International Electronic Journal of Mathematics Education
2024, 19(4), em0796
e-ISSN: 1306-3030
https://www.iejme.com

MODESTUM

Research Article **OPEN ACCESS**

The importance of Method 300 to improve the mathematical foundation of first-year STEM Brazilian undergraduates

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Citation: Paulo, G. S., Dakuzaku, M. M. G., & Ortega, E. M. V. (2024). The importance of Method 300 to improve the mathematical foundation of first-year STEM Brazilian undergraduates. *International Electronic Journal of Mathematics Education, 19*(4), em0796. https://doi.org/10.29333/iejme/15518

ARTICLE INFO

Received: 08 Jun. 2024

Accepted: 06 Oct. 2024

ABSTRACT

This research explores strategies to support first-year STEM Brazilian undergraduates in two programs, computer science and mathematics, through partnerships among faculty and student members and the implementation of an active methodology known as "Method 300" within an elementary mathematics course. The primary goal of these initiatives was to enhance the academic performance of freshmen. In Method 300, for students to benefit from grade improvements, they must assist each other, regularly attend team meetings, and commit to the activities that constitute the method. The method was implemented only during the first half of the course, fortunately it also implicated into the second part of the course, showing that a tenth of the students who performed poorly at the beginning achieved satisfactory and excellent performance in the last assessment, even though the content was more complex. According to the assessment system of the whole course, by monitoring students who initially had poor academic performance, it was found that half of them achieved satisfactory performance by the end of the course, which contributed to a final approval rate above 73% of all students. The condition of student heterogeneity is crucial for the effective application of Method 300; without it, this could become a potential limitation to its successful implementation. In addition to this strategy, the course was supported by voluntary extracurricular tutors, although these were underutilized by the freshmen, prompting us to consider new ways of providing support. These results suggest that future research in this field should focus on improving students' academic performance by systematically replicating Method 300 in other courses for freshmen students.

Keywords: Method 300, meaningful learning, integration, STEM

INTRODUCTION

It is important to reaffirm the fundamental role that mathematical knowledge plays in the history of humanity. The advances achieved in the field of science and technology in different areas, in general, use some mathematical concepts. Man, when producing his existence, built and organized mathematics, reaching very high levels of abstraction, allowing this science to solve problems of social practice and transcend reality. However, such importance and richness of mathematical theories are not accompanied by effective learning in this field of knowledge. Even students who like mathematics and seek degree courses in the area or related areas, such as engineering, experience many difficulties in the first years.

The data organized by the Program for International Student Assessment (PISA) provide an important international historical overview about Brazilian system education. This program was launched by the Organization for Economic Co-operation and Development (OECD) and conducted its first assessment in 2000. PISA assessments are not just focused on measuring how much the students can reproduce what they have learned; but also on how well students can apply the knowledge they have learned at school in their personal and future professional lives (OECD, 2023a).

It is necessary to be careful when looking at PISA results, which present specific objectives and cannot necessarily measure effective student learning, but it is still a concrete indicator to be considered.

According to the PISA report (OECD, 2023a, 2023b, 2023c), Brazil is below the mean of the OECD countries in all subjects considered (reading, mathematics, and science) and it appointed that in mathematics, low-achievers became stronger and high-achievers became weaker (see **Figure 1**).

The low score of the Brazilian students in mathematics, which can be seen in **Figure 1**, has revealed the need for an effective policy to improve the Brazilian educational system. As the implementation of the new education policy in a country is a complex

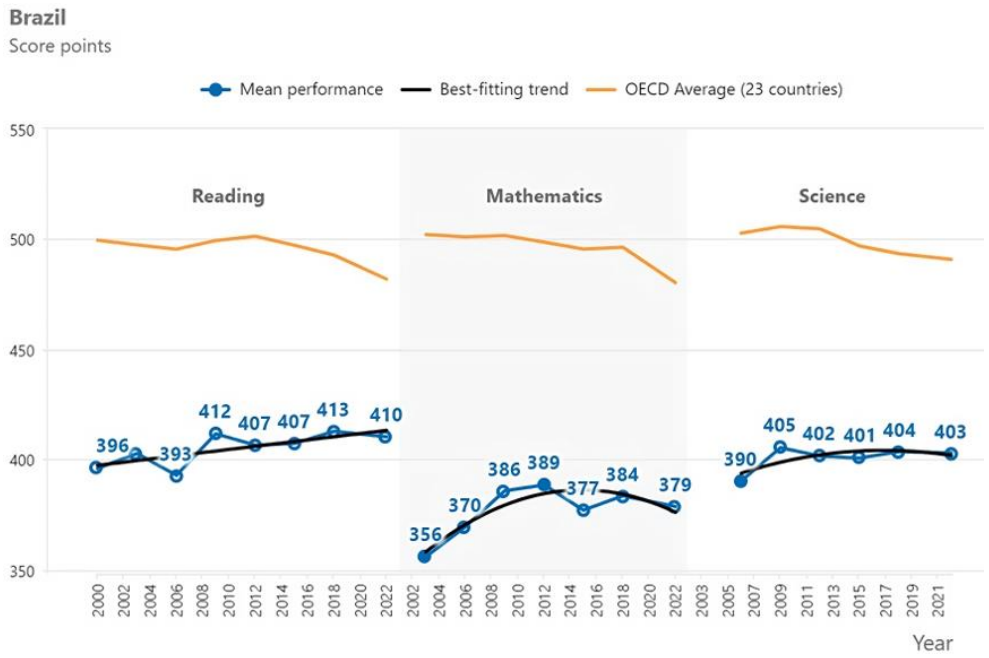

Figure 1. Trends in performance in mathematics, reading and science (https://oecdch.art/a40de1dbaf/C359)

issue and it may reflect their results in a medium-long period of time, the poor foundation in mathematics of first-year STEM undergraduate students has fallen on the university.

