

## Comparative analysis of the Khan Academy virtual college course to improve new students' academic performance in Faculty of Engineering

### Análisis comparativo del curso propedéutico virtual en Khan Academy para mejorar el desempeño académico en estudiantes de nuevo ingreso en Facultades de Ingeniería

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#### Abstract

The low performance of the engineering student is an underlying problem in mathematics subjects, derived from the various situations that surround the student and for which he is exposed to school dropout. However, there are technological learning tools (Khan Academy), which, if well implemented and in a timely manner, at the beginning of their higher education, help to improve the understanding of mathematical and logical concepts in the field of basic sciences and mathematics. especially in the latter, because it contributes greatly to the formation of the Engineer. The comparative analysis of the Virtual College Preparatory Course implemented in the Khan Academy platform over a period of 4 years was carried out, which shows the evolution of the new student, as well as the results with the comparative analysis of the diagnostic and final exam obtained each year. It is notorious reservation of young new students to make use of the various educational platforms on the Internet, however, the comparison suggests a positive impact by the use of these, with the appropriate guidance and experience.

College preparatory course, Khan Academy, Mathematics, E-Learning

#### Resumen

El bajo rendimiento del estudiante de ingeniería es un problema subyacente en las materias de matemáticas, derivado de las diversas situaciones que rodean al alumno y por lo cual se encuentra expuesto a la deserción escolar. Sin embargo, existen herramientas tecnológicas de aprendizaje (Khan Academy), que bien implementadas y de forma oportuna, en el inicio de su educación superior, coadyuva para mejorar la comprensión de los conceptos matemáticos y lógicos en el ámbito de las ciencias básicas y matemáticas, especialmente en esta última, por que contribuye en gran medida a la formación del Ingeniero. Se realizó el análisis comparativo del Curso Propedéutico Virtual implementado en la plataforma Khan Academy en un periodo de 4 años, lo cual muestra la evolución del estudiante de nuevo ingreso, así como los resultados con el análisis comparativo del examen diagnóstico y final obtenido cada año. Es notoria la reserva de los jóvenes estudiantes de nuevo ingreso hacer uso de las diversas plataformas educativas en internet, no obstante, la comparación sugiere un impacto positivo por el uso de estas, con la guía y experiencia adecuada.

Curso propedéutico, Khan Academy, Matemáticas, Aprendizaje virtual

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## Introduction

When students start a new educational level mathematics teachers receive them with uneven knowledge in this area, which were provided in the immediate previous level (Díaz-Perera, Luna-Flores, & Salinas-Padilla, 2019), example of this, is the great diversity of public and private schools in the upper secondary education level, this has a direct impact on the different ways in which educational programs are approached, the lack of homogeneity in knowledge and good independent study habits by students, contributing in a high heterogeneity (Aguirre-Jones, 2020), which affects students in their first semesters in Higher Education Institutions (HEI).

Studies conducted on the decrease of such knowledge show the increase in failure rates mainly in the first semesters in HEIs (Gómez, 2011) (Petríz-Mayen, Barona-Ríos, López Villareal, & Quiroz-González, 2010). Students accepted in IES present low performance due to several factors among which are the massification of the number of students attended per official group, which causes many of the activities of education to lower in quality, such as personalized attention, academic advising and homework review; mainly the evaluation activity, is one of the most affected since the work involved, is multiplied by increasing the number of students, causing a high failure rate (Aguirre-Jones, 2020). "The problem of low student achievement tends to worsen as students are arriving worse prepared than in previous years" (Posso-Agudelo, 2005).

In the training of the Engineer, Mathematics is of utmost importance, because it promotes the development of skills that allow posing and solving practical and theoretical problems inherent to the professional work; this is achieved through the formulation, solution and interpretation of models that represent the behavior of systems in the face of the phenomena of nature (Muñoz-Amariles & Alvarez-Gonzalez, 2015). Therefore, it is justified that employers give the lowest valuation to the analytical and logical capacity of young people to their ability to solve problems, to work autonomously and exercise leadership at work (Martinez-Sánchez & Lara-Gomez, 2019).

Because of this situation, HEIs have developed different strategies to solve this academic trend: such as propaedeutic, virtual or tutoring programs (Díaz-Perera, Luna-Flores, & Salinas-Padilla, 2019).

Propaedeutic courses are one of the tools used by higher level educational institutions that allow leveling incoming students, allowing them to adapt more easily from one level to another (Cosgalla-Barrera, Castro-Villagrán, & Diaz-Rosado, 2019).

