TEACHING AND LEARNING THROUGH ADAPTIVE STRATEGIES – A CASE IN HIGHER EDUCATION

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Abstract

Student selection and admission processes into Higher Education are numerous and distinct, both in global and even national terms, nevertheless there is a common phenomenon in almost all courses – the different "academic histories" of their students, and there are cases where these training differences have a significant impact in their future academic life. This impact is huge when dealing with "constructive" subjects as Mathematics or foreign languages, even leading to higher failure and dropout rates. This paper will describe a strategic and adaptative plan whose main objective was to level up students' Maths literacy and skills in a first year basic and general Mathematics Course in an Accounting and Management degree at the Polytechnic of Porto. A detailed description of the target audience is presented, going through student's background analysis by means of secondary area characterisation and diagnostic assessment quantification. All project methodologic steps are sequentially described in detail, going through its pedagogical and scientific adaptive design, subject structure, boards' submission and approval, development and maintenance and result presentation. Finally, an analysis of its actual and experienced pros and cons is presented, as well as a reflection on its transferability to other subjects and a brief description of several sustainability issues.

Keywords: Adaptive Learning, Active Learning, Teaching Methods, Educational Experiences, Mathematics Curricula, Higher Education, Student Engagement, (Un)Success.

1 INTRODUCTION - FRAMEWORK AND CONTEXT

To enable a global view and better comprehension of the work presented here, we will begin by describing the organizational framework of our institution within the Portuguese higher education system, a brief description of our entire educational system and the entry process into higher education in Portugal. Since this is a pedagogical experience in the teaching of Mathematics to non-mathematicians, we analyse the exams required as specific tests for the above-mentioned entry process into higher education, as well as a brief reference to the syllabus for the Curricular Unit (CU) presented and those appearing in the several alternative paths from the pre-university education (secondary education).

1.1 P. Porto and ESEIG

The Polytechnic of Porto (P.Porto) is a Higher Education Portuguese institution providing undergraduate and graduate studies, with a long history, whose origins go back to 1852 [1]. This academic community has more than 20,000 students, faculty and researchers, assigned to one of its eight Organic Units (UO) spread across three campuses – Porto (Campus 1), Póvoa de Varzim/Vila do Conde (Campus 2) and Felgueiras (Campus 3).

The former School of Industrial and Management Studies (ESEIG) was one P. Porto’s UO that, as a consequence of a strategic reposition of the institution in 2016, was transformed into P.Porto Campus 2, which currently houses two new schools: the School of Hospitality and Tourism (ESHT) and the School of Media, Arts and Design (ESMAD). It originally had two buildings, one in Póvoa de Varzim and one in Vila do Conde in 1990, and it was only in 2001 that ESEIG was housed in a new single building. With 26 years of history, ESEIG had an educational offer of 8 undergraduate degrees, seven postgraduate programmes, seven Master degrees and two technological specialization courses in areas ranging from Accounting and Administration, to Design, Hotel Management, Engineering, among others, with about 1,500 students and more than 100 faculty members.
1.2 Portuguese Educational System

The Portuguese Education System encompasses three separate educational levels: basic/primary, secondary and higher education (see Fig.1. and Fig.2).

![Portuguese Education System Diagram](image1)

**Figure 1. Portuguese Education System ([2], pp.9).**

![Portuguese Education and training system Diagram](image2)

**Figure 2. Portuguese Education and training system ([3] pp 25).**

With twelve years of compulsory education (starting when they are 6 years old and finishing high school at 18), since 2016, the first six school years (1st and 2nd cycles – from 6 to 12) are, currently, the only ones which guarantee that all Portuguese students have gone through the same educational curricula. From the 7th to the 9th grade (3rd cycle or lower secondary) and from the 11th to the 12th grade (upper secondary cycle) there are alternative paths – General/Training Courses and General/Vocational, respectively. Since all these distinct alternative cycle curricula are interchangeable, students can proceed to the third cycle (higher education) from any previous secondary cycle path they choose (Ministry of Education, 2007). Currently, there are also post-secondary technological specialization courses (CET), which are not taught in HEI, and the Professional Technical Superior Courses (CTeSP), which are a higher education programme of two academic years, which do not grant a degree, not showed in the presented images.

