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MONITORING STUDENT PERFORMANCE. A DATA DRIVEN DECISION SUPPORT SYSTEM APPROACH

Case Study

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Decision Support System
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Higher Education

JEL Classification
I21, C89

Abstract

Data Driven Decision Support Systems are mature technologies whose effectiveness in business and management seem to be well established and uncontroversial. Under the circumstances of increased competition between universities in their attempt to better position themselves on the market of educational services, a Data Driven Decision Support System could become a powerful instrument meant to enhance all the decisions that target various aspects of the educational process. This paper is a case study conducted in a Romanian university, presenting the development of such a system, emphasizing the analytical capabilities related to student results at exams, as this topic is of interest for the users of the system.

1. Introduction

Decision support systems (DSS) are computer-based information systems that serve the operations and management by presenting business data so that users can make business decisions more easily. According to Power (2002), "DSS are designed specifically to facilitate decision processes, should support rather than automate decision making and should be able to respond quickly to the changing needs of decision makers". Unlike Transaction Processing Systems (TPS) which are primarily designed to automate transaction processing and reporting, the purpose of a DSS consist in assisting decision making and decision implementation. The use of DSS brings benefits to an organization consisting in: time saving, enhance effectiveness, improved interpersonal communication, competitive advantage, cost reduction, increased decision maker satisfaction, increased organizational control and incentive to learn. The time savings advantages have been documented to be significant although there have not always been demonstrated that the decision quality was improved. Assessing the effectiveness of a DSS is a tough issue, the items taken into account varying based on the domain. Some of the items used to evaluate it are: user satisfaction, avoiding decision errors, decision quality, and decision satisfaction and decision time. Although difficult to measure, there are studies supporting the idea of DSS effectiveness. A paper targeting the investment decision (Bhandari, Hassanein, & Deaves, 2008) demonstrates the effectiveness of DSSs in debasing behaviourally-challenged investors especially in decision environments where the bias level is likely to be higher. In relation to competitive advantages, vendors frequently claim this advantage for the system they propose. In a study based on interviews with executives and directors at 25 globally competitive organizations Davenport (2005) proves that analytic technologies can provide organizations a measurable competitive edge in the global economy. The competitive advantage is not always a likely outcome. According to Power (2005) the effectiveness of a DSS depend on three conditions: 1) after the implementation the DSS become a significant capability of the organization, 2) the DSS must be unique and proprietary to the organization and 3) the he advantage provided by the DSS must be sustainable for a longer period of time (few years) to insure an adequate return on the investment. In relation to cost reduction advantage, although this is not a goal of a DSS, there are studies documented savings from labour in decision making. Power (2000) states that a DSS has the potential to "create a major cost advantage by increasing efficiency or eliminating value chain activities".

There are several types of DSS classified based on their focus (data, model, communication etc.) and their scope (one user and standalone analysis or groups of users). One of the taxonomy of DSS include: a) communication-driven DSS b) data-driven DSS, c) document-driven DSS, d) knowledge-driven DSS and e) model-driven DSS (Power, 2009).

Data driven decision support systems are that type of decision support systems that emphasize the access and analysis of large volumes of data coming both from inside and outside of an organization. The success of a data driven decision support system depends on the way it can assure rapid access to large volume of accurate, well organised multidimensional data. Today, a so called data warehouse gathering data from operational system of the organizations and sometimes from external sources, serving as a central repository for data with the declare purpose of offering "a single version of the truth" (Inmon, Strauss, & Neushloss, 2008) and OLAP tools which enable users to easily and selectively extract and browse data from different points of view are the state of the art solution for the analysis of large volume of historical data (Giovinazzo, 2000). Using a data driven decision support system "managers can more easily access a single version of the truth, perform their own analyses, have access to reliable, consistent and high-quality information, make better informed decisions, and have more timely information" (Power, 2009).

The benefits of decision support systems in business environment seem to be well established and uncontroversial. On the other hand universities have begun to accumulate large amount of student level data they could use to make better decision in order to better position themselves on the market of educational services.

A data driven decision support system for higher education could bring universities the following benefits (Lachlan , 2013): a better understanding of recruitment trends and a better analysis of the degree of success for its programs for attracting students; clarifying student enrolment trends to different programs and assess the effectiveness of the courses offered; synchronizing marketing strategies with student feedback and taking advantages from demographic, psychographic and geographic trends within student population; better tracking of the financial transactions between students and university for a more efficient management of funds from tuition fees; aligning student courses to labour market requirements in order to increase successful job placement upon graduation and providing the university decision makers the possibility to easily analyse operational data, from across faculties and functional areas. These benefits could be of great importance for universities in the context of higher education

recent trends. These trends relate to increased competition between universities in their attempt to attract more students and the adoption of market type mechanisms to better position themselves on the market of educational services (Petruzzellis, D'Uggento, & Romanazzi, 2006). Under these circumstances the development of new instruments meant to enhance the quality of teaching and research activities is required as decision makers in higher education need effective decision support tools to accurately inform them, and assist in all managerial processes (Bresfelean & Ghisoiu, 2009).

