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MOOC of Mathematics, a Strategic for Strengthening Basic Competencies and Concepts in Higher Education

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MOOC of mathematics, a strategic for strengthening basic competencies and concepts in higher education

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Abstract

Due to the high rates of failure in mathematics, the Department of Basic Sciences of Santo Tomás University - Bucaramanga (USTABUCA), with the support of its Virtual Campus, proposes the design of a Massive Open Online Course (MOOC) to help in the development of mathematical competencies and processes that allow students to perform successfully in the Differential Calculus course. The course was designed in four sections: Arithmetic, Algebra, Trigonometry and Geometry, which were structured in lessons with practical exercises and entry and exit tests to check the competencies achieved in each section of the course. To determine the effectiveness of the MOOC a research with a mixed methodological approach was carried out in two stages: a quantitative one with the application of questionnaires and satisfaction surveys and a qualitative one with the application of interviews to students who participated in the MOOC and teachers in charge of the Differential Calculus course. The results indicated the relevance of the course to improve students' catching-up processes and the improvement.

Keywords: MOOC, mathematics, competition, higher education, educational strategy.

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MOOC de matemáticas, una estrategia para el fortalecimiento de competencias y conceptos básicos en la educación superior

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Resumen

Debido a los altos índices de reprobación en matemáticas, el Departamento de Ciencias Básicas de la Universidad Santo Tomás - Bucaramanga (USTABUCA), con el apoyo de su Campus Virtual, propone el diseño de un Curso Masivo Abierto Online (MOOC) para ayudar en el desarrollo de competencias y procesos matemáticos que permitan desempeñarse con éxito en Cálculo Diferencial. El curso se diseñó en cuatro apartados: Aritmética, Álgebra, Trigonometría y Geometría, los cuales se estructuraron en lecciones con ejercicios prácticos y pruebas de entrada y salida para comprobar las competencias alcanzadas en cada apartado del curso. Para determinar la efectividad del MOOC se llevó a cabo una investigación con enfoque metodológico mixto en dos etapas: una cuantitativa con la aplicación de cuestionarios y encuestas de satisfacción y otra cualitativa con la aplicación. de entrevistas a alumnos que participaron del MOOC y profesores encargados del curso de Cálculo Diferencial.

Palabras clave: MOOC, matemáticas, competencia, educación superior, estrategia pedagógica.

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For some years now, the USTABUCA academic community have wondered about the percentage of students who manage to pass the Differential Calculus course, seeking to determine the causes of low performance and high failure rates. For example, in the first semester of 2015, 40% of students failed and, when we look at the first part of the second semester of the same year, we find that 52% of students also failed; the number was increasing and hindering students' permanence in the program.

When a thorough review of the literature was conducted, it was found that the problem was not exclusive. Several of the universities mentioned in the different studies reported much more worrying figures, such as the University of Panama, where the average failure rate reached 70% and desertion 40% (Bernal et al., 2011). On the other hand, the Technological Institute of Querétaro reports a failure rate of 80% of first semester students who were taking Differential Calculus in engineering programs; also, 40% dropped out of school when they reached third semester because of their low results (Gaona, 2013).

Neither do we deal with a problem of the 21st century only, since studies such as that of Rubí et al. (2010) show that high failure rates in Differential Calculus have been occurring in Mexico since the 1970s and on several occasions the phenomenon has been related to problems in the knowledge and skills acquired in Algebra and Trigonometry, deficiencies with which students arrive at higher education; this situation fully coincides with what has been observed by first semester professors at USTABUCA.

To respond to the problem, a strategy was proposed that would contribute to the development of mathematical competencies and, at the same time, reduce the failure rate in Differential Calculus. The University Department of Basic Sciences, with the advice of its Virtual Campus, decided to create a MOOC in Mathematics to help first-year students catch up with basic concepts of Arithmetic, Algebra, Geometry and Trigonometry. The MOOC was chosen because it is a flexible tool that favors mass participation and self-learning by allowing students to schedule their study time and organize themselves to work at their own pace.

Additionally, it gives the possibility of access from anywhere in the world –as long as they have Internet connection- and can work with a considerable number of users at the same time.

After several semesters of offering the Math MOOC to students, a natural question arises in the teaching endeavor: Is the Math MOOC succeeding in helping students acquire the knowledge they require for Differential Calculus? This question is the starting point for a research that aims to establish the role of said MOOC in first-semester students' catching-up processes and whose details are shared in this document.

Conceptual References

MOOCs (Massive Open Online Courses) are massive, open-access virtual courses, widely used nowadays for training by a large number of universities worldwide and whose roots are attributed to George Siemens, although the term was apparently first coined by Dave Cormier and Bryan Alexander (Siemens, 2012).

Siemens (2005), developed a theory characterized by allowing the establishment of connections between educational resources, activities and participants (figure 1). From there, a learning environment is fostered from the networks generated among the different types of dynamic elements of the course. From this conception, where the creation of knowledge is based on the establishment of connections, between the greater the number of nodes, considerably more possibilities of learning in a given course. Therefore, the change from closed educational platforms to open learning environments has meant the possibility of thousands of people from all over the world following different educational initiatives (Salguero & Gómez, 2013).