Furthermore, it is crucial to consider that the transition from high school to university does not unfold seamlessly for every student, adding complexity to the current situation. At the institutional level, Alexander and Gardner (2009) discuss the need for first-year institutional policy and provide a self-study model developed by the Policy Center on the First Year of College to improve the freshman experience. The book edited by Feldman (2017) brings other levels of discussion of the first year of college, including articles on the influence of society, demography, affordability, persistence, practices and behaviors change, for example.

As a good academic practice, it is well known that active learning methodologies provide a positive impact on student learning outcomes, socialization with classmates, and the sense of belonging to the institution, among other benefits. Here are some examples of active learning methodologies: peer instruction (Mazur, 2015), team-based learning (Michaelsen et al., 2004), problem-based learning (Barrows, 1986; Siagian et al., 2019), project-based learning (Bender, 2014; Nguyen et al., 2019), Method 300 (Fragelli, 2019), flipped classroom (Bergmann & Sams, 2012), gamification (Chou, 2015; McGonigal, 2011; Rincon-Flores, 2018), and flipped dialogue (Pavlova, 2024).

Method 300 was originally proposed by Fragelli (2019), a faculty member who developed and applied this method for 250 students in the calculus I course into the engineering programs at the University of Brasília (UnB), Brasília, Brazil. In this specific Brazilian context described by Fragelli (2019), there was a registered 174% improvement in the grades of students who had previously presented poor academic scores.

To connect the three presented variables: gaps in mathematical foundations, issues in the transition from high school to university, and good academic practices through the active learning methodologies; this research focuses on Method 300 to integrate freshmen into the university environment and address deficiencies in mathematical foundations more immediately. Method 300 had not previously been applied and reported for freshmen in the computer science and mathematics programs, at our public research intensive university campus, in the elementary mathematics I course before.

Therefore, motivated by the experience reported by Frangelli (2019), this present research addresses a fundamental question: “Is Method 300 capable of influencing the academic performance of first-year STEM Brazilian undergraduates, specifically in the computer science and mathematics programs, at a public research intensive university campus, in the elementary mathematics I course?” This evaluation is conducted in comparison to the support provided by peer tutors, being senior students, for freshman students requiring special assistance.

This paper is organized, as follows: we describe the initial planning, the people involved, and the main institutional support received. Then we briefly describe the Method 300 (Fragelli, 2019). After that we attract attention to specific details of Method 300 applied to our research. We then display results and discussions when Method 300 is applied and when only peer tutors are designed to cooperate with the students. Finally, we explain conclusions.

CONTEXT AND ELEMENTS FOR THE PROJECT DESIGN

The development of the present research took place in the first half of 2023. The faculty member, who had participated in some training workshops on active learning supported by the office of the vice provost for undergraduate affairs of a public research intensive university in Brazil, was responsible for teaching “*matemática elementar I*” (elementary mathematics I) about

mathematical foundations to the 2023 freshmen of the computer science and mathematics programs. The classes occurred weekly in the evening period, initially with a total of the 72 students by combining computer science and mathematics programs.

In order, to maximize support for this heterogeneous group of students, the faculty member implemented the following actions:

- Selection of volunteer peer tutors (senior undergraduates/at the last year of the mathematics program) to support first-year students that required special assistance on the content.
- Implementation of Method 300 (Fragelli, 2019) in the first two months (first part) of the elementary mathematics I course to motivate and achieve better performance and social engagement among students, since the Method 300 is strongly recommended to be applied in classrooms composed of heterogeneous students.
- Integration between students of different educational levels (undergraduate students and postgraduate students) through a program for enhancement and support of teaching in higher education supported by office of the vice provost for graduate studies of a public research intensive university in Brazil.

The development of this research was directly a collaboration between researchers from two areas: computational and applied mathematics (the researcher who taught the elementary mathematics I course and is interested on good practices in high education in STEM) and mathematics education (the researcher with experience in teaching mathematics and teaching methodologies and teacher training in mathematics for early elementary education), and a student of a postgraduate program in computational and applied mathematics in order to assist the implementation of Method 300 taking care with the tools involved.

The partnership among different faculty and student members was a core of this project to implement good practices in the first-year STEM high education at a public research intensive university in Brazil, particularly at the course about mathematical foundations.

A BRIEF DESCRIPTION OF METHOD 300

Method 300 is an engagement pedagogy originally proposed by Fragelli (2019), a professor at UnB. It is based on active and collaborative learning and can be applied to various teaching and learning contexts, including traditional classes or other adopted methodologies, whether in-person courses or in virtual learning environments.

The course proceeds as usual until the first assessment, which can take various forms, such as written exams, oral exams, assignments, seminars, and etc.

After this initial assessment, groups are strategically organized based on the grades (Fragelli, 2019). Each group should consist of approximately 5 students, with those who scored above a certain cutoff grade (being designated as “helpers”) and those who scored below the cutoff (named “helpee”). The highest-scoring student in each group becomes the leader. This group organization is obtained using a specific spreadsheet implemented by Fragelli (2023) for Method 300.

Subsequently, goals and deadlines for individual and team activities are established. Typically, the deadline is set between 7 to 15 days for in-person courses. During this period, the helpers prepare activities for the helpee students and also schedule study meetings with the team. The common activities include exercise lists related to the content that needs improvement. The leader/helper is responsible for providing evidence of these meetings (photos, for example). Here, every action must be reported to the faculty member, who has a complete view of the development of Method 300.

In case the goals and activities are done within the specified timeframe, the helpee students have the opportunity to participate in another assessment called “test 300”. This assessment is different from the initial one but covers the same content and has a similar level of complexity. Helpee students have their initial assessment grade replaced by the test 300 grade, but only if it is higher.

