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Impact of a basic mathematics course on the performance of college students in algebra subject

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Abstract. A common problem for universities is the lack of knowledge and mathematical skills of new students because this deficiency creates difficulties in their studies throughout their career, which can cause their dropout. The aim of this paper is to describe the impact of a basic mathematics course on the performance of college student in algebra subject. This is a 32-hour course which is developed in 16 sessions in parallel to the algebra classes and is mainly offered to students: a) identified with low performance on mathematics component of national high-school test, and b) remitted by the subject teacher. The main findings are: a) the pass rate for students who attended to more than half of the sessions of the course is 95%, and b) the average grade of the subject tends to increase as with the attendance level to the course of the students. Consequently, these results lead to the conclusion that the course has a positive effect on the students' performance.

1. Introduction

Mathematics throughout history have shown that they are of great importance in most of the fields of life, *e.g.* personal finances, daily work tasks, social and cultural activities [1]. Moreover, it is important for today's professional to learn mathematics efficiently, since its application is very present in working life, mainly in engineering and related careers.

It is important to highlight that despite the importance of learning mathematics; these subjects are the ones in which students have poor academic performance throughout their college studies. The academic performance can be understood as the student's ability to respond to the requirements of a specific curriculum [2]. This definition implies that the curriculum has a great relevance, taking into account that it is also influenced for many variables, among which we can mention: students temperament, previous knowledge, their learning strategies [3,4], teaching strategies of teachers, didactics used in the classroom [5], family influences [6,7] and the infrastructure of the place of study [8]. These factors must be taken with priority to be able to improve the academic performance of the students in an appropriate way.

[9] claim that there is a high dropout rate in the first year of university careers. The main causes of this phenomenon are the difference between the previous training of the entrants, the competences and knowledge that are required for university studies and their socioeconomic status. In this regard, the Universidad Simón Bolívar (USB), Colombia, carries out a characterization process of all first-semester students in the different academic programs. In the 2019-1 period, 58% of these students showed poor



performance in the mathematics component of the national high-school test. This represents a difficulty in the formation of students in subjects related to mathematics, especially algebra.

Due to this situation, the USB designed a basic mathematics course, hereinafter called BMC, with the aim of improving the students' performance in this subject. This course is a strategy through which the USB seeks to prevent early dropout of students by academic factors. Authors such as [10-12] implemented remedial or leveling courses in mathematics in similar contexts. These courses are offered to students before they enter the university, however, there is no evidence of work where the course is offered as an accompaniment to the students during their academic period.

2. Method

The USB, Colombia, has implemented various strategies to improve the academic performance of students in order to reduce their dropout. Within these strategies, the USB has the “centro de apoyo a las matemáticas y la física (CAMFI)”, (support center for mathematics and physics), consisting of teachers and students, which seeks to strengthen the apprehension in the management of mathematics in the students of the institution. Accordingly, CAMFI is the part of the USB responsible of offering the basic mathematics course.

The USB defines basic courses as academic spaces that seek to improve the basic skills of students. The target population of these courses are first-semester students with difficulties in their performance in basic subjects. Accordingly, the aim of the basic mathematics course is that students acquire the necessary bases and skills to study their own subjects in the curriculum and thus improve their academic performance. This course is of vital importance for students in the engineering and management and business faculties, where their curriculum contains multiple subjects of mathematics or based on mathematics.

2.1. Access to the basic mathematics course

Students attend to the BMC in three ways:

- Remitted by follow-up route: students with a score in the mathematics component of the national high-school test below to the national mean. They must attend to the BMC in a mandatory way.
- Remitted by subject teacher: students identified by their teacher with low performance during the development of the algebra classes. They also attend to the BMC in a mandatory way.
- Volunteer: students that voluntarily attend in order to improve their performance, their learning process or complement their knowledge.

2.2. Basic mathematics course structure

The goal of the BMC is to strengthen the basic skills in mathematics of students so that they can face and overcome the different subjects of the area of mathematics that are part of his basic professional training. This is a 32-hour course and it is developed in one session of two hours per each of the 16 weeks of the academic semester. The main skills and competences that students work through the BMC are:

- Interpretation and representation.
- Formulation and implementation.
- Argumentation.