In the beginning, MOOCs were cost-free for participants; they were loyal to their roots by being offered openly. However, organizations and universities found the potential of the courses and changed the training conditions incorporating paid certifications, in which students' identity is verified with biometric technology including fingerprints, retina and facial analysis, among others (García-Peñalvo, Fidalgo-Blanco & Sein-Echaluce, 2017). This type of follow-up is done to recognize the participants and avoid impersonation.

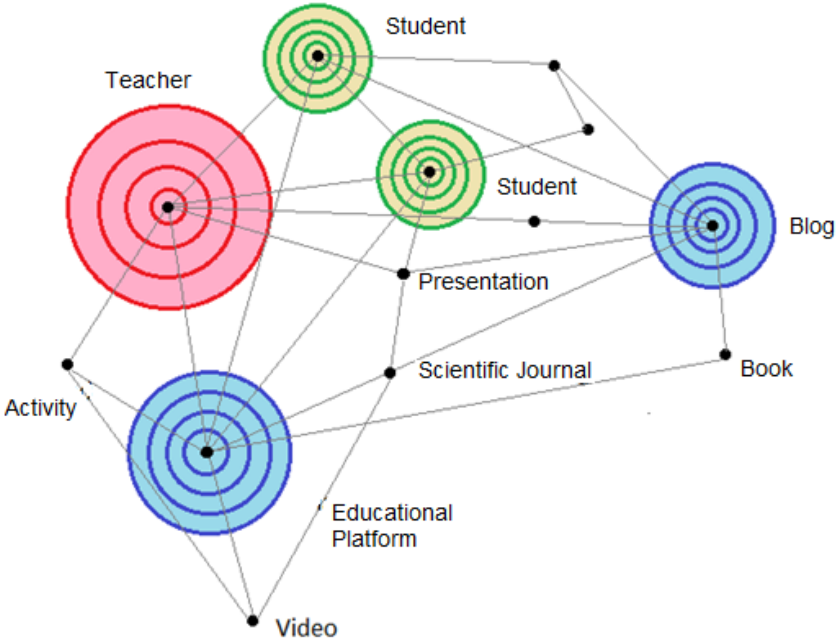

Figure 1. Learning in a Connective Environment (data collected by the author)

Another aspect to highlight is that MOOCs do not require the permanent accompaniment of the tutor to give feedback on the evaluation activities of the course. As they are open courses, the possibilities of registration exceed thousands of people. In addition, MOOCs make use of social networks, which consolidate Learning Communities (Vázquez-Cano, López & Sarasola, 2013). This opportunity to build academia was taken advantage of by recognized universities around the world (figure 2).

The MOOCs are based on four principles: re-distribute, re-elaborate, review and re-use (Cafolla, 2006; Dezuanni & Monroy-Hernández, 2012; Sangrá et al., 2011). Furthermore, they have been considered the most significant educational innovation of 2012 (Khan, 2012), as they are massive open training resources, which can be offered to any public and under the guidance of the most renowned university teachers (Fombona et al., 2011; Vázquez, 2012; Young, 2012).

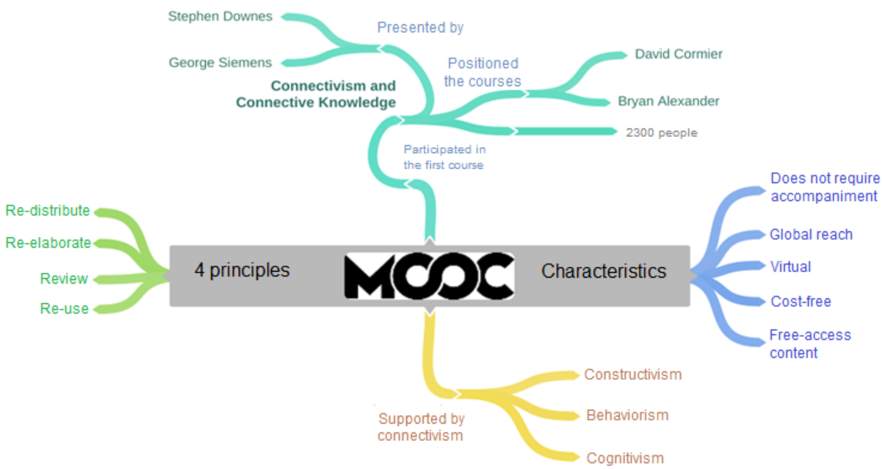

Figure 2. Characteristics and principles of MOOCs (data collected by the author)

Since its creation, new characteristics have been incorporated with variations among the designs, the number of participants, course administration, teacher role, interaction, pedagogical mediation, work methodology, among others. With them, MOOCs are defined and classified according to their own characterization. Today there are more than 11 typologies, among which we have: xMOOC, cMOOC, sMOOC, tMOOC, bMOOC, gMOOC, SPOC, BOOC, DOOC, NOOC and SMOC, as seen in figure 3.

