the students selected in the sample. Data provided by the researchers.

In the context of this study, an exhaustive descriptive analysis of the data collected both in the pretest and in the posttest was carried out, with the purpose of evaluating the impact of the use of the Khan Academy educational platform on the mathematics learning process among students enrolled in the mathematics-physics study program of the Daniel Alcides Carrión National University. The results revealed a significant improvement in math learning after the intervention with Khan Academy. In the pretest, the mean score was 11.16, but in the posttest, this figure increased substantially to 17.89, indicating a substantial advance in knowledge. In addition, the median increased from 12:00 to 20:00 in the posttest. The mode in both groups was 20, reflecting the prominence of this score. However, the greater dispersion and concentration around the mean in the posttest were reflected in a higher standard deviation and kurtosis. These findings suggest that the utilization of Khan Academy had a positive effect on the mathematics learning of the participating students, supporting the hypothesis that this platform may be an effective tool in the teaching of mathematics in a university context.

The normality test was performed emphasizing the results obtained: from the pretest and posttest and with the help of the SPSS version 25 statistical software. You have the proof in the following table:

Table 2 Normality Test Results

Normality Tests

	Groups	Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistical	Gl	Gis.	Statistical	Gl	Gis.
Results	And	,218	19	,018	,880	19	,022

	S	,447	19	,000	,487	19	,000

aLilliefors Signification Correction

In this study, normality tests were performed to evaluate the distribution of data in groups E (Experimental) and S (Control). For group E, the Kolmogorov-Smirnov statistic was 0.218 (gl = 19) with a significance of 0.018, while the Shapiro-Wilk statistic was 0.880 (gl = 19) with a significance of 0.022. In group S, the results showed a Kolmogorov-Smirnov statistic of 0.447 (gl = 19) with a significance of 0.000 and a Shapiro-Wilk statistic of 0.487 (gl = 19) with a significance of 0.000. These results indicate that the data in both groups do not follow a normal distribution, as the significance values are lower than a typical significance level of 0.05. In addition, the Lilliefors significance correction was applied to address any potential deviation from normal in the data.

Table 3 Homogeneity test results

Variance Homogeneity Test

		Levene Statistician	GL1	GL2	Gis.
Results	It is based on the average	,301	1	36	,587
	It is based on the median	,242	1	36	,626
	It is based on the median and with adjusted gl	,242	1	23,933	,627
	It is based on the cropped average	,002	1	36	,966

A test of homogeneity of variance was carried out to assess whether the variances of the groups were statistically equal. The Levene statistic was used in different configurations, including those based on the mean, median, and clipped mean. For the mean-based test, the statistic was 0.301 with 1 degree of freedom for the numerator and 36 degrees of freedom for the denominator, with a significance value of 0.587. Similarly, the median-based test yielded a statistic of 0.242 with 1 degree of freedom for the numerator and 36 degrees of freedom for the denominator, with a significance value of 0.626. The median-based test with adjusted degrees of freedom resulted in a statistic of 0.242 with 1 degree of freedom for the numerator and 23.933 degrees of freedom for the denominator, with a significance value of 0.627. Finally, the test based on the trimmed mean showed an extremely low statistic of 0.002 with 1 degree of freedom for the numerator and 36 degrees of freedom for the denominator, and a significance value of 0.966. Taken together, these results indicate that no significant differences in variances were found between the groups, supporting the assumption of variance homogeneity for the study data.

Table 4 Test Statistician for Hypothesis Testing

Test Statisticiansa

	Input & Output Testing
Z	-3,105b
Asymptotic sig. (bilateral)	,002

aWilcoxon's Sign Rank Test

bBased on negative ranges.

Hypothesis testing was carried out using Wilcoxon's signed rank test to assess the difference between input and output samples. The Z-test statistic was -3.105, and the asymptotic (bilateral) significance was 0.002. These results indicate that there is a statistically significant difference between the input and output samples. In particular, the negative value of Z suggests that scores in the output sample were on average significantly lower than those in the input sample. This finding supports the hypothesis that there has been a significant change between measurements made before and after the intervention.

4. Discussion

The study set out to explain how Khan Academy affects the educational process in Mathematics for UNDAC students. An effort was made to corroborate the relevance and effectiveness of the platform's content and tactics in order to enhance mathematical instruction. Likewise, analysis tools were created and certified to evaluate how this platform affects areas such as educational research, the social commitment of the university and mathematical training in the Mathematics-Physics program. The results obtained in this research solidly corroborate the hypotheses proposed, underlining the significant and positive influence that the use of the Khan Academy platform exerts on the teaching-learning process of mathematics in students of the Mathematics-Physics study program of the Daniel Alcides Carrión National University (UNDAC). These findings are consistent with a growing empirical evidence base and align with previous research that has examined the impact of Khan Academy in similar educational contexts.

In line with the results presented by Perez Armijo (2021), the present research confirms that students who have incorporated Khan Academy as an educational support resource have achieved notable improvements in their performance in mathematics. The concordance of these results with previous research is a strong indication of the consistency and replicability of Khan Academy's positive effects on academic performance.

The results of an examined research underline that students' perseverance in using Khan Academy triggers substantial improvements in academic performance. This study goes even deeper by revealing statistically significant differences in scores, at both low and high levels of distribution (Santos & Santos, 2021). This suggests that Khan Academy not only benefits students who struggle to comprehend mathematical concepts, but also offers advantages to those seeking further skill development in the subject.

