Repositório ISCTE-IUL

Learning scorecard: monitor and foster student learning through gamification

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Abstract. This paper presents the Learning Scorecard (LS), a platform that enables students to monitor their learning progress in a Higher Education course during the semester, generating the data that will also support the ongoing supervision of the class performance by the course coordinator. The LS uses gamification techniques to increase student engagement with the course. Business Intelligence best practices are also applied to provide an analytical environment for student and faculty to monitor course performance. This paper describes the initial design of the LS, based on a Balanced Scorecard approach, and the prototype version of the platform, currently in use by graduate and undergraduate students in the fall semester of 2016-2017.

Keywords: Balanced Scorecard. Business Intelligence. Student learning. Gamification.

1   Introduction

A recurrent problem in Higher Education is the lack of information about the progress of student learning in "real" time. Various statistics are calculated by Planning and Institutional Research offices offering a post analysis of academic success for each semester (e.g., evaluated, approved, and retention rates). Current pedagogic guidelines also encourage course coordinators to clearly define a set of tasks that students should perform autonomously additional to the course classes (e.g., exercises to be solved, basic and complementary bibliography that should be read). However, there is still little institutional support provided to students and faculty regarding the monitoring of the student learning experience and ongoing autonomous work completion throughout the semester. On the one hand, students do not know if they are correctly performing the proposed autonomous work, that is supposedly "a route to success in the course". On the other hand, a faculty has no information regarding the real commitment of students to the learning experience, apart from his/her experience-based perception of the class behavior.

The Learning Scorecard (LS) is a platform that enables students to monitor their learning progress in a course during the semester, generating the data that will also support the ongoing supervision of the class performance by the course coordinator.

The LS was initially developed by a group of students in the context of a course on Decision Support Systems (DSS) of the master program in Computer Science Engineering in the 2015-2016 spring semester, at ISCTE – University Institute of Lisbon, a public University in Lisbon, Portugal. The LS is a tool that helps students with the planning and monitoring of their learning experience in a course, using gamification and business intelligence techniques. Gamification was used to foster student interaction and positive competition. The LS has been initially designed to support the learning of the Data Warehouse course, which is a core subject of the Computer Science Engineering and Informatics and Management programs. This is a very demanding course in terms of study hours and practical assignments; hence, time management is critical for student success. Due to its characteristics, this course is a good case study to test the LS functionalities.

This paper describes the initial design of the LS, based on a Balanced Scorecard approach, and the prototype version of the platform, currently in use by students in the fall semester of 2016-2017. The LS is presently the research subject of two master dissertations in Computer Science Engineering, and new improved versions of the platform are scheduled to be released in the next two semesters.

2   Business intelligence in Higher Education

Business intelligence (BI) and analytics techniques are used for data-driven decision making. BI encompasses a "broad category of applications and technologies for gathering, storing, analyzing, sharing and providing access to data to help enterprise users make better business decisions," [1]. The ultimate goal of a BI is to measure (i.e., the data related component), in order to manage, in order to enable a continuous improvement of an organization or a specific process. Hence, BI is deeply linked with performance management, requiring a positive and pro-active type of management and leadership.

An analytical mindset includes the use of data, different types of analysis (e.g., methods, approaches), and a systematic reasoning to make decisions [2]. BI and analytics are widely used in the business context, as well as in Higher Education [3,4]. Learning analytics, is a relatively recent research area [5], focusing on the "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," [6].