The first initiatives contemplated two types of MOOC: xMOOCs, with a traditional behavioral approach as e-learning proposals are structured, such as the case of the commercial and educational platforms offered by the most prestigious universities, as opposed to cMOOCs focused on the original proposal of MOOCs based on connectivism, where the interaction between educational resources and participants generates a learning environment through multiple connections (ITESM, 2014; Osuna-Acedo et al., 2018).

Then came the sMOOCs, courses where learning processes are encouraged in social interaction through collaborative activities. In addition, due to their ubiquitous characteristics, they can be accessed from anywhere and on any digital device. There are also gMOOCs, with game-playing strategies, where games are used while solving problems (Altinpulluk & Kesin, 2016) and bMOOCs, which arise from the combination of different features. On the other hand, a differential proposal called tMOOC arose, with activities that encourage collaborative work, the assignment of original tasks, peer evaluation strategies, with flexible time opening, contents that are easily transferred to the professional environment and in different formats (Osuna-Acedo, Lazo & Frau-Meigs, 2018) (figure 3).

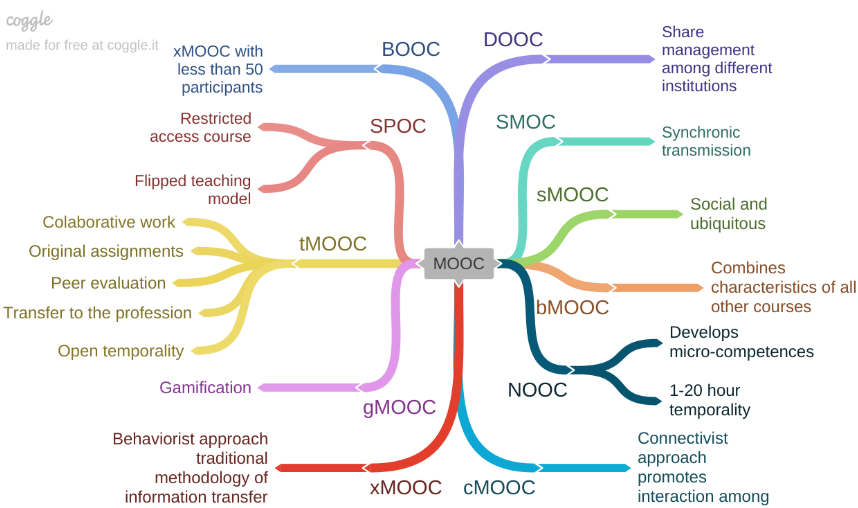

Figure 3. MOOC typologies (data collected by the author)

For the Observatory for Educational Innovation, in its report EduTrends (ITESM, 2014), there are other types of MOOCs, such as SPOCs, with restricted access and based on the flipped-teaching model and BOOCs, a type of xMOOC with a maximum enrolment of 50 students. DOOCs share the administration of the course between different institutions which implies a concerted effort to establish roles and pedagogical planning. GCOS are transmitted in a synchronous manner, i.e. real-time communication is encouraged, as in face-to-face environments. Finally, we have NOOCs, courses of smaller size and execution time focused on the development of micro-competences that imply following learning routes with individual activities and others of co-evaluation among the participants (INTEF, 2019).

The Math MOOC developed in the training proposal is an xMOOC, with an additional element: permanent accompaniment to provide precise and immediate guidance on any question regarding activities. Likewise, it is a scenario that meets the conditions to optimize the learning process, favoring the acquisition of contents, experiences and pedagogical processes, based on explanatory videos that allow new ways of approaching the topics.

The purpose of this MOOC is to develop the mathematical skills and processes needed to start the Differential Calculus course. To do so, it is necessary to address mathematical thinking corresponding to numerical, measurement, geometric, algebraic, and analytical systems, which are referenced in the Curricular Guidelines and Basic Standards for Mathematical Competence, published by the Ministry of National Education (MEN, 1998), as a guide for educational establishments to design their curricula, guided by the same principles that give the route to be followed in each grade cycle. The following table 1 describes the types of thinking related to the topics addressed in the Math MOOC.

Table 1
Math MOOC Topics (MEN, 1998)

Type of thinking	Description
Numerical	Understanding of numbers in different contexts and operations between them, making mental or written calculations with digital or estimation devices.
Geometric	Recognition of figure attributes in objects from their lines, identification of elements, measurement of areas, volumes, and transformation in space.
Metric	Study of the handling of magnitudes or dimensions in the construction of flat or three-dimensional figures. Here we propose geometric models that allow the study of patterns, estimates and conservation of measurement units.
Variational	Relationship of numbers, approximations, successions, dependent and independent variables and magnitudes, where the development of models to analyze changes in problem situations is studied.

Among the competences to be developed in the Math MOOC are:

- Understand the different representations of numbers in everyday problem solving.
- Solve problems involving the relationship between ratios, proportions, percentages and decimal expressions.

- Identify the characteristics and relationships between the elements of the figures to establish the properties of similarity and congruence.
- Calculate areas and volumes of geometric figures from the composition and decomposition of objects.
- Propose algebraic expressions to represent situations that involve the modeling of phenomena
- Solve linear and quadratic equations from the application of different algebraic methods
- Establish geometric relations for the demonstration of basic theorems.