The Higher Education System in Portugal is divided into two sub-systems – University and Polytechnic – (see Fig. 3) with a network of public Higher Education Institutions (HEI) made up of 14 Universities, 20 Polytechnic Institutes and 6 institutions of military and police Higher Education. In the private sector HEI comprises 36 Universities and 64 Polytechnic Institutes [4].
1.3 Entering High Education in Portugal

Portuguese governments have established several higher educational policy priorities aiming "to extend higher education access to a wider public and stimulate the development of scientific and technical activities, promoting equity and reducing the numbers of early school-leavers" (Ministry of Education, 2007). In this sense, the creation of technology specialisation courses was encouraged with the objective of increasing level 4 vocational training provision, extending access to this training to a wide range of people and, consequently, opening up new ways of entering higher education.

The general entry conditions to higher education:

- To pass an upper-secondary education course or legally equivalent qualification;
- To take the necessary exams, known as Entrance Tests, for the course that a student wishes to attend with a minimum mark of 95 points;
- To satisfy the necessary pre-requisites (if applicable) of the course they are applying to.

are, as it will be referred, very wide ranged as there are, for most of high education degrees, several possibilities of Entrance Tests, opening specific degree areas to almost all secondary student’s
background studies. Some Entrance Tests (2-digit code) even admit the possibility that more than one exam that can be performed (3-digit code), as it can be seen in the next table (Table 1).

<table>
<thead>
<tr>
<th>Entrance Tests</th>
<th>Exams to Perform</th>
<th>Entrance Tests</th>
<th>Exams to Perform</th>
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<tbody>
<tr>
<td>01 German</td>
<td>501 German (initiation - Biennial)</td>
<td>02 Biology and Geology</td>
<td>702 Biology and Geology</td>
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<tr>
<td>03 Drawing</td>
<td>706 Drawing A</td>
<td>04 Economy</td>
<td>712 Economy A</td>
</tr>
<tr>
<td>05 Spanish</td>
<td>547 Spanish (initiation - Biennial)</td>
<td>06 Philosophy</td>
<td>714 Philosophy</td>
</tr>
<tr>
<td>07 Physics and Chemistry</td>
<td>715 Physics and Chemistry A</td>
<td>08 French</td>
<td>517 French (continued - Biennial)</td>
</tr>
<tr>
<td>09 Geography</td>
<td>719 Geography A</td>
<td>10 Descriptive Geometry</td>
<td>708 Descriptive Geometry A</td>
</tr>
<tr>
<td>11 History</td>
<td>623 History A</td>
<td>12 History of Culture and Arts</td>
<td>724 History of Culture and Arts</td>
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<td></td>
<td>723 History B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 English</td>
<td>550 English (continued - Biennial)</td>
<td>14 Latin</td>
<td>732 Latin A</td>
</tr>
<tr>
<td>15 Portuguese Literature</td>
<td>734 Portuguese Literature</td>
<td>16 Mathematics</td>
<td>635 Mathematics A</td>
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<td></td>
<td></td>
<td></td>
<td>735 Mathematics B</td>
</tr>
<tr>
<td>17 Mathematics Applied to Social Sciences</td>
<td>635 Mathematics A</td>
<td>18 Portuguese</td>
<td>639 Portuguese</td>
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<td></td>
<td>735 Mathematics B</td>
<td></td>
<td>239 Only for severe deaf</td>
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<td></td>
<td>835 MACS</td>
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<tr>
<td>19 Mathematics A</td>
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There is also another system that makes access to higher education simpler and more flexible for people over 23 years old, with appropriate training and experience. This is one of the several extraordinary access modalities (along with Transfer requests, holders of other Higher Education degree, among others) that has been established to promote equal opportunities, improving attendance and completion of courses, attracting new students and diversifying the provision of education.

