PROMOTING STUDENTS SUCCESS WITH A BUSINESS INTELLIGENCE SYSTEM

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Abstract: The promotion of the students' success is usually associated to the closely monitoring of the students' activities. This requires the implementation of mechanisms that, in the scope of the teaching/learning process, allow the students' academic activities monitoring, the students' academic success/failure evaluation and the teacher/tutor approximation to the students' day-by-day academic activities. Although important, the activities involved in these processes do not take place in many higher education institutions, due to the lack of an appropriate support. To sustain these complex processes and activities, a conceptual framework and a technological infrastructure was proposed and integrated in a *Student Relationship Management* (*SRM*) *System*. The *SRM System* supports the *SRM concept* and *practice* and it has been implemented using concepts and technologies associated with the *Business Intelligence* systems. To validate the *SRM System*, several application cases were implemented in real contexts. They demonstrated the system relevance in the process of acquisition of knowledge about the students and their academic behaviours. The system supports the decision making process in the teaching/learning scope and facilitates the automatic interaction with the students. The impact of the several undertaken actions are presented and analysed in this paper.

1 INTRODUCTION

In the generality of the Portuguese Higher Education Institutions there still exists a high rate of failure and abandon, mainly in the first year of the graduation courses. Some statistical result can be seen in the official *web* page http://www.gpeari.mctes.pt. Several actions have been undertaken by the institutions to identify and to analyse the reasons of failure, and to propose actions to invert this trend (Nóvoa, Curado and Machado, 2005, 2006). One of the actions largely accepted as a way to promote the students' success is by implementing mechanisms that allow the students closely monitoring, the evaluation of their success/failure and the day-by-day academic activities approximation by the teacher/tutor (Pile and Gonçalves, 2007) (Pereira, Motta and Vaz, 2006). However, the implementation of all these tasks does not take place in many institutions. Among the reasons, we point out the huge number of students with failure in the first graduation year, the huge number of new students in some courses and the work overload of the teaching staff, once they are involved in lecturing, researching and management tasks. It is required the definition of institutional practices and an adequate technological support to these practices. To overcome these conceptual and technological limitations, in this work it is developed a conceptual framework which includes a concept, a practice and the technological infrastructure that supports the concept and the practice. The conceptual framework and the technological infrastructure are in this work integrated in a *Student Relationship Management* (SRM) *System*. To validate the *SRM concept* and *practice* it was adopted a methodology based on the *Grounded Theory* principles. To validate the *SRM system* it was adopted a methodology which includes

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the prototype implementation and the development of a set of application cases in real contexts. The concretization of the application cases demonstrates the SRM system relevance and usability in the students' knowledge acquisition process, in the early identification of failure situations, in the decision-making support in the scope of teaching/learning processes and in the automatic interaction with the students. The results of the implemented actions and their impact are also presented and analysed in this paper.

This paper is organized as follows: Section 1 summarizes the motivation for the *SRM system* proposal; Section 2 includes an overview of the *SRM* principles and presents the *SRM concept* and *practice* (as it was understood in this work) and the adopted methodology to their validation; Section 3 describes the *SRM system* architecture and gives some details about the *SRM system* implementation. It also describes the methodology adopted for the *SRM system* validation; Section 4 describes the application cases, analysing the impact, on the students' behaviour, of the several actions that were carried out under the principles of the *SRM practice*; Section 5 concludes mentioning the advantages of the *SRM system* and summarizing some upcoming tasks for future work.

2 CONCEPTUAL FRAMEWORK

The *SRM system* was inspired in principles associated to the *Customer Relationship Management* (*CRM*) systems. In short, a *CRM system* is used in a business environment to support and manage the relationship between the organization and their customers. These systems help to translate *customer information* into *customer knowledge*. This *customer knowledge* is obtained using the information and business transactions available in the organizational databases. Supported in this *customer knowledge*, the organization defines strategies/activities/actions able to maintain a stronger relationship with clients. Values like reliance, fidelity, loyalty and durability are present in this relationship (Payne, 2006).