In conclusion, all students involved, both helpers and helpee, must complete a questionnaire, akin to a peer evaluation form, that uses a 5-point Likert scale and contributes to improving the helpers’ grades. In this survey, helpers assess their contribution to the team, and helpee students evaluate the assistance they received from the helpers. Based on the completed questionnaires and also on the new grade achieved by the helpee on test 300, the helper students’ grades are recalculated to include a bonus, which can be worth up to 1.5 points.

Fragelli and Fragelli (2017) argue that the method helps not only the students who are helped, but those who help put themselves in the perspective of thinking about effective ways of teaching and can review the meaning of their concepts. Another important aspect is the act of sharing learning, which generates empathy and humanization of the teaching and learning process.

For further details about Method 300, please, see Fragelli (2019).

METHOD 300 IN MATHEMATICAL FOUNDATIONS

In this section, we will describe some relevant points of the step-by-step process outlined before, highlighting how we applied the Method 300 in the elementary mathematics I course for the classroom composed initially by 72 heterogeneous students of computer science and mathematics in high education programs, based on the method developed by Fragelli (2019).

The course attended elementary mathematics I was offered in the in-person modality and in evening classes. To facilitate data collection and analysis, we chose to organize the dynamics of Method 300 in the virtual environment Google Classroom because it is a powerful tool for both students and teachers, and we were already familiar with it.

The assessment system relative to the part of Method 300, at the first half of the course, included one (first) individual and mandatory written tests (grading P1) for all students; the test 300 (grading P300) for helpee students, in order to review and reinforce their understanding of the content related to the first assessment; and the bonification (grading B300) for helpers, according to the rules of Method 300 described before.

Discussing further important details regarding our approach, some students had jobs, lived in other cities, or encountered difficulty attending the university outside of class hours to participate in the team meetings required by Method 300. Therefore, we opened the possibility for team meetings to be held via video conferencing, using Google Meet, for example. We noticed that this form was used in cases of genuine difficulty, as students provided evidence of their participation in Method 300 through photos, videos of the meetings, or digital screenshots of the video call, allowing us to monitor the context in which these meetings took place.

In addition to verifying the efficiency of the group meetings, students provided evidence of the preparation of the exercise lists by helpers and the resolution of these exercises by helpee students.

Ultimately, a Google Form questionnaire was administered to all participants, in which the helpee students assigned scores to each helper in their group, and the helpers self-assessed their level of assistance. The scores ranged from 1 to 5, with a score of 1 indicating “did not help me/I did not help at all”, and a score of 5 indicating “helped me a lot/I helped a lot”. Both the score achieved in the questionnaire assessment and the new grade obtained by helpee on P300 were converted into a bonus between 0 and 1.5 (B300), which was added to the P1 score of the helper student.

In summary, at the end of the application of Method 300, the new score (N1) will be determined, as follows: for helpers, N1 = P1 + B300; and N1 = max {P1, P300}, for helpee students.

Before closing this section, some details about data collection and analysis will be more explicit. The instructions, tasks, survey and due dates were posted in the virtual environment (Google Classroom) in different manners for helper and helpee. Hence, both students’ views will be reported, as follows:

Helpers view of the new environment “Method 300” into Google Classroom:

#1. Welcome and publish the list of group formation.

#2. Instructions to helpers–explaining their responsibilities (tasks) which will be covered in separate items below.

#3. Task 1: Elaborate to helpee students a list of exercises about the first content - it must be delivered here until the due date, before test 300.

#4. Task 2: Provide evidence about the team meetings–it must be delivered here until the due date, before test 300.

#5. Task 3: Questionnaire for helpers via Google Form–it must be delivered here until the due date, during test 300.

Remarks:

(i) Each group could have more than one helper student. Therefore, to prevent duplicate data, only one of them, the leader for instance, must deliver the tasks within the due period.

(ii) Schedule team meetings is a responsibility of the helpers, according to the common availability of the groupmates.

(iii) As test 300 should be done only by helpee, the helpers could use this timeframe to complete their survey about their level of help.

(iv) Questionnaire for helpers: “Score your level of help for each helpee of your group: 1. I did not help at all; 2. I helped a little; 3. I helped reasonably; 4. I helped much; 5. I helped a lot”.

Helpee view of the new environment “Method 300” into Google Classroom:

#1. Welcome and publish the list of group formation.

#2. Instructions to helpee–explaining their responsibilities (tasks) which will be covered in separate items below.

#3. Task 1: Solve the list of exercises about the first content elaborated by helpers–it must be delivered here until the due date, up to test 300.

#4. Task 2: Questionnaire for helpee via Google Form–it must be delivered here until the due date, a day after test 300.

Remarks:

(v) The helpee students could participate in test 300 only if they fulfilled their responsibilities, including the participation in the team meetings scheduled with helpers.

(vi) (vi) Questionnaire for helpee: “Score the level of help you received by each helper of your group: 1. did not help me; 2. helped me a little; 3. helped me reasonably; 4. helped me much; 5. helped me a lot”.

Note that faculty members had a complete view to collect all important data to be analyzed in the context of Method 300. In addition, the faculty members were able to post reminders, which is very important to promote engagement of the students to elevate the chances of success with Method 300.