Our paper is a case study related to the development of data driven decision support system built to aid decision making in higher education system. The study focuses on one subject of the DSS, the one that targets the student achievement as this seems to be one of the preferred subject of the users of such a system. On the other hand monitoring student performance provide information about level of knowledge transferred from teacher to student, encourage future learning and examines how well teachers carried out their tasks (Klein, 2014).

2. The research methodology

The present paper relies on a case study developed at a higher education institution from Romania (Bucharest University of Economic Studies). Currently the university uses an integrated university management system that focuses mainly on the operational activities and to some extent offers analytical capabilities. This system served as primary source of data for the Data Driven DSS.

According to Power the design and development of a Data-Driven DSS includes five steps: 1) Initial Data Gathering or Diagnosis; 2) Designing and Mapping the Data Store; 3) Loading and testing Data; 4) Building and Testing the Data-Driven DSS and 5) Rollout and Feedback. The first step of the development, *Initial Data Gathering or Diagnosis*, involves mainly the defining of main subjects of the DSS, user interface requirements and outputs. The achievement of these goals is usually done through interviews with key future DSS users. The step *Designing and Mapping the Data Store* consists in designing the conceptual model of the central repository of data (data store, data warehouse) using concepts of the dimensional modelling: facts, dimensions, attributes. Loading and testing data include processes that target the population of the data warehouse with data extracted from operational systems. Data undergo an Extraction-Transformation-Load process (ETL) through which data is identified in the operational systems, transform according to the requirements of analysis and finally load into the data warehouse. During the next step *Building and Testing the Data-Driven DSS* the user interface is created (menus, output formats and predefined reports are created) and test to optimize speed and accuracy are performed. This step requires an active involvement of the decision makers in building attesting the newly created system. The final phase of the Data-Driven DSS development targets the *DSS deploying, training of the users, maintaining and improving DSS following users' feedback.*

In our study initial data gathering and diagnosis was perform through interviews with members of the teaching and management staff of the Bucharest University of Economic Studies (teachers, department chairs, dean, vice deans, vice-presidents). One of the objectives of the interviews was to assess the need for a DSS and to identify the features of a Data-Driven DSS that are most important for a future user of such a system. Using a five point Likert scale the interviewees were asked to assess the importance they give to each of the following features of a Data driven DSS: 1) Ad Hoc Data Filtering and Retrieval, 2) Alerts and Triggers, 3) Create Data Displays, 4) Data Management, 5) Data Summarization, 6) Excel Integration, 7) Metadata Creation and Retrieval, 8) Report Design, Generation, and Storage, 9) Statistical analysis, 10) View predefined data displays. Another objective of the study consists in defining the main subject of the DSS. Starting from a predefined list of decisional situations, using the results of the discussions had during interviews, we tried to refine the initial list and to add other subjects that present interest from the perspective of the future users. The initial list consisted of following items: 1) Student Recruitment/Enrolment; 2) Interruption of studies; 3) Financing and budgeting of educational programs; 4) Expelling students; 5) Tutorial activities; 6) Curriculum and teaching resources; 7) Exams Student Results; 8) Exams results review or appeal; 9) Bachelor final exam results; 10) Career development opportunities; 11) Course schedule; 12) Students' transfer; 13) Extension of studies; 14) Research grants; 15) Scholarships; 16) Evaluation of teaching staff and 17) Scientific production evaluation.

For the second step Designing and Mapping the Data Store on the basis of requirements identified in the previous phase the conceptual model of the data warehouse was designed. The third step „Loading and testing Data" consisted in defining the procedures used to perform the initial load of data warehouse and to update it at regular intervals. The source of data loaded into the data warehouse was the integrated university management system. In the next step the user interface was created and the entire system was tested.

3. Results and discussion

One of the first objectives of our study consisted in defining the main subjects of a DDS built for higher education. The results of the interviews conducted with members of the university staff revealed that although the operational system currently used in the institution offer to some extent analytical capabilities there is a lack of tools specially oriented towards analysis. From the list of subjects initially proposed to the potential future users the most appreciated were the following: Exams Student Results, Bachelor final exam results, Exams results review or appeal, Research grants and Curriculum and teaching resources. Also appreciated but not to the same extent were the following subjects: Scholarships, Interruption of studies, Students' expelling, Students' transfer and Extension of studies. During interviews other decisional situations are found interesting by the interviewees from the perspective of their inclusion in the DSS: Student attendance, Staff continuous training, Courses held by foreign teachers and Courses held by business experts. The distribution of decisional situations (DSS subjects) over different type of users is presented in Figure 1.