The *SRM* system is based on the principles described above, but supports mainly activities related with the students and associated with the *teaching-learning* processes. Underlying to the *SRM concept* is the scholar success promotion, as it is widely accepted that there exists a high correlation between the closely monitoring of the students and their academic success.

To exemplify the similarity between the *CRM/SRM* actions, it is possible to compare the actions developed by the customer's manager, that on the scope of the banking activity alerts the customer when he/she exceeds his/her credit account, and the actions developed by the student's tutor/teacher, that on the scope of the monitoring processes sends an alert message to the student when detects that he/she misses several lessons.

The "*Student Relationship Management or SRM or CRM in Higher Education*" terms were already used in technological/commercial environments to refer solutions mainly dedicated to support processes related with the students in academic areas (students' management information, courses and lessons management, admissions management, enrolment and registration management) and areas related with available services (communications, marketing, financial aids, accommodation) among others (Fayerman, 2002). Moreover, these solutions do not make possible trailing the academic path of the students in activities concerned with the *teaching-learning* processes.

In the scope of this work, it was proposed a concept, the *SRM concept*, focused on the students' academic success promotion. The *SRM concept* is understood as a process based on the students' acquired knowledge, whose main purpose is to keep an effective *student-institution* relationship through the closely monitoring of the students and their academic activities. This concept, as already stated, was based on the premise that there exists a strong correlation between the closely monitoring of the students' academic activities and their academic success promotion. The *SRM practice* is defined as a set of activities or actions that should guarantee the student individual contact, and an effective, adequate and closely monitoring of his/her academic performance. To validate the *SRM concept* and the set of activities included in the *SRM practice*, a research methodology based on the *Grounded Theory* principles was adopted. It included the concretization of a set of interviews (Hansen and Kautz, 2005). The selected interviewers were teachers with institutional responsibilities (courses directors, institution directors, council members). Each interview was recorded, transcribed and analysed. The interviews analysis process was done following the *Grounded Theory* principles and supported by the *NVivo* software (a *Computer Assisted Qualitative Data Analysis Software*) (Budding and Cools, 2007). Each interview was guided by a script, prepared beforehand, including also open questions (semi-structured interviews).

The interview questions included topics like: academic success/failure, activities to promote the success, *student-institution* relationship, practices to maintain an effective *student-institution* relationship, monitoring indicators, behaviour patterns, identification of activities that can be automatically supported, among others (Piedade and Santos, 2008).

3 SRM SYSTEM

The SRM system is the technological infrastructure that supports the *SRM concept* and the set of activities integrating the *SRM practice*. To undertake an S*RM practice* it is necessary: (i) to have adequate, consistent and complete information about the students. This information must be stored in an appropriate data repository, maintaining a single view of the students' data; (ii) the analysis of such data in order to obtain knowledge about the students and their academic behaviour; (iii) the trigger of automatic actions over the students whenever specific situations or behaviours are detected; and (iv) the assessment of the impact of the undertaken actions over the students.

The structural topics related with i) and ii) require the implementation of a *data warehouse* system and its exploration using data analysis tools. Based on this, the *SRM system* is implemented using the technological infrastructure that traditionally supports the *Business Intelligence systems*, once these systems combine data gathering, data storage and knowledge management with analytical tools to present integrated and useful information to support the decision making process (Negash and Gray, 2003).

With respect to the issues related with iii) and iv), the set of relevant indicators and the behaviour patterns that characterize the different situations to supervise were identified, as well as the actions to be automatically done by the different participants in the *SRM practice* (teacher, tutor, course director) were defined and implemented. After the implementation of a set of actions, their impact on the students' academic behaviour and their final assessment results were analysed.