The data collected via Google Classroom, Google Forms and also via scores of the written tests (P1 and P300) were transferred to a specific Microsoft Excel spreadsheet implemented by Fragelli (2013) for recalculating the new scores N1. The new score N1 for helpee is simpler to update, just replacing P1 score to P300 score as definite before N1 = max {P1, P300}. For helpers, the new score

Table 1. Bonification system for helpers (adapted from the Microsoft Excel spreadsheet implemented by Fragelli, 2013)

Performance situation of the helpee from P1 to P300	**Round up average of Likert scale and bonification to helper**				
	1	**2**	**3**	**4**	**5**
A. Helpee continues with low performance: improvement **less than 1.0** point.	0.00	0.25	0.25	0.40	0.50
B. Improvement **larger or equal to 1.0 pt**. P300 score is still less than 4.5 points	0.00	0.25	0.25	0.50	0.75
C. Improvement **larger or equal to 1.0 pt**. P300 score is larger than or equal to 4.5 points.	0.00	0.25	0.50	0.75	1.00
D. Amazing improvement: P300 score is larger than or equal to **7.0** points.	0.00	0.25	0.50	1.00	1.50

depends on the performance of the helpee on test 300 and also the points obtained through the questionnaires, accumulating a bonification B300 on the initial grade P1 of the helpers (N1 = P1 + B300).

The bonification system is an important stage to motivate the engagement of the helpers, who are crucial to the success of Method 300. The faculty members are allowed to establish upper limits to define situations in which helpee students will belong after doing test 300. These situations are displayed in the first column of **Table 1**. The upper limits chosen were 1, 4.5 and 7 points, considering our assessment system ranged from 0 to 10 points. Regarding the questionnaires, a round up average of the points obtained from a helper and your helpee was adopted. For instance: related to one specific partnership, a helper grade 3 to him/herself (I helped reasonably) and received 4 from one of his/her helpee (helped me much), then the valid scale to helper is 4, when analyzing the referred helpee. **Table 1** displays the bonification for helpers–0, 0.25, 0.4, 0.5, 0.75, 1.0, or 1.5–according to the questionnaires and the level of improvement of helpee from P1 to P300 scores. Finally, for a helper we considered the maximum bonification score among those obtained for each helpee.

To clarify, consider one group with 3 helpees (helpee-1, helpee-2, and helpee-3). Suppose:

- Helpee-1: P1 = 3.0, P300 = 6.75 > 4.5, improvement of 3.75 > 1.0; and the valid questionnaire scale to helper is 4. In **Table 1** the bonification for helper is given by C4 (0.75);
- Helpee-2: P1 = 1.05, P300 = 3.75 < 4.5, improvement of 2.7 > 1.0; and the valid questionnaire scale to helper is 5. In **Table 1** the bonification for helper is given by B5 (0.75); and
- Helpee-3: P1 = 0.0, P300 = 5.5 > 4.5, improvement of 5.5 > 1.0; and the valid questionnaire scale to helper is 5. In **Table 1** the bonification for helper is given by C5 (1.0).

Then the helper receives a bonification of 1.0 point (B300 = max {C4, B5, C5}).

Furthermore, to establish a counterpoint to the Method 300, another engagement pedagogy via volunteer peer tutors was emphasized during the learning process related to the content of the second part of the course, that was evaluated by the second mandatory written test (grading P2).

Next section will describe the results of these evaluations and self-assessments, as well as the scores from the first assessment (P1), the test 300 (P300), the second assessment (P2), and also the final exam that is required by the university.

RESULTS

In this section, the implementation of the rating system and performance assessment will be presented and discussed, comparing the application of Method 300 to the use of peer tutors for assisting students.

Method 300

For participation in Method 300, the classroom consisted of 60 students, with 30 helpers and 30 helpee students. Students who dropped out at the beginning of the course were excluded from the calculations presented in this research. As previously described before, the helpers and helpee students were classified based on the tool (a spreadsheet) implemented to Method 300, considering the score of the first assessment (P1) and a cutoff score that needs to be a little below the satisfactory score. The score varied on the ranging from 0 up to 10, being a satisfactory score above or equal 5. In order to motivate helpers engage on the project, a cutoff score of 4.5 was defined.

It is worth conducting a brief review of the data, it could be seen as coincidental that there was an equal number of helpers and helpee students. However, it was not at all, Fragelli (2019) mentions in his book that the failure rate in calculus I courses has an average of 50% in Brazil, sometimes reaching as high as 95%. In our case, it was not calculus I but an important first-semester course to cover the gap on mathematical foundation.

Analyzing the scores of the first assessment (P1) for the entire classroom, with scores ranging from 0 to 10, the average score was 4.88. After applying Method 300, analyzing the score N1, the average score was 6.10, showing a 25% improvement. When considering only helpee students, the percentage of improvement was even higher. The average score in P1 was 2.0, and it was 3.89 in N1, indicating a 94.5% improvement in their performance. These data are exhibited in **Table 2** and show how much the classroom is heterogeneous, considering the discrepancy between the average score when the entire classroom is considered in the calculation and when we pay attention only to the helpee students. In fact, the hypothesis of heterogeneity among the performance of the students was verified on the first assessment (P1). It is fundamental for applying Method 300, since it is necessary to have students with good technical conditions to teach and help their classmates with gaps in the content.

Now, attention must be drawn to the bonus system for helpers. Considering the assessment from the questionnaires administered as part of the Method 300, which range from 1 to 5, the average score given by the helpee students to the helpers

Table 2. Average scores of the first assessment, ranging from 0 to 10, before (P1) and after Method 300 (N1)

System assessment	Total of 60 students	Helpee
P1	4.88	2.00
N1	6.10	3.89
Percentage increase	25.0%	94.5%

