Learning Analytics: A Way to Monitoring and Improving Students' Learning

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Abstract: This paper focus on the potential contributes of Learning Analytics in the improvement students learning. The analysis of student's data collected from Virtual Learning Environments is important to ascertain student's engagement. This paper presents the analysis of data collected in the ambit of *MatActiva* project. Data was analysed with Google Analytics, Course Dedication and Moodle Reports. Promising results were obtained.

1 INTRODUCTION

Virtual Learning Environments (VLE) are widely used in all degrees of teaching. A huge number of educators find that VLE can improve the teaching process. Especially in large universities courses VLE can reach a great amount of students in different geographical areas. It is undeniable that the number of resources increased sharply but, as pointed out Dyckhoff et al. (2012), the use of VLE by itself does not improve the teaching process and today the challenge is to create more motivating and engaging learning materials and activities.

After preparing and providing online materials, it is crucial to assess changing student's behaviours and performances.

The enormous quantity of data produced surrounding the interactions in VLE provides the basis material to a new research field, called Learning Analytics, that has emerged in the last years. The focus of interest is how this data can be used to improve teaching and learning (Greller and Ebner, 2014).

In this paper it is intended to analyse the *MatActiva* Moodle site, in order to check students' engagement in several courses, since this is a relevant issue in the project.

This paper is structured in the following way: in section 2 we define Learning Analytics concept and some tools used in this paper are summarized.

Section 3 describes the profile of *MatActiva* site, in section 4 we present some questions driving the research focus in this paper. Data collection is exhibited and data analysed throughout section 5. Section 6 draws conclusions based on the research, and in the 7 and last section, we try to pull together some of the key points made in previous sections.

2 LEARNING ANALYTICS

In any new research area many new terms introduced must be clarified in order to achieve greater understanding and therefore a better contextualization of the problem.

In the literature there is some confusion between the concepts of Learning Analytics (LA) and Academic Analytics (AA) (Sclater, Peasgood and Mullan, 2016). These terms are commonly used but without clarity as to what the words are intended to mean. LA focus on the learning process whereas AA reflects the role of data analysis at an institutional level (Long and Siemens, 2014). To better clarify this difference, Siemens and Long (2011) present some details and a comprehensive list comparing LA and AA (Table 1).

According to the Society for Learning Analytics Research (SoLAR - www.solaresearch.org), "learning analytics is the measurement, collection, analysis, and reporting of data about learners and their contexts, for the purpose of understanding and

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optimizing learning and the environments in which it occurs". This definition appeared in 2011 in the 1st International Conference on Learning Analytics & Knowledge (LAK). Similarly Harmelen and Workman (2012, p. 34) define Learning Analytics as "the application of analytic techniques to analyse educational data, including data about learner and teacher activities, to identify patterns of behaviour and provide actionable information to improve learning and learning-related activities". According to these authors the first use of analytics in education goes back to 1995 in a study that examined student retention and performance. However, it appears that widespread interest in analytics has only been increasing since 2007 (Harmelen and Workman, 2012).

Table 1: Differences between Learning Analytics and Academic Analytics and the respective beneficiaries (Siemens and Long (2011)).

TYPE OF ANALYTICS	LEVEL OR OBJECT OF ANALYSIS	WHO BENEFITS?
Learning Analytics	**Course-level**: social networks, conceptual development, discourse analysis, "intelligent curriculum"	**Learners, faculty**
	Departmental: predictive modelling, patterns of success/failure	**Learners, faculty**
Academic Analytics	**Institutional:** learner profiles, performance of academics, Knowledge flow	**Administrators, funders, marketing**
	Regional (state/provincial): comparisons between systems	**Funders, administrators**
	National and International	**National governments, educational authorities**

Siemens (2012) highlights the potential of LA to dramatically impact the existing models of education and to generate new insights into what works and what does not work in teaching and learning.

ECAR (2015) strengthens this idea saying that LA allows to move into an era where we can predict student learning outcomes leading us to the concept of predictive learning analytics. In US there are several published results supporting the educational success, in quite a lot of Higher Education Institutions (HEI), either private or public. This source first presented in a Panel by Norris and Baer (2012) and after in EDUCAUSE online (2013) with a complete report about 58 pages by the same authors.

With LA we can see which resources are more often used and if offering documents/tests and other related topics could be interesting for students (Recker, Walker and Lawless, 2003; Bourkoukou *et al.*, 2016). We also could provide courses that match the learning style of learners and "Several educational theories and studies agree that learners learn easier when their learning styles match with the teaching style" (Graf *et al.*, 2009, p. 1280).

