Webology, Volume 17, Number 1, June, 2020

Information Visualization to Support the Decision-Making Process in the Context of Academic Management

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Received December 16, 2019; Accepted February 20, 2020

Abstract

Universities are dealing with a huge volume of data, but they use them less than expected levels. The aim of the current study was to use visual information for supporting the decision-making process. In this cross-sectional study, 30 academic managers were recruited at Tabriz University of Medical Sciences. A structured interview was prepared for collecting data based on the related literature. The instrument was approved in terms of validity and reliability (α=98%). SPSS 21 was used for analyzing data. Then, a list of 85 Key Performance Indicators (KPI) was organized for designing the digital dashboard. A three-layer architecture was selected as the architectural pattern, and the conceptual model of the system was developed by applying the UML. Finally,

the Qlikview was utilized to design the dashboard for the visualization of information. Twelve main features, including 85 KPIs, were determined for designing dashboards. User interface items were visualized using the most important features and KPIs. By applying a designed dashboard, academic managers can identify trends, strengths, and weaknesses. Moreover, visualized information can help users to gain insights and make decisions as quickly as possible.

Keywords

Information visualization; Decision making; Business intelligence; Academic education; Dashboard

Introduction

Decision making is important for every organization in all size and nature and can influence all components of the system (Ejimabo, 2015). Quality information is vital and necessary for effective decision making (De Alwis & Higgins, 2002; Ajibola & Ogungbemi, 2011). In the information-intensive situation, it is necessary for managers to know what information is important and how they can use them (Choo, 1996).

Universities as examples of information-intensive organizations are increasingly dependent on information management of educational data (Şuşnea, 2013), and are dealing with a huge volume of data, but they use them less than expected levels (Kabakchieva, 2015). In regards to access to valuable, correct, timely, and applicable information, universities are facing with challenges that describe the overall 'business picture' for efficient decision making (Obonyo, 2015) and their dealing with the increasing volume of data is another challenge (Zhang & Whinston, 1995). A good decision means the use of some software that supports the decision-making process, improves the performance of universities, and decreases the negative impact of defects (Turban, Cameron Fisher, & Altman, 1988). "Decision support systems are powerful tools that assist corporate executives, administrators, and other senior officials in making a decision regarding the problem" (Ada & Ghaffarzadeh, 2015).

Dashboards are special types of Decision Support Systems (Arnott & Pervan, 2005), the design of which plays an important role in decision making (Hansoti, 2010). Malik defines dashboard as "a rich user interface that displays the information in a graphical form using a variety of elements including charts, tables, and gauges" (Malik, 2005); it is also a visual and smart tool for monitoring KPIs that can capture key data from different systems and display them in a summarized form, which can be read and interpreted more easily for users (Karami, Safdari, & Rahimi, 2013). Data visualization is a graphically focused design that provides data in a way that can provide faster insight, understanding, pattern recognition, trends or anomalies (Dasgupta et al., 2015).

There is a few research conducted about decision support systems (DSS). For instance, Agbo (2013) noted that DSS should be introduced for administrators of Nigerian universities and the administrators were trained to make use of it because of its important roles for educational administration (Agbo & Ogai, 2013). Şuşnea (2013) presented an intelligent decision support system (IDSS) and a conceptual model for designing an army higher education IDSS. This model allowed users to access data from many sources and choose a different level of data aggregation (high-top management, low-students and teachers) (Şuşnea, 2013). Kabakchieva (2015) believes that the great potential of business intelligence (BI) tools is the analysis of available data and extraction of useful information for decision making (Kabakchieva, 2015). Duan and Zhang (2007) designed a web information system based on workflow analysis of academic degrees and graduate education systems. The system improved work efficiency and service quality. For successful development of a DDS system, all those who use the information must be members of the team designing the system (Group, 2003).

The medical education and healthcare system have been integrated in Iran. Therefore, the information requirements of managers are very important for designing a decision support system. The information requirements of academic managers were first identified in this study, and then a digital dashboard was designed and implemented for visualizing information.