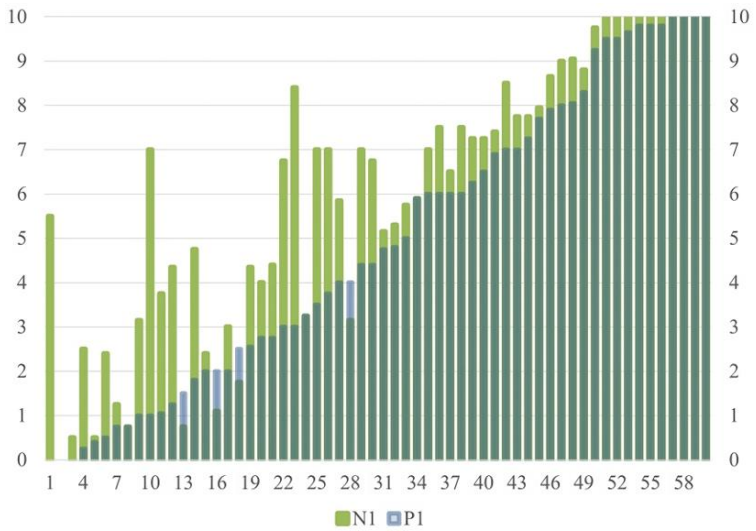

Figure 2. Initial P1 score and the new N1 score according to the rules of Method 300 (Source: Authors' own elaboration)

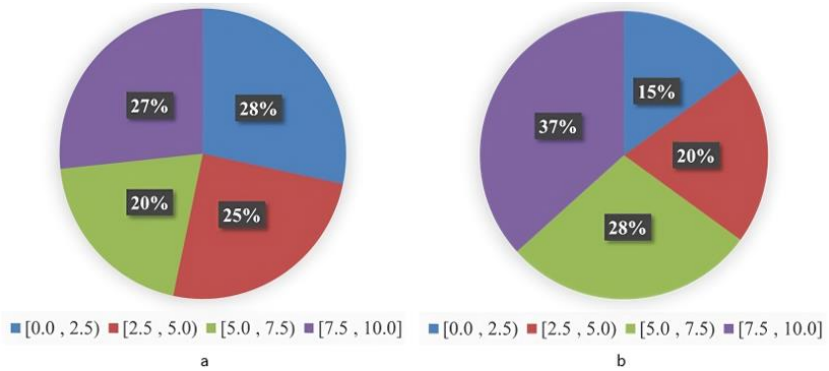

Figure 3. Percentage of students in each grade range: (a) P1 & (b) N1 (Source: Authors' own elaboration)

was 4.79 (using roundup to a Linkert scale, it means 5), while the average score given by the helpers to themselves was 3.39 (using roundup to a Linkert scale, it means 4). This indicates that the helpers were stringent in their self-assessments and the helpee students valued the commitment and dedication of their classmates who helped them. This step involves reflection of all students as a group, which may strengthen new partnerships for the freshmen facilitating the transition from high school to university.

In order to have a general and clear overview of the performance of the 60 students participating in Method 300, we can examine **Figure 2**, a bar graph where the horizontal axis represents the enumeration of each student, and the vertical axis represents their scores. We can clearly observe an overall improvement in the students' performance from P1 to N1. However, helpee students numbered 2, 8, 13, 16, 18, 24, and 28 did not achieve better mastery of the content, because their grades in P300 were the same or worse than in P1 (see **Figure 2**). Helper students are numbered from 31 to 60. It is notable that five helper students (numbered 34 and 57-60) did not receive any bonus because the first student dropped out of helping his/her groupmates, and the four latest had already achieved the maximum score at the first assessment. In this last case, despite knowing they would not receive any bonuses, the students took part in Method 300 as helpers. This shows their willingness to engage in cooperative work, demonstrating once again that Method 300 is capable of creating a welcoming environment among classmates.

For a more detailed analysis, we divided the test scores into four score intervals: [0, 2.5), [2.5, 5), [5, 7.5), and [7.5, 10]. The results for P1 are displayed in part a in **Figure 3**), and the results for N1 are decapitated in part b in **Figure 3**) using percentage. Note that 47% of the students scored 5 or higher in the first assessment, while after applying the Method 300 assessment, this value increased to 65%. A percentage difference of 18% increase (from P1 to N1). It is important to highlight that 10% (the majority) moved into the range with scores greater than 7.5. On the other hand, the most significant reduction in unsatisfactory scores (below 5) occurred in the range from 0 to 2.5 points (13% of percentage difference). These results indicate that Method 300 has great potential to influence the academic performance of first-year STEM Brazilian undergraduates, specifically in the combination of students from two different programs (computer science and mathematics), in the elementary mathematics I course, taught on a public research-intensive university campus.

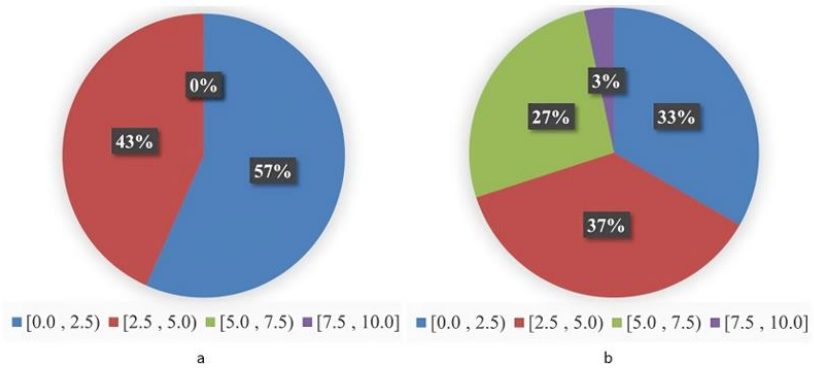

Figure 4. Percentage of helpee in each grade range: (a) P1 & (b) P300 (Source: Authors' own elaboration)

Table 3. Number of students in each grade range for the system of the first assessment

Intervals	Total of 60 students		Helpee		
	P1	N1	P1	P300	N1
[0, 2.5)	17	9	17	10	9
[2.5, 5)	15	12	13	11	12
[5, 7.5)	12	17	0	8	8
[7.5, 10]	16	22	0	1	1

Focusing more closely only on the results of helpee students, we have compiled their performances in part a and part b in **Figure 4** for P1 and P300, respectively. Observing part a and part b in **Figure 4**, we can see that the majority of helpee students experienced a significant improvement in their scores, reducing the number of students with scores below 2.5 and seeing students achieving scores between 5 and 7.5 and even between 7.5 and 10. In percentage terms, we can say that 30% of helpee students recovered the initial course content, with 3% of them achieving excellent academic performance, scoring above 7.5 points.