The Balanced Scorecard (BSC) is a performance management system used to support strategic decisions. Originally developed by [7], the BSC has been successfully applied in many industries, including Higher Education (HE). Most BSC applications in HE are implemented at the institutional level, providing a performance management framework linked to the goals and strategic plans of the HE institutions. There are many examples in the literature reporting the institutional use of the BSC in academia, predominantly in the United States [8,9,10,11] and United Kingdom [12,13], but also in

many different countries [14,15,16]. The use of the BSC approach to strategically manage academic programs and to support the learning process is less common. Recently, [17] discusses the design of a BSC to support student success, in particular for accounting students, enabling student engagement with the educational process, as well as with the accounting profession. Other relevant examples are: [18] discussing the benefits and potential components of a BSC for an accounting program (US and Canada); [19] describing a case study, in which the BSC was applied to the Master of Business, Entrepreneurship and Technology at the University of Waterloo (Canada); and [20] describing the design of strategy maps for program performance measurement in HE. The Learning Scorecard, presented in this paper, designed according to the best practices of BI and BSC systems development, aims to measure and manage the performance and quality of the learning process. Since the LS goal is first and foremost to support students in their learning experience, it is also a valid application of learning analytics.

3   Gamification in Higher Education

Gamification is defined as the use of game design elements in non-game contexts [21]. Game elements are artifacts regularly used in game design, such as points, levels, quests or challenges, avatars, social graphs, leaderboard, badges, and rewards. Gamification, albeit being a recent trend, has been applied in several non-game contexts, such as productivity, finance, health, sustainability, and also in education [21,22]. When using gamification the designer should keep in mind the following aspects: (1) games are to experienced voluntarily; (2) games should involve learning or problem solving; and (3) games should have some structure (i.e., game rules) but the gamer should have the freedom to explore and have fun. Barata et al. [23] present an interesting approach to gamification in education, applied to a master course in the Information systems and Computer Engineering program. In their experiment, they added a set of game (e.g., points, levels, leaderboards, challenges and badges) to the traditional course, and compared the impact of the introduced gamification on student performance and satisfaction. After a period of two consecutive years, results were very positive, with increased student performance in terms of class attendance, number of lecture slides downloads, and number of post on the course's forums [23]. This experiment was inspirational to the design of the Learning Scorecard, given that the institutional context and student profile are similar. That is, both projects are realized in Public Universities in Lisbon, Portugal, with students enrolled in similar programs (i.e., Computer Science Engineering master programs; although the LS is also being tested by undergraduate students of Information and Management).

4   The Learning Scorecard

Effective time management is pivotal for student academic success. Higher education students need to conciliate their personal and often professional responsibilities with their academic ambitions. Poor planning of tasks, in terms of effort and scheduling,

often results in failing a course or achieving a lower grade than expected. In this context, the use of a strategic management tool – like the Learning Scorecard – customized by the course's faculty can provide a valuable support to students. The LS enables the formulation of strategic objectives, performance indicators and targets that support students with a baseline for the performance in the course that will yield a successful outcome. The LS also enables students to monitor their performance throughout the semester in comparison with the average performance of the entire class. This increases students' awareness of their leaning efforts, for instance, if they are falling behind the objectives defined by faculty or if they are in line with the average progression of the class. Additionally, students will be notified of incoming deadlines and their general course delay, in a proactive and motivating approach. Gamification techniques were used to design the LS, since the tool is used voluntarily by students. Gamification enables the motivation of students in terms of achieving the course goals, and provides a healthy competition environment towards the best course performance.

The LS is also a valuable tool for faculty, providing an aggregated view of students' performance and its evolution throughout the semester. The LS enables the course coordinator to identify the pain points of the course experienced by students. Namely, what are the tasks that generally demand an extra effort from students (comparing to the faculty planning) and how many students are at risk of failing the course. The analysis of student performance data can be used by the course coordinator to improve the course syllabus, with the goal of improving the teaching quality and the student learning experience.