3.1 Architecture

The *SRM system* architecture aggregates four main components: the *Data Acquisition and Storage* component, the *Data Analysis* component, the *Interaction* component, and the *Assessment* component (Figure 1). The *Data Acquisition and Storage* component is responsible for storing the students' data in a *data warehouse*. Data from different data sources were gathered and were submitted to the ETL process (*Extraction, Transformation and Loading*). The *Data Analysis* component, responsible for obtaining knowledge about the students, includes appropriate data analysis tools that allow the patterns identification. The obtained knowledge was stored in an adequate *knowledge database*. The *Interaction* component is responsible for maintaining an adequate and effective relationship with the student, using the obtained student's knowledge. A set of actions are automatically triggered (with the students as target) when it is verified a specific situation or behaviour. The *Assessment* component is responsible for the assessment of all the carried out actions and their impact, through the monitoring of the students' academic behaviour and, also, through the verification of different rates (assiduity, marks, and interactions with the e-learning platform).

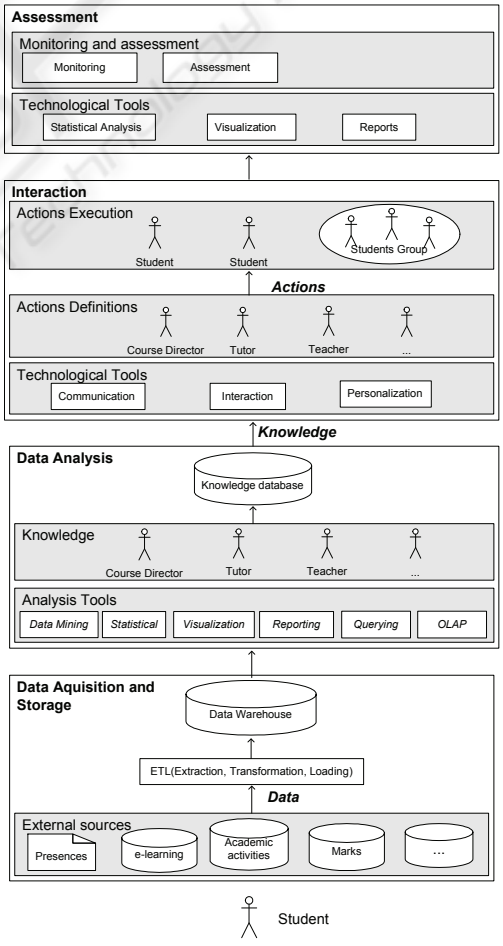

Figure 1: The SRM system's architecture.

3.2 Implementation

The *SRM system* prototype implementation has been done using database management tools, *Business Intelligence* tools and *web* development tools. Considering the context in which this work takes place, the selected development tools integrate the *Microsoft* environment: *SQL Server Business Intelligence Development Studio (MSqlServerBIDS)* and *Visual Studio .NET*. The first one includes a set of integrated components, *Database Engine*, *Integration Services*, *Analysis Services*, *Reporting Services* and *Notification Services* for developing and managing *Business Intelligence* solutions (Mundy, Thornthwaite and Kimball, 2006), and the second one includes a set of development tools for building ASP.NET *web* applications.

3.3 Validation

To validate the *SRM system*, a prototype was implemented. This prototype shows the relevance of the *SRM concept* and supports the *SRM practice*. After the prototype implementation, demonstration cases were carried out in real higher education contexts.

4 APPLICATION CASE

An application case implementation includes the following tasks: (i) scenario identification; (ii) data acquisition and storage; (iii) data analysis; (iv) interpretation of the obtained results; (v) actions definition; (vi) execution of the automatic actions over the students; and (vii) impact assessment of the carried out actions.

