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Índice

Changing assessment for active learning in an Algebra course

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Abstract

The course takes place in a Civil Engineering Integrated Master program. It has three hours of theoretical classes and two hours of practical classes each week. The contents are the usual of Algebra engineering courses. The assessment method used previously were two tests during the semester followed by exams to improve final grades or to have the chance of replacing failing grades. The percentage of success in the previous years was between 50% and 60%. Several reasons were presented as causes for these low rates of success. It was decided to innovate the assessment while trying to involve students along the semester. The upgrade consisted in including an evaluation of each student along the semester valued at 15% of the final grade. Each student was called randomly at least two times during the semester to solve on the board the problems assigned for each practical class and answer four questions during the theoretical sessions. This allowed to detect understanding problems of students, to motivate students to be prepared for each class and to value the work done along the semester besides the written tests.

Keywords: Assessment, Formative, Continuous.

1. Context

This description addresses the academic year of 2019/20 since innovation addressed in this paper was introduced in academic year of 2020/21. Algebra course is at the first semester of the five year program in Civil Engineering program. Makes part of the preparatory disciplines to provide competences in Mathematics and Physics to the future engineers. It is a theoretical course with some problems applied to engineering. The learning outcomes and competences are: a) to define vector spaces, bases of spaces (finite or infinite dimensional) arrays, linear applications, quadratic forms, linear systems, eigenvalues and eigenvectors; b) to compute these entities in specific problems, solve problems that use these notions as tools and to apply these concepts and properties that are involved in

solution seeking procedures; c) to analyze the validity of solutions and to handle problems with one or more solutions or open solutions; d) to formulate problems with algebraic components in mathematical terms; e) to draw conclusions from calculations performed on the basis of mathematical properties or known algebraic theories. Program is composed by a) Vector spaces: definition and examples, subspaces, generated subspaces, linear dependence, bases and dimensions, sum of subspaces; b) Matrices: definition and examples, operations and properties, changes of basis, special classes of matrices; c) Linear transformations: definition and examples, kernel and image, inverse transformation, projections, symmetries, vector space of linear transformations, matrix representation, inversions and rotations; d) Determinants: systems of linear equations, homogeneous and non-homogeneous, discussion of systems; e) Eigenvalues and eigenvectors: invariant subspaces, calculation of eigenvalues, diagonalization of matrices, canonical forms; f) Euclidean spaces: scalar product and norm in spaces of dimension n, projections, vector product, mixed product; g) Analytic geometry: the n-dimensional space, a brief review of intersections, parallelism and perpendicularity, distances and angles, relative positions (FEUP, 2021).

The discipline is composed by theoretical classes for the whole student group and practical classes with about twenty five students per group. The total of weekly load is of three hours for the theory and two hours for the practising problems classes. The discipline lasts generally for sixteen weeks. There are generally two exams per semester with one at middle and second at the end. Students have another chance of improving results during an extraordinary period after all examinations are complete and without any penalty in the final grade. Students need to attend a minimum of three quarters of each type of classes as pre-condition to attend the exams. Theoretical classes are of expository type with the whole class. Dialogue is established when questions arise from students that need immediate clarification.

Teachers have fixed weekly periods to clarify individually and privately questions about the subjects. Practical classes are intended to apply the theoretical subjects in concrete problems. These problems make part of a publication of about one hundred and fifty examples. Students are informed in the previous week of the problems to solve in each week. In practical classes the problems are addressed and questions by students are answered. At the end of each class the teacher solves the scheduled problems. The students studies and works are supported by related bibliography and by additional digital materials provided in a Moodle learning management system (Moodle, 2021).

The exams that define the grade of each student in a scale of zero to twenty points are without consultation of books or notes. Each exam has three or four questions with items and a multiple choice set of about ten questions. Each exam lasts for two hours and in 2020/21 it had a duration of ninety minutes due to the pandemic restrictions. The exams have different weights in the calculation of the final grade being forty five percent for the first exam. This difference in relative importance is due to the amount of subjects generally addressed in the first part of the semester that is inferior to the quantity of subjects examined in the second assessment. In terms of final grade of each student, there are no other elements included in the calculation besides the two exams. The evaluation does not involved any assessment of work done by each student along the semester besides the two tests (FEUP, 2021).

Failing grades in this discipline of algebra are around 50% of registered students that attended exams. In table 1 the values of students, participation of students in the exams and average grades are presented for academic years of 2017/18, 2018/19 and 2019/20 (FEUP Statistics, 2021).

A quick analysis of table 1 reveals that rates of approval of those students attending examinations varied in these three years between 50 and 66%. These are low approval rates

with a clear deterioration from 2017 until 2019. The rates of approval for those registered were lower than these ones ranging from 42 to 53%.

Table 1: Grades of students

Results	**2017/18**	**2018/19**	**2019/20**
Registered	204	238	226
Examined	166	207	194
Approved	109	121	96
Examined/Registered	81%	87%	86%
Approved/Registered	53%	51%	42%
Approved/Examined	66%	58%	50%
Average/Examined	9,6	9,4	8,8
Average/Approved	11,5	11,4	11,2

2. Description of pedagogical experiment

Due to the context of results the teachers of this discipline made a proposal to academic director to try to improve participation of students along the semester and, consequently, to increase rate of approvals. This innovative change was planned for the academic year of 2020/21. The innovation was based on a combination of characteristics of the Algebra subjects with theories of active learning and of peer learning. This approach included only the new students of that year since the students registered in previous years had the option of missing classes either theoretical or practical. The innovation was intended to benefit the new students in that year.