The contents of the BMC are focused on the following topics: number sets, basic operations with whole and rational numbers, combined operations with whole and rational numbers, powers and exponents, radicals, logarithms, algebraic expressions and factorization [13].

2.3. Administrative management of the basic mathematics course

Next, we detail the responsible people and their main functions in the administrative management process that is carried out for planning and executing the BMC.

- CAMFI coordinator: To ensure the optimal provision of the services under its responsibility, to promote the dissemination of the center's services and to keep the general operating statistics and evaluate the management.
- Formation in values and self-development coordinator: Send underperforming students to the support center.
- Coordinator of the institutional program of academic excellence: To follow up each student of assigned career with low academic performance and to remit them to the BMC.
- CAMFI teacher: To prepare and to develop the activities corresponding to the development of the BMC regarding methodology, contents, support materials and evaluation mechanisms.

3. Results

3.1. Description of participants

A total of 297 students attended to at least to one session of the basic mathematics course during the 2019-1 academic period. This group of students can be described as follows: a) approximately 64% of the students were men and 36% were women, see Table 1; b) as shown in Table 2, most of students (97%) were remitted by the university and the rest were volunteers; and c) about 64% of students were enrolled on engineering careers and the other 36% were enrolled on management and business programs, as detailed in Table 3.

Table 1. Gender of participants.

Gender	Students' number
Female	108 (36.4%)
Male	189 (63.6%)
Total	297 (100%)

Table 2. Type of access.

Access	Students' number
Remitted	289 (97.3%)
Volunteer	189 (2.7%)
Total	297 (100%)

Table 3. Faculty and career of participants.

Faculty	Career	Number of students
Management and business	Business management	42 (14.1%)
	International business and commerce	24 (8.1%)
	Accounting	40 (13.5%)
Engineering	Biomedical engineering	37 (12.5%)
	Multimedia engineering	27 (9.1%)
	Systems engineering	67 (22.6%)
	Industrial engineering	25 (8.4%)
	Mechanical engineering	23 (7.7%)
	Mechatronic engineering	12 (4.0%)
	Total	297 (100%)

3.2. Impact of attendance on students' performance

In order to describe the impact of the basic mathematics course on students' performance, we analyzed the variation of the pass rate and the average grade according to the attendance level of the students. We created an attendance level per each 25% the total number of sessions (16), *i.e.* 4 sessions, as follows:

- Low level: 1 – 4 sessions
- Medium level: 5 – 8 sessions
- High level: 9 – 12 sessions
- Superior level: 12 – 16 sessions

We present the distribution of attendance levels to the 16 sessions of the basic mathematics course in Figure 1. Among remitted students, more than 50% of them are at high or superior level, *i.e.* attended to more than a half of the sessions. In contrast, volunteer students were on low or medium level, which is mainly explained by the voluntary nature of their attendance.

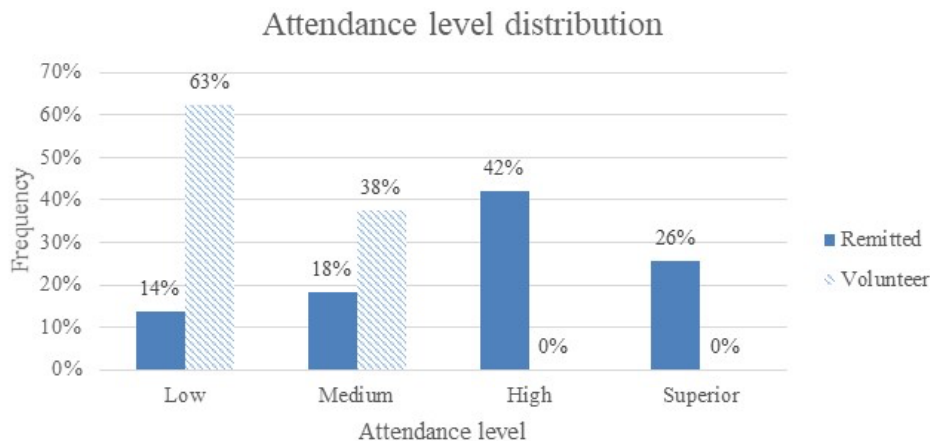


Figure 1. Distribution of the attendance level to basic mathematics course.