Another objective of the interviews consisted in assessing the importance given to each of the feature of Data Driven DSS by the user of the system. The interviewees found all the features interesting but most appreciated features were: 1) Excel integrations; 2) Ad Hoc Data Filtering and Retrieval; 3) Data Summarization and 4) Alerts and Triggers and Statistical analysis.

For the second step Designing and Mapping the Data Store on the basis of requirements identified in the previous phase the conceptual model of the data warehouse was designed. The conceptual model of the data warehouse is based on star schema. In a star schema data is organised in facts and dimensions. A fact table is the primary table in a dimensional model where the numerical performance measurements of the business are stored (Kimball & Ross, 2002). The other tables in the schema are dimension tables. Dimension tables contain the textual descriptors of the business and they have many columns or attributes. Dimension tables attributes are the sources of constraints and labels used in various reports, they support the main types operations performed when browsing the data stored in the data warehouse (slicing, dicing, roll-up and drill down) being used to implement the user interface to the data warehouse. Given the fact that in the previous step, the most appreciated subject from the perspective of user was Exams Student Results we choose the star schema that support the analysis of student results to be presented in this paper. The fact table of this schema (ExamResultsFact) contains the main fact taken into account in the analysis of student results: the grades they obtained at exams. The dimensions of the schema consist of four tables that store the items used to analyse the student results from different perspectives: students (StudentDim), disciplines (DisciplineDim), time (DateDim) and instructors (InstructorDIm). The date dimension table is contained in every data warehouse as it needs to support the analysis of historical data. The other dimension tables depend on the subject of the data warehouse (Figure 2). A date dimension table built for monitoring student performance is somehow special because of the specific of student evaluation. These evaluations do not occur every day but in several sessions during a year. This is why the date dimension contains attributes like School Year, Semester and Session along with the other common attributes of a date dimension table.

The next steps in the development of the DSS involved the creation of the procedures used to populate the data warehouse with data extracted from operational system and the development of user interface. The user interface is a web-based interface which has the advantage of scalability, accessibility and easiness to install and maintain. Figure 3 presents a part of this interface. Through this interface users can access complex displays, can choose between different predefined displays like bar and pie charts, and can use these displays to analyse historical data in a time sequence.

In the final step of the DSS development the system was deployed and users were trained. As the development of a data driven DSS uses a spiral approach that implies the continuous development of the system, all the steps involved by this process must be taken again, multiple times in order to enhance the system.

5. Conclusions

A case study was carried out in a higher education institution on the topic of Data Driven DSS. After presenting the characteristics of DSS and the potential benefits of using such systems in higher education institution the paper presents steps performed in the development of the system. During the first step of the development process the main subjects of the DSS are identified. A list of subjects (decisional situations) which actually defines the requirements of a data driven decision support system for higher education is obtained. A star schema for one of the subject identified in the previous step, the Exams Student Results, is developed. The star schema for this subject is the foundation of the analytical capabilities of the DSS related to monitoring student achievement and performance.

The limits of study reside in limited context of the research which was conducted in only one university but we believe that the results of the study can be extended to decision support systems built for many Romanian universities. Future

research will target the development and refinement of the DSS.