4.1 Application Case Description

As already mentioned, application cases were undertaken in real contexts of Portuguese Higher Education institutions. Due to the huge complexity and diversity of processes related with the students and having in attention that the "*students' academic success promotion*" is the main issue underlying this project, this complexity and diversity was limited to the *teaching-learning* process. In this application case, it was selected a graduate course and one of its curricular units/signatures. The relevant data were identified and collected. These data include information about the unit, the adopted *teaching-learning* process, the adopted assessment method, the developed activities, the students and their interaction in the developed activities and in the *teaching-learning* process. Afterwards, the *data warehouse* model was designed, implemented and loaded. The model follows a *constellation* schema. Figure 2 represents the *data warehouse* model for this application case.

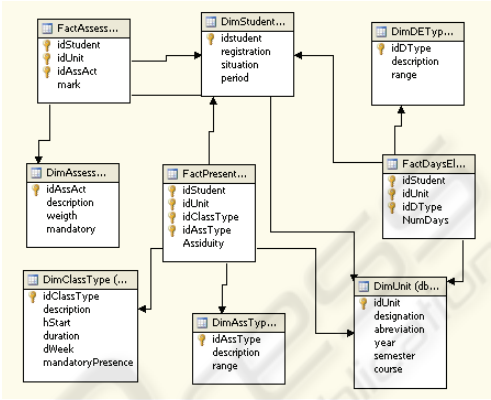

Figure 2: *Data warehouse* model example.

The facts and dimension tables implementation was supported by the *Database Engine* component. The loading process followed the *ETL* process steps, in which the relevant data were extracted from the source databases, were cleaned (when errors in data were detected) and were transformed in order to accomplish the *data warehouse* format. The loading process was supported by the *Integration Services* component. The *data warehouse* exploration was been done using *OLAP* and *data mining* techniques. This data analysis process was supported by the *Analysis Services* component.

OLAP techniques allow the analysis of the data under different perspectives, using the multidimensional structure of the *data warehouse* model. Several cubes were created to analyse the correlation between the different facts (for instance, classes presences, *e-learning* platform accesses, and results assessment) and also the influence of the different attributes related with the student (for instance, full-time/worker-student, registration year, admission phase, assiduity type). Figure 3 shows an example of a cube extract. More details about this cube can be found in (Piedade and Santos, 2009a).

Data mining techniques allow identifying models that exhibit patterns and trends in data. In this particular case, the *data mining* main purpose was to identify the students' profile in order to decrease the failure rate and the failure risk in future unit editions. A *classification* task was implemented to find a model that describes the predictable attribute as a function of the input attributes. The

				Description		
				low		
Dim Student	Phase	Situation	Description	Assiduity	Num Days	Mark
36	rep	full-time	Final	0	19	12
			Project	0	19	8
58	rep	full-time	Final	0	13	-1
			Project	0	13	-3
62	rep	full-time	Final	0	18	10
			Project	0	18	9
64	rep	full-time	Final	0	0	-1
			Project	0	0	-3
68	1phase	full-time	Final	0	1	-1
			Project	0	1	-3
7	rep	worker	Final	8.33	21	-1
			Project	8.33	21	-3
47	rep	full-time	Final	8.33	0	-2
			Project	8.33	0	-3
48	rep	full-time	Final	8.33	37	15
			Project	8.33	37	14
12	2phase	full-time	Final	16.67	8	-1
			Project	16.67	8	-1
15	rep	full-time	Final	16.67	52	-2
			Project	16.67	52	8
29	rep	full-time	Final	16.67	11	-1
			Project	16.67	11	-1
30	rep	full-time	Final	16.67	38	12
			Project	16.67	38	12
33	rep	full-time	Final	16.67	23	11
			Project	16.67	23	8
40	rep	full-time	Final	16.67	10	-2
			Project	16.67	10	-3
13	rep	full-time	Final	25	16	-1

Figure 3: OLAP cube extract example.

classification task was carried out using a *decision tree* algorithm.

One of the obtained models describes the *mark* attribute as a function of the input attributes: phase of admission to higher education (*phase*), students' origin local (*origin),* theoretical classes assiduity rate *(theoretical)* and unit interaction through the e-learning platform *(NumDays)*. Analysing the obtained model, the students' profile, considering the *mark* results - *Fail*, *Satisfactory*, *Good* and *Very Good*, was identified.