The specification of LS included the following functional requirements:

- users need to have a profile and authentication credentials
- the LS platform needs to be integrated with the e-learning system (having access to quiz results, forum participation, downloading of materials, etc.)
- two types of accounts or views: student and course coordinator
- dashboards for monitoring individual student performance (student view)
- dashboards for monitoring class performance (course coordinator)
- automatic course schedule with deadlines and studying guidelines, customized by the course coordinator
- the LS platform should include game elements (i.e., scores, ranks, quests, leaderboard)

The design of the Learning Scorecard platform also encompasses the following non-functional requirements:

- portability across web browsers (Firefox, Google Chrome, Safari, Edge) including mobile devices
- intuitive and user-friendly interface (input data from students should be kept to a minimum)
- student identification data must be private (ethical requirements), i.e., the course coordinator will only have access to aggregated class data, even for the case of at-risk students.

The former non-functional requirement can be sensed as a miss-opportunity, since course coordinators would want to know, individually, which students are at-risk. However, the LS was mainly designed for students to support their learning experience in the course. By introducing privacy in student identity, students are more likely to voluntarily use the Learning Scorecard and experience the benefits of this platform, without fearing any potential consequences of faculty scrutiny.

4.1   Strategic design of the Learning Scorecard

The Learning Scorecard was designed according to the BSC methodology proposed by [24]. For the purpose of this paper, we will focus on the design decisions of a few selected steps. In the design of an organizational BSC this step usually entails the clarification of the strategy to be executed, including a strategic analysis of the organization, and the definition of mission and vision statements, as well as the organization's values. Since the LS is a thematic scorecard, the strategic analysis of the 'organization' will not be presented. The mission of the Learning Scorecard is to *"to provide Higher Education students with an analytical environment enabling the monitoring of their performance in a course, contributing to an enhanced student learning experience."* Three values encompass the design and implementation of the LS: Pursue Growth and Learning; Enjoying Participation; and Self-discipline (Make it happen). The vision statement was defined as follows: *"by the end of the academic year of 2017-2018, the Learning Scorecard application should be used by at least 50% of the enrolled students in the DSS courses at ISCTE-IUL."* The vision statement complies with the guidelines proposed by [25], in which three elements must be clearly defined: a niche (*enrolled students in the DSS courses at ISCTE-IUL*), a stretch goal (*used by at least 50% of enrolled students*) and a time frame (*by the end of academic year of 2017-2018*).
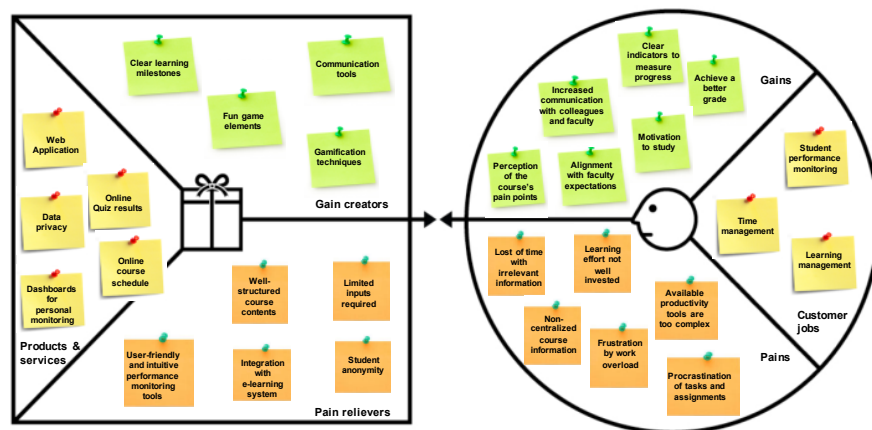