Now, within each type of thinking, mathematical processes such as reasoning, problem solving, modeling and elaboration, comparison and exercise of mathematical procedures can be developed (MEN, 1998). These processes overlap and can be present in the same problem situation, as well as the types of thinking integrated, giving greater meaning to mathematics with real contexts. On the other hand, reasoning involves the understanding of procedures, which leads to answer "how" and "why", from there we have the conjectures and predictions to justify the application of algorithms. Problem solving requires the deployment of certain strategies and methods to find solutions, thus, we can find ways to justify the hypotheses. Modeling allows to represent, by means of algebraic expressions, situations where the behaviors of the phenomena can be studied. The elaboration, comparison and exercise of procedures are some of the processes where greater calculations are required to be made; therefore, it becomes necessary to choose methods to solve them.

Problem Statement

The latest research in the educational field recognizes the crucial role of technologies in the training and research processes through MOOCs. The use of resources through platforms is changing the way virtual education is conceived, where it is not necessary to link a course to a formal process. Instead, a movement is emerging that provides free access to knowledge and training possibilities in prestigious universities, with quality contents that favor the learning of the participants (Weinhardt & Sitzmann, 2019).

Weinhardt and Sitzmann (2019) affirm that some of the best universities are using MOOCs because of their versatile, open-access, mass-market features. In particular, at Santo Tomás University, training needs have changed the way the world is interpreted and new technologies are being implemented to solve problems in the academic environment. From the department of Basic Sciences, there has been concern about the low levels of performance shown by engineering students in the diagnostic tests for admission and in the level of approval of Differential Calculus.

Taking this problem into account, the department's teachers asked themselves the following questions: How does the Math MOOC influence first-year students' catching up processes in the engineering and economic science divisions at Santo Tomás University - Bucaramanga? Which mathematical competences do first-year students have the greatest difficulties and strengths in? What aspects of the Math MOOC should be adjusted to meet the catching-up needs of engineering students? What competences does the Math MOOC allow to be developed that impact student performance in other subjects? These questions marked the path of inquiry at each stage and focused the process of this study.

Methodology

The design of the MOOC was based on some ideas set out in Jordan (2015), which states that the success of a MOOC is closely linked to the percentage of students enrolled who complete it and that, statistically speaking, this percentage is related to the time that must be invested to complete the course; basically, the longer the course, the higher the percentage of students who will leave it unfinished.

Also, several of the ideas presented in the work of Weinhardt and Sitzmann (2019) guided us in the adaptation of the virtual course. They state that we must first understand that MOOCs are a tool with which we can reduce the gaps or differences in training, as they translate into an opportunity to learn at your own pace and from the comfort of your home.

Despite this specific limitation, since it requires internet and, of course, devices that allow the student to manipulate the interface correctly. Even so, we consider that, in Colombia, MOOCs have a great potential to reduce differences that may exist in the educational levels of students in certain regions of the country.

Weinhardt and Sitzmann (2019) also state that it is of the utmost importance that the activities of these mass courses be budgeted to be developed in a prudent time frame, so that students who need more time to carry out their training are neither harmed nor left behind. Similarly, users must be able to monitor their own training and progress, which is possible when the activities automatically provide feedback to the user with the grades or scores obtained.

It is true that the above information from Weinhardt and Sitzmann's (2019) work is based on totally free MOOCs where learners' motivations could be called internal, while the course that generated this research has a certain additional motivation for our students, because it is linked to the Syllabus (Class Plan Document) of one of the first-semester courses and has a 10% weight in the course's first grade of the semester. This is not a bad practice, since, according to these authors, in a developing country, one of the ways to increase participation in these courses is to incorporate MOOCs as part of the curriculum.

One of the possible fears when creating and offering a MOOC is whether students have enough autonomy and responsibility to take charge of their own learning, as this is a crucial aspect of achieving learning goals. Often, students tend to underestimate the time and effort they must invest in completing tasks, so they end up losing confidence in their abilities and choose to drop out of the course (Weinhardt & Sitzmann, 2019). In an attempt to avoid our students being in the presence of the situation described above, we created a sensible schedule for the completion of the sections and tests which was presented to all the participants in the virtual course.

The most common way to measure the effectiveness of a MOOC is by a contrast between the number of students enrolled and the number who drop out or do not complete the entire course; for example, a review of 9 million students found that between 82% and 95% dropped out before completing a MOOC and commonly only 10% of people complete one (Weinhardt and Sitzmann, 2019). The idea is that MOOCs can become as effective as classroom instruction, and to this end, these authors suggest that those tests or activities that do not affect the final grade be configured in such a way that students can repeat them as many times as they consider necessary; this aspect was considered in the configuration of the virtual environment of the course.

In order to answer the research question of the initial proposal, it was necessary to follow a methodological design based on the post-positivist paradigm that gives an epistemic support, which considers the use of the mixed method analyzing the phenomenon from the qualitative and quantitative perspectives to achieve an approximation to the reality of the participants. By using both views, the comprehension of the investigation can be achieved by considering that there are different epistemological and ontological foundations. In addition, inductive and deductive logic is used to validate the results (Creswell, 2012; Mertens, 2005; Williams et al., 2005; Teddlie & Tashakkori, 2003).

