Towards the Development of Decision Support in Academic Environments

Vasile Paul Bresfelean, Nicolae Ghisoiu, Ramona Lacurezeanu, Dan-Andrei Sitar-Taut
Babes-Bolyai University, Faculty of Economics and Business Administration, Cluj-Napoca, Romania
paul.bresfelean@econ.ubbcluj.ro, nicolae.ghisoiu@econ.ubbcluj.ro, ramona.lacurezeanu@econ.ubbcluj.ro, dan.sitar@econ.ubbcluj.ro

Abstract. Due to increased competition in higher education environments, the universities adopted modern Information and Communication Technologies (ICT) with the aim of completing quality educational processes. They plan to use more efficiently the collected data, develop tools so that to collect and direct management information, in order to support managerial decision making. The collected data could be utilized to evaluate quality, perform analyses and diagnoses, evaluate dependability to the standards and practices of curricula and syllabi, and suggest alternatives in decision processes.

Data mining (DM) and Decision Support Systems (DSS) are well suited technologies to provide decision support in the higher education environments, by generating and presenting relevant information and knowledge towards quality improvement of education processes and management.

Keywords. Decisions, higher education, Decision Support Systems (DSS), data mining (DM), Information and Communication Technologies (ICT).

1. Introduction

Higher education institutions have increasingly approached education utilizing a service quality perspective, and the colleges and departments have become excellence providers of information and knowledge to their students via the classroom [14]. One of the guidelines is to support effective decisions regarding the selection, development, deployment, management, and utilization of information technologies in higher education.

Universities seek to apply more the accumulated data, invest more resources in tools that allow them to collect and direct information management, in order to support managerial decision making. When universities personify the excellence perspective, they set greater emphasis on meeting students’ needs and expectations, implementing change by enhancing quality of service provided to students, enrolment, tutorial allocations, course excellence, etc. [11]. The majority of the institutions counsel students with regard to careers, graduate school preparation, financial aid, and even personal issues. In addition, the position of the lecturer becomes particularly important: he/she is responsible for delivering the product and carries the burden of ensuring transactional success [14].

Modern ICT significantly facilitates access to data, information, and knowledge resources, but it also pressures to a possibly overload in the decisional processes. Decision makers in all areas of activity face progressively more demanding environments, overloaded with information, data distributed throughout the organization, under risky and uncertain conditions. This demands the development of efficient decision support tools to accurately inform them. The combination of the latest ICT technologies has led to sophisticated assistance – available in diverse fields from medical diagnosis to traffic control, to engineering applications – to support decision making [15] which has the potential to improve decisions by suggesting solutions that are better than those made by the human alone.

In the present article, the authors present several issues in higher education environments, emphasizing the role of DM and DSS for quality decision processes. It is also projected an architecture of a DSS in higher education suited for the profile of Faculty of Economics and Business Administration (FSEGA) at Babes-Bolyai University (UBB) of Cluj-Napoca.
2. Decisions and modern decision processes

Decision issues in the present world have become more sophisticated, time consuming and difficult for managers, leading to modern approaches to the decision-making processes. Such a process involves more factors and aspects that traditional decision making models, for instance [9]:
- Use of own and external knowledge,
- Involvement of various “actors,” aspects, etc.
- Individual habitual domains,
- Non-trivial rationality,
- Different paradigms, when appropriate.

The decision belongs to a person or group of persons who have authority and responsibility for the efficient use of resources [6] and is intended to be an essential element of managerial activity, as an expression of dynamic management, through which it can accomplish its functions.

The decision making processes rely primarily on the information perceived and how well it is understood. An effective manager [18] is one who perceives problems correctly and knows how to respond to a situation using analytic techniques, when required, and exercising judgment to find good solutions. Making the right decision, generating solutions and strategies in business and life are frequently based on the value of the data and on the ability to search through and analyze it to discover tendencies. It involves the implementation of efficient decision support tools to properly inform the decision process and also demands other desirable features, such as imagination and creativity. Computational creativity and modern ICT can provide valuable help for decision makers in this regard [5].

3. Decision Support Systems issues

DSS comprise various definitions, but it is largely considered that they are built to assist decision processes and help to identify and resolve problems. Academician Florin Filip [6] stated that DSS symbolized a specific class of information systems designed to help users which rely on knowledge, in a range of decision-making positions to solve the encountered problems that matter for the organization’s prosperity. In general, they provide support for decision makers by bringing together human judgment and computerized information in an attempt to improve the effectiveness of decision-making [21]. DSS can range from a system to answer simple queries that allow a subsequent decision to be made, to a system that provides detailed querying across a spectrum of related datasets, and further to complicated systems which directly ‘answer’ questions, in particular high-level ‘what-if’ scenario modeling [17].