Materials and Methods

In this cross-sectional study, the research community included the managers at Tabriz University of Medical Sciences. The used instrument was a structured interview prepared based on the literature related to management books and authoritative articles (Shafia, 2001; Şuşnea, 2013). A validation form was prepared to verify the validity of the questionnaires, in which three aspects of relevance, clarity, and simplicity were considered for each item. The validation forms were provided to 10 health information management specialists. The content validity index (CVI) and content reliability ratio (CRR) were measured for each item and those that received low scores were eliminated from the questionnaire. In order to determine reliability, the questionnaire was provided to 10 managers. Then the internal correlation among the questionnaire items was measured with a Cronbach's alpha of 0.98. This structured interview was conducted from January-April 2018 to extract information requirements of managers for decision making. Only 30 out of 50 questionnaires were answered by managers who had management experience at operational or senior levels.

The questionnaire contained essential features of a dashboard product and was classified into 12 main categories, including Assets (7 items), Costs (6 items), Income (4 items), Liability (6 items), Students (9 items), Professors (6 items), Meetings (8 items), Performance Appraisal (7 items), Marketing (8 items), Amenities (7 items), and Relationships with other universities and industry (8 items). The scales of importance ranged from 1 to 5, with 'very high importance'' to

‘no importance’ and ‘your suggestion’ labels, respectively. The questionnaire was completed during the structured interview. Data were analyzed using SPSS 21 statistical software package, and tabulated with the means of continuous variables. Mean scores of below and above 2 drops were measured in the desirable and undesirable ranges. A three-layer architecture including user interface (visualization) and business and database layers was followed for designing the dashboard. The Visual Paradigm software was applied to develop a conceptual model. The most important features and KPIs were used for the user interface. As our aim was to design a system for the school of management and medical informatics, the school manager was selected as a final user to determine a set of user interface requirements. Finally, the Qlikview was utilized to implement the dashboard for the visualization of information in the user interface.

Results

The average age of participants was 48 years in the range of 35-61 years. Among participants, 53.3 and 40 percent PhD and MSc holders, respectively, and 6.7 percent were medical specialists. Out of participants, 23.3 and 76.7 percent were senior and operational managers, respectively, with an average work experience of 6.37 years.

Table 1 indicates the average values of the most important elements for designing dashboards according to the opinion of the managers. In this table, the indicators marked with an asterisk were added to the list based on managers' suggestions.

Table 1. Key performance indicators (KPI) from the managers' point of view

	Key Performance Indicators	Mean	Key Performance Indicators	Mean	Key Performance Indicators	Mean
Assets	Construction	1.93	Stock inventory	1.43	Investment	1.43
	Main equipment and devices	1.93	Available cash	1.70		
	Vehicles	1.60	Accounts Receivable	1.50		
Costs	Salaries of employees and professors	1.40	Repairs and maintenance expense	1.67	Supplies	1.80
	Student loan	1.67	Health expenditure and development	1.93	Costs of research	1.57
	Costs of training program	1.90	Utilities (water, electricity, and gas)	1.77		
	Administrative charge	1.53	Other expenses (the cost of academic congresses and graduation ceremony)			1.50
Income	Tuition fee	1.33	Gifts and grants	1.53	Interest	1.37
	Government budget	1.37	Outsourcing to private sector	2.34	Workshops	1.50

Liability	Pay taxes	1.47	Bank loan	1.57	Deferred Debt	1.60
	Payment documents	1.67	Salaries payable	1.57		
Students	Number of new students per year	1.30	Number of student's project conducted per semester	1.53	Number of student workshops and JOURNAL clubs	1.50
	Number of students (bachelor, MSc, PhD/doctorate)	1.90	Number of articles published in reputable journals	1.57	Number of students participating in annual conferences	1.57
	Number of students being suspended or expelled per semester	1.90	Number of articles published in International Journals	1.67	Number of students participated in Olympiads	1.52
Professors	Number of professors separated with an academic degree	1.77	Number of books published by professors	1.53	Number of citations for papers of each professor	1.70
	Number of professors studied at overseas or Iranian universities	1.60	Number of articles published in international and national journals	1.60	Number of innovative and technological research projects	1.70
Meetings	People who should attend at meetings	1.80	Purposes of meetings	1.70	Subject of meetings	1.30
	Duration of meetings	1.50	Secretary of meetings	1.57	Session decisions	1.60
	*Follow up of meeting approvals	1.87	Minutes	1.53		
Performance Appraisal	Results of student evaluations	1.50	Staff Annual Evaluation	1.60	Number of creative and innovative students	1.62
	Results of professors evaluations	1.60	Numbers of talented students	1.52		
	Number of employees by degree	1.80	Number of staff with poor performance	2.30		
Marketing	Recognizing departments and related organizations to the field of study	1.40	Feedback from institutions where graduates are employed	1.27	Number of graduates who reached a higher level	1.70
	Number of unemployed university graduates	1.40	Introducing diverse ranges of job skills to graduate students	1.40	Number of recruited graduates	1.67
	Number of graduates per year	1.60	Recognizing expectations and priorities knowledge and skills required employer			1.63
Amenities	College Dining Hall	1.63	Publishing and Copy unit	1.70	Number of buffets	1.63
	Amphitheater	1.70	Dormitory	1.90	Gymnasium	1.93

