Difficulties in the teaching of calculus I in distance engineering courses – Study and comparison with universities of face-to-face teaching

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ABSTRACT
The offer of distance learning courses and blended learning has gained space in the academic scenario year after year. The method uses technology and the facilities provided by it become allies in the learning process. Factors such as time, place and age group are no longer an obstacle for those who want to improve the curriculum. In engineering courses, in particular, performance in common axis disciplines such as Calculus remains a major difficulty on the part of students. The study shows possible causes and association with students in both teaching modalities. It should be noted that the difficulty of entering a higher education institution, such as the entrance exam, becomes a water divider in terms of the educational basis obtained in secondary and elementary education.

Keywords: Blended learning, Active learning methodology, Calculation for engineering, Higher education.

1 INTRODUCTION

The ease of information has made technological advancement the reason why large educational centers have adapted the way to offer their greatest product – knowledge. This, associated with technology, has become a strategy eliminating barriers such as distance, time, place, in addition to the age group of students (VIDAL and MAIA, 2010).

It can be said that distance education in Brazil occurred effectively from 2001, when public institutions offered it as an option for complementary activity (GIOLO, 2008). In the following year, private institutions also began to offer the new teaching modality, given a possible educational dispute.

In distance learning the student becomes an active subject in the learning process (CAPELETTI, 2014), making discipline essential and constant search for complementary materials to their training. Another crucial factor and often neglected by students who are interested in this type of teaching modality is the need for basic knowledge in the technologies linked to the media used to monitor classes and carry out evaluative activities. Freitas (2007) highlights the so-called "digital excluded", who often associate the flexibility of distance learning, detaching it from the technology involved in the whole process.

2 OBJECTIVE

This article aims to identify causes that justify the difficulties on the part of the student body in the Hybrid Engineering courses of a Higher Education Institution with regard to the discipline of Differential and Integral Calculus I in the academic year 2018. A comparison with face-to-face students from other universities is also presented.

3 METHODOLOGY

It was analyzed the academic performance in the discipline of Calculus I of the students enrolled in the five Engineering courses offered in the hybrid modality in an Institution with Campus in the city of Curitiba; They are: Civil Engineering, Electrical Engineering, Mechanical Engineering, Mechatronics Engineering and Production Engineering.

Table 1. Evaluative method for hybrid engineering courses

EVALUATION METHOD	KIND	MAXIMUM SCORE	DURATION	MODALIS
AE 1	Essay questions	0,5	3rd to 5th week of class	Online
AE 2	5 multiple choice questions	0,5	5th to 7th week of class	On-line
AE 3	Essay questions	0,5	7th to 9th week of class	On-line
AE 4	5 multiple choice questions	0,5	Week 9-11 of class	On-line
SCG	10 multiple choice questions	0,5	4th to 9th week of class	On-line
MAP	4 essay questions	2,5	1st to 11th week of class	Online
Evaluation	30% dissertation, 70% multiple choice	5,0	10th week of class	Classroom

Chart 1 presents the evaluative methods analyzed for the composition of the average for approval, which is equal to and/or greater than six. The first four methods concern the study activities (AE 1, AE 2, AE 3 and AE 4) that occur from the third week of class. These activities are elaborated by the teacher trainer of the discipline and are made available in the virtual learning platform. The first activity is available in the third week and offers a period of 14 days to students. After this period, the second evaluation activity is also available online and has the same time for delivery. This occurs with the third and fourth activity, and can add up to a score of up to 2.0.

The acronym SCG is the "General Knowledge Week" that aims to expand knowledge beyond engineering. As its name implies, it deals with general subjects, and may be unrelated to the course in question. Subjects such as art, economics, current affairs are presented in three online videos and subsequently the student must answer ten multiple-choice questions on the subject addressed. The maximum score for this evaluation is 0.5 points.

The "Practical Learning Assessment Material" (MAPA) is a document made available on the virtual platform from the first week of class. The document is usually divided into four stages in order

to contemplate the entire syllabus of the discipline associated with real situations of application. The deadline occurs one week after the end of the course and maximum grade is equal to 2.5. The evaluation, on the other hand, is carried out in the tenth week in person, also contemplating all the content of the two months and has a maximum value of 5.0 points.