Beside the above information, it is important to know what the goals are, when using LA. Davenport, Harris and Morison (2010) suggest that we have to answer some questions, presented in Table 2.

Table 2: Questions that the research using Analytics would answer.

	Past	Present	Future
Information	What happened?	What is happening now?	What will happen?
Insight	How and why did it happen?	What's the next best action?	What's the best/worst that can happen?

2.1 Google Analytics

Google Analytics (GA) is a tracking application offered by Google that tracks and reports website's traffic. It started in 2005 (Hasan, Morris and Probets, 2009) and the first studies that used is focused on the analysis of e-commerce sites. This application generates statistics about the visits and the user interactions and allows users to export report data in to MS Excel© format. Most of the data in GA, that we analyse, are number of sessions and Average Sessions. A "session" is a group of interactions that take place on your website within a given time frame and an "Average session duration" is the total duration of all sessions (in seconds) divided by the number of sessions (support.google.com/analytics/).

In GA and with some adaptions for an Educational Website, there are some questions suggested to explore such us: "Which pages do people visit?", "How does this change with date and time?", "Where do visitors come from geographically?" and "Is my site user-friendly?"

2.2 Moodle Reports

Moodle, especially in the last versions, has a lot of reports and statistics that can substitute in some aspects Google Analytics. There are many reports that could be obtained, but in this work we emphasise the following topics: Activity report, Course participation and logs.

In Siemens (2011) opinion a learning management system like Moodle or Desire2Learn captures a significant amount of data, including time spent on a resource, frequency of posting, number of logins, etc. This data is fairly similar to the data that we get from the Google Analytics. However, GA gives some results that it is not necessary to reanalyse or to do extra effort to extract knowledge.

2.3 Course Dedication

This is a Moodle plugin that allows us to see and analyse the estimate dedication time of the students for each topic and activity included in Moodle Courses. More detail information can be found here: https://moodle.org/plugins/block_dedication or in the authors site: http://www.cicei.com.

3 *MatActiva* PROFILE

The *MatActiva* site has been developed in ISCAP/P.PORTO in order to improve learning and increase the levels of success in the mathematics subject areas. Initially, this site covered two programmes namely Accounting and International Commerce but it is still been extended to others.

The project was started in 2007 to help students, especially in first year (home students, distance students, ERASMUS students, Lifelong Learners) who have weak Math preparation, poor consolidated basis on the subject and different backgrounds, wanting to improve their performance and success (Azevedo *et al.*, 2009).

The general objective of this project is to increase student's Mathematics literacy and their rate of success in Mathematics, taking into account that this subject is an important component in all educational systems. The project attends a large number of students by helping them developing transversal skills that could be useful in their active life.

The challenge was innovating the teaching and learning process, exploring VLE as a pedagogical resource to create more motivating and engaging learning materials and activities.

Engaging materials and temporal flexibility supporting the individual and collaborative study of students, has been of great importance. The development of this project was crucial, especially for working students and for students in geographical areas away from school, who cannot always attend classes and timely access to the support materials. In addition, for students with a weak preparation and without consolidated basis this project was determinant to encourage and give them more self-confidence. Communication abilities among fellow students and among students and teachers increased.

The *MatActiva* project is intuitive and provides a set of useful functionalities according to the subjects taught in mathematics department, such as Algebra, Calculus, Statistics, Financial Mathematics, etc... offering support materials and promoting self-learning.

In the initial menu we can find eight topics:

- About us – Information about the project.
- Mathematics Zero – An area supporting students who have difficulties and gaps in basic mathematics. Video lectures followed by a set of proposed exercises related with the issue presented in the video are available in this topic. They can also find and solve online diagnostic tests to validate prerequisites skills necessary for different subjects.
- Learning – In this topic students can find interactive eBooks, tables of formulae, working sheets about topics related with contents taught in several mathematic courses. They can find as well links to pages about mathematical subjects.
- Tests – Here students can find and solve online diagnostic tests, evaluation tests with multiple choice or true/false questions. A large bank of questions originates a series of self-evaluation tests, which the student can solve and submit, taking conscience of their level of knowledge.
- Doubts – A forum where students can put their doubts online and receive answers giving by a teacher. More students are willing to participate in an asynchronous forum than are willing to speak up in class because forums are asynchronous and students can take their time composing a reply.
- MathChallenge – One-year competition open to all ISCAP/P.PORTO community with a set of 6-7 challenges/problems to stimulate the students' interest in mathematic problems. Learning mathematics should also be done through activities research and discovery. The challenges reinforce the motivation, thinking and communication.