This process of obtaining students *knowledge* follows the traditional steps of the knowledge discovery in databases process: *data selection*, *data treatmen*t, *data pre-processing*, *data mining* and *results interpretation* (Fayyad and Uthurusamy, 1996).

Figure 4 shows the obtained model in a tree form. Each tree node has a set of conditions that lead to a specific decision. More details about this model can be found in (Piedade and Santos, 2009b).

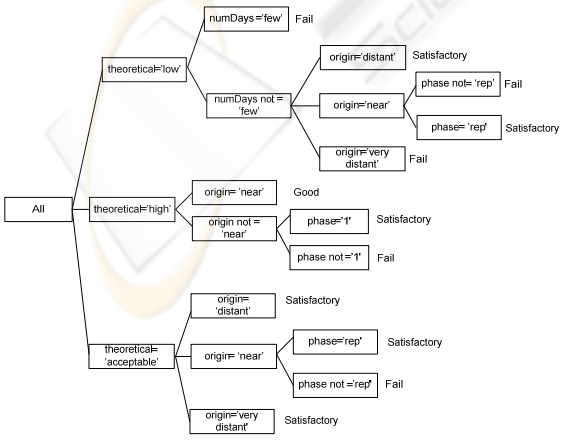

Figure 4: *Data mining* model.

OLAP and data mining analyses allow us to verify that to decrease the failure profile it is necessary to take special attention to the new students differentiating them through the admission phase and, also, by looking at origin local, since several students are away from their familiar environment.

The students that are at the first time in the unit must be encouraged to go in a regular basis to the different types of classes. These students are, in many cases, influenced by older students that say to them to avoid classes, mainly the theoretical classes.

For the second phase students, an additional support must be given to them as they arrive to the University when half semester has already passed. Due to this situation, these students lose the initial curricular contents explanation and the subsequent curricular content comprehension, fact that could help to explain their failure rate. For these cases, the institution could adopt specific activities or procedures, as extra classes or tutorial orientation, providing them additional support. It is also necessary, for all the students, to verify the evolution of the project implementation, motivating the students and providing them additional support when necessary. This support can be achieved using tutorial classes. This was not the case of the current edition of the unit. In what concerns repeating students, it is also necessary to motivate them to go to the classes, although in many situations these students have timetable incompatibilities. To overcome this limitation, the institution could adopt a differentiation in the schedule, like classes in the morning for the first year students and in the afternoon for the second year students. In complement, it is also necessary to motivate the use of the e-learning platform increasing the interaction of the student with the unit. These different situations need to be evaluated without neglecting the students that present a "success profile". Regarding the students that are away from home, the course director/coordinator must take a special attention to these students, verifying if they have some integration difficulties and providing them additional support, if necessary.

The analysis of the obtained profile allows the identification of the characteristics of the students that *fail* the unit and also the ones that are *approved* (positive marks) in the unit with *satisfactory* and with *good* marks.

One of the actions identified to fight against the *fail* behaviour is the presence of the students in classes, as the students must go in a regular basis to the different type of presential classes (theoretical, practical and tutorial classes). This confirms that the

presences monitoring is one of the activities that must be included in the *SRM practice*. Due to its importance, this activity was already implemented and is now supported by a *web application*.

The *web application* integrates several functionalities related with the management of several entities: the graduate courses, the curricular units, the groups, the classes, the teachers, tutors, or course directors, and the students. Figure 5 shows a page view related with the classes presences. All the information that could be used to identify a student was omitted.