Similarly, a sequential explanatory design is followed starting from a collection and analysis of the quantitative data, then moving on to a look from the qualitative component to complement and better understand the phenomenon under study; in this way, the qualitative results are used to explain the quantitative results (Flores & Valenzuela, 2012). It is important to mention the longitudinal scope of the study: observations are made at different times with the purpose of establishing trends over time in the groups observed.

In the quantitative component, the numerical results of the tests conducted during the MOOC were contrasted to establish significant differences in the scores obtained by the students and some semi-structured interviews were carried out with some students and teachers. In this process, we were able to observe and establish the benefits of the virtual course, aspects to be improved and visualize a tool that should contribute to the training of secondary school students in the region.

In this way, the research proposal qualifies teaching, research and social projection by generating a process of reflection to seek new pedagogical strategies to overcome learning difficulties, enabling new scenarios and resources, which have been designed for students who begin their higher education at USTABUCA.

Thus, this research followed some phases that helped answer the initial questions of the approach:

- The initial phase was based on structuring the technology-driven learning scenario, carefully organizing each element that made up the virtual classroom, from planning the schedule, designing educational resources, learning and assessment activities, validating each link, up to the registration process.
- The second phase (implementation) began with the welcome and the diagnostic test that gives the opening to each of the sections. In each of them there was an exit test per area and a final test.

  Four sections were created for this MOOC: Arithmetic, Algebra Trigonometry and Geometry; in each, there were short explanatory

videos and, from each video, a small test that did not add up to the course grade; it was possible to take the test several times. This allowed the student to prepare for a final test of each section, which was not activated if the student had not passed the "training test". The final tests did affect the course grade.
Each of the above-mentioned tests was scheduled from the beginning of the course and its dates were socialized with the students; this is a measure we decided to take, as an attempt to minimize the probability that students would leave all the work for the last day and think about turning to third party help when they felt they would not be able to complete it. This is one of the situations that we are particularly careful about, since in previous years the level of difficulty of the MOOC caused some students to give up and some to seek a third party to finish it for them, which goes against the objectives of this methodology; this fact led us to rethink some activities with the purpose of adjusting the level of difficulty. Upon completion of all sections, the student was faced with a final test that had a 30% weight in the course grade. This test was scheduled from the beginning of the course and the date was shared with the students the first time they accessed the course.

- The third phase (qualitative data collection) was the deliberate selection of the sample, consisting of (3) three teachers of Differential Calculus and (10) ten students of the MOOC: (5) five with the best performance and (5) five with the lowest. In addition, at the end of the course, a survey appeared in the virtual course to find out the degree of acceptance and experience upon taking the course. This instrument consisted of 14 questions that the student had to rate from 1 to 5, where 5 was the highest satisfaction score.
- The fourth and fifth phases (data processing and analysis) consisted of the tabulation and analysis of test and survey responses. The coding of the interviews was carried out until the variables that explained the study questions were saturated. The information obtained was codified and simplified to achieve comprehensive categories that were related by means of concept maps (Miles et al., 2014)
- The sixth and seventh phase (conclusions and innovation) showed the result achieved from the analyses that responded to the study's proposals. Here the findings and the aspects to be improved in future

studies were combined, as well as the recommendations to improve the educational proposal.

Results

The MOOC in Mathematics was created in 2015, and since then it has been used as a tool for first-semester students at Santo Tomás University - Bucaramanga. Semester by semester, application after application, it has been adapted, generating experiences on the correct way to carry out the MOOC with students of our context. For this reason, we will focus on analyzing the results of the 2019-1 application.

An entry test was given to 309 students; it consisted of 20 multiple-choice questions, 5 questions on basic Arithmetic, 5 questions on Algebra, 5 on Geometry, and 5 on Trigonometry. The overall average score for this test was 2.8, with a possible maximum score of 5.0 and a minimum score of 0.0. Only 37% of the students who took the test scored above 3.0, meaning that about 63% of the students failed the initial test.

These results translate into strong evidence in favor of the idea put forward by some research and by the assessments of our teachers: first-time university students do not arrive with the necessary prior knowledge of mathematics to efficiently face subjects such as Differential Calculus.

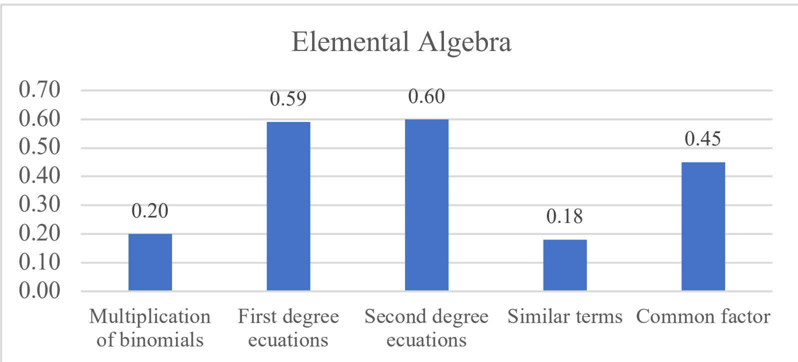

Figure 4. Passing rates for Elemental Algebra questions in the entry test

When looking at the results in detail by the concept associated to each question, we found that, in Elemental Algebra, the greatest difficulty lies on multiplication of binomials and addition of similar terms, while the best results appeared in the solution of equations, since these questions were answered correctly by more than 60% of the students (figure 4).