In order to analyze the performance of students in these engineering courses, a survey was conducted based on the grades obtained by them in the discipline of Calculus I for the year 2018. In addition to the grade, a relationship was made with age group, gender and financial incentive (scholarships). This information is important to define the target audience in the modality presented - men or women, if they are people who have just completed high school and, still, if age is a watershed for the choice.

3.1 BLENDED LEARNING

In this teaching model the academic year is divided into modules (bimestres) and in each module are offered two to three disciplines, which are determined in the curricular matrix and unalterable throughout the course. With this modular feature, there are four opportunities for new students to enter during the year. The discipline of Calculus I is taught once a year, always in the fourth and last two semesters. Thus, the case study contemplated the performance of 155 students for that year.

The two-month period lasts ten weeks, divided into nine weeks with virtual classes and also face-to-face, and the tests are held in the tenth week. The classes are taught by the teacher trainers of each discipline remotely, and in person by the facilitating tutors. The classes are recorded at the Institutional Headquarters and broadcast live once a week, on a pre-defined day and time. These lessons are later recorded, allowing the student access to when, where and as many times as necessary.

The tutors are professionals trained in engineering and have the function of developing face-to-face activities/exercises at the poles, since the live class is transmitted throughout the country and makes it difficult for individual doubts to be resolved. The classes are based on the so-called scripts in order to assist the student in doubts and also ensure the homogeneity of the model in all poles of the country.

It is noteworthy the lack of prerequisites in this teaching model, that is, failure in a discipline such as Calculus I does not preclude enrollment in Calculus II, for example. But the discipline in which the student failed must be taken again until he reaches approval; thus fulfilling the entire curriculum required for the formation of the future professional.

3.2 METHODOLOGY OF MATHEMATICS

Engineering courses require a theoretical foundation and a solid foundation with regard to the field of mathematics. Previous knowledge addressed in elementary and secondary education is essential for the good monitoring of the course, especially in the initial phases in which most of the disciplines are directly associated with the use of calculus and physics, constituting the so-called common axis of disciplines to the training of any engineer.

The teaching of mathematics in Brazilian schools can be seen as unsatisfactory for a long time. Many ways of evaluating teaching have been created since 1988, with the main objective of verifying its efficiency. Libâneo (2008) points out that by following the quality of what is taught and learned, we meet the rights of all students in the learning process.

The National High School Exam, Enem, seeks to assess the level of graduate students, in addition to serving as a test for admission to many universities in Brazil. The exam conducted in the years 2011 and 2012 pointed out that among the enrolled students, less than 1/3 received the certification that proves the mastery and ability in the area of knowledge of mathematics (Microdata ENEM, 2011-2012).

Another way to analyze the teaching process concerns the Program for International Student Assessment (PISA), applied to 15-year-old students. The survey conducted in 2015 showed that among the 70 countries registered, Brazil was in position 65 and, compared to South American countries, was ahead only of Peru. This research includes not only elementary and high school students from the public network, but also those enrolled in private schools. Students from Brazilian private schools had lower grades compared to students from public schools in countries such as China (OECD, 2016).

Mendonça Filho (2016) analyzes that the admission of students in high school has increased in the last twelve years, but this does not meet the quality of education offered. The reasons for such a situation are diverse and concern not only the lack of didactics of many teachers, but also the lack of interest on the part of students (Cordeiro, 2017).