Currently, it is important the acquisition of knowledge through the innovation of educational technology, implementing modern methodologies of education, to allow achieving different strategies, techniques and educational processes facilitating learning in the construction of knowledge (Ruiz-Reynoso, Delgadillo-Gómez, Hernández-Bonilla, & Coteria-Regalado, 2018).

There are several online learning platforms, however, one of the most recognized worldwide is the well-known Khan Academy, which has short classes in the form of videos and includes exams and exercises to complement them. The success and recognition it achieves is due to the constancy and frequency of use by the student, which is self-administered at their own pace (Lara-Pinales, Neira-Rosales, & Cedillo-Salazar, 2020). Some studies demonstrated the direct relationship between the use of information technologies and increased academic performance in higher education students, one can also mention the possibility of a relationship between the use of information and communication technologies, self-regulated learning and academic performance (Onivehu, Adegunju, Ohawuiro, & Oyeniran, 2018).

In the Faculty of Engineering of the Autonomous University of Campeche since 2018 the virtual propaedeutic course has been applied, through the online learning platform Khan Academy for incoming students, of the six Bachelor's Degrees in Engineering, due among many reasons for the impossibility of carrying out a face-to-face propaedeutic course or the implementation of a zero semester mainly due to administrative and legal aspects of the University (Canto-Canul, López-Martínez, Salazar-Uitz, & Lezama-Zarraga, 2020).

### Methodology to be developed

Starting in 2018 and year after year, the propaedeutic course has been taught online on the Khan Academy platform to incoming students of the Faculty of Engineering of the Autonomous University of Campeche. The structure of the propaedeutic course is made up of four main topics:

1. Pre-algebra.
2. Fundamentals of algebra.
3. Algebra 2.
4. Trigonometry.

Of which the activities are distributed by the type of educational resource and by the subject to which it belongs Table 1, 2 and 3

| School Cycle<br>2018-2019<br>2019-2020 | Pre-algebra | Fundamentals<br>of algebra | Algebra 2 | Trigonometry |
|--|-------------|----------------------------|-----------|--------------|
| Videos                                 | 13          | 35                         | 19        | 9            |
| Exercises                              | 16          | 27                         | 15        | 7            |
| Questionnaires                         | 3           | 5                          | 5         | 0            |
| Unit Testing                           | 0           | 3                          | 0         | 1            |
| Articles                               | 6           | 6                          | 7         | 5            |
| Subtotals                              | 38          | 76                         | 46        | 22           |
| Total                                  | 182         |                            |           |              |

**Table 1** Structure of the Propaedeutic Course of the 2018-2019 and 2019-2020 school cycle

Source: Own Elaboration

Table 1 shows the activities of the propaedeutic course implemented in the 2018-2019 and 2019-2020 school cycles, including video exercises, questionnaires, unit tests and articles totaling 182 activities.

Table 2 shows the activities of the propaedeutic course taught in the 2020-2021 school year, different from the activities of the two previous years, because some activities have been removed from the platform or the contents were updated, so new activities were selected congruent with the needs of the course, with a total of 168 activities.

| School Cycle<br>2020-2021 | Pre-algebra | Fundamentals<br>of algebra | Algebra 2 | Trigonometry |
|---------------------------|-------------|----------------------------|-----------|--------------|
| Videos                    | 12          | 32                         | 14        | 9            |
| Exercises                 | 16          | 28                         | 13        | 7            |
| Questionnaires            | 3           | 4                          | 2         | 0            |
| Unit Testing              | 0           | 3                          | 0         | 1            |
| Articles                  | 6           | 6                          | 7         | 5            |
| Subtotals                 | 37          | 73                         | 36        | 22           |
| Total                     | 168         |                            |           |              |

**Table 2** Structure of the Propaedeutic Course of the 2020-2021 school cycle

Source: Own Elaboration

Table 3 shows the activities of the propaedeutic course in the 2021-2022 cycle, including video exercises, questionnaires, unit tests and articles for a total of 189 activities, again the contents were updated, but always complying with the initial needs.

| School Cycle<br>2021-2022 | Pre-algebra | Fundamentals<br>of algebra | Algebra 2 | Trigonometry |
|---------------------------|-------------|----------------------------|-----------|--------------|
| Videos                    | 13          | 40                         | 19        | 8            |
| Exercises                 | 16          | 29                         | 15        | 7            |
| Questionnaires            | 3           | 5                          | 3         | 0            |
| Unit Testing              | 0           | 3                          | 0         | 1            |
| Articles                  | 6           | 8                          | 7         | 6            |
| Subtotals                 | 38          | 85                         | 44        | 22           |
| Total                     | 189         |                            |           |              |

