The e-Learning Excellence Awards 2017

An Anthology of Case Histories

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Note to readers: Some papers have been written by authors who use the American form of spelling and some use the British. These two different approaches have been left unchanged.

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MatActiva Project – A Mathematical Dynamic Environment to engage Students in the Learning Process

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Abstract: Several studies report that mathematical subjects have high failure rates from earlier grades to higher education. Nowadays, higher education institutions are facing many unprepared students with regard to the mathematical skills. Although students avoid mathematical courses, yet science, technology, engineering and mathematics fields keep among the job-growth areas.

Aware of this reality, in 2007, a group of Mathematics lecturers from ISCAP (Institute of Accounting and Administration of Porto) started the development of an online project on the *Moodle* platform called, *MatActiva*. This project arose as a need to improve learning and increase the levels of success in the first years Mathematic courses. It aims to enhance mathematics education, creating a learning environment aligned with real needs of the students, in which they can learn at their own pace, motivating and encouraging them to overcome the difficulties, and giving them more confidence. It is a whole learning environment that provides innovative resources and carefully constructed materials (e.g. video-lectures, multiple-choice tests, challenges) on topics such as Elementary Mathematics, Calculus, Algebra, Statistics and Financial Mathematics.

Nowadays, it is supported by several math lecturers and ERASMUS students.

Throughout the development of the project some challenges were found and gradually exceeded. One of them is related with mathematical symbols and the *TeX* language. Another problem concerns the construction of good multiple-choice questions and how to obtain a good bank of questions. Many doubts also arose when we began producing video-lectures in 2009 as there was little information about that.

The project´s success is measured by platform usage´s volume and student´s engagement using learning analytics tools and by student´s opinion, regularly inquired during the project.

In addition to continuous improvement of the materials, we plan the development of an app for smartphones and switch to a more recent *Moodle* version with further capabilities and tools.

1. Introduction

Conscious that the ability to change in Higher Education Institutions (HEIs) is crucial to the sustainability of the educational progress, and students' "troubles" with mathematical concepts do not end in High School, a group of Mathematics lecturers from the ISCAP developed a new online project, called *MatActiva*, in order to support students and promote self-study autonomy. We found that a major cause for the failure in mathematics courses in our HEI is the weak preparation of students in mathematical basis. The project has been developed in *Moodle* following the main objectives of study support and the development of math skills directly related with the curricular units (CU) in the scientific area of Mathematics, and it was built in a pure e-learning format (Azevedo *et al.*, 2009). Initially, this project was a resource to carry out learning objectives related with the content covered in the Mathematics CU of the first year of several course degrees in ISCAP, but quickly the project expanded to other CU. To build this project, we took into consideration what technology can and must be used in mathematics instruction and for that we follow the John Keller's ARCS model, that defends proper instruction must implement: Attention, Relevance, Confidence and Satisfaction (Keller, 2010).

New technologies bring up challenges and at the same time provide tools to teachers promote differentiated learning opportunities for students (Lopes, 2011) and its use is recommended by a number of European organizations such as the European Parliament and the European Open and Distance Learning Liaison Committee. Despite the increasing use of computers by teachers, there is still a gap between the amount of technology currently available in schools and its use for educational purposes (Kopcha, 2012). The Organisation for Economic Co-Operation and Development (OECD) through the Centre for Educational Research and Innovation (CERI) warned for the importance of spreading free knowledge by publishing "Giving Knowledge for Free - The Emergence of Open Educational Resources" (Hylén and Schuller, 2007).

The Europe 2020 strategy's main priorities are to ensure smart growth, based on knowledge, innovation and a digital society; sustainable growth, based on competitiveness, the fight against climate change and resource efficiency; and inclusive growth, promoting high employment, better skills and social as well as territorial cohesion (Commission, 2010). Skills and qualifications are one of the key factors determining the economic success of the Europe. Converting education requires pedagogical, organizational and technological innovation. The increase use of the Internet brought in a new era in course design and delivery to the mainstream model of traditional education. This is particularly true for Open Educational Resources (OER). The European Commission, through the "Opening up education through new technologies" (*Strategic framework – Education & Training 2020*), has made this document the topic of discussion in order to encourage Member States to exploit the potential of new technologies and digital content to complement traditional educational approaches. The European Commission proposes actions at EU and at national levels to "support the development and availability of OER" in education and skills development. Opening up Education focuses on three main areas:

- Creating opportunities for organizations, teachers and learners to innovate;
- Increased use of OER, ensuring that educational materials produced with public funding are available to all;
- Better ICT (Information and Communication Technologies) infrastructure and connectivity in schools.