- ERASMUS – Multiple choice tests in English to support ERASMUS students.
- ETC – Provides curiosities, cartoons, contests and games to test math skills.

A question bank of more than 1 100 questions divided into categories according to the four subjects – Algebra, Calculus, Statistics and Financial Mathematics – support the multiple choices tests available in this topic. These tests were constructed according to the guidelines proposed in Torres *et al* (2011) and Haladyna (2004). Furthermore, feedback is provided for each question, allowing students to see the proposed solution, step by step.

It is important to find out levels of students' engagement in the several materials provided.

4 METHOD

In this study, we analyse the students' data using new instruments installed in the project web site. Those instruments were Google Analytics, Moodle reports and Course Dedication, which were installed in Moodle platform. Data was collected from the topics described in section 3. We use Google Analytics to retrieve data related to the number of sessions and average time of sessions of the students. Dynamic Table by Excel© was used to generate the graphs.

We also used Moodle Reports and Course Dedication to generate some of the results.

The data was extracted and analysed to better help our students at ISCAP/P.PORTO. We did quantitative analyses of the data.

The research questions were the following: i) how deep do visitors navigate in the website pages? ii) are some of the contents more interesting than others? iii) it is important the day of the week when we want to propose problems/tasks to be solved in a limited time period? iv) have the goals been reached? v) are the materials available enough for the purpose for which they were created?

All those questions guided a reflection around students' engagement and behaviour and intend to answer to a broader question about the effectiveness of the project.

5 MONITORING STUDENTS' LEARNING

First, we started by characterize the students. In Figure 1 we can see that majority of students access our Project in our area, Porto, followed by a considerable number of students whose geographical area cannot be identified. The next city is Vila Nova de Gaia, which borders Porto. In fourth, appears Lisbon which is at a distance of 300 km from Porto. This seems a little strange to us, and it can be related with the IP (Internet Protocol) assignment made by the Internet Service Provider (ISP). The following cities are within a radius of 50/70 Km away from Porto. The remaining cities are apart from more than 100 Km from Porto, but the number is residual.

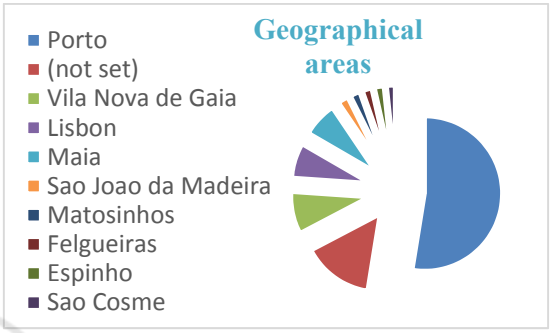

Figure 1: Accesses to *MatActiva* from major cities.

The age of most of the students that access our site is between 18 and 24, as we can see in Figure 2. It is possible to verify that there are many "older" students. The main reason for this happen is that in our School there are several programmes for adult students, in special students that work during the day and study during the night (from 18h30 to 23h).

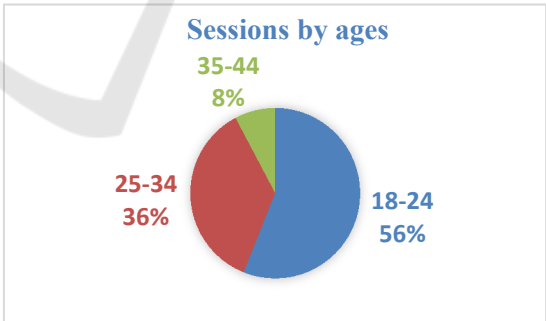

Figure 2: Percentage of sessions in site by age.

Interestingly we observe that although the students in range 35 to 44 only have 8% of sessions (Figure 2) they spend 25% of the time in each session (Figure 3). The older students perhaps have more difficult in some areas, thus they need more time in each session to solve some quiz or understand some concepts.

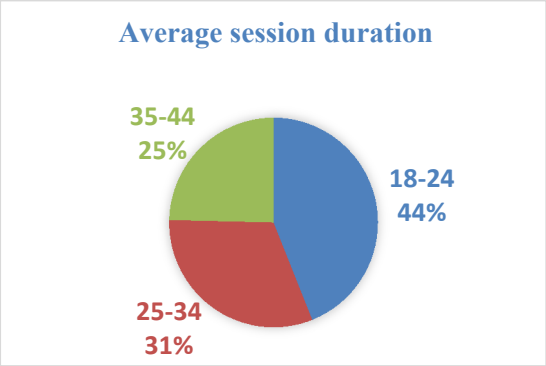

Figure 3: Percentage of average sessions duration by students age.

