



## LEARNING ANALYTICS IN PRACTICE: DEVELOPMENT AND IMPLEMENTATION OF A SUPPORT SYSTEM TO THE MANAGEMENT OF THE TEACHING ACTIVITY

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### ABSTRACT

*The use of technological platforms based online has become increasingly important in the formative activity of higher education. In this context, by its almost universal use in educational institutions, the LCMS (Learning Content Management Systems) stand out. From the activity of students and teachers in these platforms a huge amount of data ends up being recorded, with great potential for management, which are not used. The idea of the Learning Analytics is related to the organization and analysis of these data, transforming them into intelligible information so that people and bodies of Institutions of Higher Education (IHE) can control actions and make more informed decisions, in terms of the adoption strategy of LCMS and the discovery of patterns that enable statistical inferences. The Learning Analytics in education is in its infancy at the theoretical level, which is reflected in the difficulty in maintaining a stable discourse, and, even more evident on the practical level of development and use of these systems. This paper presents the results of the work of design, development and operationalization of a Learning Analytics system to assess the integration of the LCMS in the teaching and learning process in higher education. The proposed system combines the reading of data from two sources: from the automated reporting platform and from a scale applied to students. As a methodological approach to the subject the Design Science Research Process model was followed. The results achieved were reflected in a backoffice of the extraction and analysis system within the LCMS and in the development and validation of a scale to assess the integration of the LCMS in the formative process in higher education. In this paper the operation of this system is done in a real context in a face to face Curricular Unit (CU) for the first semester 2013-2014, at the Universidade Católica Portuguesa - Porto. The results indicate that this system, when crossing data from two sources, has the potential to allow the process of decision making to be more informed by teachers or leaders of the educational institution, opening new possibilities in the field of pedagogy and organizational efficiency.*

**Keywords:** Design science, Learning analytics, Higher education, Management.

Received: 10 February 2014/ Revised: 12 March 2014/ Accepted: 15 March 2014/ Published: 18 March 2014

## 1. INTRODUCTION

The Learning Content Management System (LCMS) has a ubiquitous presence in Higher Education Institutions (HEIs) in various parts of the globe (Lonn *et al.*, 2011), and, in many cases, they are the only platforms with an institutionalized widespread use in support of the teaching activity. These platforms offer tools that allow, in an online environment, the provision of information and content; collaboration through synchronous and asynchronous communication tools; and evaluation. The various actions performed by teachers and students in the LMCS are recorded in databases, and this data, when organized and transformed into intelligible information, can be used to support more informed decision-making, opening doors to new management models for Higher Education Institutions (HEIs) in the fields of organizational efficiency and pedagogy.

For several years now the business world has been implementing technological systems for advanced analysis of the data produced online and by its technological platforms. These systems are increasingly indispensable in monitoring the strategy and in the information for decision making, critical requirements for an efficient management process. The interest of HEIs in this new wave, which is embodied in a new way of using the data, only now is awakening. These organizations are rehearsing, albeit timidly, their systems of *Analytics*: “More recently, institutions of higher education are starting to adapt these methods to target fund raising, inform enrollment decisions, target marketing efforts, improve student support processes, and to better understand retention/persistence patterns.” (Bach, 2010).

A Society for Learning Analytics Research (SoLAR) provides a definition of Learning Analytics in which all aspects of this issue converge: “Learning analytics is defined as the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs” (SoLAR, 2012).

The use of Learning Analytics by HEIs will take several years to mature, however, their presence is already being felt and it should not be ignored (Picciano, 2012). In this line, the 2013 edition of the *Horizon Report* (Johnson *et al.*, 2013) pointed out a period of two to three years for the adoption of these systems by HEIs, and the 2014 preliminary edition of this report (New Media Consortium, 2014) anticipates this for a year or less. The organization of conferences dedicated to the subject – e.g. three editions of *Learning Analytics and Knowledge Conference* in 2011, 2012 and 2013 (SoLAR, 2013) – and the increasing number of scientific publications are other indicators of the emergence of the topic and its relevance.

Like any new area of research, the *Analytics* in education has imported a variety of terms and expressions to describe concepts and processes from other areas of knowledge, often with significant differences in the conceptual and functional level, and also using different terms for the same conceptual definitions and functions (Barneveld *et al.*, 2012). This difficulty is enhanced at the practical level, in which the completion and implementation of *Learning Analytics* systems in HEIs is still a glimmer on the horizon.

In the development and use of LA, the HEIs face two major challenges: the technological challenge and the educational challenge (Ferguson, 2012):

The technological challenge relates to the ability of HEIs to develop software that enables deeper modes of extraction, aggregation and visualization of data and preparation of reports to make them into *Analytics*. In the view of Dawson and Fergusson these valences, which are fundamental to the LA, are still at a very embryonic stage: “Although student tracking capabilities are typically included as generic software features, the depth of extraction and aggregation, reporting and visualization functionality of these built-in analytics has often been basic or non-existent” (Ferguson, 2012). Ferguson (2012) summarizes the problem of the technical challenge in the adoption of the LA: “The first driver, then, is a technical challenge: How can we extract value from these big sets of learning-related data?” .

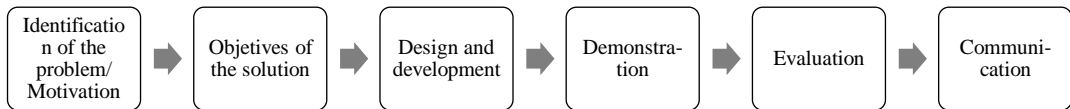
The educational challenge is related to the ability of the HEIs’ actors to manage and to optimize the use of information in management and enhance the effectiveness of the teaching learning process (Ferguson, 2012).

The present work falls within this context. It describes the process of designing and developing a Learning Analytics system to evaluate the integration of LCMS in the teaching and learning process in higher education, which aggregates data from two sources - automated reporting from the platform and a scale applied to students - and its operationalization is made in a face to face UC of a university degree, of the winter semester of 2013-2014 at Universidade Católica Portuguesa, Centro Regional do Porto Católica - Porto).

The methodological basis followed for the development of this Learning Analytics system was the Design Science Research Process model (DSRP), proposed by Peffers *et al.* (2006) which predicts a sequence of six steps to conduct and control the entire process, ranging from problem identification/ motivation to carry out the prototype to the evaluation and reporting of results. Taking into consideration this introduction, this paper is divided into four sections: in section 2 the methodological framework of the research is done and justified, in light of the objectives of the work, in section 3 the results achieved in the work done on the design, development and operationalization of Learning Analytics are presented and discussed, and in section 4 the main conclusions are summarized.

## 2. METHODS

The Design Science Research Process (DSRP) model, proposed by Peffers *et al.* (2006) that results from an effort to systematize the theoretical and practical knowledge in the area of design science, served as a guide in the construction of the Learning Analytics system. The proposed model satisfies three requirements: i) consistency with the theoretical and practical knowledge produced within the paradigm of design science; ii) it presents a scheme with multiple stages for conducting the design science process; iii) it defines a mental scheme with the output characteristics of the research. Figure 1 represents schematically the DSRP model, where six stages can be identified in conducting research.

**Figure-1.** Design Science process for the Learning Analytics, according to Peffers *et al.* (2006)

Identification of the problem and motivation – The Learning Analytics is an emerging theme in the literature and its potential for the management of the learning activity is recognized. Católica - Porto has implemented a LCMS to support the teaching learning activity, which records in a database the activity performed by teachers and students within the platform. However, it has not made an effective use of this data to assess the integration of the LCMS in the training process, wasting this immense potential for the management of the learning activity, particularly for the control of actions and more informed decision making. The fact that the automatic reports of the LCMS do not provide organized information on its integration into key dimensions of education strongly contributes to ignore these data. Furthermore, in the educational institution there is no form of data collection specifically aimed to assess the perceptions of students about the integration of LCMS in their learning activities.

Objectives of the solution – To design, develop and operationalize the context of a CU, Learning Analytics that combines the analysis of data from the extraction and analysis system within the LCMS - built in *backoffice* - with the results of the scale applied to students to assess the integration of the LCMS in the formative process in higher education.

Design and Development - Mobilizing knowledge in the field of science education and Analytics to define the model of analysis. The analysis model was designed in order to address the following three areas: organizational, educational and technological.