In terms of the number of students, more details about these data are displayed in **Table 3** and show the improvement in students' grades. Analyzing line by line, the number of students in the two lowest grade ranges, [0, 2.5) and [2.5, 5), decreased from P1 to P300. Consequently, the number of students in the two highest grade ranges increased.

These facts underscore the importance of adopting a system that allows students to review and reinforce the content to achieve meaningful learning. Method 300 has proven to be an excellent alternative for ensuring content review for first-year STEM Brazilian undergraduates, as we will see a counterpoint in the next section.

From a more critical perspective, about two-thirds of students still score below 5 points, with only one-third advancing to higher score bands. According to Moran and Bacich (2018), when faced with the complex challenges of life, we need to learn actively. While they do not disregard learning through transmission, asking questions and experimenting can play a significant role in enhancing learners' understanding. It is important to emphasize that for Moran and Bacich (2018), the term 'active' must be connected to reflective learning. Centered-student learning is not enough; it is essential that they critically and reflectively understand what is being proposed in a given activity.

Moreover, it is important to note that Method 300 group work was applied specifically to the initial content of the elementary mathematics I course, which is just one of several courses in the freshman curriculum. This fact immediately raises a question for future research: Could implementing the Method 300 in all first-semester freshman courses yield even better results?

This approach appears promising, as the subjects, though distinct, intersect and foster the development of complementary skills. Clearly, implementing this methodology requires substantial mobilization from all faculty members who teach freshmen. Additionally, support from other teaching departments, such as mathematical education or pedagogy, may be needed to provide theoretical backing for the practical work. Furthermore, involvement from graduate and senior students would be beneficial to monitor and assist throughout the process.

Peer Tutors

Another action aimed at fostering interaction among first-year and senior students enrolled in the computer science and mathematics undergraduate programs of a Brazilian research intensive university was the selection of volunteer peer tutors. These tutors were tasked to support students that required special assistance, facilitating a deeper understanding of the subject matter, and promoting the development of social skills conducive to enhanced learning outcomes. From the perspective of senior students, this action also enhances their experience and skills (see, for instance, Gardner, 1999), but this issue is not the goal in the present research.

Peer tutors were available to freshmen throughout the entire duration of the course on mathematical foundations, including the initial two months dedicated to Method 300. Upon the completion of Method 300 activities, the reinforcement of learning the contents related to the second part of the course (the latest two months, focusing on the second assessment [P2]) involved the support of both peer tutors and faculty member during extra classes, which were scheduled to assist students in addressing their doubts.

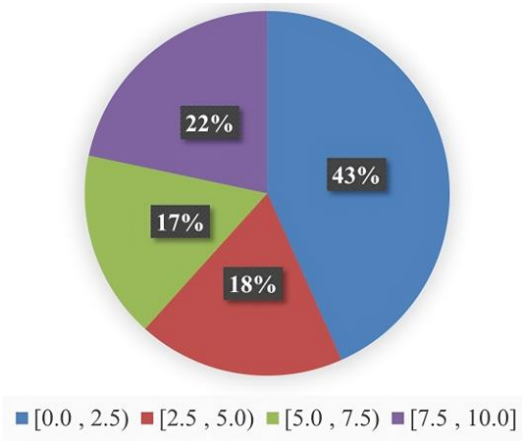

Figure 5. Percentage of students in each grade range in P2 (Source: Authors' own elaboration)

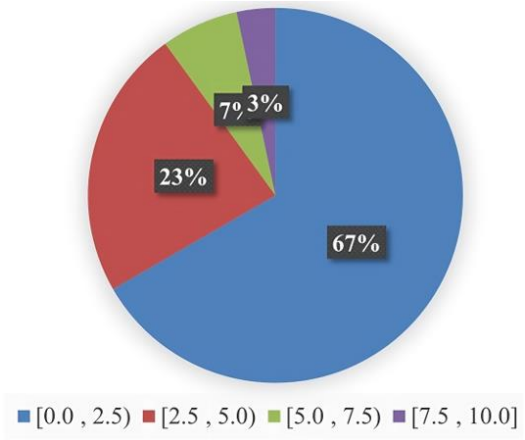

Figure 6. Percentage of helpee in each grade range in P2 (Source: Authors' own elaboration)

Table 4. Number of students in each grade range for the second assessment (P2)

Intervals	Total of 60 students	Total of 30 students who were helpee initially
[0, 2.5)	26	20
[2.5, 5)	11	7
[5, 7.5)	10	2
[7.5, 10]	13	1

At the end of the course, students took a second written assessment (P2), and we can see their performance in **Figure 5**. In quantitative terms, only 39% of the students achieved satisfactory results (above 5 points). This outcome reflects the low demand for additional support in tutoring sessions. Given that the content of P2 was more complex, both the instructor/faculty member and tutors expected that the tutoring sessions strategy would be utilized more frequently by the students.

A more optimistic perspective on these data is when we analyze **Figure 6** regarding those students who had been helpee at the beginning of the course (through Method 300). We can see that 10% of these students achieved scores above 5 points in P2, with 3% of them scoring above 7.5 points. Therefore, by tracking the students who initially did not achieve satisfactory scores, we can observe that some of them managed to change their situation very successfully.