Fig. 1. Student value proposition canvas

The Business Model Canvas (BMC) is a strategic tool used to describe, in an intuitive and accessible language, the business model of an organization [26], i.e., how an organization intends to create, deliver and capture value. Nine building blocks constitute the BMC: customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure. For the purpose of the BSC design, two building blocks are of importance – customer segments and the value proposition. In order to effectively design a value proposition, matching the needs and expectations of the customer segments, [27] proposed a new canvas – the Value Proposition Canvas (VPC). In the LS we have to address the needs and expectations of both students and the course coordinator, hence we need to define two customer segments. Figures 1 and 2 present the the LS value proposition canvas for students and course coordinator, respectively. Customer segments are represented on the right-end side and the value position on the left-hand side of these figures.
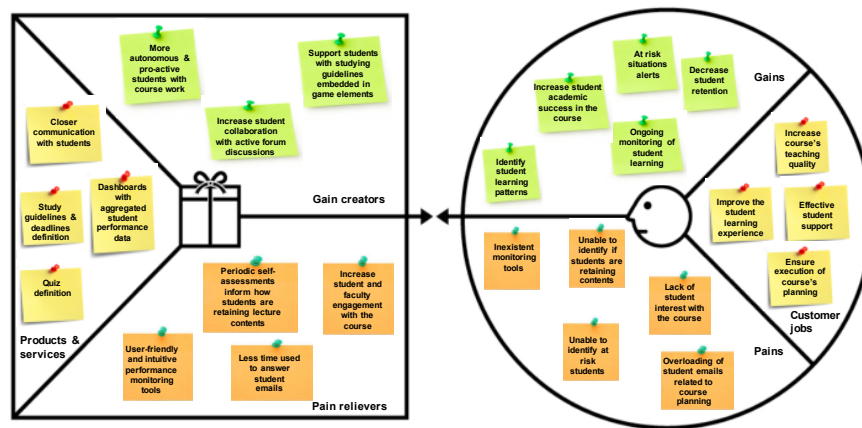

Fig. 2. Course coordinator value proposition canvas

In the VPC model, customer segments are defined in terms of customer jobs, pains and gains. The student VPC (see Figure 1) will be used as an example to explain the model. A customer job is related to what the customer is trying to get done; it can be a task, a problem or even a basic need (e.g., time management). The pains are the negative aspects encountered by the customer in his/her current way of dealing with the 'jobs'; including negative emotions or hurdles, undesired costs and risks (e.g., lost of time with irrelevant information). The gains reflect the benefits a customer expects or desires to achieve with the product or service; it can be translated into, for instance, a functional utility, positive emotions or cost savings (e.g., perception of the course's pain points). The value proposition block in the VPC is described in terms of three components: (1) products and services (a list of products and services offered and their link to the customers' jobs); (2) pain relievers (to eliminate or reduce the customers' pains); and (3) gain creators (describing the positive outcomes and benefits that products and services

deliver to customers). An example of these components are, respectively, (1) online course schedule, (2) well-structured course contents, and (3) clear learning milestones.

The observation and design of the customer segment profile comes first. Then follows the design of the value proposition, addressing the most relevant and critical jobs, pains and gains of the target customers. In this way, the design process of the product/service is enclosed by the real needs of customers and there is a concrete mapping with expected benefits. This process is also useful to determine the differentiator factors of the product/service, which will be useful for the definition of performance indicators in the BSC.
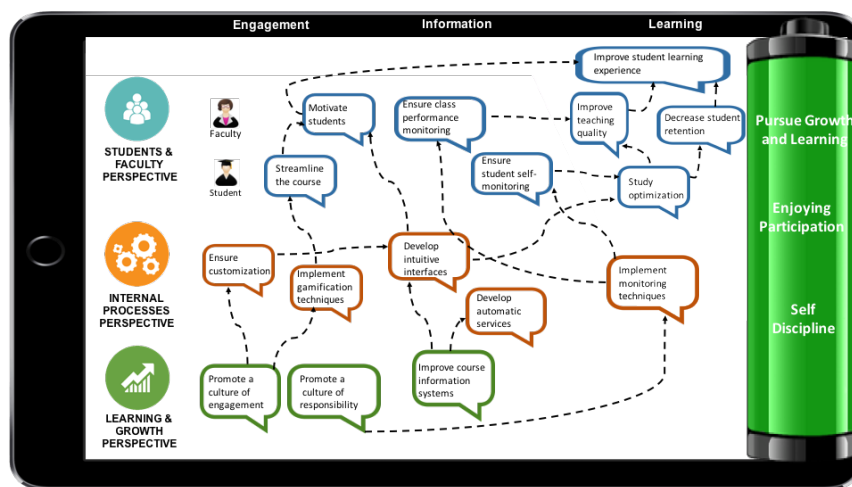