Demonstration – The demonstration of the system's effectiveness was accomplished through the operationalization of the system in a CU of a university degree, in the winter semester of 2013-2014, at Católica - Porto. The CU chosen to operationalize the system was the one that, according to the data of automatic reports (Figure 3), showed a higher degree of integration of the LCMS in the teaching and learning process among all CUs of the educational institution, becoming therefore a suitable stage for the evaluation of all the dimensions of the model.

Evaluation – Observation and execution of successive tests; presentation of progress to top management, with the aim of fitting the model to the needs of the educational institution's information; submission of the work done to journals and conferences with refereeing for validation by the scientific community.

Communication – Information about the results to the top management of Católica - Porto and submission to journals and conferences with refereeing.

Figure 1 shows the phases of the model DSRP (Peffers *et al.*, 2006) which are presented sequentially, however, that does not mean that the developing process of the *Learning Analytics* had been linear. In fact, every *input* of information and knowledge gained at any stage demanded a retrospective reading of the road already travelled. For example, the technological limitations or

the evaluation performed by testing, of the leaders or the scientific community, led to redefining the design and development of the solution.

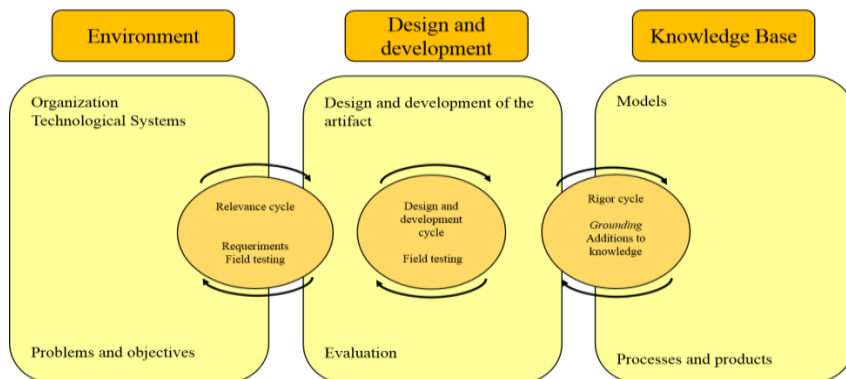
The various stages of the DSRP model are intrinsically related and contain three fundamental cycles identified in the work of Hevner (Hevner *et al.*, 2004). The three-cycle view of design science research (Hevner *et al.*, 2004) which inspired the DSRP model is a landmark in terms of conceptualization and definition of guidelines to understand, implement and evaluate the design science applied to the Information Systems.

In figure 2 the three cycles of the design science research (Hevner *et al.*, 2004) are presented schematically:

The relevance cycle is measured by the response that the produced artefact offers to concrete problems and how it can contribute to the improvement of organizations.

The design and development cycle is the core of the process and that is where the building products are subjected to evaluation, which feedback is the basis of the future redefinition of the design and development. The rigor cycle integrates scientific knowledge and the methods in the construction and development of the system. At this stage, the submission of the work done at conferences and specialized journals is critical in ensuring that rigor.

**Figure-2.** Design Science cycles, according to Hevner *et al.* (2004) perspective



### 3. RESULTS

In this section the results achieved in the design, development and operationalization of the Learning Analytics are presented. The implementation of this system was carried out in a real context, in this case in a CU of a university degree with 314 students enrolled, which ran in the winter semester of the academic year 2013-2014. This section is organized into three subsections: 3.1 describes the process of design, development and operationalization of the automated reporting system in backoffice in the LCMS; in 3.2 the operationalization of the scale to assess the integration of the LCMS in the formative process in higher education is presented and done; in section 3.3 a combined reading of the results coming from the two data sources (automatic reports + scale) is performed.

### 3.1. Automatic Reports System in Backoffice in the LCMS

Throughout this chapter are presented the various stages of the design and construction of the automated reporting system, which aims to make the positioning of each CU in the five stages of the evolution of the LCMS integration in the teaching and learning activities. This system was engineered and developed in *backoffice* within the *Blackboard*. This subchapter is divided into six parts, which correspond to the different stages of the DSRP (Peffer et al., 2006) which was the methodological approach.

#### 3.1.1. Motivation/ Identification of the Problem

Several factors have acted as motivational catalysts to design and develop a *Learning Analytics* system at Católica -Porto:

- 1) The investment of the educational institution in implementing an LCMS to support the training activity – The Blackboard is the technological platform to support the teaching and learning process with greater centrality in Católica - Porto. The institution's investment in the purchase of the successive versions of this platform and the training available for teachers to make a more efficient use of this technological resource are indicators that show institutional commitment.
- 2) The LCMS is the platform of *institutionalized use in supporting the training activity* - The creation of CUs and their assignment to the teachers who teach them and to the students that attend them, simultaneously in administrative systems and in the *Blackboard*, corroborates the institutional role in the use of the LCMS; the high number of recorded hits is another indicator of the centrality of the LCMS.
- 3) The importance of monitoring the introduction of technology in the formative activity of the HEIs - Católica - Porto has in operation a System of Assurance and Evaluation of Internal Quality (SAEIQ), however, its action does not include a specific assessment of aspects related to the use of technology in the teaching and learning process, in particular the LCMS. Published work recommends that specific criteria for evaluating the introduction of technology in teaching and learning, in order to facilitate the transition to the new paradigm: “Management has to focus on transition, be proactive and serve as a role model, since changes in technology often produce chaotic situations. Furthermore, the institution’s internal quality assessment model for teaching and learning has to be expanded to include criteria specific to e-learning” (SNAHE, 2008).
- 4) The Recognition of the Learning Analytics as an emerging theme and with transformative potential in higher education - The Learning Analytics is referred to in published work as an emerging theme and one with high potential in the transformation of higher education: “Basing decisions on data and evidence seems stunningly obvious, and indeed, research indicates that data-driven decision making improves organizational output and productivity” (Long and Siemens, 2011).

The investment and the commitment of Católica - Porto in the use of technology to enhance teaching practice, demonstrated throughout its history, is an incentive and justifies treading this path (Ferreira and Andrade, 2013).

5) Lack of information on the use and integration of the LCMS in the training process - The problem that laid the foundation for defining the purpose of designing and developing a system of Learning Analytics is a result of limited information of the original reports made available by the Blackboard, which did not allow the understanding of the effective integration of the different services offered by this platform in the teaching and learning process, precluding an assessment of their impact on training activity. Apart from academic interest, this information is invaluable for the management, as it can be used in actions of control, evaluation of policies and defining strategies to enhance and promote the successes and correct the most backward sectors, favoring a quicker adaptation to new situations (Kotter, 1996; Kotter and Cohen, 2002; Kotter and Rathgeber, 2009).

### 3.1.2. Objectives of the Solution

To respond to the identified problem - the limitations of the reports with their origin in the Blackboard, that did not allow the assessment of the integration of the valences of the platform in the various dimensions of the educational process - and to meet Católica – Porto's need of information, a system was designed and developed in backoffice, within the platform itself, which fulfills the following requirements:

- 1) To sort the data collected by the platform on the use of several services offered, enabling to position each CU in stages of evolution of the LCMS integration in the teaching and learning process, in a pedagogically grounded way and technologically feasible;
- 2) To facilitate the reading and interpretation of reports through a mode of presentation that combines tables and charts;
- 3) Automatically collect all data for the preparation of reports, so as to exempt the user from entering any additional information in order to obtain results. With this, we sought to ensure that the new reports do not bring any disturbance, namely, they do not add working time to the teachers.

### 3.1.3. Design and Development

#### 3.1.3.1 The Organizational Triangle – Educational – Technologic

The design and development of a Learning Analytics system requires a balance between the organizational, educational and technological aspects (Ferguson, 2012). The genome of the Learning Analytics success depends on the response to the dimensions of this triangle:

- 1) Organizational dimension - It is expected that the Learning Analytics answers to the requirements of the educational institution in terms of information, providing useful data on the integration of the LCMS in the teaching and learning process, which can be aggregated by multiple levels of analysis that reflect the organization of the institution. Like many HEIs, Católica - Porto is organized in multiple levels: the Regional Centre is divided into various universities/schools; in which teachers are integrated; that teach various CUs.