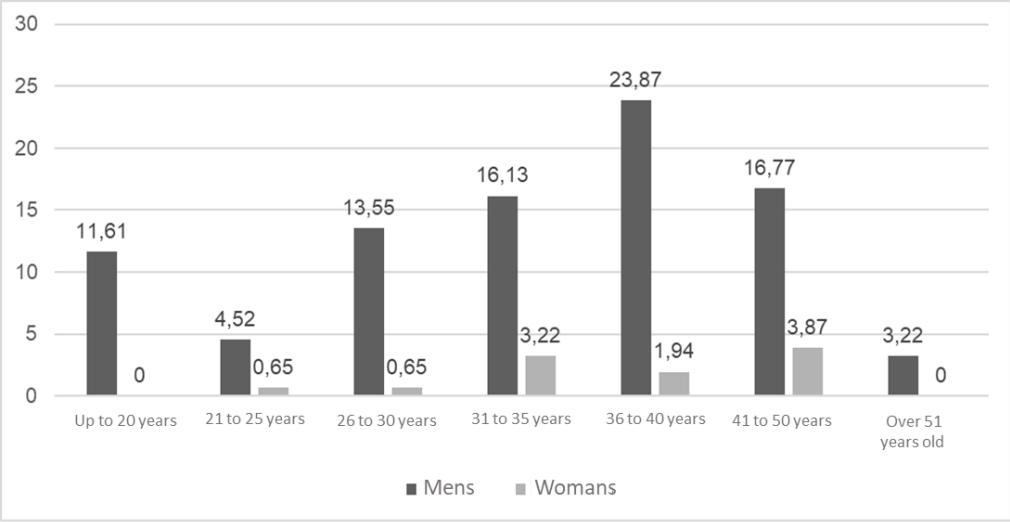
4 RESULTS AND DISCUSSIONS

We analyzed the academic performance for the 155 students enrolled in the discipline in 2018. It should be noted that these students are still enrolled in the course, three years after this analysis. Therefore, the research does not include students whose enrollment is canceled and/or locked.

Regarding gender and age, Figure 1 shows that the majority of hybrid engineering students in that year are male, and the highest percentage of those enrolled is in the age group between 36 and 40 years. For the female gender, the greatest search for an engineering course in this modality is in the interval between 41 and 50 years.

The original consultation of the research shows that the youngest student enrolled in the course in that year was 17 years old, in contrast to the student whose age of majority was 57 years old; both male.

Figure 1. Result of the research on the issues of gender and age in hybrid engineering in the analyzed Institution located in Curitiba.



Another important factor in the gender analysis shows that there were no women under the age of 20 or over 50 years enrolled in the course. Of the 155 students, almost 20% were under 20 years of age and were male. Only 5 students were older than 50 years.

The survey shows the percentage of 89.68% of men to 10.32% of women enrolled in the courses. This predominance of the male gender in engineering is a very old fact, however, with the gain of autonomy of women over the years, this difference becomes smaller and smaller.

According to Silveira and Silva (2003) based on the Brazilian IBGE statistics yearbook, the female class of engineers in 1950 was only 0.6%. This percentage rose to 1% twenty years later and, in the early 90s, rose to the order of 17%. Since these values correspond to a face-to-face engineering course, a certain convergence with the hybrid modality can be assessed. Thus, the percentage of 10.32% of the female gender in the hybrid engineering of the analyzed Institution shows a satisfactory number for the set of five courses inaugurated in 2018 in that Teaching Center.

Table 2. Comparison of approved students according to the assessment method

	AVERAGE OF ALL STUDENTS	**STANDARD DEVIATION**	**PERCENTAGE APPROVED STUDENTS**
Final Average - Test + Papers	7,27	1,61	95%
Final Average – Fictitious composed only by the face-to-face test	4,25	2,99	30%

Another interesting analysis of this study is based on the evaluative method provided to enrollees. Chart 2 provides the average of the averages of the students who attended the discipline of Calculus I. When analyzing the averages as they really are – composed of both online evaluative activities and face-to-face test – we noticed an approval in the order of 95%. However, if only the test score was evaluated (adjusting it from 50 to 100% of the composition) a percentage of approved equal to 30% would be found. It is noteworthy that for these values were not considered situations in which the student fails for withdrawal or in case of dismissal for having attended it in another institution or course; that is, only those who performed all the activities that make up the final grade are considered.

With the parallel presented in section 3.2 of this article, it is understood that a deficient basis in the field of mathematics will directly affect the performance of students who are interested in higher education courses in the area of exact sciences. For Machado (2008), the unsatisfactory performance in the Teaching and learning of Calculus can be understood as a set of causes related to the didactic nature of the teacher; to the cognitive nature of those who do not understand mathematical complexity and also to the difficulties of an epistemological nature – confirming that the problems related to the Teaching of Calculus are not tied to space and time. Still, it can be considered that both the mathematical basis in elementary and secondary education, as well as the method required for admission to the Higher Education Institution, will directly reflect on the performance of the academic.