Fig. 3. The Learning Scorecard strategy map

The strategy map is a design tool [8] that helps to tell the story of the strategy, highlighting in a creative way the dependencies, called cause-and-effect relationships, between the strategic objectives. The map, displayed in Figure 3, has three perspectives: Students and Faculty (S & F), Internal Processes (IP), and Learning and Growth (L & G). The financial perspective, the fourth standard perspective in a Balanced Scorecard is not relevant for the Learning Scorecard, which is focused solely on the student learning experience. Three strategic themes were also defined to frame the definition of strategic objectives: Engagement, Information and Learning. These themes are the main drivers to achieve the vision. That is, if we aim to have the LS platform being used by at least 50% of all enrolled students, then it is key to foster student engagement, provide updated information of performance monitoring, and help students to optimize their learning experience in the course.

The strategy map should be read bottom-up, following the cause-and-effect relationships between objectives. As can be seen in Figure 3, the final strategic objective (the ultimate effect) is to improve the student learning experience, which is the central goal of the Learning Scorecard. Values are included in the strategy map, at the right end side

of the "mobile phone", a metaphor for the portability of the LS platform, since the development of a mobile application is contemplated in the near future.

A crucial part of the balanced scorecard is the definition of performance indicators to measure the achievement of the intended strategic objectives. In this project, a subset of these performance indicators will also be used to populate the student and course coordinator dashboards provided by the LS platform. The key performance indicators (KPI) of the LS, presented in Table 1, are either measured biweekly or at the end of the academic semester. As already mentioned, this paper describes the initial version of the LS platform. More functionalities are being developed in the LS platform, integrated in two Computer Science Engineering Master dissertations, which will be completed until September 2017. It is therefore foreseeable that new indicators may be able to be calculated, depending on new source data.

Table 1. Learning Scorecard KPIs

Persp.	Strategic Objective	KPI	Frequency
S & F	Streamline the course	Average forum activity	fortnight
S & F	Motivate students	Average number of points	fortnight
S & F	Ensure class performance monitoring	Number of visualizations of class dashboards in the LS faculty view	fortnight
S & F	Ensure student self-monitoring	Number of visualizations of student dashboards in the LS student view	fortnight
S & F	Study optimization	% completed quests within course milestones	fortnight
S & F	Improve teaching quality	Average final grade	semester
S & F	Decrease student retention	Course retention rate	semester
S & F	Improve student learning experience	Student satisfaction index	semester
IP	Ensure customization	% of used LS input options	semester
IP	Implement gamification techniques	Number of LS game elements	semester
IP	Develop intuitive interfaces	Student usability assessment index	semester
IP	Develop automatic services	% quests without manual user input	semester
IP	Implement monitoring techniques	Number of LS data visualizations	semester
L & G	Promote a culture of engagement	% LS active students	fortnight
L & G	Promote a culture of responsibility	Average quest delay	fortnight
L & G	Improve course information systems	Number of new implemented LS functionalities	semester

5   LS prototype

The LS platform was developed using Node.js. The front-end was developed using HTML and CSS. Javascript, specifically Express.js, was used for the back-end implementation. Several modules were used: Bootstrap, for platform design, Chart.js, for the implementation of the charts in the LS dashboards, Passport and Crypto, for secure authentication of students in the LS. The LS pilot also includes a MySQL database that stores data from the e-learning system and custom data provided by the course coordinator (input format .csv).