In terms of the discipline characteristics, Algebra is a subject where learning is based on a constructivist approach along the semester. An ineffective learning of one previous taught subject may lead to a lack of understanding of future related subjects. For instance, to determine eigenvalues of a matrix it is necessary to understand vector spaces. Of course, it is not sufficient condition but it is one of the necessary subjects that must be understood to apply the tools to find the eigenvalues. What happened was that in the other three disciplines of the semester was that each one had the mid semester exams in weeks either before or after the Algebra mid semester exam. Those circumstances implied that during three weeks most students were studying other subjects to prepare themselves to these exams and neglected studying Algebra. That implied that after the Algebra mid semester exam most students were not learning properly the respective subjects. To aggravate the situation the weight of grades in the second half of the semester was higher than that of the first part.

The concepts of active learning and peer learning were analysed by the teachers to improve the student participation throughout the semester. In terms of active learning, the concept was motivated by the involvement of students in the resolution of problems in practical classes and in answering short quizzes in theoretical classes (Mizokami, 2017). The peer learning approach was introduced by the fact that each student would be solving in the practical classes a problem for the other students (Topping, 2017). These two strategies had the intention of keeping the students ready to answer the problems in each week by studying continuously the subjects and keeping up to date along the semester. This formative assessment intended also to identify the difficulties of students in each subject and provide support for the topics that presented more difficulty (Andrade, 2011).

To encourage active learning and participation and motivate peer learning it was decided to engage each student along the semester through having a portion of 15% of the final grade attributed to the capacity of solving problems during class and to answer short questions during theoretical classes. Ten percent of the grade was attributed to the practical classes and the rest to the participation in theoretical classes. The evaluation of the practical classes was made by each teacher as a consequence of the student capacity of solving a random problem among those problems assigned to that week. Students were called randomly with the condition of solving at least one problem in each half of the semester. The rubrics used to grade the student preparation were quality of answer written on the board, capacity of explaining the theoretical background of each solution and ability to explain to the other colleagues questions or main aspects of the problem. In terms of evaluation in theoretical classes students had to answer four short quizzes of four multiple choice questions randomly given along the semester.

3. Analysis of Results

The academic year of 2020/21 results were analyzed potential benefits of the innovative approach using final results. Table 2 presents the final results of the discipline for students in general between students of 2019/20 and of 2020/21. Table 3 presents the comparison of grades between new students in 2019/20 and in 2020/2021.

Table 2: Global results comparison

Results	**2020/21**	**2019/20**
Registered	276	226
Examined	232	194
Approved	118	96
Examined/Registered	84%	86%
Approved/Registered	43%	42%
Approved/Examined	51%	50%
Average/Examined	8,9	8,8
Average/Approved	11,7	11,2

Table 3: New students results comparison

Results	**2020/21**	**2019/20**
Registered*	154	143
Examined	136	132
Approved	72	67
Approved/Registered	47%	47%
Approved/Examined	53%	51%
Average/Approved	11,8	11,2

Registered numbers of table 3 include only those that did not abandon the discipline during the semester. In tables 2 and 3 results in terms of final grades show slight improvements in percentages of approved students over examined students and in average final grades. That is true to the global group of students, new and repeating students, and to the group of new students. There is an increase of 0,5 points for the global group and a 1% improvement in terms of approved versus examined. Those increases, respectively, are of

0,6 points and 2% for the group of new students in 2020/21. To note that subjects taught in 2020/21 excluded Analytical Geometry and that these related topics were the ones where students usually had better performance. The semester also occurred during the pandemic restrictions and lockdowns with less personal contacts with students, especially on the theoretical classes. Another important factor was that time for exams was reduced from two hours to an hour and a half.

A co-lateral consequence of the described approach in practical classes was the implementation of a form of "authentic assessment" (Vos, 2011). A simple definition of an authentic assessment is a demonstration by the student of the understanding, of the thinking and of performance of defined tasks. Authentic assessment addresses what are the acquired competences instead of checking what the student knows. The techniques used may be presentations, experiments and skill labs. This approach is aligned with the etymology of the verb assess. Assess word has its Latin origin in "assidere" that means their own learning, adjustment of teaching to take account of the results of assessment, fostered students' motivation and self-esteem and ensured students assessed themselves and understood how to improve.to "to sit with" (Glare, 2012).

Several research works have indicated that teacher needs to sit with learner to evaluate effectively the respective learning accomplishments (Green, 1998). The current experiment is an example of debating with each student the theoretical and practical achievements while presenting the solutions to the given problems while providing effective feedback to students. Related research presented benefits of sitting with students (Rodgers, 2009). In fact, the approach in practical classes facilitated students' active involvement in

4. Conclusions

Results show that even in a difficult situation created by the pandemic restrictions there were increasing rates of percentage of approved students and of the average grade for passing students. It is not clear what was the correlation and effect of the grades between the formative assessment part and the discipline final grades. Additional statistical studies will be welcome trying to understand possible correlations among grades of the assessment along the semester and the final grades and make a comparison of grades in 2019/20 with grades in 2020/21 resulting only from two exams. Other investigations could assess if participation of new students in the examinations improved with the formative assessment.

Another interesting research could be the analysis of the behavior of new students in the other disciplines during 2020/21 to verify if the pandemic situation affected similar disciplines like Calculus in positive or negative performance in terms of final grades. As a major conclusion the fact of involving students in solving problems together with the other students in class with the mentoring and tutoring of the teacher could also develop other competences like speaking in public, assuming responsibility in terms of explaining to others the solutions of the problems and being able to defend their thoughts and reasoning. Especially it would be good to repeat the experience in a year that would not be affected by the pandemic restrictions and lockdowns.

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