The findings of recent research confirm the effectiveness of Khan Academy by highlighting that 70% of the students who participated in the study achieved high levels of skill development in mathematics (Mota-Macías et al., 2022). This finding reinforces the notion that Khan Academy not only improves learning overall, but also fosters mastery and proficiency in the area of mathematics, which is essential for students' academic and professional training.

A critical evaluation of students' perception of Khan Academy is crucial, as it demonstrates that the platform not only delivers high-quality and relevant content, but also achieves a high degree of satisfaction among users (Lasso Cardona & Conde Rodríguez, 2021). The fact that the vast majority of students give high ratings to Khan Academy reinforces the idea that this platform presents itself as a wise choice for the enrichment of the learning experience.

Finally, another fundamental aspect: the use of Khan Academy not only boosts learning in mathematics, but also promotes student autonomy and appreciation for the learning process (Vidergor & Ben-Amram, 2020). This autonomy and willingness to learn on one's

own are essential skills in an ever-changing world, where the continuous acquisition of knowledge is an imperative.

Taken together, the results of this research and the previous research analyzed point to a compelling conclusion: the use of Khan Academy is a highly effective strategy to improve mathematics learning in college students. This conclusion transcends the limitations of this specific study and suggests that the implementation of technological resources such as Khan Academy in educational settings can contribute significantly to the achievement of more robust and effective teaching and learning objectives. These findings have important implications for the education community and should motivate educators and policymakers to consider the use of innovative educational technologies as an effective means of fostering learning in STEM (Science, Technology, Engineering and Mathematics) disciplines and beyond.

Proposal

Based on the results of this study, a comprehensive strategy for learning mathematics using Khan Academy in an educational context, whether face-to-face, blended or virtual, is proposed. This strategy has been carefully designed to maximize the benefits of using Khan Academy and is summarized in the following steps:

1. Custom Content Selection: Students will start by selecting courses, units, and lessons on the Khan Academy platform, accessing a wide range of resources, such as videos, articles, exercises, and problems. This stage ensures that students have access to content that is relevant and appropriate to their individual needs.

2. Flipped Classroom Implementation: The strategy promotes the implementation of a flipped classroom approach. Students will work independently or in groups to internalize the information provided by Khan Academy, under the guidance and active supervision of the teacher. This approach encourages active participation and engagement with the content.

3. Exercise and Problem Solving: Students will tackle exercises and content-related problems individually first, and then be encouraged to work in groups to tackle more complex challenges. This methodology encourages collaboration and critical thinking.

4. Verification of Results in Khan Academy: Students will be able to check their answers using the Khan Academy platform. This provides an opportunity for self-assessment and immediate feedback, facilitating the process of autonomous learning and correction of errors.

5. Personalized Feedback: In the event that students require corrections or clarifications, personalized feedback will be provided by the teacher. This ensures that each student can address their specific areas of difficulty and make effective progress in their learning.

This strategy combines Khan Academy's flexibility and personalized approach with the guidance and pedagogical support provided by the teacher. By allowing students to be the protagonists of their own learning while providing a solid structure, this strategy has the potential to significantly transform the teaching-learning process of mathematics, providing students with the tools necessary to reach a strong level of proficiency and a lasting appreciation for this discipline

Contribution to scientific knowledge

The research presents an essential contribution to the academic field by empirically validating the positive influence of technological tools, in particular, the Khan Academy platform, in the strengthening of the teaching and learning process of mathematics in the university context. This validation not only reaffirms the initial hypotheses, but also broadens the understanding of the effective integration of educational technologies into

conventional academic programs, thus enhancing student achievement. Additionally, the study emphasizes the relevance of fostering autonomy in learning, a key element in contemporary pedagogy. Taken together, these findings provide fresh insight into the teaching and learning of mathematics and set a precedent for future research and applications in the education sector.

5. Conclusions

The findings of this research corroborate the positive and significant impact of the Khan Academy platform on the process of teaching and learning mathematics among students of the Mathematics-Physics study program of the Daniel Alcides Carrión National University (UNDAC). These results not only validate the hypotheses raised, but also align with growing empirical evidence and previous studies that have evaluated the efficacy of Khan Academy in analogous educational contexts.

It is remarkable how students who have integrated Khan Academy into their educational process have experienced significant improvements in their performance in mathematics. In addition, the importance of perseverance in the use of the platform is highlighted, evidencing that Khan Academy benefits both students who face difficulties and those who seek to perfect their skills in mathematics.

On the other hand, it is underlined that Khan Academy not only improves learning in general terms, but also promotes mastery and competence in mathematics, essential aspects for the comprehensive education of students. This idea is reinforced by students' positive perception of the platform, which highlights the high quality and relevance of Khan Academy's content.

Finally, the emphasis on promoting student autonomy and their appreciation for self-learning highlights the importance of cultivating essential skills in an ever-evolving world. In this sense, the evidence presented in this research ponders that Khan Academy is an essential tool to enhance the learning of mathematics in the university environment. These findings should inspire the educational community to adopt and promote the use of innovative educational technologies, not only in STEM disciplines, but across the academic spectrum, to achieve more ambitious and effective educational goals.

Thanks

To the students of the VI semester of the Mathematics-Physics study program of the Daniel Alcides Carrión National University (UNDAC), 2021.

Conflict of Interest

The authors declare that they have no conflicts of interest in relation to the research, authorship and/or publication of this article

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