Chart 3 presents a research conducted by Lopes (1999) in which the approval in the discipline of calculus in certain courses may be related to the difficulty to enter the Institution. The author points out that courses such as Computer Science, Electrical Engineering and Chemical Engineering at UFMG were the ones that presented the lowest failure rates between 1995 and 1997, coinciding with the performance in the vestibular obtained by them.

Table 3. Percentage of failure in Calculus I at UFMG

COURSE	1995	1996	1997
Computer Science	17,1	11,8	28,9
Statistics	48,7	57,5	82,3
Physics	33,3	34,8	40,6
Mathematics	54,8	47,5	37,2
Chemistry	48,5	58,0	64,7
Civil engineering	38,1	35,4	47,2
Electrical Engineering	12,5	29,2	29,0
Metallurgical Engineering	35,1	60,1	67,4
Geology	50,0	84,9	67,5
Mining Engineering	74,4	66,8	67,5
Chemical engineering	24,2	14,2	30,7

Source: Adapted from Lopes (1999).

The research was also applied in the Engineering and Mathematics Degree courses at USP for the same years analyzed. The failure rate in the discipline of Calculus by the students of Engineering

(35%) was considerably lower if compared to the students of Mathematics (53.1%), converging again to the analysis that concerns the score obtained for admission to the university.

The universities mentioned present the same scenario as another well-regarded institution such as UFRGS. If a minimum grade were required in the mathematics test in the entrance exam, only 22% of the students who entered that year would actually be approved. It is alluded to students enrolled in Calculus I without understanding topics such as fractions – an understanding that is expected to be acquired in elementary school (Lopes, 1999).

Years later, Rafael and Escher (2015) made the same comparison between the performance in the discipline and the score for those who passed the entrance exam at the Federal University of Rio de Janeiro. Courses such as Mathematics, Chemistry, Meteorology, Astronomy and Geology pointed to a failure rate in the order of 56% for enrolled students, while for engineering courses, whose admission requires a better performance of the candidate, this rate oscillated between 42 and 48%.

Taking into consideration the Hybrid Engineering Institution analyzed in this article, it is possible to verify that of the 29 students who entered through ENEM, only eight dropped out and did not perform any evaluative activity. The others were approved with an average of around 6.89 and are part of the percentage of 30% discussed in Chart 2. All of these students received some kind of incentive as scholarships; granting them discounts of 10 to 33% on the tuition fee of the course.

Table 4. Types of scholarships and discount percentages awarded

PURSE	DISCOUNT GRANTED	AGE GROUP OF THE STUDENT
ENEM	10%	24
ENEM + FATHER	33%	28
High School Graduate	10%	36

Table 4 presents the types of incentive scholarships provided to 80% of the students enrolled in hybrid engineering courses in 2018, that is, of the 155 students, only 30 made the full payment regarding the monthly cost.

The scholarship entitled as ENEM is awarded to students who took such a test and obtained a satisfactory performance – it is understood as grades equal to or above the average compared to the students who took the test that year. The acronym PAI is known as Intelligent Installment and allows the student a longer term for the payment of the installments of the undergraduate course and without the incidence of interest. The last incentive that Table 4 provides concerns the discount granted to students who have completed high school in a period of less than two years. It can be seen that the age group of the students who received this scholarship is around 36 years old. This data, together with the official documents of the research, shows that a large part of the target audience obtained the certificate of High School after attending supplementary.

The interruption in studies and the "race" after a long period without the practice and encouragement of education, makes the imposed expectation and the reality obtained completely divergent aspects.

5 CONCLUSION

The difficulties presented by students of different courses and Institutions of Higher Education in the discipline of Calculus I brings as a common cause a weak base with regard to the understanding and understanding of mathematics of elementary and secondary education. Analyzing more deeply, it is perceived a certain convergence of performance among those who are exposed to a vestibular contest, for example, and need to present dominance in front of their competitors. It is not defended the fact of a test itself, but the relationship between student and study when the same is under situations in which knowledge is put to the test.

The teaching of Calculus I in the hybrid modality, in addition to the challenges also found in face-to-face education, points out the difficulties of using technology as an ally in the learning process to an audience whose age group is often disassociated from digital media.

The ease of access to information of when and where, become underutilized when the subject who should be active in the process does not present baggage of prior knowledge or discernment to understand the purpose of hybrid teaching.

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