110 students are currently testing the pilot implementation of the Learning Scorecard in the Data Warehouse course; in the 2016-2017 fall semester this course is offered to four different programs. In the LS, students are divided into classes according to their program. Students begin with zero points, and are thus encouraged to learn to earn points, and increase their game level. A summary of the leaderboard is always visible (at the left down corner of Figure 4), presenting not only the top-5 gamers (ordered by points) but also the ranking of classes in terms of the percentage of active students using the LS. In the ranking, each class is identified by the respective program acronym (in Portuguese): MEI, IGE, IGE-PL, and METI. Figure 4 presents the initial page of the LS for a student (i.e., a "gamer"). In this page the student can visualize his/her performance (in points) and receive alerts about incoming quests deadlines. Since the first LS experiment in ongoing, Figures 4-9 display real data as of November 18, 2016 (week 9 of the semester, which comprises 12 weeks), kindly sent by students to the course coordinator for the purpose of this paper. Figure 5 displays the detail of the leaderboard, with the identification of top gamers.
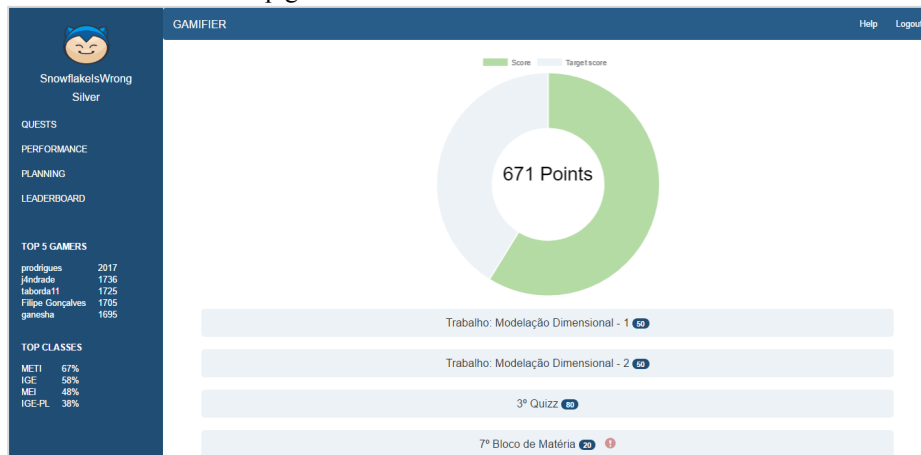

Fig. 4. LS student view: quests and points

The planning functionality is developed based on the course syllabus (currently still in Portuguese). Each semester, the course coordinator needs to customize the set of quests as well as course's milestones, and their respective deadlines or due dates. For instance, the following five milestones were defined for the Data Warehouse course in

2016-2017 fall semester: (1) group and practical assignment theme selection; (2) first group tutorial meeting; (3) second group tutorial meeting; (4) practical assignment submission; and (5) practical assignment discussion. Figure 6 presents the planning page in the LS platform for the Data Warehouse course, describing in detail the quests for weeks 9 and 10. By clicking on each quest in this list, the student can visualize a pop-up interface with a detailed description of the quest, aligned with the information of the syllabus, and the number of points that can be awarded. Quests can be mandatory or optional. It is also possible to customize how many points students loose if they fail to comply with the quest deadline. For mandatory quests, the deadline must be met, otherwise no points are awarded. Quests are related to reading of lectures' slides, solving exercises, completing the milestones of the practical assignment, class attendance, solving quizzes, participating in the course's forum, etc.
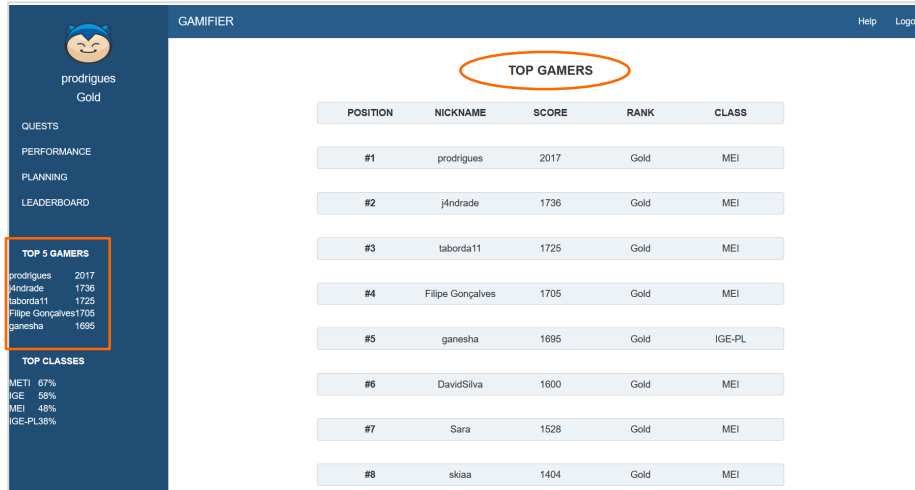