The recent view on decision support and expert systems has shifted from considering these as solely analytical tools for assessing best decision options to seeing them as a more comprehensive environment for supporting efficient information processing based on a superior understanding of the problem context [7]. Such kinds of DSS integrate problem domain knowledge to develop their information processing and provision capabilities. They encompass systems where knowledge or answers are sought in systems with incomplete or very complex data. A DSS then provides decisions based on rules or algorithms derived from an understanding of the business or application domain [17].

There are several approaches to DSS systems, each of which support the process in a diverse ways. D.J. Power [16] offered an extended classification of DSS based on the dominant technology that determines the features of the decision-making: communications-driven DSS, data-driven DSS, document-driven DSS, knowledge-driven DSS, and model-driven DSS. Some DSS are hybrid systems driven by more than one major component.

Development of any DSS has a number of generic stages [17]:
- Data gathering and collation,
- Data storage, access and mining,
- Data analysis,
- Data reporting.

Every stage is essential to guarantee that the information provided is correct and that it answers the intended question of the user. Therefore, the data must be complete and comprehensive, stored in a scalable and searchable manner, semantic inference must be fully researched and defined, and the system presented to the user in such manner that the necessary questions can be asked of it and the correct answers displayed [17].

A DSS must be simple, robust, easy to control, adaptive, comprehensive on important issues, and easy to communicate with, and provides users with a flexible set of tools and capabilities for analyzing important blocks of data [5]. DSS contain standard software packages to help make decisions developed for
some specific problems. It highlights change, flexibility and a rapid response and can evolve as the decision maker learns more about the problem. These packages are made available for public use because [20]: many people make these decisions, so the potential market is large; and the decisions factors and objectives are the same for all of them, allowing the use of standard algorithms or chart representation. The following packages of software are usually available in a DSS [20]:

1. Database management packages;
2. Query and information retrieval packages;
3. Statistical data analysis packages;
4. Forecasting packages;
5. Graphing packages.

4. Data mining contribution to decision processes

The increasing implementation of ITC in all aspects of life has led to the storage of massive amounts of data. The use of database systems in supporting applications that utilize query based report creation continues to be the major fixed use of this technology. However, the size and volume of data being managed raised new and interesting questions [1]:
- Can we utilize methods on data which can help businesses achieve competitive advantage?
- Can the data be used to model underlying business processes?
- Can we gain insights from the data to help improve decision processes?

Large scale data mining applications involving complex decision-making can access the enormous quantity of data. More than just complex queries, DM provides the means to discover information in raw data. In many areas, it has become a business imperative. The information discovered through DM is valuable not only to gain a competitive advantage, but to assist in the decision-making processes. DM has becoming increasingly widespread in the private and public sectors, while industries such as retailing, banking, insurance, medicine et cetera frequently use it to reduce costs, develop research, and boost sales [19]. In the public sector, data mining applications originally were used as means to identify fraud and waste, and have also developed to be applied for measuring and improving program performance. As a result, DM has attracted considerable attention during the past decade and has found its way into applications that incorporated both data mining and decision support technologies.

DM is well suited to provide decision support in the education environments, presenting relevant information and knowledge to sustain evaluation and choices for performance. Higher education institutions are confronted with increasing pressures to improve the quality of education processes and management. In view of the fact that universities courses gradually require students to utilize online tools in their studies, there are many prospects to mine the resulting large quantity of student learning data for helpful information.

The complementary use of DM technologies on the data provided by current universities ICT resources, can lead to new and further extraction of information and knowledge, not typically provided by universities’ systems. Here are some of the improved outcomes and analyses achievable for our university through implementing several DM processes and techniques (classification and association learning, data clustering, etc.):

- prediction of students’ scholastic abandonment;
- evaluation of transfers;
- results of special training;
- students with multiple specializations;
- students who choose subjects with major credit resulting in a faster graduation process;
- orientation and professional development after graduation - observing the correlation between specialization and the chosen employment path;
- to which extent the specialization determines the employment path;
- determining the subjects, courses, labs with high degree of difficulty, which may cause: scholastic abandonment, transfer, study breaks / interruptions of studies, etc.;
- determining subjects (groups of subjects) that permit pursuing multiple specializations;
- other information (predictions and analysis) on courses studied, accumulated credits, financial aid;
- interesting subjects, courses, labs, facilities, etc. that might probably attract new students (Marketing researches);
- analysis and predictions on the quality of decision-making processes, etc.
5. Evolving to a DSS for higher education

A first step for the creation of a DSS in higher education would be to develop appropriate academic analytic tools to gather, synthesize, and evaluate relevant data and information for effective decision making. Such tools, for example an efficient management information system, would have the role to:

- Supervise existing educational activities, processes, and resources which entail students, teaching and auxiliary staff, curricula, syllabi, and all administrative services;
- Collect data on education and research processes;
- Develop a collaborative environment, monitor its activities and measure the accomplishment of its objectives;
- Present important information to assist constant evaluation, and alternatives for performance;
- Offer feedback for constant development.