When we consider the gender, 63% of the sessions are from females and 37% are from males. The average session duration is 59% for females and 41% for males, which indicate that females spend a little bit more time in each of the sessions.

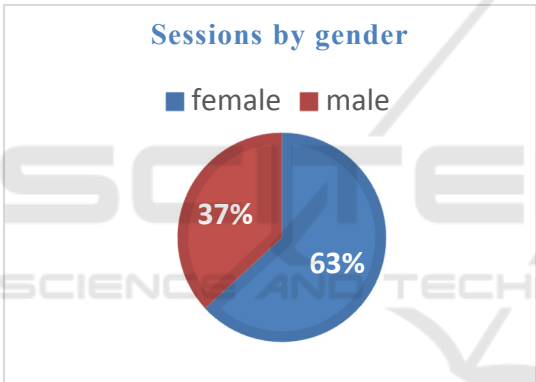

Figure 4: Percentage of sessions in site by gender.

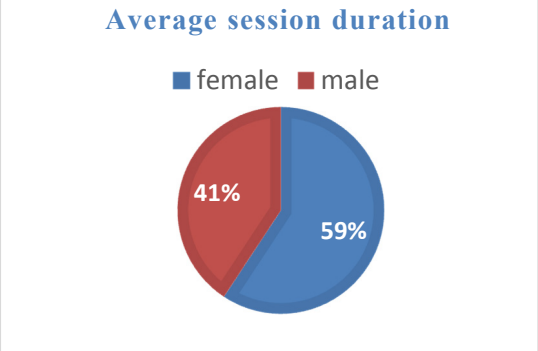

Figure 5: Percentage of average sessions duration by student's gender.

Figure 6 presents the allocation of the sessions by topics available in MatActiva. It should be noted that the numbers appearing in the graph are the sum of various activities included in each of the topics, as described in Section 3. GA shows the number of sessions by topic. We can observe that "Learning" is the most accessed topic.

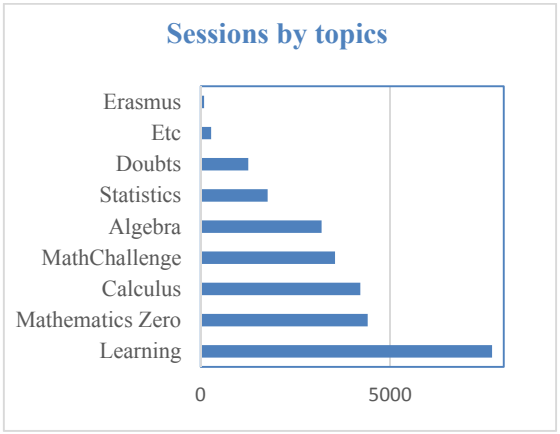

Figure 6: Number of sessions by topics.

Despite that Learning is the topic with the biggest number of sessions, we can see that the topics Etc and Mathematics Zero are the ones with more average time by session. This fact is not surprising and can be justified by the type of contents available in each topic.

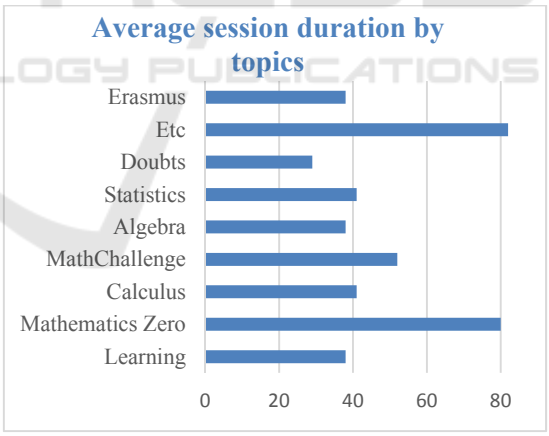

Figure 7: Average sessions (in seconds) by topics.

In Figure 8 we can see the number of students' sessions by month of the year. We can observe that January and November are the months with more students' accesses to the platform. Surprisingly we still have accesses during July and August which are traditionally holidays.