Educational Resources	Total number of Latin and Persian books available in the library	1.67	Films and CDs available in the library for training	1.73	Internet access rates	1.40
	Number of RFID systems in the university library	1.63	Number of labs and classes equipped with modern and new appliances	1.63	Number of English Labs	1.53
	Total number of Latin and Persian journals available in the library	1.70				
Relationship with other universities and industry	Number of professors from other colleges per semester	1.73	Number of foreign students per semester	1.63	Number of training courses held for executive centers	1.63
	Number of professors attending other colleges each semester	1.57	Number of scientific joint projects with other universities	1.59		
	Number of guest students admitted per semester	1.53	Number of scientific joint projects with research institutes	1.40		

Figure 1 illustrates a three-layer architecture that includes the user interface layer, business layer, and database layer. A DBMS provides all the requirements necessary for working with data resources. For the data acquisition, the dashboard utilized a combined dataset from the SAMA (a training management system), SAFA (an electronic learning system), accounting system, LMS (an electronic learning management system), MIS, and Pazhoohan (a research information system). Some of the data were extracted from other databases and, in some cases, manual materials, converted to SQL server format, and then aggregated and visualized within the Qlikview (Figure 1). The business layer section presents the UML class diagrams.

Figure 1. The three-layer architecture of the proposed model

The class diagram of this system represents the concepts, their attributes, associations with other concepts, generalizations in which the concept is involved, and constraints (Figure 2).

