Institutional Knowledge to Institutional Intelligence: A Data Mining Enabled Knowledge Management Approach

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Abstract
Significant amount of knowledge is created in Higher Educational Institutions (HEIs) as a result of the academic, research and administrative activities. Deployment of the knowledge generated towards performance enhancement, decision making and process improvement will yield effective results such as enhanced planning and development, better administrative services, improved teaching and learning processes, effective faculty and student performance evaluation, efficient research, and better placements and recruitments. To generate the desired outcomes, the institutions need to better access, analyse and utilize the institutional knowledge for extracting the existing relationships, associations, patterns and trends in knowledge.

The author proposes a tiered architecture for capture and storage of institutional knowledge and its transformation into institutional intelligence. The research adopts a three phase approach, the first phase consisting of identification of the functional domains and performance indicators that determine performance, the second phase being the proposed architecture and the third phase consists of modeling the architecture using knowledge management and data mining methods. This paper covers with the first two phases of the research and the third phase is proposed to be taken up as a future work.

Keywords – Data Mining, Functional Domains, Higher Educational Institutions, Institutional Intelligence, Knowledge Management, Knowledge Repository, Performance Indicators

1. Introduction

Higher educational institutions encounter many challenges that prevent them to achieve their quality objectives (Delavari, Shirazi and Beikzadeh, 2004). Some of these problems stem from the lack of robust KM capabilities in HEIs. The increasing competition for performance has forced the HEIs with the challenge of having more efficient, effective and accurate educational processes. Knowledge evolves continuously in the functions and processes of HEIs but lack of proper acquisition, storage, deductions, conclusions and analysis of the available knowledge prevents the institutions from utilizing the institutional knowledge towards their educational objectives. Today HEIs face the important challenge of reaching a stage to facilitate more efficient, effective and accurate educational processes (Delavari, 2005). Knowledge gaps exists in HEIs due to lack of proper mechanisms for knowledge transformation into useful patterns, relationships and associations. Knowledge management and data mining techniques in integration can help to bridge the knowledge gaps by providing additional insight into the functions and processes of administration, teaching and learning and research and acting as tools towards better decisions in the educational activities.

One important task for HEIs is to identify the existing knowledge and tailor its knowledge management interventions in order to apply the institutional knowledge towards enhancement of performance rate. In order to capture and analyze the institutional knowledge more effectively, it is important to develop a holistic and reliable system that attempts to examine, assess and predict how multiple variables influence the performance of the institution while taking into account the vagueness and fuzziness of the factors involved (Sahay and Mehta, 2010). A transformation process that converts the knowledge chunks, explicit as well as implicit, into explicit and objective constructs has to be emphasized. The authors propose a tiered architecture for creating and sustaining institutional intelligence from institutional knowledge through knowledge management and data mining techniques. HEIs can apply the institutional intelligence towards fulfillment of KM services of performance enhancement, decision making and process improvement. This will facilitate to bring advantages such as enhanced planning and development, better administrative services, improved teaching and learning processes, effective faculty and student performance evaluation, efficient research, and better placements and recruitments.

2. Knowledge Management and Data Mining Applications – Background and Research

Knowledge management and data mining have been interesting areas of research in the educational domain. Kidwell, et al.(2000) discussed how an institution wide approach to KM can lead to exponential improvements in knowledge sharing in educational institutions and the subsequent surge benefits. Ranjan and Khalil (2007,pp. 15-25) argued that in order to build and develop a robust and thriving knowledge environment the institutions need to look beyond technology and develop the overall culture of accessing, collaborating and managing knowledge. Huveida, Shams, and Hooshmand(2008, pp. 695-702) demonstrated the relevance of problem solving and decision making theory in assessing the purpose of organizational KM activities and suggested new ways to conceptualize KM practices. Nagad and Amin (2006, pp.60-65) concluded that effective KM may require significant change in culture and value, organizational structures and reward systems.

Rowley(2000, pp. 325-333)in the study on KM in higher education said that KM challenges lie in the creation of a knowledge environment and the recognition of knowledge as intellectual capital and emphasized that effective KM in higher education requires significant change in the culture and values, organizational structures and reward systems.