Table 4 numerically describes the information from **Figure 5** and **Figure 6**, showing more clearly that, overall, when considering all 60 students, the scores for P2 were low. However, the interesting fact to be emphasized is related to the meaningful learning achieved by the students classified as helpee in the first assessment. As the content progressively became more complex, some of those students who initially had less than a 4.5 points, after the entire process of Method 300, were able to retain the previous content (related to the first part of the course), from that learn the more complex content (related to the second part of the course), and consequently move into the higher score ranges, above 5.0 points.

These steps are in accordance with Ausubel (1963) who states that meaningful learning takes place when new information is connected to the student's pre-existing knowledge, resulting in enhanced comprehension and improved retention. In this direction, a more recent study conducted by Hattan et al. (2024) systematizes a range of existing literature on prior knowledge and how to activate prior knowledge in text comprehension. Hattan et al. (2024) ensure that:

> "There has been no systematic review of prior knowledge since 1999 and no reviews that have expressly focused on prior knowledge and its activation in relation to reading comprehension"(p. 77).

Table 5. Number of approved students in the discipline

Initial condition of the student	Total number	Approved directly	Approved after exam	Total number of approval
Helpee	30	10	5	15
Helpers	30	27	2	29
Total	60	37	7	44

In our mathematical context, Hattan et al. (2024) emphasize the great gap in this field:

> "The most common domain in which participants read was science (n = 36), followed by reading or language arts (n = 29); social studies or history (n = 23); psychology, statistics, or economics (n = 13); and media or technology (n = 2). These results demonstrate that knowledge activation techniques have been investigated across multiple domains. However, students were infrequently asked to activate knowledge about mathematics or the arts. The former may reflect the reliance on mathematical symbols over connected discourse, while the latter may reflect a dependence on visual content in the arts" (p. 87).

Another point to be noted in the systematic research by Hattan et al. (2024) is that most techniques for activating prior knowledge are based on the individual's prior knowledge. They suggested applying collaborative techniques to support students' learning and referenced other authors (Andreassen & Bråten, 2011; Carriedo & Alonso-Tapia, 1995; Lupo et al., 2019) who also defend that groups or pairs studies are positive for students' comprehension.

Thus, future research in mathematical education could further investigate Method 300 as a viable technique for collaboratively activating prior knowledge, in order to address the gap identified by Hattan et al. (2024).

Assessment Metrics and Student Success Rates

The assessment system of the entire course included two individual and mandatory written tests (grading P1 and P2), one in each two months; the participation on Method 300, determining a new score N1 to replace P1, that include the test 300 (grading P300) for helpee students and a bonification (grading B300) for helper students. The final grading of the course consisted of the arithmetic mean (MS) of the scores N1 and P2.

According to the institutional criteria, the student is considered approved (directly) if this grading is at least 5 ($MS \geq 5$). In case this threshold is not met, students who did not achieve a satisfactory score are permitted to participate in an exam, in accordance with university regulations.

Considering the 60 students who participated in Method 300 (who did not drop out of the course), 61.67% was approved directly, and the remaining 38.33% had to take a recovery exam.

After the recovery exam, the approval rate in the course "elementary mathematics I" increased to 73.33%, meaning there was a 26.67% failure rate on this course. These data and further details are displayed on **Table 5**.

Analyzing in detail those 30 students who were initially helpee, we can see that 15 of them were approved in the course, namely, 50% of the students with initially lower performance achieved satisfactory performance by the end of the discipline. Out of the 30 helpers, who had good performance at the beginning of the course, one of them ended up in the failure rate because this student did not attend any later assessments.

CONCLUSIONS

The application of Method 300 to recover the initial content of a course offered in the first semester for first-year STEM Brazilian undergraduates of two programs, computer science and mathematics, demonstrated to have been a successful strategy. Overall, most teams seemed to support each other. According to the data, half of the students who faced difficulties at the beginning of the course (named helpee) managed to improve their performance and obtain approval.

The decision not to apply Method 300 to recover the content of the second assessment and, instead, wait for the students to carry the group study experience into the peer tutors strategy at the second part of the course had mixed results. Extra-class tutoring sessions were empty, and the grades on the second assessment were low, indicating that relying on the previous group study experience was not totally sufficient. However, it is important to highlight the positive consequence of the Method 300 into the second part of the course, although the second content was more complex, 10% of the students who had been helpee at the beginning achieved satisfactory performance at the second assessment, with a little more than 3% of them obtaining grades in the highest range.

The overall conclusion is that the integration among faculty members, freshmen, and senior undergraduate and postgraduate students to implement new teaching and learning strategies, such as Method 300, was very beneficial and played a crucial role in guiding freshmen in computer science and mathematics undergraduate programs of a Brazilian research intensive university. Furthermore, the participation of postgraduate students provides them early experiences in higher education.

Based on the results of this study, the primary recommendation for future research is to engage all faculty members involved in courses for freshmen to implement Method 300 across all introductory courses. This would necessitate extensive collaboration among faculty, including researchers from related fields such as mathematical education or pedagogy, as well as senior and graduate students. Key questions that need to be addressed include whether Method 300 should be implemented simultaneously across all freshmen courses, or whether Method 300 should be phased in at different times for each freshmen course rather than

implemented simultaneously. Another consideration is if Method 300 should be applied in some courses based on specific criteria, and what those criteria might be.

Additionally, it is important to consider the limitations of studies involving Method 300. The method is effective in heterogeneous classes where helpers can provide support. However, in homogeneous classes with low performance, or performance close to the cutoff grade, the results may be less promising due to the absence of sufficiently competent helpers.

According to the systematic literature review conducted by Hattan et al. (2024) on research related to prior knowledge and its activation in reading comprehension, there is a notable lack of scientific studies addressing these concepts in mathematics, particularly in the context of group or pair work. Considering that our approach allowed students with initially poor performance to achieve satisfactory outcomes even with more complex content, future research in mathematics education could further investigate Method 300 as a potential technique for collaboratively activating prior knowledge. This could help address the research gap identified by Hattan et al. (2024).