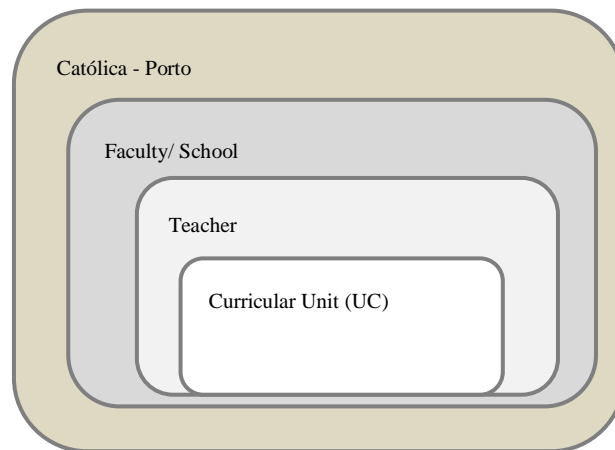
The choice of CU as the core of the analysis allows the aggregation of several CUs in order to obtain the desired information. This organization by levels of detail allows conditional access to



information, if that is the objective of the educational institution. In this case, each teacher will only have access to information about the CU he or she teaches, the director of university/school to all CUs taught at the place he runs, the SAEIQ and the direction of Católica - Porto to all information.

Figure 3 shows this possibility, where the CU is the atom of information from which the aggregation is made to hierarchically superior levels. One of the limitations identified in the automated reports of LCMS was precisely the inability to obtain relevant information at the level of the CU. (Ferreira and Andrade, 2011).

**Figure-3.** Aggregation of the information reflecting the operating model



2) Educational dimension – It is expected that the Learning Analytics can provide relevant information on educational matters. To ensure this requirement all the dimensions considered in the matrix of analysis were justified and put into context in published documents.

3) Technological dimension – The design of all the backoffice of the extraction and analysis system was conducted to meet the requirements of organizational and educational dimensions but requiring a constant reconciliation with technological feasibility. In a dialectical process progressive approximations were made in order to ensure that the Learning Analytics reflects a balanced management of the three dimensions of the triangle.

### 3.1.3.3. The Matrix for the Analysis of the LCMS Integration in the Formative Process

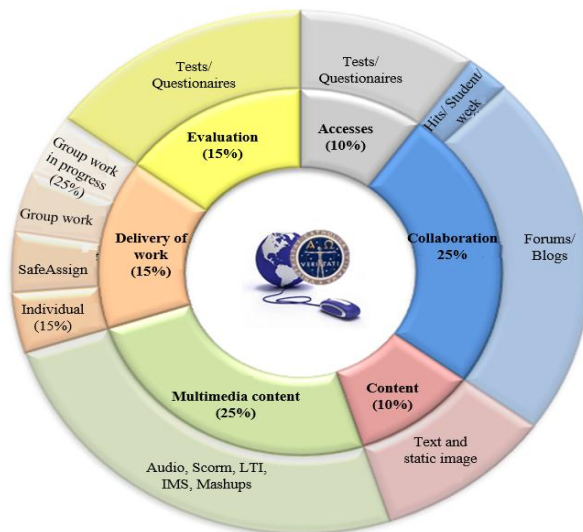
The Technology Integration Matrix (Florida Center for Instructional Technology, 2011) associates five stages of evolution of technology integration (introduction, adoption, adaptation, immersion and transformation) with the characteristics of meaningful learning environments promoters (Jonassen *et al.*, 2003) which result, for example, in the use of collaborative tools, digitally rich content and assessment activities in the construction of knowledge. Inspired in the Technology Integration Matrix, a positioning matrix of CUs and schools/universities was developed, considering the same five stages.



To overcome the information gap of the original reports of the LCMS, on key aspects for measuring the degree of this platform's integration in teaching and learning, we have defined six dimensions. These dimensions include the main valences offered by the LCMS, and cumulatively they take into account the aspects referred in published papers as being critical to the development of teaching activities in the online environment.

Figure 4 presents the model followed in the review, where it is shown the relationship between the six dimensions and the features of the LCMS. In the same picture it is also possible to see the weighting factors of each dimension (as a percentage of the total of the dimensions considered), according to the importance they assume in the teaching and learning process.

**Figure-4.** Dimensions and indicators used in the Learning Analytics system



Next, we present the clarification of what is evaluated in each dimension:

Dynamic access - Frequency of access to LCMS to follow the activities of the CU (Kaczynski *et al.*, 2008).

Collaboration – Collaborative activities in groups, forums and blogs (Jonassen *et al.*, 1999; Salmon, 2004; Lonn and Teasley, 2009; Florida Center for Instructional Technology, 2011).

Contents – Text content and statistical image without added value with respect to printed materials (syllabus, notes, books, articles, ...) (Kaczynski *et al.*, 2008; Lonn and Teasley, 2009)

Multimedia content - digitally rich multimedia contents, which go beyond the text and still image (Jonassen *et al.*, 1999; Jonassen *et al.*, 2003; Salmon, 2004; Jonassen, 2007; Kaczynski *et al.*, 2008; Florida Center for Instructional Technology, 2011): video, audio, scorm, LTI, IMS, mashups.

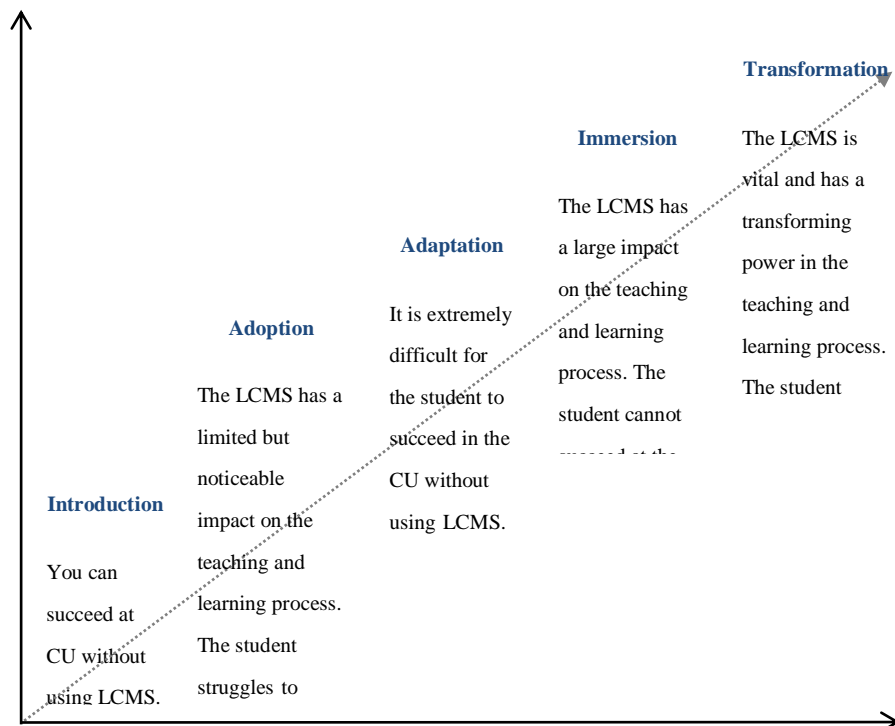
Delivery of Works - Use of plagiarism detection tools, delivery of individual and group work, checking group work in progress (Lonn and Teasley, 2009; Lonn *et al.*, 2011).

Evaluation – Tests and questionnaires (Kaczynski *et al.*, 2008; Lonn and Teasley, 2009).

To the dimensions collaboration and multimedia contents was assigned a higher weighting factor (25%). This procedure is based on published work. In fact, these two dimensions are regarded as fundamental in the development of courses with some online component (Jonassen *et al.*, 1999; Jonassen *et al.*, 2003; Salmon, 2004; Jonassen, 2007; Kaczynski *et al.*, 2008; Florida Center for Instructional Technology, 2011). Within the collaboration dimension, 10 % was given to the formation of groups (an indicator that shows the propensity for organizing collaborative work, but that does not provide information on the type of collaborative activities done) and 90% to the collaborative activities effectively developed and registered in the LCMS reports, namely forums and blogs. With regard to multimedia content, there has been integrated in this dimension the contents that go beyond text and static image, such as videos, audio, scorm, LTI and mashups.