Researchers have explored various applications of data mining in context of education. Luan (2001) introduced a decision support tool using data mining in the context of knowledge management. Shyamala and Rajagopalan(2006) developed a model for prediction of student performance by finding similar patterns from data gathered. Ranjan and Malik(2007) proposed a framework for effective student counseling process using data mining techniques. Ranjan and Ranjan (2010) explored the application of data mining techniques in higher education from the Indian perspective. Sahay and Mehta (2010) developed a software system to assist higher education in assessing and predicting key issues related to student success using data mining algorithms. Ehlers, et al. (2009) reported on a decision support system for research management for higher education using clustering technique of data mining to bridge the inherent ambiguity across different academic disciplines. Delavari (2004) proposed a model for improving the efficiency and effectiveness of higher educational processes using the capabilities of data mining technologies.

Though there are many established research activities available on KM intervention in higher education, few studies have focused on data mining enabled knowledge management intervention. This is the motivation for this paper.

3. Research Methodology

The research adopted a three phase approach, the first phase consisting of an interview and questionnaire method for the identification, verification and validation of the functional domains and performance indicators, the second phase being the proposed tiered architecture for transforming institutional knowledge to institutional intelligence and the third phase consisting of modeling the proposed architecture using knowledge management and data mining methods. This paper covers the first two phases of the research and the third phase is proposed as a future work.

A Identification of the Functional Domains and Performance Indicators

Interviews with faculty members and other functionaries in engineering colleges and business schools, observation of procedures and processes as well as study of work already done (Ashish and Arun, 2006, Ranjan and Khalil, 2007) were used to identify the functional domains and performance indicators that determine the performance in HEIs. The outcomes were analyzed using the content analysis technique. Content analysis consists of analyzing the contents of documentary materials(books, magazines, newspapers) and verbal materials (interviews, group discussions) for the identification of certain characteristics that can be measured or counted (Kothari, 2010). The list of performance indicators identified in the functional domains was distributed to senior faculty members with experience more than 7 years, heads of departments and deans for rating on a five point likert scale (1 for not important and 5 for most important). 160 faculty members participated and only those performance indicators with standard deviation (SD) of 1.0 or less and average rating of 3.5 out of 5 and above were considered and the rest were eliminated. This process eliminated about 32% of the initial list of performance indicators. The criteria (SD < 1.0 and mean >= 3.5/5) offer a suitable definition of threshold for stability (Yeoh, Gao and Koronios, 2009) and hence considered appropriate. This study facilitated to identify the generic performance indicators in functional domains of HEIs. The research focusses on these performance indicators for the development of institutional intelligence in HEIs.

B Transformation of Institutional Knowledge to Institutional Intelligence : A Knowledge Management and Data Mining Approach

This section presents the proposed architecture based on the capture and storage of institutional knowledge and its transformation into institutional intelligence using data mining methods (Figure 1). The institutional knowledge is generated in the form of performance indicators as a result of interaction between processes, people and environment within the HEI functional domains. Knowledge is captured and stored in a central knowledge base called the knowledge repository. The knowledge repository is a structured collection of the institutional knowledge that ensures the availability of related knowledge quickly and efficiently at the same place. Data mining techniques such as clustering, classification, prediction and association are applied to the stored knowledge to create institutional intelligence in the form of patterns, trends, rules and relationships. These outcomes from the data mining process are used as KM services to enhance the functions of decision making, process improvement and institutional performance management in the HEIs.

Classification is a data mining function used to classify the data group into pre-defined classes based on certain criteria. Classification assigns items in a collection to target categories or classes with the goal to accurately predict the target class for each case in the data (Oracle® Data Mining Concepts, 2008). Clustering is used to segment a dataset into subsets or clusters based on a set of attributes. It results into division of data into groups of similar objects where each cluster consists of objects that are similar between themselves and dissimilar to other objects. Prediction focuses on predicting certain events or behaviour based on historical information. Association consists in finding affinities among a collection of data objects. Association rules help to detect relationships or associations between specific values of categorical variables in large data sets.

The performance indicators are illustrated in Table 1; only two functional domains have been considered due to lack of space. The main objective of the proposed architecture is to identify how each performance indicator can be improved through data mining techniques leading to the overall improvement of the functional domain. The data mining functions that can be applied to the performance indicators in order to achieve useful outcomes in the form of institutional intelligence and the benefits that the stakeholders can draw by deployment of the institutional intelligence to their decisions and actions are illustrated in table 1.