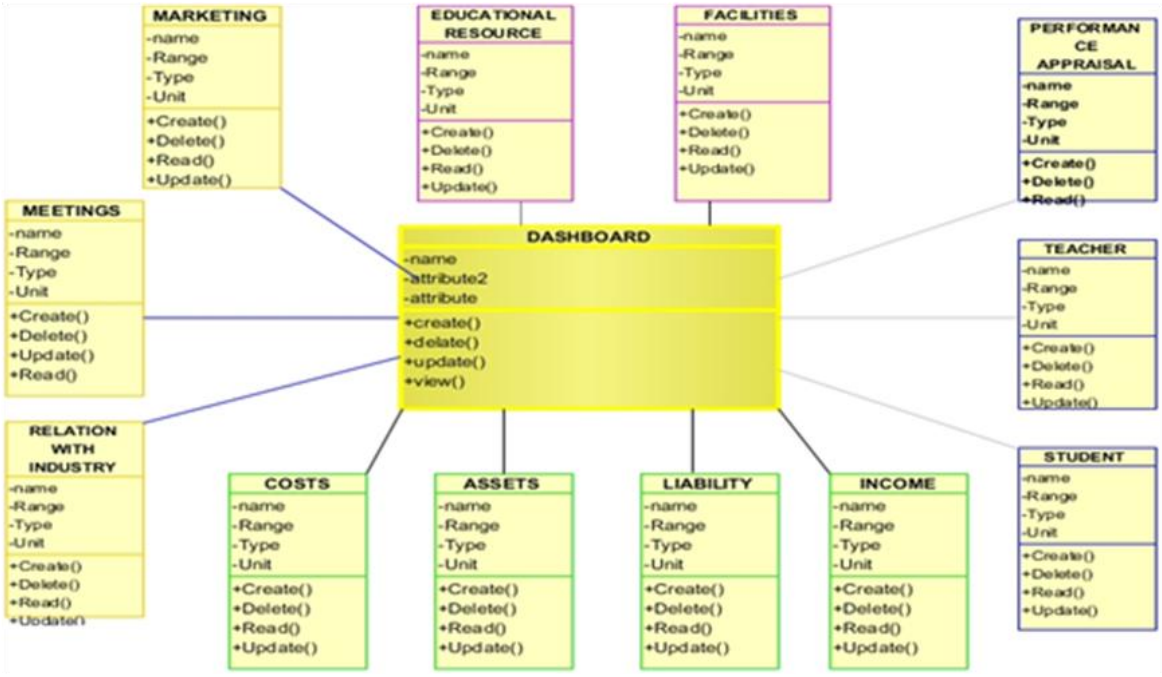

Figure 2. The UML class diagram of the Academic Monitoring Dashboard

Finally, the dashboard is shown in the user interface layer. The dashboard can display a number of KPIs, for example, new students per year and number of students (BSc, MSc, Ph.D./doctorate, etc.) (Figure 3).

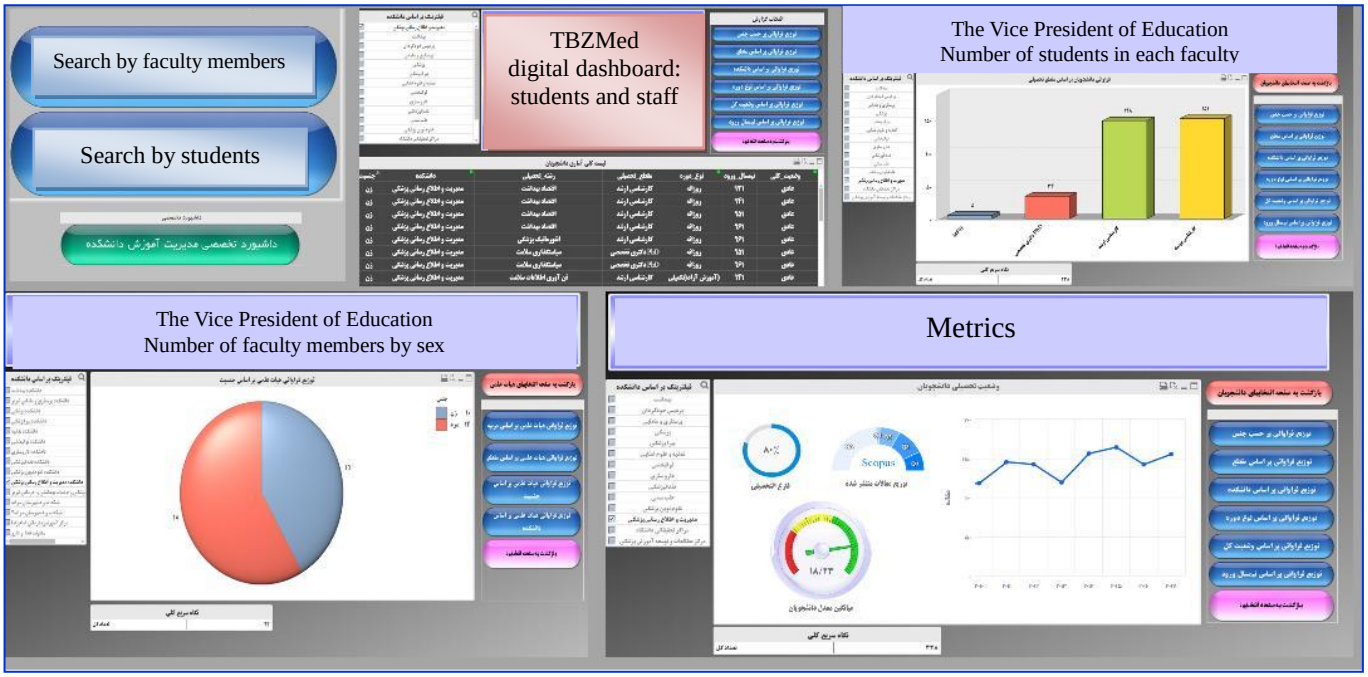

Figure 3. The Academic Monitoring Dashboard

Discussion

The main goal of an organization is to be cost-effective in its products and services using its resources including land, capital, people, technology, etc. In academic contexts, people consist of professors, students, and employees. One of the important issues with university students is employment after graduation. Marketing was one of the main features extracted from this study, which refers to the interaction and coordination between the university education and the market of the country to resolve the problem of employment, so that universities attract students in each field according to the market needs in the country. On the other hand, the market should also be taken into account, given the welcome to university students to expand the volume and variety of their job market that designed dashboard makes notification this issue.