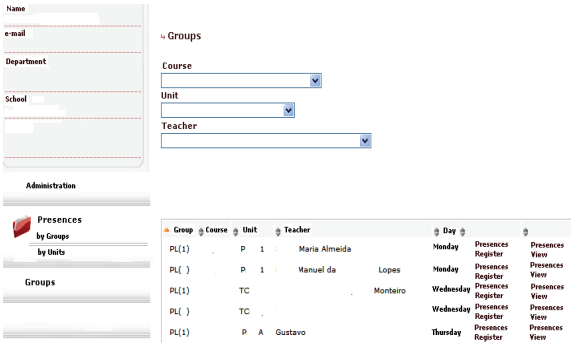

Figure 5: Classes page view.

As already mentioned, this application registers the presence/absence of students in classes. An automatic alert message is sent by email to the students when they match certain behaviour (in this case, a deviating behaviour related with class presences).

The main purpose of this action is to alert the students to the importance of their presence in classes and to the need of a daily study.

An automatic email is also sent in a weekly basis to the course director/coordinator and to the teacher responsible by the unit, integrating a report with the students' presences. Through this process, the course director/coordinator, and also the teacher, know how the semester is going. In case of abnormal situations, they can take the necessary actions to motivate the students to be present in the classes. This procedure also allows the detection of any problem related with the students and that can affect their behaviour.

Figure 6 shows a view of the presences report. Neither the student nor the institution is identified in this example.

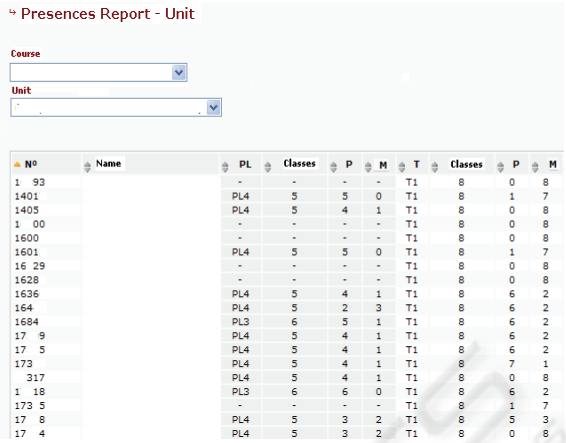

Figure 6: Presences report view.

The *web application* is now functioning by the first time. A trial version was used on the second semester of the 2008/2009 curricular year, during the last five weeks. After this experience, it is possible to confirm that the automatic *e-mailing* of the alert messages has a positive effect on the students' behaviour, once their reaction is in general to make a replay with a personal justification and, also in general, they attend to the next classes.

The impact of these actions, in the students' results (marks), could not be assessed with precision due to fact that the *web application* operation was available only during five weeks.

It is only possible to confirm that more students were evaluated in the final exams, comparatively with the previous curricular year. However, this behaviour could not be associated, as a whole, to the impact of the *web application* operation.

In this current curricular year (2009/2010), the *web application* is already in operation (since the beginning of the classes). It is expected, at the end of the semester, the assessment of the results of the undertaken actions.

Next steps in this project include: (i) the implementation of other activities that integrate the SRM practice and that enable the closely monitoring of the students; (ii) the SRM practice assessment, verifying its impact on the students' behaviour and on their final results.

5 CONCLUSIONS AND FUTURE WORK

With the implementation of the *Bologna Process*, the number of contact hours between the teachers and the students decreased. This requires, among

other things, greater student autonomy. In this scenario, it is essential to design and to implement mechanisms that facilitate the monitoring and the supervising of the students' academic activities and that facilitate the interaction with the students. In this context, we believe that the *SRM concept* and *practice* implementation, supported by the *SRM system*, create an advantage towards the students success promotion, and, therefore, in the institution success, ensuring an effective *student-institution* relationship.

The development of this project has occurred in different stages. In the first stage, it was defined the *SRM concept* and *practice* and, also, their validation was carried out. It was also verified the lack of an adequate technological support to the *SRM concept* and *practice* (such as defined and understood on the scope of this work). The second stage included the structural framework definition and the *SRM system* architecture proposal. The third stage includes the SRM prototype implementation and validation. The future work includes concluding the prototype implementation and its validation.

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