**Table 3** Structure of the Propaedeutic Course of the 2020-2021 school cycle

Source: Own Elaboration

The application of a diagnostic test together with a survey before starting the propaedeutic course is relevant because it allowed measuring the level of knowledge of incoming students. The test consisted of 10 problems of medium difficulty and also included six questions as a survey to gather information on the preferences they have regarding study in this modality:

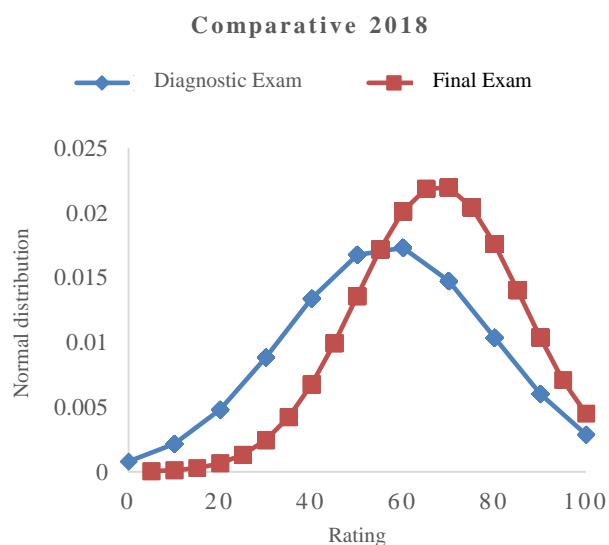
1. What method do you prefer to study?
2. Have you used any of these digital teaching methods?
3. Do you consider that the digital teaching methods have displaced the conventional methods?

4. How do you prefer to take a propaedeutic course?
5. What do you consider to be the main disadvantage of distance learning?
6. What do you consider to be the main disadvantage of studying face-to-face?

After the propaedeutic course to measure the level of knowledge acquired with respect to the diagnostic exam, a final exam was administered with the same difficulty; an exit survey was also included in which opinions were collected regarding the experience and degree of satisfaction with the course in this modality. The two exams were administered by means of Google Forms.

## Results

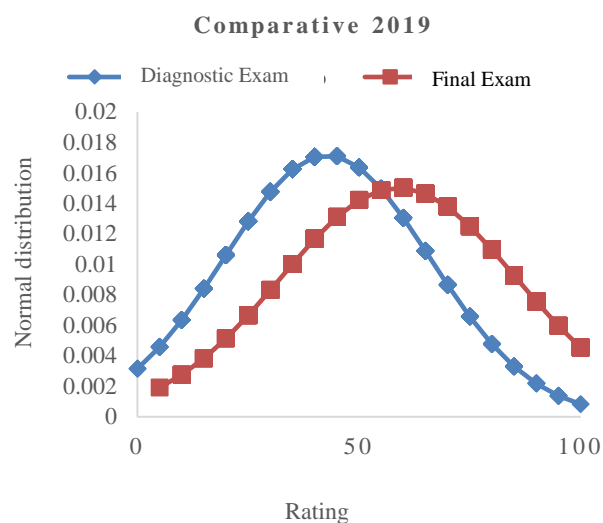
The results were obtained in a period of four years in which the propaedeutic course was applied in the virtual modality.



**Graph 1** Comparative normal distribution of the 2018 diagnostic and final exam

Source: Own Elaboration

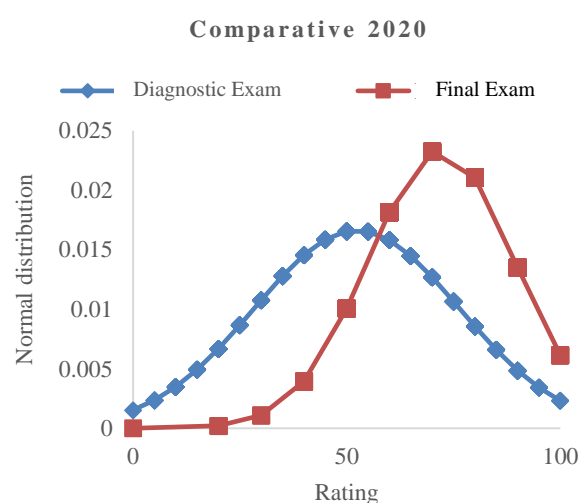
Graph 1 shows the normal distribution of the diagnostic and final exam results, proving that for year 2018 the propaedeutic course caused a positive impact on incoming students, reflected in displacement, with respect to the mean of diagnostic exam grades, of the mean of final exam grades, from 56.7 to 67.8 with an improvement of 11.1 grade points: the curve of the final exam is higher than the curve of the diagnostic exam which indicates that a greater number of students improved their grades.