The dimensions of work delivery and assessment are fundamental in formal education, where training has to be certified, having been assigned a weighting factor of 15% to each. As far as the delivery of work dimension is concerned, the assessment has been divided into four items (i - delivery of individual work; ii - delivery of group work in progress; iii - detection of plagiarism; iv - delivery of group work), each with a weight of 25%. In dimension evaluation, we considered the use of the LMCS assessment tools, namely tests and surveys. The content dimension refers to the provision of information and material in the LCMS that contain only text and static image. Despite reporting to the transposition of the elements of a more traditional classroom learning environment for an online environment, it is an indicator of the importance of the LCMS in the provision of information, hence the allocation of 10% as a weighting factor.

**Figure-5.** Evolution of the LCMS integration in the teaching and learning process



The frequency with which students access the LCMS for monitoring the activities gives considerable useful, and not negligible, information about the dynamics of this environment, and therefore the weighting factor of 10% given is justified.

In Figure 5 the five stages of evolution of the LCMS integration in the teaching and learning process are described.

Metrics for each of the dimensions of the matrix are given in table 1. These metrics can be redefined and parameterized so as to serve the interests of the HEIs at each moment.

**Table-1.** Metric to measure the position of each of the dimensions in the integration level of the LCMS in the training process

	<b>Introduction (0-20%)</b>	<b>Adoption (21-40%)</b>	<b>Adaptation (41-60%)</b>	<b>Immersion (61-80%)</b>	<b>Transformation (81-100%)</b>
<b>Access (10%)</b> (nr access / student / weeks)	0-1	2	3	4-5	≥6
<b>Collaboration (25%)</b> Groups (10%) Forums } 90% } Blogs }	0* (forums/blogs)	1 (forums/blogs)	2 (forums/blogs)	3 (forums/blogs)	≥4 (forums/blogs)
	* Midpoint of the range plus 10% if groups are formed	* Add 10% if groups are formed	* Add 10% if groups are formed	* Add 10% if groups are formed	* Add 10% if groups are formed
<b>Content (10%)</b>	0-2	3-4	5-6	7-8	≥9
<b>Multimedia content (25%)</b> - Videos - Audio - Scorm - LTI - Mashups <i>Total= Σ various types</i>	0-2	3-4	5-6	7-8	≥9
<b>Delivery of work (15%)</b> - SafeAssign - Individual - Group work - Group work in progress <i>Total= 25% per each item used</i>	0 (unused)	1 (functionality of work delivery used)	2 (functionality of work delivery used)	3 (functionality of work delivery used)	4 (functionality of work delivery used)
<b>Evaluation 15%</b> Tests - Questionnaires <i>Total= Σ of both types</i>	0	1	2	3	≥4

### 3.1.4. Demonstration

#### 3.1.4.1. The Report's Structure

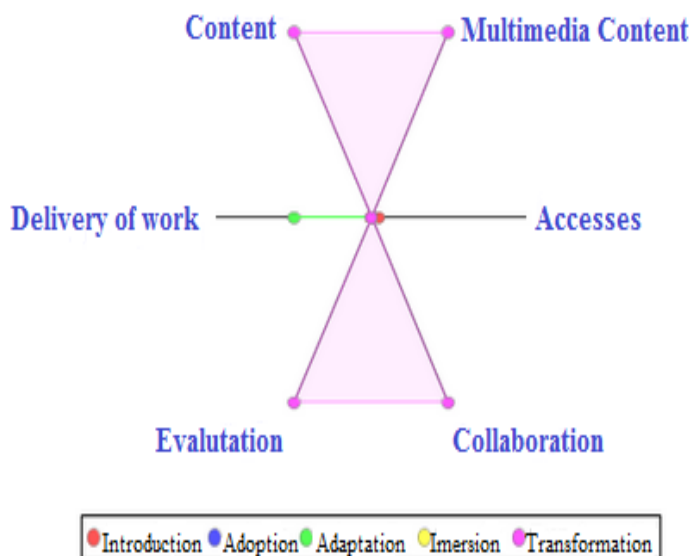
The stages of each CU and university are determined automatically through the LCMS reports that meet the requirements defined in the design and development phase. Figure 4

summarizes the data that is automatically collected and its aggregation in the different dimensions (access, collaboration, content, multimedia content and online reviews), indicating the weighting used for the purposes of calculating and positioning in the five levels of the LCMS integration in the teaching and learning process (introduction, adoption, adaptation, immersion and transformation).

Figure 6 presents the report of the CU's LCMS that is the subject of this study. The report is displayed within the administrator panel, however, in a phase of full implementation of this system it can consider the possibility of defining the permission for restricted access to the data for other users, for example, to enable teachers to access the reports of the CU they teach, to enable principals of different universities to access the CU's of the university they run and to give full permission for data access to the direction of Católica - Porto and SAEIQ; or alternatively to make all data public within the campus of Católica - Porto.

**Figure-6.** Automatic report from a CU of the 1<sup>st</sup> semester of 2013/2014

Data of the Curricular Unit			
CU code	Curricular Unit	Stage	Point of Maturation (%)
201314_F814C1072S1	CU_ 2013/14 (2 <sup>nd</sup> semester)	Transformation	83



Dimensions	Stage	Maturation Point (%)	Item	Total	Average p/week
Accesses	Introduction	5	Accesses	545	0,25
Collaboration	Transformation	100	Groups	12	N/A

Dimensions	Stage	Maturation Point (%)	Item	Total	Average p/week
Delivery of work	Adaptation	50	Forums	7	N/A
			Blogs	0	N/A
			Individual	8	N/A
			Group work in progress	0	N/A
			SafeAssign	1	N/A
			Group work	0	N/A
Content	Transformation	100	Content	62	5,17
Multimedia content	Transformation	100	Videos	3	N/A
			Audio	0	N/A
			Scorm	0	N/A
			LTI	0	N/A
			IMS	0	N/A
			Mashups	19	N/A
Evaluation	Transformation	100	Tests	29	N/A
			Questionnaires	0	N/A

The report consists of three parts:

i) At the top the CU is identified - through a code and name - and it is indicated its overall positioning in one of the five stages of the LCMS integration in the formative process. The maturation point from which the placement is made within a certain stage, results from the calculation of weighted averages for each dimension, as foreseen in figures 4 and 5 and in table 1.

The calculation method to place the CU's in the different stages can be changed and customized, so that it can meet the objectives of the educational institution at all times.

The maturation points of each dimension can be flexibly parameterized, according to the objectives of the educational institution. In Figure 7 we can observe the backoffice for the parameterization of the adaptation stage, existing five tables of parameterization, corresponding to an equal number of stages of the model. For each item it is necessary to set up the minimum and maximum values and the maturation point of each dimension is determined by an algorithm where the weight of its items is done. Similarly, from the results of the maturation points of the different dimensions (Figure 4), the global stage of the CU is calculated. The positioning of the CU in the stage is done through an algorithm which reflects the weights assigned to each of the dimensions.

$$\Sigma = (\text{access} * 0,1) + (\text{collaboration} * 0,25) + (\text{content} * 0,1) + (\text{multim.content} * 0,25) + (\text{papers} * 0,15) + (\text{evaluation} * 0,15)$$

Figure-7. Parameterization of the system

3. Adaptation

* Hits per week (minimum)	<input type="text" value="3"/>	* Hits per week (max)	<input type="text" value="3"/>
* Delivery of work (minimum)	<input type="text" value="2"/>	* Delivery of work (max)	<input type="text" value="2"/>
* Forums + Blogs (minimum)	<input type="text" value="2"/>	* Forums + Blogs (max)	<input type="text" value="3"/>
* Content (minimum)	<input type="text" value="5"/>	* Content (max)	<input type="text" value="6"/>
* Multimedia Content (minimum)	<input type="text" value="5"/>	* Multimedia Content (max)	<input type="text" value="6"/>
* Evaluations (minimum)	<input type="text" value="2"/>	* Evaluations (max)	<input type="text" value="2"/>

ii) In the middle part a radar chart is presented, in which the dimensions of the model in analysis are placed, allowing a quick understanding of the most dynamic and the ones in which there is a lower investment.

iii) The bottom of the report provides a detailed reading of each CU and its dimensions and of the elements constituting each of those dimensions.