Moreover, one of the most important tasks at universities is the relationship with other universities and the industry, which was emphasized in this study as one of the main features in decision making for university managers. It includes consultation, technical services, consultancy services, and research with external organizations (industrial centers, organizations, organizations, and institutions). In our study, 12 main KPIs, including 'Assets, Costs, Income, Liability, Students, Professors, Meetings, Performance Appraisal, Marketing, Amenities, and Relationships with other universities and the industry were used for the dashboard design. In a study, nine entities, including alumni, military students employers, teachers project (director/member), faculties, financial resources, educational resources, specific resources for military training, and e-learning, were introduced for designing an intelligent decision support system (IDSS) for an army university (Şuşnea, 2013). Therefore, these results are consistent with those of our study, but more detailed and wider entities were used here. In our study, 85 KPIs of 12 main features were used for the visualization dashboard. In another study, 92 KPIs, including seven main groups as "safety, service, internal and external customers, teaching and research, resource utilization, financial performance, and excellence in the workplace" were introduced for a medical imaging department (MID) (Karami, 2014), which disagrees with our results. This contradiction maybe because these KPIs were related to radiology that might help provide a framework for measuring efficiency in radiology function whereas our KPIs are useful for decision support in academic areas. In addition, the KPIs must be related to the objectives and strategies in an organization.

In this study, data warehouse of universities is fed from various transactional data sources such as SAMA (a training management system), SAFA (an electronic learning system), Accounting system, LMS (an electronic learning management system), and Pazhoohan (a research information system). In a study, data warehouse was fed from student information system, human resources, research, finance, academic information system (course management, library services, online education), and external sources (performance data of other institutions, workforce and employment data, national comparative data, etc.) (Muntean, Sabau, Bologa,

Surcel, & Florea, 2010). Therefore, universities can modify their data warehouse according to their particular needs.

Muntean et al. (2010) suggest a four-layer architecture including 1) data warehouse, 2) reporting layer, 3) analytical layer, and 4) monitoring layer, for DSS in a university. In another study, a DSS was used with three components of the DMS subsystem (Data Management Subsystem), the MMS subsystem (Models Management Subsystem), and the user interface (UI) (Şuşnea, 2013). In our study, a three-layer architecture, including user interface layer, business layer, and database layer were used for designing a DSS. This architecture is used based on the separation of different sections divided logically, which have specific tasks and are extensible and modifiable (Chen et al., 2003). As a university is a dynamic environment, it seems that the three-layer architecture can be a good option.

Conclusion

The dashboard of the School of Management and Medical Information was launched in this research. To use it, managers can enter with their usernames and passwords introduced previously into the relevant page. Then, they can observe different results and diagrams by selecting different filters. Making decisions is necessary at universities to follow their strategies and to achieve their goals. Using the designed dashboard, academic managers can identify trends, strengths, and weaknesses. Moreover, visualized information can help users to gain insights and make decisions as quickly as possible. Academic managers can not only enhance their performance, productivity and quality of services, but can also compare their performance in national and international level rankings. They can also follow organizing the marketing for attracting better students in both private and public sectors, admission of better MSc and Ph.D. students, and collaboration with other colleges.

Acknowledgments

This paper is the result of an approved research project carried out with the financial support of the Tabriz University of Medical Sciences, Tabriz, Iran [IR.TBZMED.REC.1396.1152]. We would like to thank the academic managers of the university the faculty members of School of Health Management and Information Sciences for supporting the researchers in carrying out this study.

References

Ada, Ş., & Ghaffarzadeh, M. (2015). *Decision Making based on management information system and decision support system* (Vol. 93).

Agbo, I. S., & Ogai, N. A. (2013). The need for introducing decision support system (DSS) in Nigerian universities management and administration. *Environment, 3*(10), 96-100.