**Graph 2** Comparative normal distribution of the 2019 diagnostic and final exam

Source: Own Elaboration

Graph 2 shows the normal distribution of the results of the diagnostic and final exam, proving that for the year 2019 the propaedeutic course caused a positive impact on the incoming students, reflected in the displacement, with respect to the mean of the diagnostic exam grades, of the mean of the final exam grades, from 42.8 to 58.9 with an improvement of 16.1 grade points: in this case the curve of the final exams was lower than the curve of the diagnostic exam, however, it is possible to observe a decrease in the number of students who obtained a grade below the average and an increase in the number of students who obtained a grade above the average.

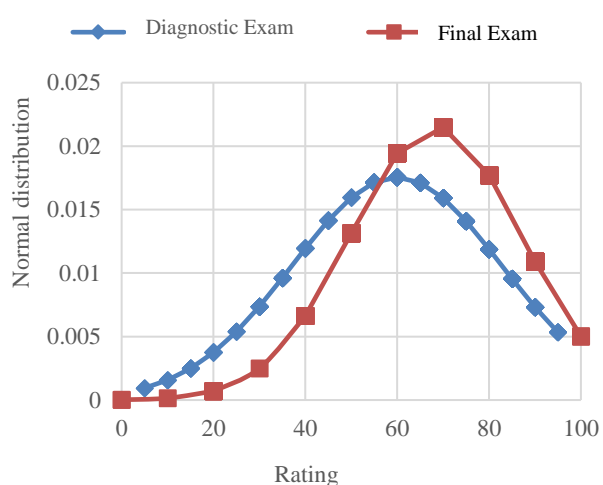


**Graph 3** Comparative normal distribution of the 2020 diagnostic and final exams

Source: Own Elaboration

Graph 3 shows the normal distribution of the results of the diagnostic and final exam, proving that for 2020 the propaedeutic course had a positive impact on the new students, reflected in the displacement, with respect to the mean of the diagnostic exam grades, of the mean of the final exam grades, from 52.4 to 72.1 with an improvement of 19.7 grade points: the curve of the final exam is higher than the curve of the diagnostic exam, which indicates that a greater number of students improved their grades.

**Comparativo 2021**



**Graph 4** Comparative normal distribution of the 2021 diagnostic and final exams  
*Source: Own Elaboration*

Graph 4 shows the normal distribution of the results of the diagnostic and final exam, proving that for 2021 the propaedeutic course had a positive impact on the new students, reflected in the displacement, with respect to the mean of the diagnostic exam grades, of the mean of the final exam grades, from 59.9 to 68.4 with an improvement of 8.5 grade points: the curve of the final exam is higher than the curve of the diagnostic exam, which indicates that a greater number of students improved their grades.

| Diagnostic Examination | Cycle 2018-2019 | Cycle 2019-2020 | Cycle 2020-2021 | Cycle 2021-2022 |
|------------------------|-----------------|-----------------|-----------------|-----------------|
| Media                  | 56.7            | 42.8            | 52.4            | 59.9            |
| Standard deviation     | 22.8            | 23.2            | 24.0            | 22.7            |
| Median                 | 60.0            | 40.0            | 55.0            | 65.0            |

**Table 4** Table of mean, standard deviation and median of the scores obtained in the diagnostic exam for the last 4 school years.  
*Source: Own elaboration*