In Figure 2, we can see that the pass rate for remitted students increases from 78% in low attendance level to 92% in medium attendance level and it goes up to at least 96% in high and superior attendance levels. From these results, we can observe that the proposed BMC yield a greater pass rate with respect to other similar courses. For instance, in an intensive course of mathematics implemented by “Universidad Nacional de Colombia” in multiple academic periods [11], the pass rate was approximately 82% which is smaller than the 92% in the medium attendance level in the BMC. Additionally, it is worth noting that the pass rate for voluntary students is 100% even though they are in low and medium attendance levels.

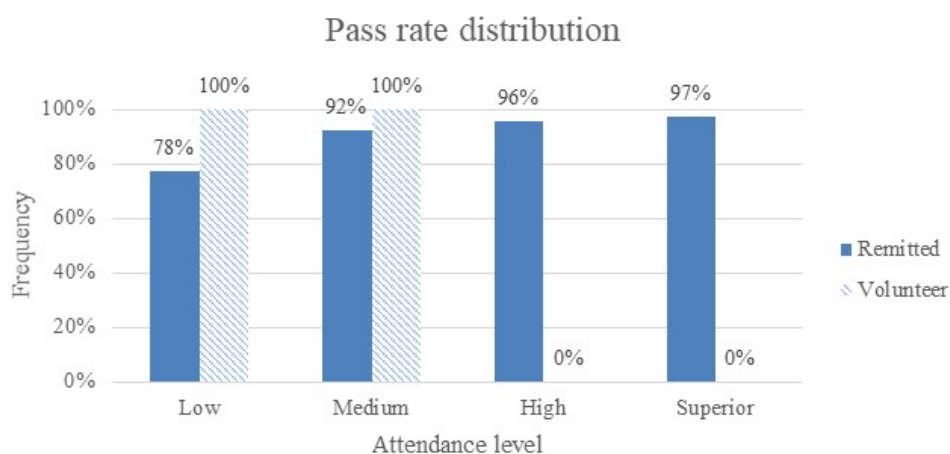


Figure 2. Distribution of the attendance level to basic mathematics course.

Regarding the average grade, we can see that it tends to increase for higher attendance levels for both remitted and volunteer students, see Figure 3. More in detail, the average grade of remitted students goes from 3.18 in low attendance level to 3.49 in medium attendance level and it reaches at least 3.67 in high or superior attendance levels; besides, the average grade of volunteer students increases from 3.29 in low attendance level to 3.70 in medium attendance level. This increasing trend of the students’ average grade is similar to the behavior found in [10,11].

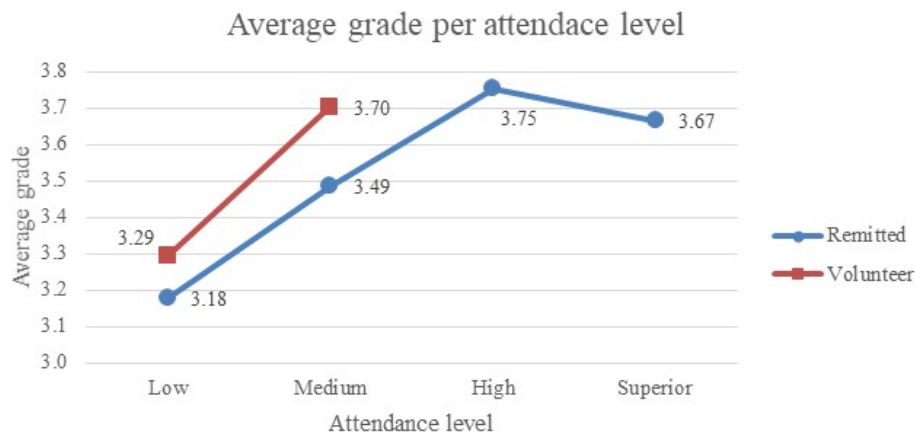


Figure 3. Average grade per attendance level to basic mathematics course.

4. Conclusions

The pass rate of the students in algebra subject tend to increase with their attendance level to the proposed basic mathematics course. There is a similar behavior to the previous one for average grade in the subject with respect to the attendance level. Besides, all students that attended as volunteers to the course approved the subject although they attend to no more than a half of the session of the course. These findings point out that the proposed basic mathematics course has positive impact on the students' performance in algebra subject.

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