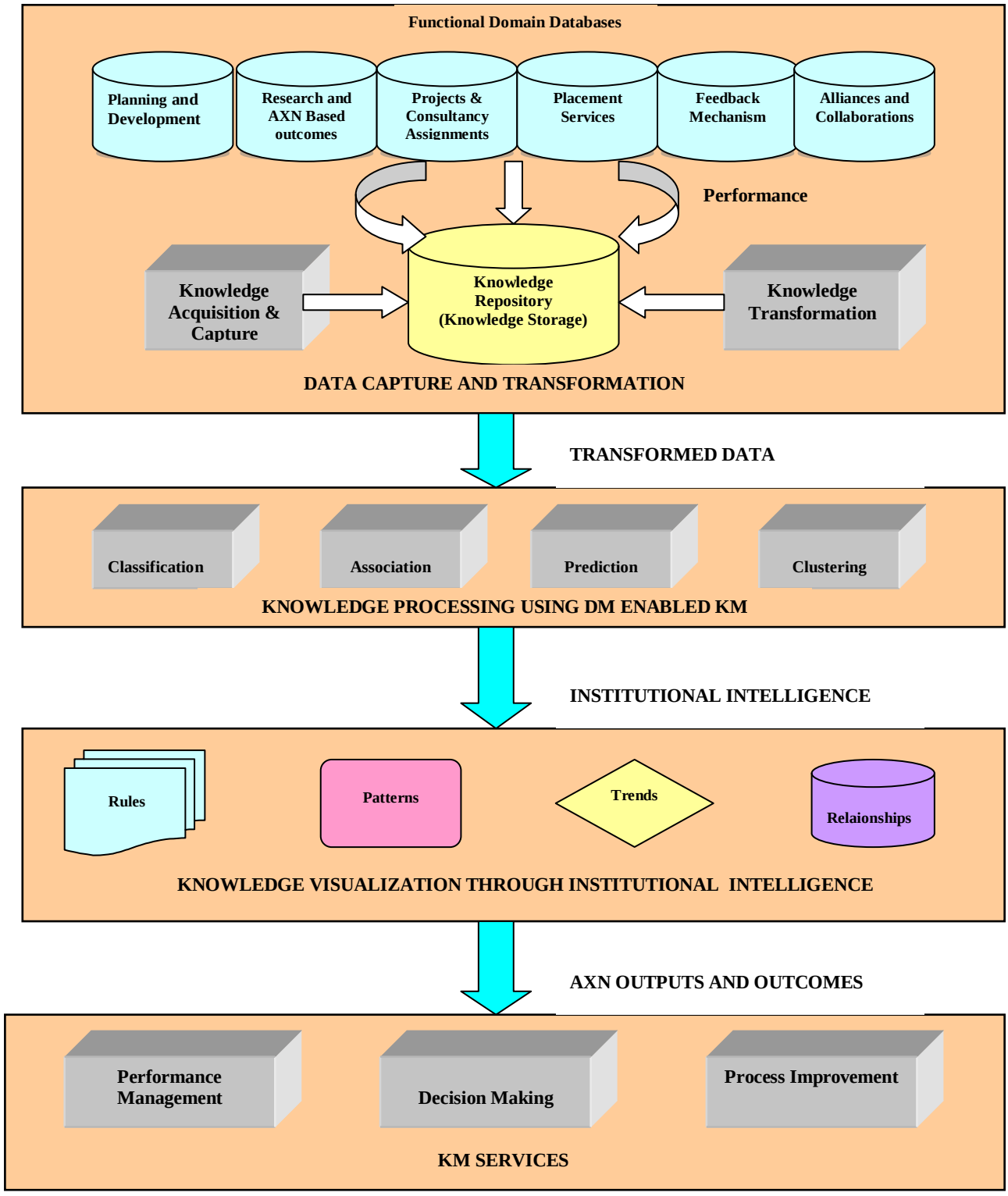

Fig. 1: A Four Tiered Architecture for Developing Institutional Intelligence

4. Conclusion and Future Work

Higher educational institutions today desire high levels of institutional intelligence in order to achieve their educational goals and objectives. Till very recently technology was not amenable to the intelligence levels required. Recent years have experienced information technology as a tool to capture, store, transform and distribute knowledge. However the utilization of the institutional knowledge into actionable intelligence has not been exploited by HEIs to enhance and deliver their services better. HEIs need to structure KM applications to facilitate capture the institutional knowledge and convert it into institutional intelligence to be used for decision making, planning and implementing the institutional processes.

In order to establish the priority for constructing institutional intelligence from institutional knowledge, the author identified the generic functional domains in HEIs and the performance indicators that determine the performance in the functional domains and further proposed a tiered architecture to transform the knowledge into intelligence. As a future work, the author proposes to implement the architecture by applying data mining methods to achieve outcomes illustrated in table 1. The author concludes that the final outcome of such application is improvement in the overall quality management system in HEIs.