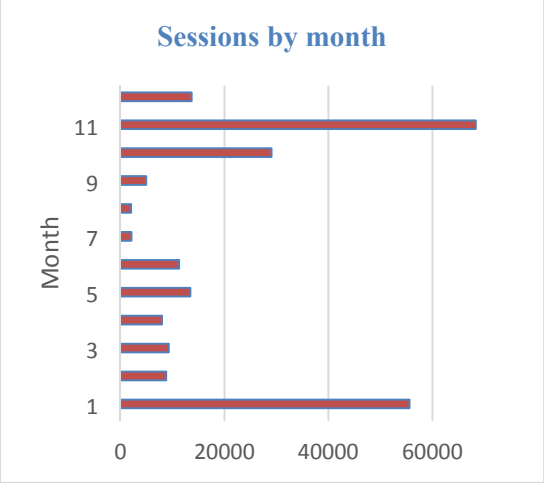

Figure 8: Sum of the sessions by month of the year.

In Figure 9, the number of students' sessions by day of the week is presented. We can observe that students use the platform mostly on weekends and Mondays.

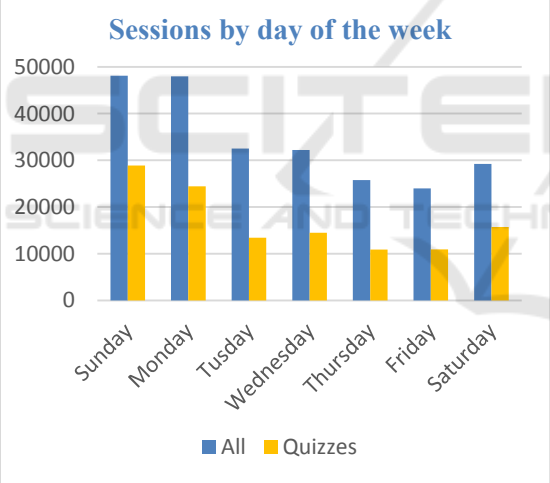

Figure 9: Sum of the number of sessions by day of the week compared with sessions quizzes.

It is possible to see (Figure 10) that in the last three academic years the number of accesses has grown up.

Other finding (Figure 11) is that in the last years the accesses to the website by phones and similar devices also increased. Note that the last academic year presented in the graph is not complete, since at moment we write this paper we were only at the beginning of the summer semester.

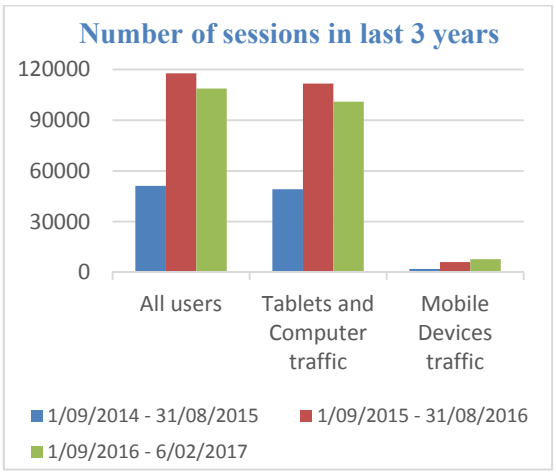

Figure 10: Sessions in last 3 academic years.

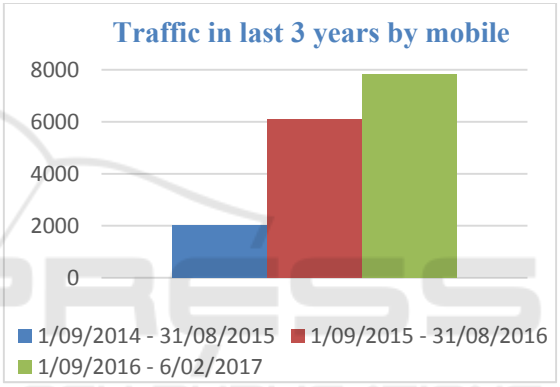

Figure 11: Traffic by mobile devices.

In Figure 12, the total dedication time (in hours) for each of the topics is presented. We can find that the Calculus, surpasses with a big difference all the other topics that we have in *MatActiva*. Note that in this graph, the data is from last 4 years.

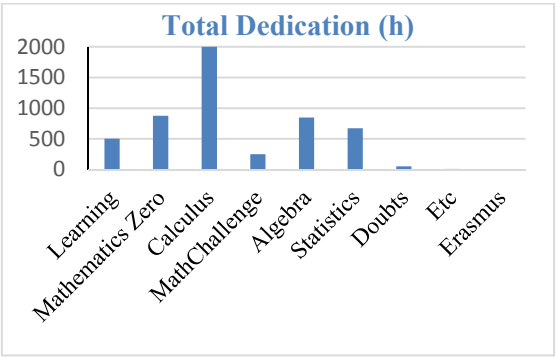

Figure 12: Dedication time in hours for each topic.