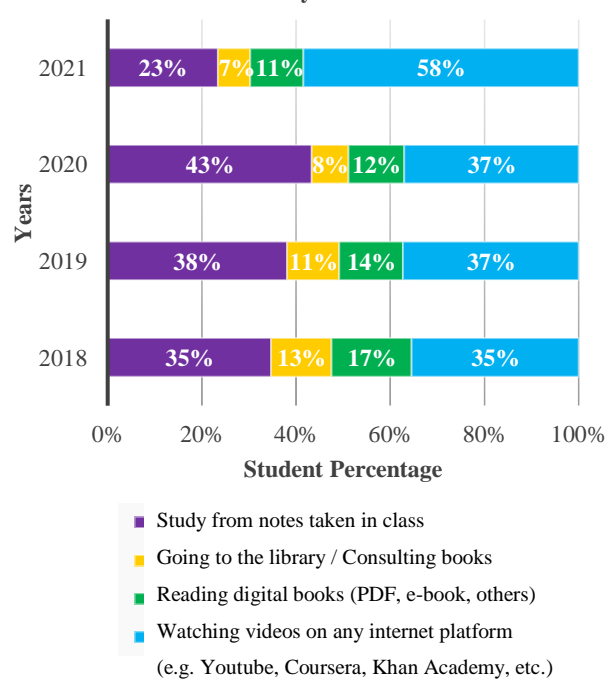
Table 4 shows that in the 2018-2019 cycle the mean was higher than the two subsequent years, in the 2021-2022 cycle the mean was above the mean of the previous years. For the 2020-2021 cycle the standard deviation is higher than the other school cycles indicating a greater dispersion of data with respect to the mean.

| Examen Final       | Cycle 2018-2019 | Cycle 2019-2020 | Cycle 2020-2021 | Cycle 2021-2022 |
|--------------------|-----------------|-----------------|-----------------|-----------------|
| Media              | 67.8            | 58.9            | 72.1            | 68.4            |
| Standard deviation | 18.0            | 26.5            | 17.0            | 18.5            |
| Median             | 75.0            | 60.0            | 80.0            | 70.0            |

**Table 5** Table of mean, standard deviation and median of the grades obtained in the final exam for the last 4 school cycles  
*Source: Own Elaboration*

In Table 5 it is noticeable that in the 2020-2021 school year the improvement in terms of the mean moved above the passing grade and the dispersion with respect to the mean is lower, therefore, it indicates a significant progress compared to the other school years. In general, the statistical parameters in Table 5 (final exam) show an improvement in their grades with respect to the statistical parameters in Table 4 (diagnostic exam).

**Preferences for study methods 2018 a 2021**



**Graph 5** Preferences for study methods in the last four school years  
*Source: Own Elaboration*

Graph 5 presents the preferences of the study methods of the incoming students in the four school cycles studied, this graph is the result of the survey of the diagnostic test of the question:

1.- What method do you prefer to study?

- a) Study from notes taken in class.
- b) Going to the library / consulting books.
- c) Reading digital books (PDF, e-book, others).
- d) Watching videos on any internet platform (e.g. YouTube, Coursera, Khan Academy, etc.).

From the 2018-2019, 2019-2020 and 2020-2021 school cycle, the percentages of preference remained similar, except in the 2021-2022 cycle where the trend leans towards Watching videos on some internet platform (for example: YouTube) with a 58% preference.

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### Conclusions

There is a trend that had been occurring, in which it states that the problem of low student achievement tends to worsen since students are arriving worse prepared than in previous years (Posso-Agudelo, 2005); this can be observed in Table 4 where the 2018-2019 and 2019-2020 cycles is evidenced by comparing the averages of the results of the diagnostic exam, which does not apply with the following 2020-2021 cycle, but if it is repeated between the 2018-2019 and 2020-2021 cycle, in the last school cycle there is a higher average score than the previous ones and the trend is no longer present. In the cases studied, none of them presents an average passing grade, so it seems critical that the immediate previous educational level is not causing significant learning in their graduates and makes it necessary to develop strategies for their regularization.

Graphs 1, 2, 3 and 4 demonstrate the relationship between the use of information and communication technologies (Lagunes-Paredes, Ramirez-Roman, Suarez-Alvarez, & Valazquez-Camilo, 2018), self-regulated learning and academic performance.

With a positive impact, increasing from 8.5 points to 19.7 points out of 100 points in the school cycles studied. Therefore, the virtual propaedeutic course is giving the expected results, however, the average of the grades obtained is worrying, because in the cases studied only one cycle is above the passing grade. Thus, efforts should be focused on moving the average grade as high as possible, improving this strategy or complementing it with other tools to improve school performance.

It is interesting to see the results of the survey on the preference for study methods, which has a percentage in the 2021-2022 cycle of 58% for the option of watching videos on some internet platform, in contrast to the school performance shown in Table 5, which shows that the average went down again, after the previous cycle it went up above the passing grade. In this case it is necessary to study what other factors influenced both in the 2020-2021 cycle compared to the 2021-2022 cycle and if there is any relationship.

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