Ajibola, M., & Ogungbemi, A. (2011). Importance of Accessibility to Reliable Data for Real Estate Practice. *Mediterranean Journal of Social Sciences, 2*(2), 223-231.

Arnott, D., & Pervan, G. (2005). A critical analysis of decision support systems research. *Journal of Information Technology, 20*(2), 67-87.

Chen, S. C., Gulatit, S., Hamid, S., Huang, X., Luo, L., Morisseau-Leroy, N., ... & Zhang, C. (2003). A three-tier system architecture design and development for hurricane occurrence simulation. In *International Conference on Information Technology: Research and Education, 2003. Proceedings. ITRE2003.* (pp. 113-117). IEEE.

Choo, C. W. (1996). The knowing organization: How organizations use information to construct meaning, create knowledge and make decisions. *International journal of information management, 16*(5), 329-340.

Dasgupta, A., Poco, J., Wei, Y., Cook, R., Bertini, E., & Silva, C. T. (2015). Bridging theory with practice: An exploratory study of visualization use and design for climate model comparison. *IEEE Transactions on Visualization and Computer Graphics, 21*(9), 996-1014.

de Alwis, S. M., & Higgins, S. E. (2001). Information as a tool for management decision making: A case study of Singapore. *Information Research*, 7(1), paper 114. Retrieved January 10, 2020, from http://InformationR.net/ir/7-1/paper114.html

Duan, R., & Zhang, M. (2007). Design of web-based management information system for academic degree & graduate education *Integration and Innovation Orient to E-Society Volume 2* (pp. 218-226): Springer.

Ejimabo, N. (2015). The influence of decision making in organizational leadership and management activities. *Journal of Entrepreneurship and Organization Management, 4*(138), 2.

Group, P. i. I. S. M. S. (2003). Cluster-randomized, controlled trial of computer-based decision support for selecting long-term anti-thrombotic therapy after acute ischaemic stroke. *QJM, 96*(2), 143-153. DOI: 10.1093/qjmed/hcg019

Hansoti, B. (2010). Business Intelligence Dashboard in Decision Making. College of Technology Directed Projects. Paper 15. Retrieved January 10, 2020, from http://docs.lib.purdue.edu/techdirproj/15

Kabakchieva, D. (2015). Business intelligence systems for analyzing university students data. *Cybernetics and Information Technologies, 15*(1), 104-115.

Karami, M. (2014). A design protocol to develop radiology dashboards. *Acta Informatica Medica, 22*(5), 341.

Karami, M., Safdari, R., & Rahimi, A. (2013). Effective radiology dashboards: Key research findings. *Radiol Manage, 35*(2), 42-45.

Malik, S. (2005). *Enterprise dashboards: design and best practices for IT*: John Wiley & Sons.

Muntean, M., Sabau, G., Bologa, A., Surcel, T., & Florea, A. (2010). Performance dashboards for universities. (2010, September). Performance dashboards for universities. In *Proceedings of the 2nd international conference on manufacturing engineering, quality and production systems* (pp. 206-211).

Obonyo, I. N. (2015). *An open source implementation of business intelligence systems: A case of the Technical University of Kenya*. Doctoral dissertation, College of Biological and Physical Sciences, University of Nairobi. Retrieved January 10, 2020, from http://hdl.handle.net/11295/90745

Shafia, M. A. (2001). *Indicators suitable for evaluating the quality of performance in Iranian higher education*. Tehran.

Şuşnea, E. (2013). Improving decision making process in universities: A conceptual model of intelligent decision support system. *Procedia-Social and Behavioral Sciences*, *76*, 795-800.

Turban, E., CAMERON FISHER, J., & ALTMAN, S. (1988). Decision support systems in academic administration. *Journal of Educational Administration*, *26*(1), 97-113. DOI: doi.org/10.1108/eb009943

Zhang, P., & Whinston, A. B. (1995). Business information visualization for decision-making support-a research strategy.

Bibliographic information of this paper for citing:

Piri, Z., Samad-Soltani, T., Elahi, S. M. H., & Khezri, H. (2020). "Information visualization to support the decision-making process in the context of academic management." *Webology*, 17(1), Article 218. Available at: http://www.webology.org/2020/v17n1/a218.pdf