The potential of ICT for the modernization of education and training has become a key priority in the European Union, and *MatActiva* contributes to this goal.

The general objective of this project is to increase the Math literacy of the students and their rate of success in Mathematics, taking into account that this subject is an essential component of all educational systems. The project will serve a big number of students by helping those developing Math skills and consequently increasing their chances to get a job after graduation.

Based on educational teaching and learning principles, this project is, at the present used for blended learning, distance education and flipped classroom in ISCAP, making use of its several separated sections (see Figure 1 - *MatActiva* Home Page - 2nd banner - top left).

Figure 1: Screen Shot of http://paol.iscap.ipp.pt/matactiva/ (25/06/2017)

We have been concerned in creating a project of simple access, intuitive and with a set of useful functionalities. The *MatActiva* project is structured in eight sections visualized in the initial menu and described in Figure 2. Each section contains diversified material ranging different students' needs and levels of knowledge. Among other areas, we can find materials in Linear Algebra, Financial Calculus, Statistics and Mathematical Analysis.

***MatActiva* Sections**	
About Us	This section is a description of MatActiva Project, provides members' contacts and news related to the Project.
Mathematics Zero	Here we find, among others: • Theoretical elementary notes that help to consolidate necessary requirements to all the CU from mathematics area; • Program Contents covered in the CU Mathematics Zero (items from Elementary and Secondary school); • Tutorial video-lectures about several Mathematics subjects, followed by exercises that can be performed online, in which the student automatically receives the quantitative results, the feedback for each question and a proposal for a comprehensive solution; • Diagnostic tests with several levels, according to the Elementary and Secondary Education programs, that can be done online. Students have access to a draft solution step by step (over 350 questions).
Learning	Exploratory section with numerous documents and several links but with different goals from the previous sections: • Taking advantage of pedagogical innovation and temporal flexibility, supporting individual and collaborative study, it allows students who do not attend assiduously to lectures and/or who have difficulties, to use the supporting documents provided by the Project at any time. The goal is not to replace the classes, but to complement these, also going through a learning of basic Mathematic concepts, in order to the contents covered in classes from several CU of Mathematics area (Algebra, Financial Calculus, Statistics and Mathematical Analysis) can be built from a more solid foundation; • Links to webpages with mathematical resources.
Tests	It presents a set of multiple-choice tests, true/false and matching. With these tests we intend to offer working instruments to promote self-regulation of students' learning, helping them to raise the performance level. A Question Pool (1163 questions) was created from the ground up, grouped into categories and subcategories: Algebra, Mathematical Analysis, Statistics and Financial Mathematics. The combination of questions in each category is randomized and it generates a high number of different tests that students can solve online, wherever they are. The tests allow multiple attempts, providing automatically quantitative results and each attempt corrected immediately. For each wrong answer presents a feedback solution, step by step. Thus, the student will be able to identify their mistakes, providing and promoting self-assessment of knowledge and skills.
Doubts	A forum addressed to clarify various issues related to theoretical subjects and exercises, moderated by the project in charge teacher. It is a space where interaction occurs effectively, supporting students in the study, in a targeted way enabling and encouraging their self-confidence.
MathChallenge	A competition open to all ISCAP community, consisting of a set 7-8 challenges, proposed throughout the school year in order to develop the interest of students in mathematics and logical reasoning, never forgetting that learning mathematics should also be made through research and investigative activities. Note that, challenges are facilitating factors to communication and reasoning, reinforcing general motivation, developing different and better ways to look at mathematics.
ERASMUS	Materials in English provided for ERASMUS students that attending mathematics courses in ISCAP.
ETC	A Math "Fun Zone" holding a "Games Blog" and "Mathematical Curiosities". The curiosity stimulation and gambling interest may be a source of pleasure and reflection for students.