3.1.4.2. Operationalization of the Report

Reading the report of figure 6, it can be seen that the CU has a maturity point of 85%, been positioned on the transformation stage, the highest. Four dimensions (collaboration, content, multimedia content and evaluations) present values equal to 100% at the maturity point, which indicates a total integration into the teaching and learning process. The dimension delivery of papers, has a maturation point of 50%, which corresponds to the use of half of the four items taken into account in the dimension (use of delivery of papers [individual] and plagiarism tool; no use of delivery of group work or group work in progress). The dynamic of access dimension has a very low maturity point (5%), being positioned in the introduction stage. This factor is justified by two situations: i) accounting of students enrolled at CU that in practice do not attend the activities; ii) the dynamical way that the accounting is done, where the number accesses / number of students enrolled / past 15 weeks (how long the semester is) is divided, which will successively eliminated the first weeks and adding the latest ones. At the time the report was prepared, the CU classes had already ended, so it is natural that accesses progressively got lower. This dimension must be reconsidered in the future, in order to be corrected.

3.1.5. Evaluation and Communication of Results

Cycles of observation and testing were done in a dialectical process, with the goal of correcting flaws and adapting the model to technological feasibility. In fact, the original model had to be adjusted due to technological limitations that prevented the counting of items on how communication is performed and the information made available within each CU (e.g. summaries, notices, calendars). Thus, the communication dimension was withdrawn from the initial model.

Additionally, the results gradually achieved were presented to top management of the educational institution for validation and submitted and published in journals with scientific

refereeing. (Ferreira and Andrade, 2010; Ferreira and Andrade, 2012; Ferreira and Andrade, 2013; Ferreira and Andrade, 2013)

The external disclosure in magazines (Ferreira and Andrade, 2012; Ferreira and Andrade, 2013) and international conferences (Ferreira and Andrade, 2011; Ferreira and Andrade, 2013), with scientific refereeing, was another important way of evaluation and reporting of results. In fact, the feedback from the peer review was integrated and contributed to the improvement of the system.

This work was registered in Horizons Projects (NMC, 2012) an initiative of the New Media Consortium (NMC, 2012) a landmark with great visibility worldwide, being rated level 5 (maximum level) on Interestingness and Relevance fields.

### **3.2. Scale to Assess the Integration of the LCMS in the Formative Process in Higher Education**

The Learning Analytics system presupposes the intersection of information extracted from the LCMS automatic reports with data collected using a scale to measure the students' perspective on the integration and importance of the information, content and activities available on the platform in the teaching and learning process. In fact, the automatic LCMS reports provide objective data on the use of the different tools of the system in the various dimensions of the teaching and learning process, allowing each CU to be positioned in one of the five levels of integration of the LCMS in the training process, but do not make it possible to measure the perception of students about the importance of the LCMS in their learning. The whole process of construction and validation of the scale was developed over three stages: 1- Identification and development of the dimensions and wording of individual items; 2- Validation of the content of the instrument by a panel of experts and masters students with deep experience on the use of the LCMS; 3- Administration of scale and psychometric analysis (Ferreira and Andrade, 2013).

#### **3.1.2. Objectives**

The scale was built so as to meet two main objectives:

a) Articulation of the dimensions of the scale with reports from LCMS - In order to make a cross-reading of data from the two sources of information (data system + students opinion). In table 2 the dimensions of the scale are summarized, and it can be seen that they correspond to the dimensions considered in the LCMS automated reports. Furthermore, the scale integrates the communication dimension, where the importance of information dissemination through the LCMS tools is gauged. This dimension does not appear in the automatic reports from Blackboard due to technological limitations that prevent counting the use of these features.

b) Time savings - The instrument should not be too extensive and, desirably, should not require more than 10 minutes to fill in. It is intended that the students complete a scale at the end of each semester for each one of the CUs they are enrolled in. This means that at the end of each semester they must fill in as many scales as the number of CUs attended.



**Table-2.** Dimensions of the scale assess the integration of the LCMS in the formative process in higher education

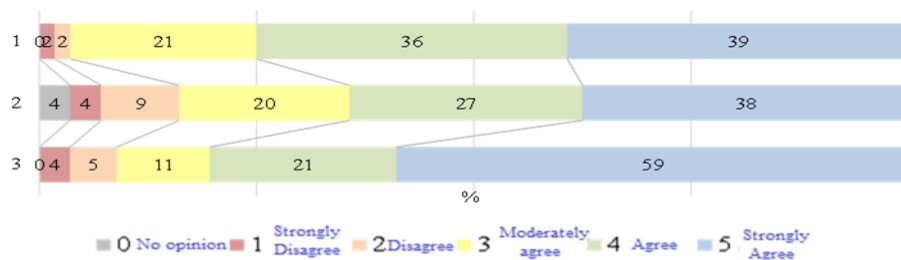
Dimensions	Perception of students on the degree of integration of the LCMS, in this CU, in their learning process
Dinamic of accesses (3 items)	Perceived importance of access to LCMS in monitoring the teaching/learning activity.
Communication (5 items)	Perceived importance of the dissemination of information on the CU activities through the LCMS tools.
Collaboration (8 items)	Perceived importance of the LCMS functionality in the collaborative construction of knowledge and in the quality of interaction with teachers and peers in carrying out collaborative activities within the LCMS.
Content (4 items)	Perceived importance of quality, adequacy, representativeness and added value of the content available on LCMS.
Multimedia content (7 items)	
Delivery of papers (4 items)	Perceived importance of the LCMS functionality on delivery, feedback and safeguarding of ethics and justice in the work done.
Evaluation (5 items)	Perceived importance of suitability, diversity, representativeness, feedback process of the evaluation conducted in the LCMS

**3.1.4.2 Operationalization of Scale**

The scale was distributed, after completing the lessons, through a link sent by the platform to the 314 students enrolled at the CU in question, which directed the students to the external server where it was hosted. Fifty six valid responses were collected, which corresponds to a response rate of 17.8%

The dynamic of accesses dimension, shown in figure 8, consists of three items, which are aimed at evaluating the perceived importance of the LCMS in monitoring the teaching activity. The answers indicate that the majority of students agree or strongly agree that they access the platform even when maintaining a regular attendance (75%), for monitoring the activities when missing classes (65%) and that the access to the platform is essential for academic success.

**Figure-8.** Scale data: Dynamics of accesses



1 - In this Curricular Unit, even when I maintain a regular attendance, I access the platform to keep up with school activities;

2 - In this Curricular Unit, when I miss classes, I access the platform to keep up with school activities;

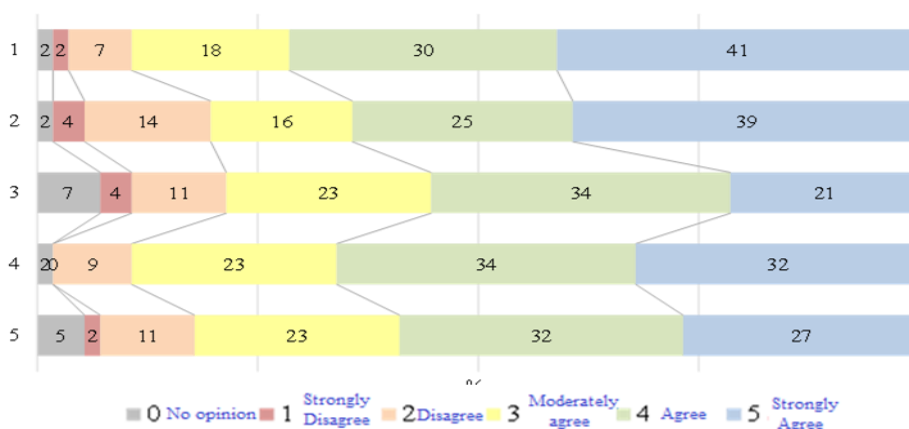
3 - In this Curricular Unit, the access to the platform is complementary to learning activities and it is essential for success in the subject

These responses, when compared with the result of the LCMS report in the same dimension (figure 6) show a mismatch between the data: the platform records position the CU at the introduction level and the answers to the scale indicate that students attach great importance to

the access to the LCMS in different situations. Retrieved what was mentioned above, this can be explained by two factors: the accounting of students enrolled but not attending the CU; the way the accounting is done, that considers only the last 15 weeks eliminating successively the first few weeks.

The communication dimension of the scale, for the reasons already mentioned, is the only one that has no match in the LCMS reports. However, it was considered important to assess the opinion of students on the use and importance of the platform valences for the communication of matters of interest about the CU. The results presented in figure 9 indicate that, in the scale's five items, between 55% and 71% of respondents agree or strongly agree that the LCMS comes out as an important vehicle in the communication of relevant information, in ensuring compliance of the agenda and to disseminate important elements for the monitoring, planning and management of the CU activities, such as summaries, syllabus and timetable.