The Accounting and Management Degree, the first degree dating from ESEIG’s inauguration in 1990, has experienced several transformations to its general curriculum, which culminated with its adaptation to the Bologna Process, in 2006. In these changes, non-nuclear areas were the most "penalized", essentially when it came to the number of contact hours (lectures), with a reduction from 6 to 3 weekly hours in Mathematics, not directly followed by a reduction in the syllabus content, according to Bologna philosophy and paradigm. This changed the role of the professor from "knowledge transmitter" to "skill developer and learning promoter", assuming a more “personal” role as tutor, manager and supporter.

In the academic year of 2005/2006, along with the Bologna Process, another drastic change was introduced when the minimum grade for the entry test (Specific Exam) was established at 9.5 in a 0 to 20 scale ([5], [6]). This decision resulted in a huge drop in the number of students that entered degrees in which the Specific Exam required was Mathematics A (National Exam). In that sense, many institutions made remarkable changes to the Specific Exam required to enter in their degrees, and in ESEIG the Accounting and Management Degree was one of those. Until 2006, in the Accounting and Management Degree students had to take one of the following entry exams: Economy; Geography and Mathematics A ([7], pp.6.4.160). Since 2007 the Specific Exams accepted were: 04 Economy, 18 Portuguese or 17 MACS (Mathematics Applied to Social Sciences) ([8], pp. 3.78).

1.4 Maths in ESEIG’s Accounting and Management Degree

Looking at the Maths courses connected with this specific degree, one can see the usual General Mathematics as a first-year course, divided in two CU – Mathematics (1st semester) and Applied Mathematics (2nd semester), Probabilistic Methods, Statistical Methods and Financial Calculus in the second year, and Operational Research in the third. The first semester Mathematics syllabus is the “usual” in any Management degree, working essentially basic Calculus items. It is not possible to determine which of the performed Exams students used as Entrance Test, since their “classification” is...
a pondered average of their secondary studies (three years) and the Specific Exam they chose: 04 Economy, 18 Portuguese or 17 MACS (see Table 1). It is not even possible to determine or exclude any area of studies from Secondary School, since the Exam performed is not directly related to the Area (for example, a student may enter with Portuguese from any area of studies). As it turns out, the students who enrolled this first semester course had the most varied basic educational background and this has an extremely notorious impact on Mathematics, since the curricula of the basic CU (Math A, Math B and MACS, not to mention students who have not had Math since the 3rd cycle) are very different from each other. This was the challenge that made us try something to help these students, in the first semester of the first year, where they feel even more strongly the impact of entering into higher education: self-questioning is often in terms of choices really wants in terms of "capacity" for the pursuit of studies, because as professors of this CU can't wait until they have acquired skills and knowledge in topics that have never analysed, studied or even known.

2 TEACHING PRACTICE DESCRIPTION

The work project proposal presented here, was introduced yearly at the Department of Mathematics of ESEIG and submitted after to the Technologic-Scientific Council, to be approved, since 2012. From that year and until 2016, it was functioning, despite all the financial constraints that we have been through. The person in charge of the Mathematics CUs in this Degree proposed the maintenance of this measure, which we will briefly describe in this section, reducing one class in the first semester of the second year of this degree, in the course of Probabilistic Methods (working with more than 70 students), allowing to annually perform the "workload duplication" in the first year, described later in this article, without increasing the number of Math Department FTE (Full Time Equivalent).

2.1 Fundamental Objective - Levelling Up

We can state that the primary objective of this measure goes beyond the increase in the "success" rates at Math CU in the 1st semester of the 1st year of the Accounting and Management Degree, as much as this is almost the only objectively "measurable". The "ultimate" and first objective of this plan is the accomplishment of CU syllabus which is to fulfill the CU program unit, realizing that many students may not understand because they have never gone through such subjects; deal with extremely different Math skills in a smooth, unifying and motivating way, fighting discouragement and desertion. In this sense, the goal was the students' knowledge and skills "leverage" in Mathematics, promoting its connection, where and when possible, with the nuclear areas of the degree course, trying to increase the level of satisfaction with the chosen degree.