The DSS for higher education management system would have to rely first on the existing data of the institution, UBB and FSEGA, on the databases of the following systems: the research activity management system; administrative activities system; management of school records application; Web based grade book available online; fee management application; online and distance education (ODL) portal. Other important data will be gathered from constant administered surveys and questionnaires which would also offer important measurements by quantifying the institutions’ quality indicators: assessments of academic quality periodically concluded, performance versus that of others faculties or across the university, learning centers, staff evaluation, surveys of graduates, master degree and PhD students, employers, departments, different longitudinal studies, etc.

The collected data will be utilized to evaluate quality, perform analyses and diagnoses, evaluate dependability to the standards and practices of curricula and syllabi, and suggest alternatives for decisions. In solving the education/training issues in a higher education environment there are several activities that should be taken into consideration for decision processes, as presented in Figure 1:

G (Generating resourceful Curricula) – has the purpose to elaborate the Curricula (the set of courses, and their content) according to the existing resources:

- teaching staff,
- auxiliary staff.
- material facilities (IT hardware, software, classrooms, books, lessons, campus, on-line tools, library, etc.)

It is put in practice by the heads of each department and approved by the institutions’ managers.

I (Implementing the Syllabi) – includes the elaboration and implementation of the Syllabi for each course (by the teaching staff).

AM (Analyzing and Monitoring) – refers to the real-time and periodical analyses of the existing educational activities and resources: staff, material facilities, etc. (by the heads of the departments and faculty’s managers).

CC (Coordinating and Controlling) – includes the coordination and control of the whole education/training process (by the heads of the departments and faculty’s managers).

P (Performing the educational activities) – refers to the execution of the educational activities’ tasks and of the general education/training process based on the variables which describe the real status of the system (by the heads of the departments and teaching staff).

Some types of decision-making problems in the educational system are:

1. Planning decisions for the programs of study and curricula, which lead to the establishment of curricula for long-term education. It consists of: curricula, syllabi, integration of theoretical education and practice, necessary investments, organizational structure (groups of students, their size, semi groups, etc.).

2. Tactical decisions:
   a. The curricula and syllabi detailed for each specialization and year of study;
   b. Defining the requirements for the accomplishments of the syllabi: specialized frameworks, necessary investment, software, etc.

The DSS architecture that we propose (Figure 2) is based on Marakas’ generalized architecture [12], and on [2], and is made of five parts:

a) the data management system,
b) the model management system,
c) the knowledge engine,
d) the user interface, and
e) the user(s).

The DSS is planned to support different decision matters of our university, to be applicable for its educational mission, training and academic services offered to the community and society.
6. Conclusions

In this article, the authors illustrated the activities reflected on decision processes for the elaboration of a DSS in higher education, emphasizing the role and importance of DM technologies for this matter. The final section comprises the proposed architecture of a DSS, a modern approach to the decision-making processes. This architecture is under further development and improvement and would be extended to other areas of a modern university: development, research, financial and administration issues, etc.

The cost establishing and management of the system design is a very complex problem whose resolution requires a thorough study of all phases of DSS design, for both software and hardware aspects. Therefore, such an approach would represent a future research theme to be completed with a separate practical concluding. In this context, we will take into account designing an application like "expert system for management costs" related to the DSS which will be included in the integrated system of the university. Today we can say with utmost conviction that the development and integration of a DSS with the university ICT systems will attain a reduced cost and time needed to resolve key issues of drafting and adopting the most appropriate decisions, for the typical complexities of higher educational systems.

Future research will also focus on the direction of detailing and developing the components of the educational DSS.

7. Acknowledgements

The research from the present article is a part of the Romanian CNCSIS IDEI 1598 grant.
“Invatamantul superior si piata muncii. Cercetari bazate pe tehnologii informatice privind corelatia dintre calificarile cerute de piata muncii si cunostintele reale ale studentilor” (Higher education and the labor market. IT-based researches on the correlation between the qualifications required by the labor market and real knowledge of the students).

8. References

[1] Apte C, Data Mining Analytics for Business Intelligence and Decision Support, OR/MS Today; February 2003.