The concern increases when analyzing the Arithmetic questions; the percentages of correct answers did not exceed 35% in any of them. We clarified that the students could not use a calculator, they only had pencil and paper; however, we considered that the exercises designed for the test did not have a high degree of difficulty. Basically, the students' problems are associated with operations with fractional numbers (figure 5).

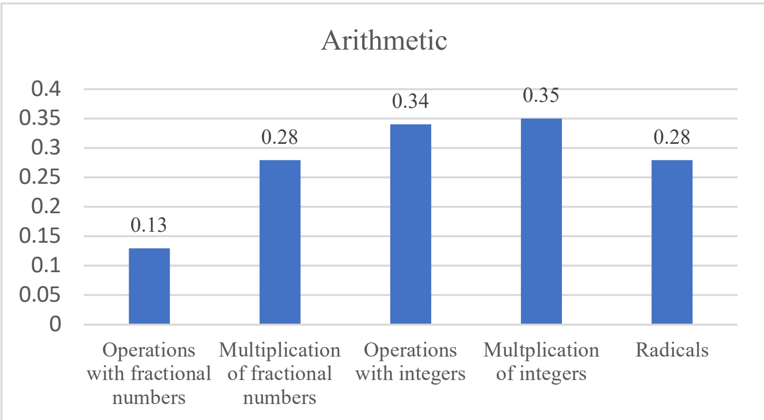

Figure 5. Passing rates for Arithmetic questions in the initial test

In the Trigonometry questions (figure 6), we found that they all exceeded 50% of students who answered correctly, except for the one that involves the multiplicative inverse relationship between the sine and cosecant trigonometric ratios. Consequently, only 50% remembered which sides of the right-angled triangle should be divided to calculate the sine ratio. It may be that trigonometry is one of the most recent topics in school experience and that would be the reason why these results are a little better compared to those of Arithmetic and Elemental Algebra, although they are still worrying (figure 6).

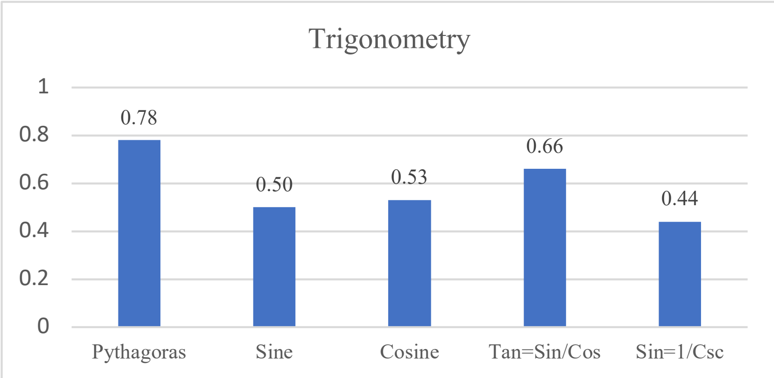

Figure 6. Passing rates for Trigonometry questions in the entry test

As far as Geometry questions are concerned, it is observed that about half the students have problems remembering the calculation of area and perimeter of basic figures such as rectangles, triangles, and circumferences. In subjects such as Differential Calculus, the similarity of triangles is used to give solutions to some problem situations, assuming that the student understands what it is about, however, in view of these results, half the students would not remember it (figure 7).

After applying the final tests of the different sections, improvements in the students' grades were evidenced; in this way, the analysis focused on the results of the final test and its contrast with the entry test.

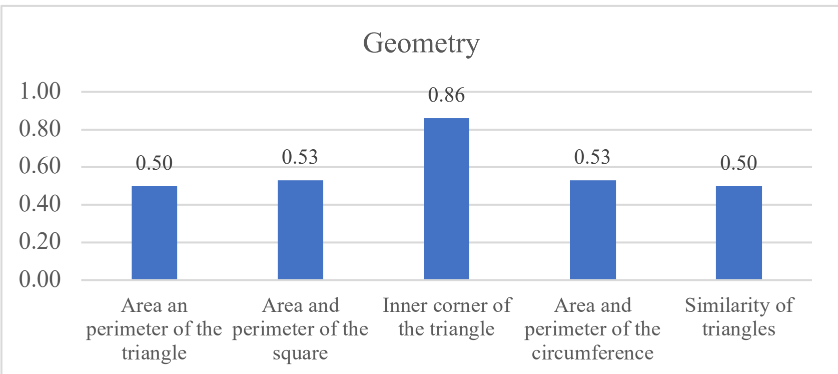

Figure 7. Passing rates for Geometry questions in the entry test

This final test was taken by 321 students and had a possible maximum score of 5.0 and a minimum score of 0.0. The students' overall average was 4.5 –let us remember that the average on the entry test was 2.8. When contrasting the means, we observe that, statistically, the average obtained in the final test is significantly higher and that the difference is between 1.3 and 2.1 with 99% confidence, as shown in Table 2.