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Figures

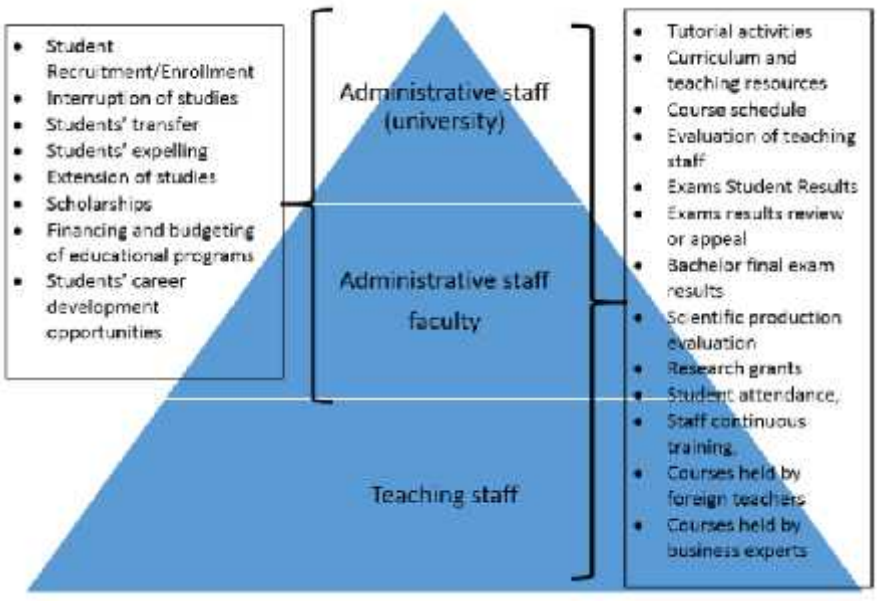

Figure 1 DSS subjects distribution over type of users. Source: (Gorgan, 2015)

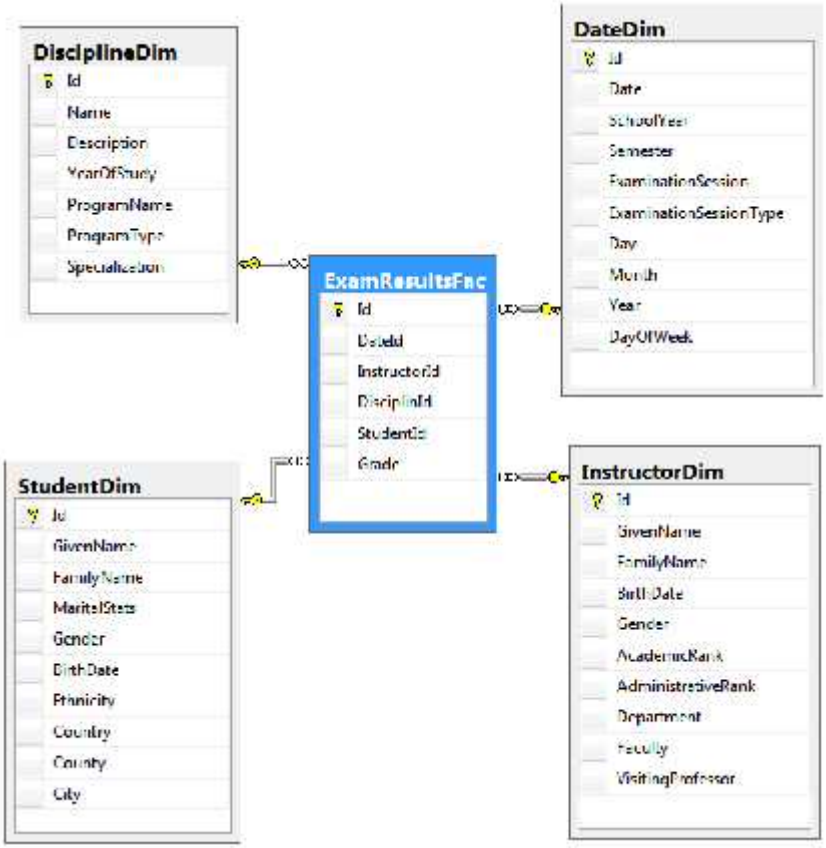

Figure 2 Star schema for student exam results analysis

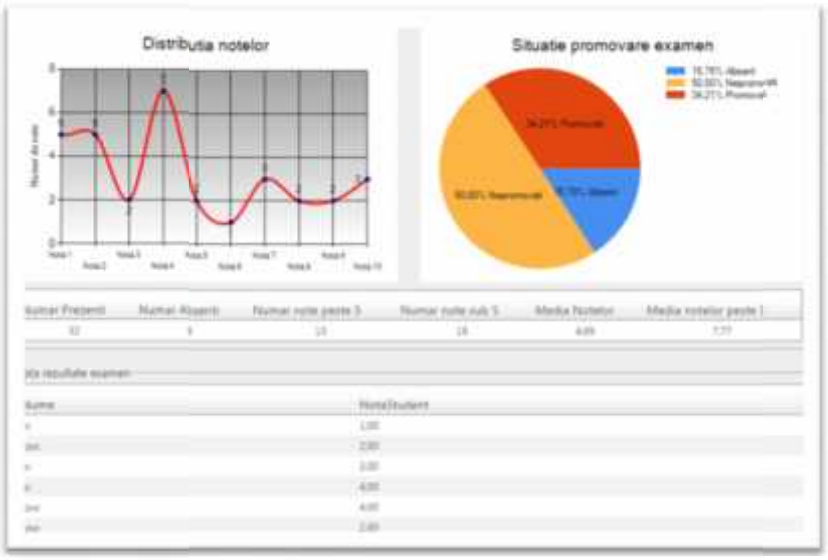

Figure 3 User interface used to analyse the student exam results