**Figure-9.** Data of the scale: Communication



1 – In this Curricular Unit, relevant information to the learning activity is available on the platform.

2 - In this Curricular Unit, the platform's system of alerts is useful because it prevents me from forgetting important dates.

3 - In this Curricular Unit, the summaries available on the platform help me follow the activities.

4 - In this Curricular Unit, the syllabus available on the platform helps me follow the activities.

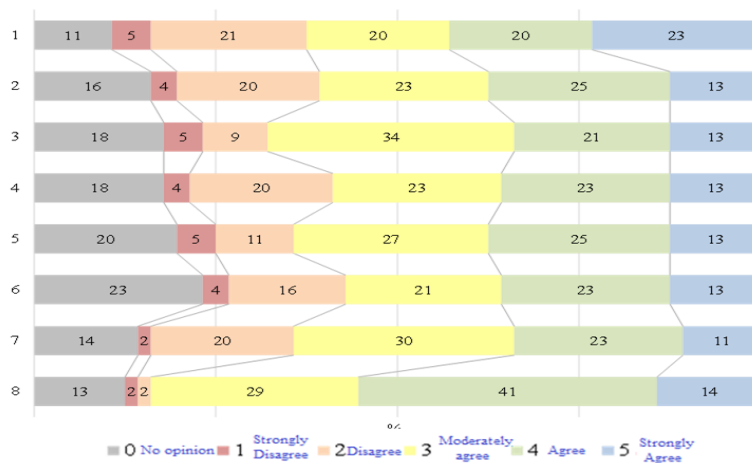
5 - In this Curricular Unit, the course calendar available on the platform helps me plan and manage my activities.

In the automatic reports, built on the positioning of the LCMS integration in the teaching and learning process matrix, the use of the platform of collaborative tools in accounted for, including groups' area and the existence of active forums and blogs. The eight items of this scale's

dimension are aimed at complementing this information, assessing the importance perceived of the LCMS collaborative features and students' interaction with teachers and peers in the construction of knowledge in activities within the LCMS.

An overview of the collaboration dimension (figure 10) revealed that, in the first seven items of the scale, the sum of the two upper intervals varies between 34% and 44%. Therefore, although the results of LCMS position the CU in the processing level, the perception of students indicates that there is still a long way to go to fully potentiate the activities and interactions of the scale collaboration. Item 8, focused on the teacher as a facilitator of activities, is the one that deserves a more favorable assessment (41% agree and 14% strongly agree)

Figure-10. Data of the scale: Collaboration



1 – In this Curricular Unit, the creation of groups on the platform facilitates my involvement with colleagues.

2 - In this Curricular Unit, the tools of the platform's "group area" facilitate my participation in collaborative activities.

3 - In this Curricular Unit, the fact that it is possible to participate in forums/blogs, created on the platform, anytime and anywhere, is important for the development of collaborative work.

4 - In this Curricular Unit, the forums/blogs created on the platform cover the key topics taught.

5 - In this Curricular Unit, the forums/blogs created on the platform are important to the construction of knowledge.

6 - In this Curricular Unit, the forums/blogs created on the platform help me to think critically about the content.

7 - In this Curricular Unit, my colleagues facilitate the achievement of collaborative activities within the platform.

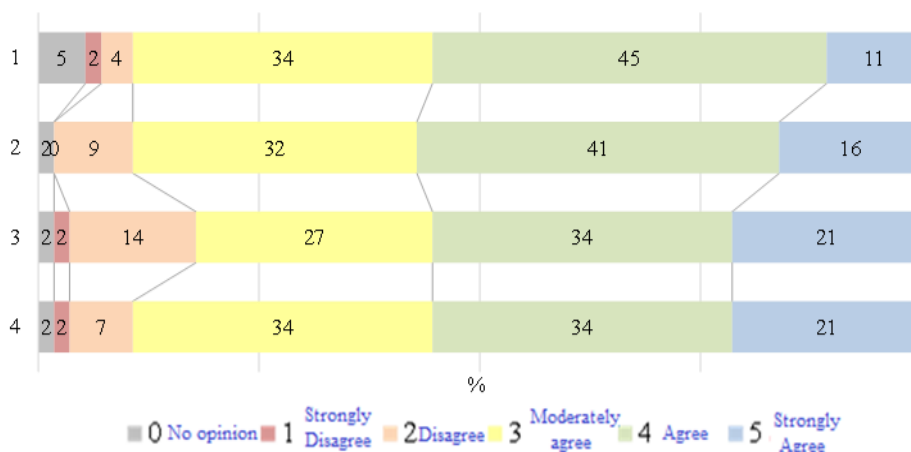
8 - In this Course Unit , the teacher facilitates the realization of streamlined collaborative activities within the platform .

Regarding the content (text and static image) dimension, in the LCMS automatic reports the documents were counted to position the CU. By integrating this dimension on the scale, we

sought to assess the students' perceived importance of the adequacy, representativeness and the added value of this type of content in the LCMS.

This dimension, shown in figure 11, consists of 4 items - covering the key themes of the CU, importance to learning, contribution to a more motivating learning and suitability to the theme - and in all of them between 55 and 57% respondents agree or strongly agree with the statements that reflect the integration and the importance of such content.

Figure-11. Data of scale: Content



1 - In this Curricular Unit, the contents of text and static image made available on the platform cover the key topics taught.

2 - In this Curricular Unit, the contents of text and images available on the platform are important to my learning.

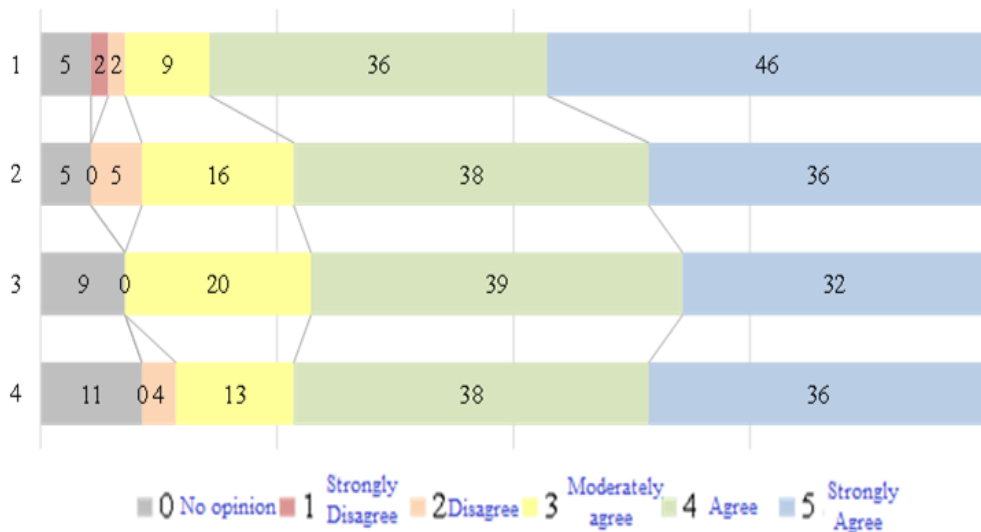
3 - In this Curricular Unit, the contents of text and static image made available on the platform make learning more motivating.

4 - In this Curricular Unit, the contents of text and static image made available on the platform are suitable for the issues addressed.

In the multimedia content dimension it was intended to measure the perceived importance of the quality, suitability, diversity, representativeness and added value of the content available on the LCMS through uploading on the platform and the indication of a link to the web.

In figure 12 it can be seen that between 57% and 77% of respondents agree or strongly agree on the quality, suitability, diversity, representativeness and added value of the content available on the LCMS.

Figure-12. Data of Scale: Multimedia content



1 - In this Curricular Unit, I submit my works via the platform.

2 - In this Curricular Unit, the process for submission of works for the platform is clearly defined in advance (dates, format, file name, ...)