Table 2
99% confidence interval for the difference between the entry and final test averages

Difference in averages		
Averages	2,82	4,56
Standard deviation	1,61	2,31
Sample size	309	321
Diff. averages	1,74	
Deviation from the difference	0,16	
t-value	2,59	
Diff. error	0,41	
Lim. inf.	1,33	
Lim. sup.	2,15	

When calculating the confidence interval for the difference between the proportion of students who passed the final test and the proportion of students who passed the initial test, we found that the proportion on the final test is significantly higher than that on the initial test, with the difference being between 41% and 57% at a 99% confidence level (table 3).

Table 3
99% confidence interval for the difference between the entry and final test passing rates

Difference between proportions		
n-successes	144	306
Proportion	0,466	0,953
Dif.	0,487	
Dev. Diff. Prop.	0,031	
t-value	2,592	
Lim. inf.	0,41	
Lim. sup.	0,57	

The results mentioned in the previous paragraphs are strong evidence that the activities, explanatory videos, and the Math MOOC in general produce favorable changes in students' prior knowledge and contribute to their catching-up on basic topics of Arithmetic, Algebra, Trigonometry and Geometry. Therefore, it is a tool that can be further improved and adapted to overcome some obstacles in the mathematical education of school students.

In the final part of the virtual course there is a satisfaction survey where the student has the possibility of evaluating each of the graphic and didactic aspects of the MOOC, assigning a grade from 1 to 5, where 1 is the lowest score and 5 the highest. The grades obtained and the items evaluated are shown in Table 4. This observation of students didn´t grade lower than 3, so we can say that the students are satisfied with all the aspects considered in the questionnaire.

Table 4
Scores of the Math MOOC satisfaction survey (data collected by the author)

Item	Rating
1. Graphic design to present the course	4.1
2. Learning path with the pedagogical guidelines to develop each section.	3.9
3. Number of activities per section for the understanding of the topics.	3.9
4. The proposed contents are relevant to performance in the Mathematics subjects offered by the university.	4.0
5. The level of difficulty of the questions is in accordance with the explanations of the resources.	3.7
6. The explanations in the videos are clear, precise and allow an easy understanding of the topics.	3.5
7. The estimated time to take the MOOC is sufficient.	3.9
8. After taking the MOOC, I would recommend it to others who need to catch up to develop math skills	3.9
9. The tutor gave adequate answers to each of the questions asked in the forums or internal messaging.	4.1
10. Your assessment to the planning of the Arithmetic section.	4.2
11. Your assessment to the planning of the Algebra section.	3.8
12. Your assessment to the planning of the Trigonometry section.	3.9
13. Your assessment to the planning of the Geometry section.	3.7
14. Your experience with the MOOC	3.7

The aspect that received the lowest score was related to the quality of the videos, which was confirmed by the comments in the final question; some videos had sound issues, which made it difficult for the students to understand. These videos were already assessed to identify production problems; some were edited, and others were replaced completely. The highest score was assigned to the Arithmetic section –the first of the course- possibly due to the simplicity of the topics covered. In general, from the results of this survey, we can establish that the MOOC is well structured in terms of explanations, course duration, level of difficulty and type of evaluation.

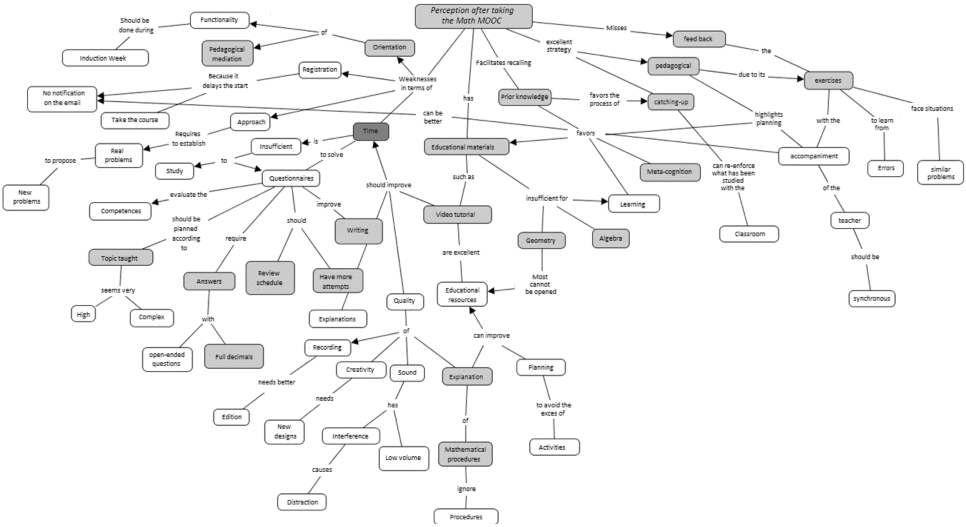

Figure 8. Perception after taking the Math MOOC (data collected by the author)