Figure 2: MatActiva sections

2. Infrastructure

MatActiva is developed in *Moodle* (free and open source software Learning Management System - LMS). This is supported by a Server installed at ISCAP using the so called LAMP software. The students can access from our site (www.iscap.ipp.pt) or from our domain (www.matactiva.com). The hardware allows simultaneous accesses from more or less 100 students.
This project was created by a core team of four teachers responsible for the design, development and continuing evolution of *MatActiva*. These are experienced professors of Mathematics with particular strengths in the development and production of digital learning resources and educational resources.

Moodle allows the use of *TeX* language to create materials with mathematical symbols. Making use of this feature, several interactive user friendly resources were elaborated.

MatActiva site also provides video-lectures guiding the study in several topics. All the video-lectures were produced from the scratch, adopting the Voice Over Presentation, using the Camtasia Software.

The project has been widely disseminated both through flyers, posters, social networks and international conferences by the presence of elements of the core team.

3. Challenges encountered, how they developed and how they were overcome

Throughout the development of the project some challenges were found and gradually overcome. One of them is related with mathematical symbols and the *TeX* language. At the beginning of the project we had to learn *LaTeX* language to be able to write mathematical formulas in *Moodle*, it was a great challenge because it took us a lot of time to write the exercise statement, the solution and the suggestion of resolution. Nowadays this problem is solved.

Another problem concerns the construction of good multiple-choice questions and how to obtain a good bank of questions. Multiple–choice test items are adaptable to various levels of learning outcomes, from simple recall of knowledge to more complex levels. Multiple-choice items need writing ability from the teachers and are difficult to construct

particularly at the higher cognitive levels. In an attempt to contribute to the knowledge in this subject we publish an article (Torres *et al.*, 2011).

4. Students' perceptions about the project

Each year an evaluation survey of the project is given to the students. Evaluation data shows that more than 90% of the students believe that the project positively contributed to their success in Mathematics Courses. The acceptance has been excellent, exceeded our expectations. The students are very satisfied with *MatActiva*, they felt that this project is very important in the improvement of their Mathematics skills.

5. Learning outcomes achieved – measurement and evaluation

In the actual technological era, the LMS are widely used and are a common tool among educators (Schroeder, 2009). The use of new technologies has become a pressing need to know if the contents reach the target audience. In this regard much has been made over recent years in the field of Learning Analytics (LA). It is not enough to put contents online, is necessary to see if this is used and how it is used. According to Long and Siemens (2011), LA can be defined as "the use of intelligent data, learner-produced data, and analysis models to discover information and social connections, and to predict and advise on learning."

Overall, the *Moodle* platform provides the teacher/administrator a wide range of information reports. *Moodle* reporting tool simplifies analysis of information about users' interactions in the platform, in diverse contexts available: site, course or activity, and the reports show information about user comments, course activity (for instance, most active, courses with most enrolled users, highest participation), LMS events logs and graph and statistics about users' activity and view/post actions. Activity Report gives us information about the activities available in the "course" in question, allowing us to have access to the questions that students do incorrectly, making a statistic for each question based on various parameters (Figure 3).

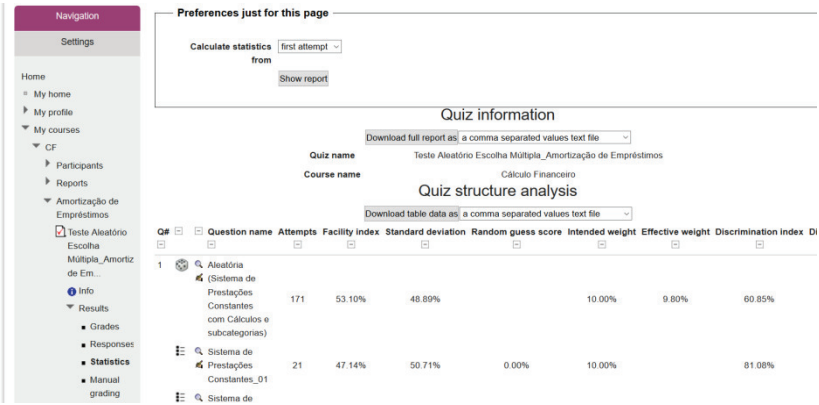

Figure 3: Statistical information in this Activity Report, referring to an exercise of *MatActiva*

Having access to information which is available on the servers, the question that arises is how to extract and analyse it in order to identify problems and improve the education system. In most institutions, the development of a LA is stopped at the level of data collection – a large amount of collected data is usually available but without extract from them any meaning or truly usefulness analyse (Elias, 2011).