**Fig. 5.** LS student view: Leaderboard

Fig. 6. LS student view: planning functionality (in Portuguese)

Fig. 7. LS student view: performance visualization (progress analysis)

The performance functionality in the student view includes three standard visualizations: progress analysis, percentage chart and radar chart, represented in Figures 7 to 9, respectively. These figures display data for the top gamer at the time (*prodrigues*) and his performance until week 9 of the semester.
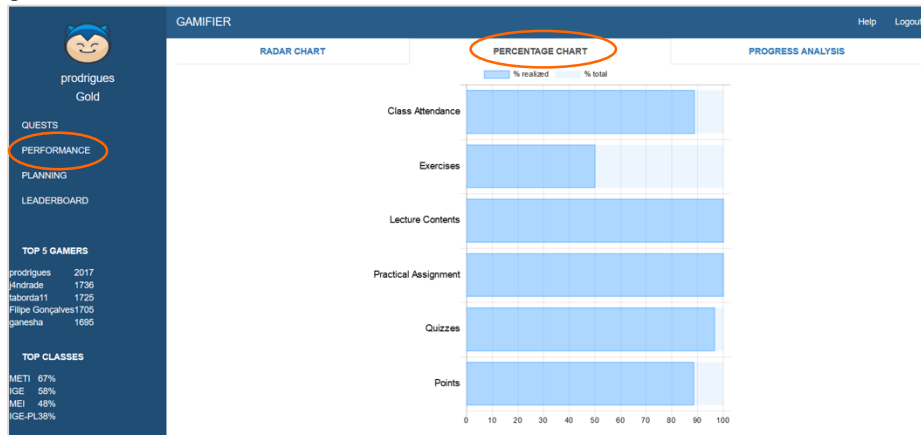
Fig. 8. LS student view: percentage chart

The progress analysis view (Figure 7) is composed by a set of charts reporting on points earned with quizzes, class attendance, practical assignment and lecture readings, as well as forum participation. As the semester unfolds, these charts are automatically adjusted to report on the performance of each week. As can be observed in Figure 7, in the chart that summarizes the total points by week, there is no performance reported on the first four weeks of the semester, which was due to a hacking problem. The Learning Scorecard database was compromised during the cyber attack, leading to a complete