First it is necessary to realize what Maths themes were part of the academic career of our students during the last three years of upper secondary education. To this end, it is essential to analyse some of the most common but different possible curricular paths, with distinct Maths programs:

- Scientific-humanistic courses – essentially directed at further study at higher education level:
  - Languages and Humanities – 2 years of Applied Mathematic to Social Sciences [10] – optional

- Technological courses, designed for students that wish to join the job market, also allowing the continuation of studies on specialized tech or higher education - 3 years of Math B ([11], [12], [13]);

- Specialised artistic courses, organised to ensure artistic training in the areas of visual and audio-visual arts, dance and music – Math – 2-year syllabus – optional;

- Vocational courses are designed for students that wish to join the job market, providing also further education courses in post-secondary non-tertiary or higher education. Modules are organized by different areas of training – Applied Math – Math Modules developed during the 3 years – optional.

2.2 Target Audience Analysis

We may say that our "target audience" were all students enrolled at Maths CU, however this "target audience" should be properly characterized and "categorized" regarding courses and Maths level
attended in the secondary school (Fig.4). According to [14], in general, there are few differences between the overall candidates’ area and the area of those who managed to be enrolled in this Degree. But the challenge to be faced, despite being related to the field of study, just goes a little beyond this issue, since the Specific Test used for entering this Degree was not, frequently, Math A.

![Figure 4. Students enrolled in Accounting and Management in ESEIG – Secondary Study Area.](image)

Making use of the information retrieved from an annual enquiry (developed by Maths teachers) that all students entering Accounting and Management Degree at ESEIG have answered in Moodle platform since 2013, (the only way, as far as we know, to access this type of information, not available in any public data base), we can see that only 26% used Mathematics A National Exam (Fig.5) as Entrance Examination, despite the 75% from Science and Technology and Socio-Economic Sciences.

![Figure 5. Accounting and Management ESEIG - National Exam performed - 2013 to 2015.](image)

More than 1/3 of students registered in the first-year course of Mathematics in the Accounting and Management Degree joined this Bachelor without attending Mathematics (A or B) in secondary education. This is, besides the 9th grade, these students only (eventually) have, in their academic curriculum the CU of Quantitative Methods or Mathematics Applied to Social Sciences (MACS), taught in the 10th year. It should also be noted that this 9th grade was, at least, completed three years before entering high education system (and "fleeing Mathematics" in secondary education, there will certainly be an underlying obvious reason – struggling with difficulties in this subject).

For several years we felt that the general lack of motivation of students in a CU where the use of basic concepts is constant, resulted fundamentally from the fact that they were not able to keep up with all the new or even “revision” themes, feeling unable to work these concepts in an autonomous way. So, in a sense, the proposed measures were attempting to provide a “more targeted” teaching practice to the general and specific gaps of those students who enter without having frequented (or succeeded) Mathematics in secondary education.
2.3 Methodology

ESEIG academic services cooperation was crucial, as they were the first contact students had with our institution at registration procedure. At that time students were formally informed about the date and time they would have to take a mandatory Diagnostic Assessment Test (DAT), giving students a brief description of the purpose of that test and noting (by signing each student) which students had been warned. The date for the completion of this test was the first morning in the first day of school, prior to students’ schedule choice.

Given the results obtained in this test (visible for students as part of the feedback presented after submission), students were advised to choose Math classes with different number of weekly contact hours. However, these options were just mere “advice” and no student was ever forced or compelled to enrol in any class against their will. When school activities began, all students who had chosen a class load of 6 contact hours assumed, before teachers, a compromise from September to January in terms of class frequency, since it was not “recommendable” to change classes, at least until the first assessment moment, due to the visible differences in schedules of different classes. The development of differentiated pedagogical practices was a constant concern, offering students a wide range of materials in digital format, accessible online, promoting their sequential utilization according to the needs of each group/class, trying to work and promote a kind of flipped teaching and learning environment.