A number of LA tools exist. Some of them are interoperable with *Moodle* and have been used in this project:

- GISMO - is a visualization tool for *Moodle*, which use log data, process them and finally produces graphical representations that can be used by teachers so as to examine social, cognitive and/or behavioural student interactions. It provides analytic statistical representations and shows a general picture of the students as a whole, analysing the more general learning process of all the students on all subjects (Mazza and Botturi, 2007). It can also provide analytical statistic representations for specific students, resources and activities.

For instance, we can have an overview of which days in a particular section was more accessed (in this case Financial Calculus, in Portuguese - Cálculo Financeiro, a subject from Winter Semester), in a certain period of time (Figure 4).

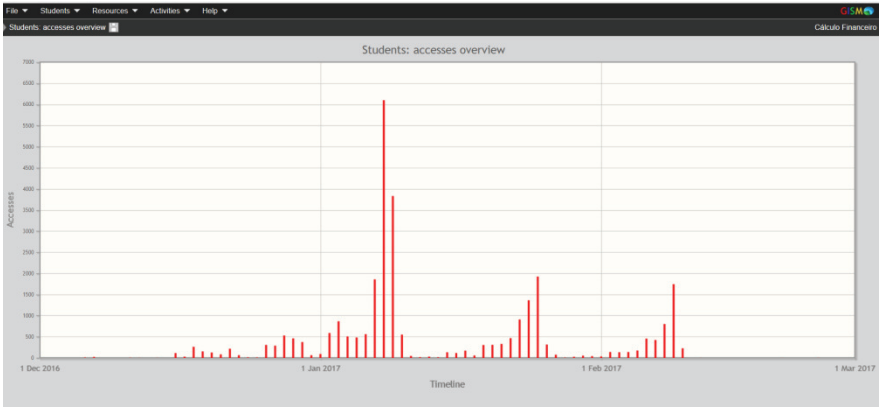

Figure 4: Number of Accesses to Financial Calculus, from December 1, 2016 to March, 2017

- COURSE DEDICATION - This block allows seeing the *estimated dedication time* by participants to a *Moodle* course. It provides three possible views.
- *Dedication time of the course*: calculates total dedication time, mean dedication time and connections per day for each student. Also we can use *Dedication time of a group* and *Dedication of a student*: detailed sessions for a student with start date & time, duration and IP (Figure 5).

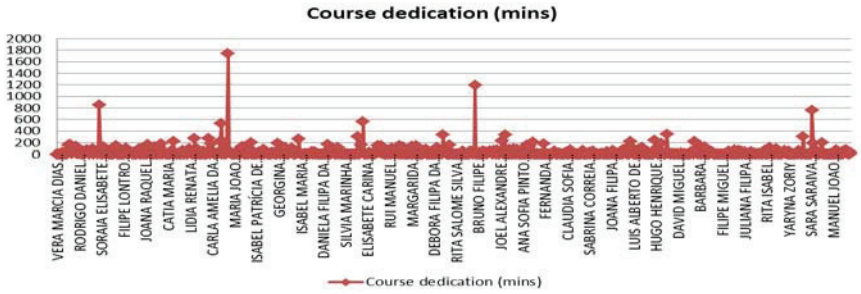

Figure 5: Course Dedication of some students in Financial Calculus Course

- GOOGLE ANALYTICS (GA) - The *Moodle* GA plugin help us to analyse our *Moodle* site traffic. It collects data regarding website's Audience, Behaviour, Conversions, Acquisition and Real time visitors. The Audience reports by GA give us an at-a-glance view of

our Project visitors. They tell us not only how many students come to our website, but also who they are, what their interests are, where they're located, and whether they are first-time or returning visitors. The below Audience Overview (Figure 6) shows us the total number of "sessions" between 01/12/2016 and 28/02/2017.