Author contributions: GSP: conceptualization, formal analysis, investigation, project administration, writing – original draft, writing – review & editing; **MMGD:** data curation, formal analysis, investigation, visualization, writing – review & editing; **EMVO:** supervision, writing – review & editing. All authors have sufficiently contributed to the study and agreed with the results and conclusions.

Funding: MMGD would like to thank Programa de Aperfeiçoamento e Apoio à Docência no Ensino Superior (PAADES) - Edital 17/2023 - PROPG/UNESP and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) - process nº 130987/2023-9.

Acknowledgements: The authors would like to thank the Department of Mathematics and Computer Science, the Postgraduate Program in Computational and Applied Mathematics, and the Department of Education at FCT/UNESP.

Ethical statement: The authors affirm that the study was conducted in an ethical and responsible manner, ensuring the confidentiality and privacy of all participants. No personal information regarding students or university staff was shared at any point during the research process. Written informed consents were obtained from the participants.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Alexander, J. S., & Gardner, J. N. (2009). Beyond retention: A comprehensive approach to the first college year. *About Campus, 14*(2), 18-26. https://doi.org/10.1002/abc.285

Andreassen, R., & Bråten, I. (2011). Implementation and effects of explicit reading comprehension instruction in fifth-grade classrooms. *Learning and Instruction, 21*, 520-537. https://doi.org/10.1016/j.learninstruc.2010.08.003

Ausubel, D. P. (1963). *The psychology of meaningful verbal learning*. Grune & Stratton.

Barrows, H. S. (1986). A taxonomy of problem-based learning methods. *Medical Education, 20*(6), 481-486. https://doi.org/10.1111/j.1365-2923.1986.tb01386.x

Bender, W. N. (2014). *Aprendizagem baseada em projetos: Educação diferenciada para o século XXI* [Project-based learning: Differentiated education for the 21st century]. Penso.

Bergmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day*. ISTE.

Carriedo, N., & Alonso-Tapia, J. (1995). Comprehension strategy training in content areas. *European Journal of Psychology of Education, 10*(4), 411-431. https://doi.org/10.1007/BF03172930

Chou, Y.-K. (2015) *Actionable gamification: Beyond points, badges, and leaderboards*. Leanpub.

Feldman, R.S. (2017). *The first year of college: Research, theory, and practice on improving the student experience and increasing retention*. Cambridge University Press. https://doi.org/10.1017/9781316811764

Fragelli, R. (2019). *Método trezentos: Aprendizagem ativa e colaborativa, para além do conteúdo* [Three hundred method: Active and collaborative learning, beyond the content]. Penso.

Fragelli, R. (2023). *Trezentos* [Three hundred]. Método Trezentos. https://www.metodo300.com/

Fragelli, R. R., & Fragelli, T. B. O. (2017). Trezentos: A dimensão humana do método [Three hundred: The human dimension of the method]. *Educar em Revista, 63*, 253-265. https://doi.org/10.1590/0104-4060.46800

Gardner, J. N. (1999). The senior year experience. *About Campus, 4*(1), 5-11. https://doi.org/10.1177/108648229900400103

Hattan, C., Alexander, P. A., & Lupo, S. M. (2024). Leveraging what students know to make sense of texts: What the research says about prior knowledge activation. *Review of Educational Research, 94*(1), 73-111. https://doi.org/10.3102/00346543221148478

Lupo, S. M., Tortorelli, L., Invernizzi, M., Ryoo, J. H., & Strong, J. Z. (2019). An exploration of text difficulty and knowledge support on adolescents' comprehension. *Reading Research Quarterly, 54,* 441-584. https://doi.org/10.1002/rrq.247

Mazur, E. (2015). *Peer instruction: A revolução da aprendizagem ativa* [Peer instruction: The active learning revolution]. Penso.

McGonigal, J. (2011). *Reality is broken: Why games make us better and how they can change the world*. Penguin.

Michaelsen, L. K., Knight, A. B., & Fink, L. D. (2004). *Team-based learning: A transformative use of small groups in college teaching*. Routledge.

Moran, J., & Bacich, L. (2018). *Metodologias ativas para uma educação inovadora: Uma abordagem téorico-prática* [Active methodologies for innovative education: A theoretical-practical approach]. Penso.

Nguyen, A., Nguyen, D., Ta, P., & Tran, T. (2019). Preservice teachers engage in a project-based task: Elucidate mathematical literacy in a reformed teacher education program. *International Electronic Journal of Mathematics Education, 14*(3), 657-666. https://doi.org/10.29333/iejme/5778

OECD. (2023a). *PISA 2022 results (volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

OECD. (2023b). *PISA 2022 results (volume II): Learning during–and from–disruption*. OECD Publishing. https://doi.org/10.1787/a97db61c-en

OECD. (2023c). PISA 2022 results: Factsheets–Brazil. *OECD*. https://www.oecd.org/publication/pisa-2022-results/country-notes/brazil-61690648/

Pavlova, N. H. (2024). Flipped dialogic learning method with ChatGPT: A case study. *International Electronic Journal of Mathematics Education, 19*(1), Article em0764. https://doi.org/10.29333/iejme/14025

Rincon-Flores, E. G., Gallardo, K., & Fuente, J. M. D. L. (2018). Strengthening an educational innovation strategy: Processes to improve gamification in calculus course through performance assessment and meta-evaluation. *International Electronic Journal of Mathematics Education, 13*(1), 1-11. https://doi.org/10.12973/iejme/2692

Siagian, M. V., Saragih, S., & Sinaga, B. (2019). Development of learning materials oriented on problem-based learning model to improve students' mathematical problem solving ability and metacognition ability. *International Electronic Journal of Mathematics Education, 14*(2), 331-340. https://doi.org/10.29333/iejme/5717