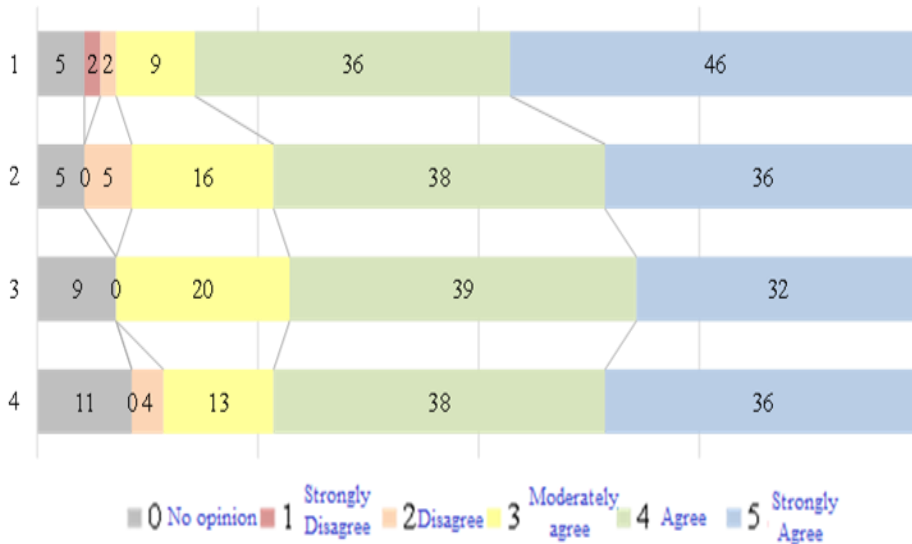
3 - In this Curricular Unit, I consider that the use of the plagiarism detection functionality of the platform is effective in safeguarding the ethical principles.

4 - In this Curricular Unit, I consider the use of the plagiarism detection functionality of the platform is effective in safeguarding justice in evaluation.

As far as the delivery of papers dimension is concerned, in the original scale it consists of six items, however, as the features delivery of group work and delivery of group work in progress were not used in the CU in review, the corresponding items have been suppressed from the scale.

In figure 13 the four evaluated items are present, that are aimed at measuring the perceived importance of the LCMS functionality in delivery, feedback and safeguarding of ethics and justice in the work done. In all the assessed items, over two thirds of respondents agree or strongly agree on the appropriateness of the submission of work by the LCMS and its importance for the safeguarding of ethics and fairness in the evaluation process.

Figure-13. Data of scale: Delivery of work



1 - In this Curricular Unit, I submit my works via the platform.

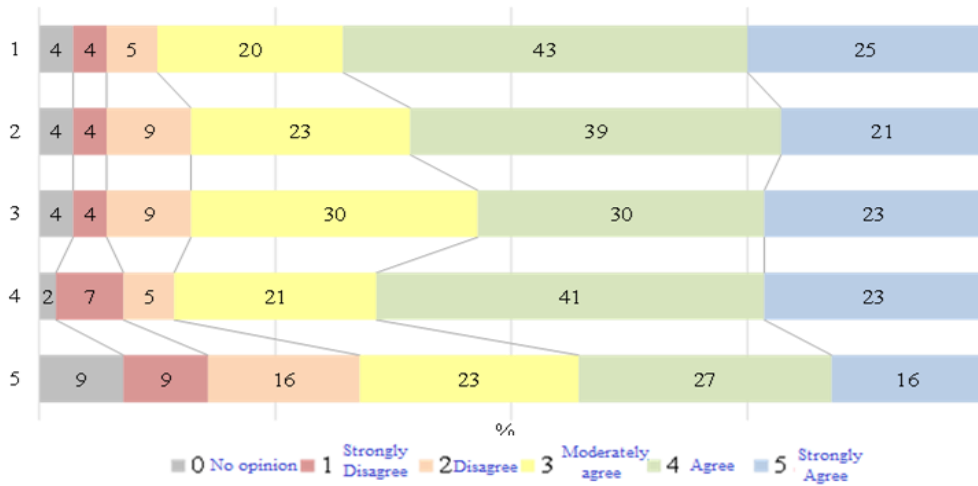
2 - In this Curricular Unit, the process for submission of works for the platform is clearly defined in advance (dates, format, file name, ...)

3 - In this Curricular Unit, I consider that the use of the plagiarism detection functionality of the platform is effective in safeguarding the ethical principles.

4 - In this Curricular Unit, I consider the use of the plagiarism detection functionality of the platform is effective in safeguarding justice in evaluation.

The last dimension of the scale is related to the evaluation and aims to assess the perceived importance of suitability, diversity, representativeness of the key themes of the CU and the system and teacher’s feedback on the tests taken place in the LCMS. The results shown in figure 14 indicate that over 60% of the respondents agree or strongly agree that the tests cover the key themes of the CU, that tests are important for learning and that clear instructions are given for their completion; 53% agree or strongly agree that the tests have diversified response items; the item with the most unfavorable answers is the one about the feedback given by the tutor/system, in which the sum of responses in the top two intervals is about 43%.

Figure-14. Data of scale: Evaluation



1 - In this Curricular Unit, the evaluation tests available on the platform cover the key themes.

2 - In this Curricular Unit, the evaluation tests available on the platform are important in the regulation of my learning.

3 - In this Curricular Unit, the evaluation tests available on the platform are diverse (multiple choice, time limit, true and false, long answers,...)

4- In this Curricular Unit, clear instructions are given in advance for the tests in the platform (timetable, time limit, location of the delivery in the platform,...)

5 - In this Curricular Unit, the system/tutor gives me feedback on the tests done on the platform

### 3.3. LCMS Data Crossing and Scale

The use of diverse methods and instruments when collecting data permits a better understanding and enhances richer analysis (Harvey *et al.*, 2000; Yin, 2009). It was by following this thought that this Learning Analytics was conceived and designed, which combines the collection of objective data from the system – via the reports designed in backoffice – and data of a more qualitative nature – via the scale to assess the integration of the LCMS in the formative process in higher education.

By aggregating data from multiple CUs, the leaders of the university may have an immediate reading of the situation and identify universities, courses and more dynamic teachers in the use and integration of the LCMS in the training process and the most behind sectors. This information can be used in the management process, for example, in an internal competition logic, in disseminating good practice and developing strategies aimed at more specific sectors.



The information is also useful for the teacher to evaluate a specific CU, as it allows him to identify, using the system's reports, the dimensions in which he has invested more and to assess the opinion of students on the impacts of his pedagogical action in each one of the dimensions.

The Learning Analytics can have a micro level that allows the teacher to define rules to monitor the activity of a specific CU or any particular student. The LCMS offer a range of skills at that level. Figures 15-17 show some practical examples of the operation at that level. Figure 15 shows the network of interactions of forum through a graph in order to evaluate the dynamics of the forum, identify the most central students in the discussion, the more absent ones and the number of interactions between individual students.

Figure-15. Network of interactions in a forum

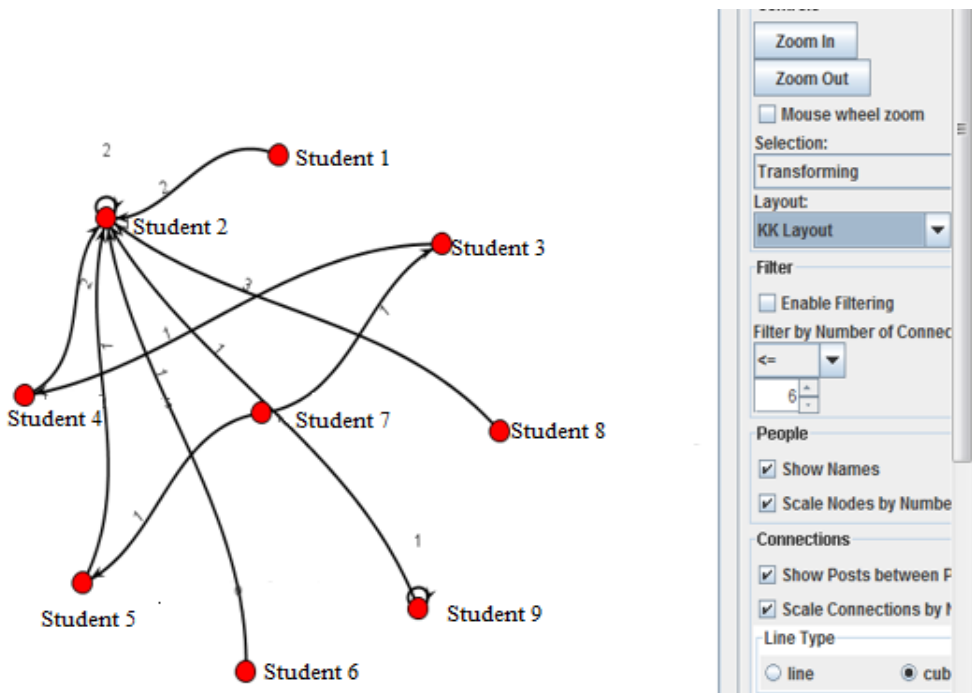


Figure 16 shows the mode of operationalization in a LCMS system of detection of students at risk, where it is possible to customize the value of each item from which the system sends the alert.