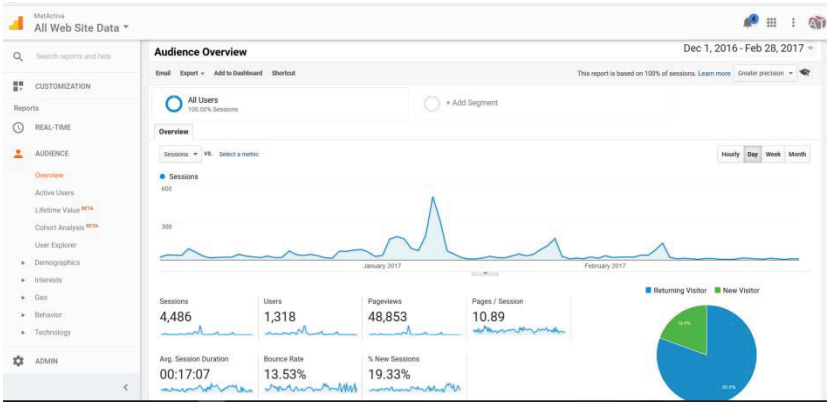

Figure 6: Audience Overview available in *MatActiva* GA

GA also provides tools, like for example, the Users Flow report that is a graphical representation of the paths users took through our site, from the source, through the various pages, and where along their paths they exited our site. The Users Flow report lets compare volumes of traffic from different sources, examine traffic patterns through our site, and troubleshoot the efficacy of our site (Figure 7).

Figure 7: Users Flow available in *MatActiva* GA

Another tool is the Behaviour Flow Report. It visualizes the path users travelled from one page or event to the next. This report can help you discover what content keeps users engaged with your site. The Behaviour Flow report can also help identify potential content issues (Figure 8).

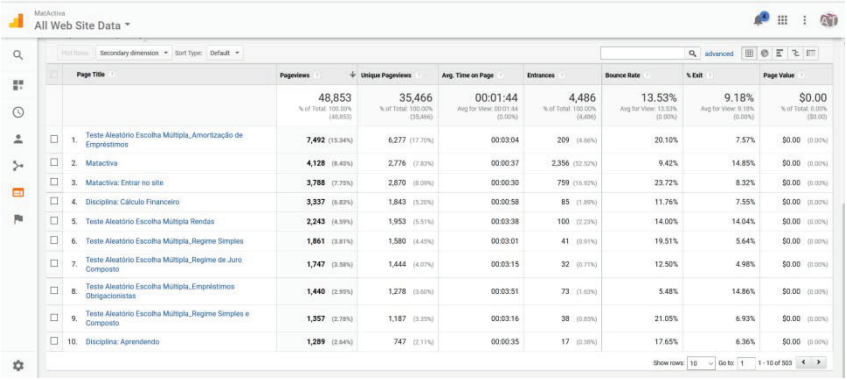

Figure 8: Behavior Flow available in *MatActiva* GA

According to Campbell and Oblinger (2007) LA is a feature to make decisions, which consists of five stages: data collection, reporting, forecasting, act and refine. These steps begin with the collection of data because data are the foundation of any study, which will be subsequently selected and organized. Later, qualified personnel will carry your query and use analysis tools allowing them to examine the information, identify

trends and patterns in data using statistical analysis which will allow predicting and acting on this forecast, aiming to redefine the design so that it can be improved.

6. Conclusions and plans to further develop the project

Since its beginning, this project has been improved in several aspects. A first concern was to improve the graphical interface in order to an easy access to the sections. Other improvements are related to the diversity of materials presented. In particular, the availability of video materials enriched the project. Also, there was an increase of materials designed to overcome students' difficulties and enable them to obtain the necessary prerequisites in order to succeed in the courses that require Mathematics tools.

However, there are many changes to implement in order to improve the project. Namely, we plan switch to the actual *Moodle* version (*Moodle* 3.3) with more capabilities and tools that can be used to support students' learning; improving the interactions and collaboration between students, and students and teachers in the Doubts forum; create groups of students with similar problems or goals and suggest some guidance to more efficiently overcome their problems; monitoring students' activities with Analytic tools in a more effective way. We intend to develop an app for smartphones that can complement and integrate the traditional site and implement some features involving teachers and students.

Similarly to what has been done, regular questionnaires allow aligning the *MatActiva* Project with learning students' needs, and we will continue to use them.

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