In Table 3 we present the number of students that accessed each of the materials available in

MatActiva, considering only the eleven ones with the highest number of accesses. We can verify that quizzes (random tests) are the ones most used with large advantage.

Table 3: The *MatActiva* activities most accessed.

Materials most viewed in *MatActiva*	
Mathematics Zero	**Accesses**
Video classes and Diagnostic Test	6651
Learning	
Support Forms, Lesson Plans and Practice Problems	4385
Calculus	
Random Test - Multiple Choice (Functions)	16784
Random Test - Multiple Choice (Integrals)	19448
Random Test - Multiple Choice (Series)	6854
Statistics	
Random Test - Multiple Choice (Permutations and Combinations)	10806
Random Test - Multiple Choice (Discrete and Continuous Distributions)	5568
Algebra	
Random Test - Multiple Choice (Matrix and Systems)	7571
Doubts	
Algebra	430
MathChallenge	
MathChallenge 2014/2015	3177
Erasmus	
Tests	55

6 DISCUSSION AND CONCLUSION

The students that access *MatActiva* are similar to the ones of the school where the project was implemented, being that we have more students in the ages from 18 to 24 years and more female students. A bigger proportion of sessions and the average session duration in this range of students' age and gender confirm this statement. It is interesting to verify that, despite the percentage of the number of sessions in the platform is only 8% for students aged 35 to 44, the proportion of average session duration increases significantly to 25% in this range of years. This can lead us to the conclusion that they spend more time in each of the resources than younger students. We think that this could be done to the fact that these older students do not study for a long time and have got more difficulties. Considering gender, the differences are not so pronounced, however females spend more time in each of the sessions than males.

Most of the students' accesses are from cities very close to Porto, which is also accordingly to the type of students in the school.

When we look at the students' preferences, the topic "Learning" presents the highest number of sessions, but they spend more time, in average, with the topics "Mathematics Zero" and "Etc". This can be due to the fact that the topic "Mathematics Zero" is more intended to promote study and it requires a more detailed and careful approach. This is a very important topic to support students with more learning disabilities leading to longer sessions. The "Learning" topic has got several support forms and working sheets in pdf format, that can be downloaded and does not require longer session's duration.

We can also verify that students have bigger dedication time (total hours spended) to the subject "Calculus", which is a subject that includes a lot of quizzes with multiple choice questions. We consider that this can be the reason for the students spend a big amount of time in this subject, since this is a way to preparing the assessment. We consider that the other materials can be very important in the students' learning process, and were very hard to develop. Thus, we must develop strategies to increase the use of other types of resources by the students.

Concerning the analyses of the number of session by month it was interesting to verify that we still have accesses during the traditional holydays period. This was a motivation for the teachers that are involved in the project. The months with the biggest number of accesses are November and January. With regard November, after one month of classes, the students start feeling difficulties and search for these tools that can help them with their learning process. As for January, students have exams at the end of that month, and thus they can also be searching for tools to help them with their study.

Considering the number of sessions by day of the week, it was surprising verify that the students use the platform during weekends. This can be due to the fact that the students live near Porto but have long voyage periods during the weeks, thus in the weekends they stay at home and can have more available time to dedicate to their study. This suggests that making quizzes and homeworks available during weekend may have better acceptance by students.

It was very stimulating to verify that the number of students using the platform is steadily increasing in

the last years. The increase in the use of mobile devices, puts some more challenges, since the site is not prepared to those types of accesses. Thus, we should consider adapting the platform. We hope that this can increase the participation of the students.

7 FINAL REMARKS

Learning Analytics have become popular in the literature. In this work, we present some instruments, such as Google Analytics, Course Dedication, and Moodle Reports, that can help to improve the students learning, based in this concept.

We described the project that we intended to improve and that is going on for some years in ISCAP/P.PORTO.

This paper constitutes an important reflexion for the members of the project. It was verified that many of the materials available are not used, and that the students prefer to access the quizzes.

In the future we are planning to inquiry the students about the reason for accessing mostly this type of resources. We also intend to define strategies to promote the other resources, since we consider that these are important tools to improve students' learning. Also, we are planning to implement predictive analytics, and other analytics resources that can improve the success of the students.

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