In this CU the continuous assessment was carried out with two tests done in class, with different weights (70%T1+30%T2) and several small tests online (implemented in ESEIG Moodle Platform), distributed throughout the semester in order to promote a “true” continuous evaluation and monitoring continuous learning results. It must be mentioned that the first moment of classroom assessment was performed when about 2/3 of the Term weeks had passed (not the middle of the semester) to enable the realization of the same test for all students enrolled at CU, regardless of the number of class contact hours that they had attended. The learning objectives for the first test were items 1 to 3 (see Fig 4), leaving for the second only item 4 – Integration. As the degree central areas were Accounting, Management and Economy, the core of all the problems was the application to these ones, whenever possible, and when reviewing secondary school subjects. We practically “ignored” Trigonometry, Trigonometrical Functions and Complex Numbers, in order to accomplish, in two months, the “levelling up schedule”.

2.4 Impact Analysis and Students’ Perceptions

In Fig. 6 the percentage results in the three years under analysis, where, to interpret these, we have separated through a chromatic scheme, the correspondent automatic feedback: Advised to attend class with 6 weekly contact hours; Advised to attend class with 3 weekly contact hours and Left to the student’s discretion.

As the test was the same in the 3 years under analysis, we have noticed a drop tendency in global results - an average of 60.5% in 2013 (standard deviation (SD) of 20.5), 50.2% in 2104 (SD = 23.2) and 52.7% in 2015 (SD = 19.7).

![Figure 6. Results of the Diagnostic Test per year (2013-2015).](image)

In the Fig. 7 we present students’ schedule choice, where “repeating” students and 1st year students enrollment options in these different classes are presented apart, in order to distinguish reactions to the Diagnostic test and students’ future perceptions.
Notice that non-freshmen students are, generally, very conscious of their competences and seek to overcome their difficulties, principally if they feel someone cares.

In Fig. 8 we present two annual assessment indicators for Mathematics CU: Relation between Successful students (S) and Assessed ones (A), in the percentage S/A and Global relation between Successful students (S) and Enrolled ones (E), in the percentage S/E.

If we separate, for the last three years, our analysis in terms of number of hours of each class, we can see the results shown in Fig. 9. From a different point of view, this question also justifies, at least partly, the difference between the rates of Successful / Enrolled and Successful / Assessed, which is also one of our concerns.
It is interesting to compare the results shown in this last image with the ones in Fig 6: when the number of repeating students in a 3-hour class is high, this is directly reflected in the rate drop (2014/15).

Even though we have conducted a satisfaction survey every academic year since 2012 that led us to maintain and increment this teaching practice, at its end, in May 2016, we developed a global assessment survey to which 130 students from all the academic years answered. In Fig 10, the "flow chart" shows all the direct answers given by students, since no one better than them will be able to "speak their minds". This survey was anonymous and answered electronically.

3 FINAL REMARKS

The development of an alternative teaching practice was described here. Aware of students’ distinct abilities and backgrounds, it allowed us to work differently with different audiences and its transferability is undoubtedly an open and possible path. It does not seem to us difficult to implement in other undergraduate and/or other institutions, with the same problem in the admission of students with different "background history". In this sense, we leave here some of the important points that should be taken into consideration while embracing a similar methodology:

- Identify previous skills and knowledge that supposedly pre-date the CU program in which the measure will be applied;
- Develop a well-designed Assessment Diagnostic Test and carry it out before the real start of school activities;
- Ask for the collaboration of academic services to ensure that all students enrolled in the first year/first time are informed of its implementation and objective;
- Guarantee that the classes with more contact hours have schedules as "nice" as the others;
- Ensure that all students are evaluated the same way, performing the same tasks and the same evaluation moments (as mentioned);
- Make sure that the students in the usual classes are not penalized by the existence of "special" classes fulfilling the UC program.

This practice required a very strict daily scheduling and it was labor-intensive but, in the end, the overall results were positive and worth the effort. There are, obviously, several difficulties to keep in mind such as, for example, financial restrictions; frequent high absenteeism rates; low motivation to learn, among others, eventually some legal questions to be considered. Students recognize teachers’ engagement and dedication into their academic development and that they are the reason for teachers/lecturers/professor’s existence; we think that this is one possible path, despite it being a “hard” one.
REFERENCES