By applying the survey instrument with quantitative reagents, qualitative information was obtained through an open-ended question that freely invited people to express their views on their experience taking the MOOC. Strengths, weaknesses, and opportunities for improvement were found to make the learning experience more meaningful (figure 8). Within the comments by the students, the following weaknesses and strengths are highlighted:

Table 5
Students' considerations regarding the course

Weaknesses	Strengths
- The time allocated for the MOOC is insufficient - The video tutorials are too long. - The quality of video recording needs to be improved. - Delayed registration - High-level competency questionnaires. - Review the wording of the statements	- The explanation of the exercises in the videos is detailed and helps re-enforce the procedures - Makes it easier to build up prior knowledge - The contents are related to the prerequisites for Differential Calculus - The exercises are related to the pre-evaluation exercises

Table 5 (continue)
Students' considerations regarding the course

Weaknesses	Strengths
- Increase the number of attempts - Re-consider schedules	- The accompaniment by the teacher is permanent

Among the strengths expressed by the participants, is the fact that they consider the MOOC an excellent strategy to strengthen their prior knowledge and, at the same time, catch-up with the mathematical competences required as a basis to perform successfully in the Calculus courses. Recognition of deficiencies is an important component in fostering meta-cognitive processes by allowing students to reflect on their prior knowledge.

One variable that stands out is the accompaniment that the teacher provides when responding to the difficulties presented during the course. The materials used in the instruction are also highlighted, such as the video, a fundamental resource to provide the necessary explanations for the understanding of the topics, especially regarding the development of mathematical processes.

On the other hand, there are the weaknesses: one of the most mentioned is the time factor to complete the MOOC, added to the delayed registration that prevents the start and errors in the platform that do not facilitate the reception of messages in the institutional mail. Another disadvantage has to do with the evaluation instruments; there are open questions that require numerical answers and answers in decimal values - mostly - which are not rounded and there are problems in validating the approximate answer in spite of having the correct answer.

It should also be said that educational materials have weaknesses in terms of the quality of recording and pedagogical mediation. One of the sections that presents the most weaknesses is Geometry since the resources do not allow for adequate instruction. It is very important that these types of resources have high production criteria so that optimal materials are generated and enriched through explanatory didactics that favor the understanding of procedures and concepts.

An opportunity for improvement is to provide spaces to discuss problems and with opportunity for feedback from the teacher. Some participants request synchronous meetings to express their doubts and concerns. As for the questionnaires, they express that they should be elaborated at the same level as the explanations, contextualized in real and meaningful situations for the participant. At the same time, the wording of the statements should be improved, attempts to complete them should be increased, and the answers should be adapted with full decimal solutions. In the same way, a redesign of the videos is needed to make them more didactic and understandable.

Another instrument used in the study was a survey of students and teachers, in which (10) ten students of the course and (3) three teachers of Mathematics I were selected. The student survey consisted of seven open-ended questions that sought to inquire about the level of competence during school training, the difficulties presented in mathematics in school studies, the strategies implemented to overcome difficulties in learning mathematics, the contributions of the MOOC to achieve the leveling process, the best meta-cognitive strategies, and aspects of improvement of the MOOC to achieve the objectives.

The survey to teachers had 5 open questions oriented to know about the importance of their students' participation in the MOOC, the contribution of the course to the catching-up process and the aspects that should be kept or reformulated in a new proposal of the course, with the purpose of finding points of coincidence between the contributions given by teachers and students.

Conclusions

One of the aspects to be highlighted about the MOOC is its graphic design, which can be seen in the organization of the virtual classroom, with banners and illustrative videos where care was taken to achieve a setting and educational resources that facilitate learning with striking content and appropriate to the context of the student. However, some videos that were made for the course had some background noise, which became a distracting element for the process; likewise, the explanations in the videos need to be strengthened to improve the understanding of the topics.

At the end of the MOOC, students had problems with the time allocated for the course activities. Although the time is appropriately calculated, for them it represents a difficulty when organizing their schedule because their first contact with virtual education is starting with this educational experience. In addition, the beginning of their first semester also brings them confusion; the delay in enrollment and the natural difficulty to grasp the dynamics of higher education leave students a bit lost and some start the course late.

From the experience obtained by leading the implementation of the MOOC in Mathematics with freshmen students on a semester-by-semester basis, it can be stated that this type of course gives us a cognitive challenge due to the type of exercises proposed that need to be solved with the support of educational material. Although the activities have an accurate level of exercise and deepening, they must be balanced by levels of competence, because if the whole course is projected with a high level, it could lead the student to drop out or to resort to third parties in order to appear to have achieved the objectives and receive a passing grade in the subject. That is why activities have been designed with performance levels that are related by areas of thought.

With the purpose of improving the academic proposal, it was necessary to know how they had found the learning experience with each of the areas. The results indicated that the best experiences were achieved in Arithmetic and Algebra, where the designed material was highlighted. In contrast, in Trigonometry and Geometry, although they did not fail, they did get a lower score. This type of assessment is due to the need to create more relevant and in-depth material, which allows for managing learning in a more relevant way.

The Math MOOC, while still in need of some adaptation to meet educational needs, has the potential to become a tool to help school-age students master the basic Mathematics concepts they will need in their first semester of college and could help in preparation for state tests.

Declarations

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