Figure-16. Customizing alerts for students at risk

<input type="checkbox"/> Included in Risk Table	Name ▲	Type	Criteria
<input type="checkbox"/>	Sim Default Activity Rule	Course Activity	Activity in the last 1 week(s) is 20% below course average
<input type="checkbox"/>	Sim Default Course Access Rule	Course Access	Last access more than 5 days ago
<input type="checkbox"/>	Sim Default Grade Rule	Grade	External Grade is 25% below class average
<input type="checkbox"/>	Sim Default Missed Deadline Rule	Missed Deadline	1 deadlines have been missed by more than 0 days

In figure 17 one can see the system’s report when a student at risk is detected (in this case, due to a low activity record and poor LCMS access). The interpretation of such data allows the teacher to assess and predict the academic progress of students and intervene in order to give students more opportunities for success.

Figure-17. Alert system for students at risk

**Students currently at risk**

23

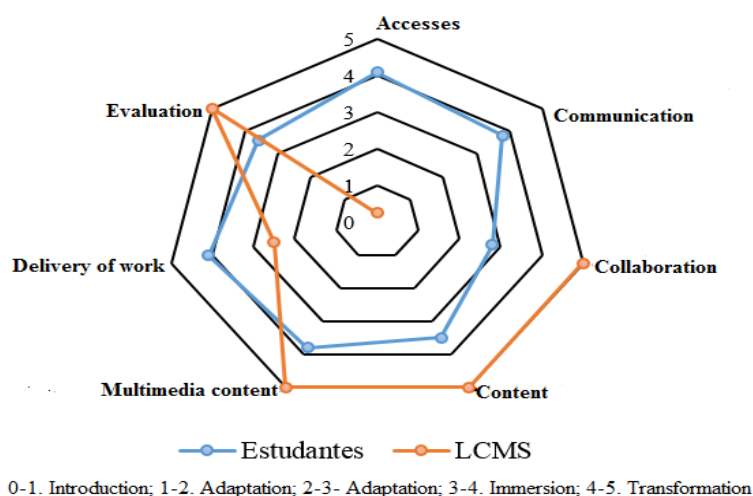
[View students not at risk](#)

STUDENT ▲	MISSED DEADLINES	GRADES ALERT	ACTIVITY ALERT	ACCESS ALERT
Student X	.	.	●	●

In figure 18 is shown a possible form of combined representation of LCMS data + scale. In this case, the versatility of the radar chart (Kaczynski *et al.*, 2008) allows to simultaneously position the dimensions evaluated on the five levels of integration of the LCMS in the teaching

and learning process. In the representation of the data from the LCMS the maturation point of the CU was used. Regarding scale data a quantitative approach was performed in order to establish the average ranking of Likert of 5 points, having been calculated the degree of concordance of the subjects who responded to the scale (level 1 associated with a lower level of integration of the CU or a more unfavorable assessment; level 5 reflects greater integration or a more favorable assessment).

**Figure-18.** Combined representation of both data sources of the Learning Analytics



In the CU in review, the quantitative results of the LCMS indicate that four of the dimensions - collaboration, content, multimedia content and evaluation - are positioned in the upper stage of the model - the stage transformation. The scale results indicate that the average ranking of the students' answers are positioned in this dimension in the adaptation stage or higher, except for the collaboration dimension, which is positioned at the upper limit of the adoption stage. From this it can be inferred that, although the students' perceptions reveal a good level of integration of the LCMS in the training process, this evaluation, of a more qualitative nature, falls short of the integration level shown by the automatic results. The analysis of the scales' results (figures 8-14) will allow the teacher to understand which aspects can be improved.

In the dimension delivery of papers, the LCMS automatic report indicates a maturation point of 50%, which corresponds to the adoption stage. This result is due to the use of two out of the four functions in the delivery of papers platform. In this case the functions used were delivery of papers with and without verification of plagiarism, and the features delivery of group work and delivery of group work in progress were not used. Regarding the features used, the average ranking of students' responses reveals a high integration in educational activities (processing stage).

The access to the platform is recognized by the respondents as an important dimension in conducting the activities (processing stage). However, for the reasons already given, the results of the platform do not corroborate these findings. This demonstrates the importance of a combined reading the two data sources for a more complete understanding of how the type of use and integration of the LCMS in the teaching and learning process.

In the communication dimension the importance of information dissemination through the LCMS tools can be inferred. The scale results indicate that this dimension is positioned at the upper limit of the stadium immersion. This information cannot be evaluated in the LCMS yet, due to technological limitations that prevent the use and count of these features.

#### 4. CONCLUSIONS

The design, development and operation in context of the Learning Analytics system to evaluate the use and integration of the LCMS in the teaching and learning process, following the various stages of the DRSP model (Peffers *et al.*, 2006) and fulfilling the three cycles of Hevner *et al.* (2004) ensured the relevance, appropriateness and accuracy of the system.

The cycle of relevance was ensured in two ways: i) demonstration of the potential of the Learning Analytics systems for the management of learning activity based on published papers, ii) response to a concrete problem of a HEI, by proposing a system of Learning Analytics to evaluate the use and integration of teaching activity. These two routes are matched with phase 1, motivation/problem identification/motivation, of the DRSP model.

In the design and development cycle the inputs of the relevance cycle were integrated and objectives were defined (phase 2 of DRSP model) in order to address the identified problem. In a dialectical process, in which the need for information required by the model was adjusted to the technological feasibility of extraction and analysis of data, the Learning Analytics was conceived, developed and operationalized. This system allows combining the reading of data from the extraction and analysis system within the LCMS - built in backoffice - with the results of the scaling applied to students to assess the integration of the LCMS in the formative process in higher education. In this cycle the effectiveness of the system was demonstrated, through its operation in a CU of a degree, in the winter semester of 2013-2014, at Católica - Porto (stage 4 of the PRSP model) and the evaluation stages (stage 5) and communication of results (phase 6) were also completed. To this end, successive tests were performed and the presentation of progress to top management of the university was made in order to adjust the model to the needs of the institution's information; submission of work to journals and conferences with refereeing for validation by the scientific community.

The cycle of accuracy is strongly linked to the previous two cycles and it was guaranteed by the theoretical basis of the dimensions evaluated in the model and by communication actions, which allowed the procedural review by the person or persons in charge of the educational institution and peers of the scientific community.

This work has as main inputs: i) the analysis of a still emerging theme and with great relevance in the pedagogical and organizational efficiency of the HEIs' fields, but which is still

largely unknown to teachers and leaders of these institutions; ii) proposal of a Learning Analytics system that answers to a concrete problem of HEIs, also contributing to the advancement of the field in which the development and practical application of these systems is still in its infancy (Ferguson, 2012); iii) the developed Learning Analytics crosses data from two sources (LCMS + students' opinions), increasing the value of information; iv) the methodological procedures used - that do not follow the traditional paradigms used in educational sciences, which continue to be studies of descriptive and explanatory type and, more recently, interpretive (Peffer et al., 2006; Sampiere et al., 2006) - proved to be very suitable, ensuring accuracy in the various dimensions of the development process of the Learning Analytics, and may constitute a methodological alternative for other investigations, when the goal of research is the development of a technological artifact that answers a practical problem.

The Learning Analytics system presented in this paper has two things that could possibly be improved in future work: the method of recording the access dimension and the integration of communication in the automated reports.

Funding: This study received no specific financial support.

Competing Interests: The authors declare that they have no competing interests.

Contributors/Acknowledgement: All authors contributed equally to the conception and design of the study. Foundation for Science and Technology, Portugal (PhD Scholarship SFRH/BD/75815/2011). Regional Secretariat for Education and Training of the Azores.

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