loss of activities. Students were asked to redo all the quests until the day of the attack and the security of the platform was reinforced. Another relevant aspect is the lack of forum activity. This is one topic that requires further development, especially on how to motivate and trigger students' discussions on the course's forum. The percentage chart (Figure 8) provides a visualization of the student's current achievements versus the total amount of points that he/she could have earned so far in the different types of quests. Finally, the radar chart (Figure 9) compares the student's individual performance versus the average performance in his/her class.
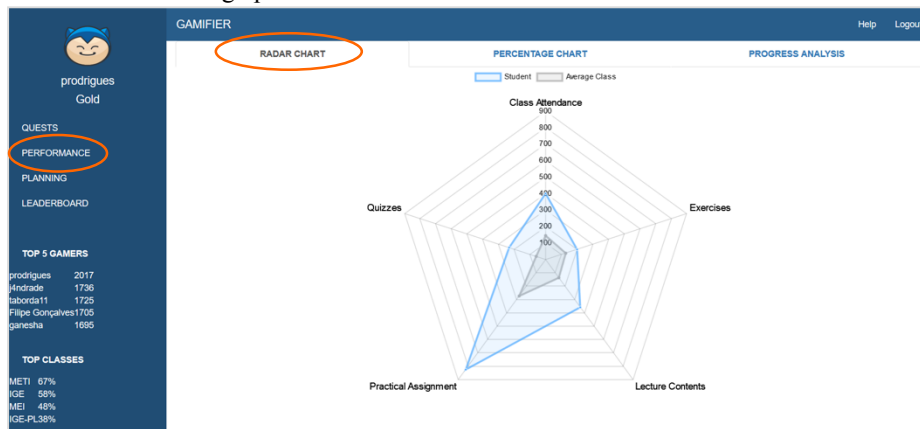

Fig. 9. LS student view: radar chart

6   Conclusions and future work

The use of gamification in Higher Education is a recent technique, in which game elements are applied to non-game contexts. In this paper, the design and prototype implementation of the Learning Scorecard was described. Apart from the integration of game elements, such as points, levels, quests and leaderboard, the LS was also designed using the best practices of business intelligence. A set of functional and non-functional requirements were initially defined, which led to the definition of the strategic management tool – the Balanced Scorecard. A strategy map was designed detailing the relationships between the critical components of the LS strategy, i.e., the strategic objectives. The full implementation of the BSC, with dashboards to visualize the KPIs that measure the achievement of strategic objectives, will be part of the next version of the LS platform, which will have the course coordinator's view fully developed. New versions of the platform are planned for the next two academic semesters, since the LS is the subject of two master dissertations in Computer Science Engineering that are due September 2017.

Currently, the LS platform is being used by 110 students in a pilot study focused on the usage of the LS student view in one course. The platform is already integrated with the e-learning platform Blackboard used at the university. The selected course – dedicated to the development of Data Warehouse systems – is a very demanding course in

terms of study hours and the complexity of the practical assignment. Initial data reports on a percentage of active students in each class using the LS platform in a range between 38% and 67%. A deeper analysis of the two largest classes in terms of number of students (accounting for approximately 85% of the total number of enrolled students) reveals that: (1) one class (IGE), from the Information and Management bachelor program, has more active students (58%), but a lower point average; (2) another class (MEI), from the Computer Science Engineering master program, has comparatively a lower number of active students (48%), but with a higher number of points (in average). Therefore, we can conclude from the initial data that MEI students have so far a greater commitment to the usage of the LS platform.

Future work entails the identification of study patterns linked to student success, using data mining techniques. The integration with Blackboard will also be further explored, particularly in terms of collaborative learning aspects already present in the tool, such as the use of the forum. The gamification part will also be extensively developed, specifically in terms of visual effects. The LS aims to be a fun tool, that really makes a difference in the way students learn and collaborate with each other. It is also planned the design and implementation of student satisfaction questionnaires, to assess student engagement, motivation, and satisfaction with the course and the LS platform. Student motivation is vital for the success of this platform. Further research also entails the design of motivation and reward mechanisms integrated with game dynamics to increase the number of active students as well as the number of completed quests and points earned.

Previous presentations

This work has been presented at the 2nd Workshop on Educational Knowledge Management [28] and has won the best paper award. This workshop was co-located with the 20th International Conference on Knowledge Engineering and Knowledge Management (EKAW 2016), in Bologna, Italy, November 19-23, 2016.

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