References

[1] Ashish, Arun, 2006, "IT Based KM in Indian Higher Education System: Addressing Quality Concerns and Setting the Priorities Right", Journal of Knowledge Management Practice, vol.7, No.3

[2] Berson, A., Smith, S,J., 2004, "Data Warehousing, Data Mining and OLAP", Tata McGraw-Hill Publishing Co. Ltd., India

[3] Chapman, P., Clinton, J., Kerber, R., Khabaza, T., Reinartz, T., Shearer, C. and Wirth, R. (2000). CRISP-DM 1.0: Step-by-Step Data Mining Guide.

[4] Chen, M.S., Han, J., Yu, P.S., 1996, "Data Mining : An Overview from a Database Perspecive", IEEE Transaction on Knowledge and Data Engineering

[5] Delavari, N., Beikzadeh, M.R. and Shirazi, M.R.A. (2004). A new model for using data mining in higher educational system. In 5th International Conference on Information Technology Based Higher Education and Training: ITEHT '04. Istanbul, Turkey.

[6] Delavari, N., 2005, "Application of Enhanced Analysis Model for Data Mining Processes in Higher Educational System", ITHET 6th Annual International Conference

[7] Ehlers, K., Jpubert, M., Kinghorn, J., Zyl, A., 2009, "A Decision Support System for Institutional Research Management in Higher Education", 2009 International Conference on Computational Science and Engineering

[8] Huveida, R., Shams, G., Hooshmand, A., 2008, "Knowledge Management Practices in Higher Education Institutions : A Different Approach", IEEE 978-1-4244-2917-2,pp. 695-702

[9] Kidwell, J., Linde, V., Johnson, S., 2000, "Applying corporate Knowledge Management Practices in Higher Education", Educause Quarterly, November 2000[10] Kothari, C.R., 2010, Research Methodology Methods and Techniques, 4th ed., New Age International Publishers

[11] Luan, J., 2001, "Data Mining applications in Higher Education", A chapter in the upcoming "New Directions for Institutional Research", 1st edition, Josse Bass, San Francisco.

[12] Nagad, W., Amin, G., 2006, "Higher Education in Sudan and Knowledge Management Applications", IEEE 0-7803-9521-2/06, pp. 60-65

[13] Oracle® Data Mining Concepts, 11*g* Release 1 (11.1), B28129-04, May 2008

[14] Ranjan, J., Malik, K., 2007, "Effective Educational Process : A Data Mining Approach", VINE, Vol. 37, Issue 4, pp. 502-515

[15] Ranjan, J., Khalil, S., 2007, "Application of Knowledge Management in Management Education : A Conceptual Framework", Journal of Theoretical and Applied Information Technology, pp. 15-25

[16] Ranjan, J., Ranjan, R., 2010, "Application of Data mining Techniques in Higher Education in India", Journal of Knowledge Management Practice, Vol. 11, Special Issue 1, January 2010

[17] Rowley, J., 2000, "Is Higher Education Ready for Knowledge Management", The International Journal of Educational Management, vol 14, No. 7, pp.325-333

[18] Sahay, A., Mehta, K., 2010, "Assisting Higher Education in Assessing, Predicting, and Managing Issues Related to Student Success: A Web-based Software using Data Mining and Quality Function Deployment", Academic and Business Research Institute Conference, Las Vegas, 2010

[19] Shyamala, K., Rajagopalan, S.P., 2006, "Data Mining Model for a Better Higher Educational System", Information Technology Journal, Vol. 5, No. 3, pp. 560-564

[20] Yeoh, W, Gao,J, and Koronios,A, 2009, "Empirical investigation of critical success factors for implementing business intelligence systems in multiple engineering asset management organisations", Cater-Steel, Aileen and Al-Hakim, Latif (eds), Information systems research methods, epistemology, and applications, pp. 247-271, Information Science Reference, Hershay

Appendix :

Table 1: Data Mining Outcomes for KM in Functional Domains

Input Knowledge (Performance Indicators in Functional Domains)	Outcome of Data Mining Process / Institutional Intelligence	Benefits to the stakeholders	Data Mining Function
Institutional Teaching and Learning Process			
Teaching material prepared by the faculty	• Clusters of teaching material in accordance with topics / relevance	• Easy and quick availability of teaching material	• Clustering
Course plans – proposed and actual	• Patterns in successful course plans	• Designing effective course plans	• Classification
Curriculum	• Patterns in curriculum revisions • Patterns in factors that determine curriculum revisions	• Design of new curriculum	• Prediction
Frequently asked Questions (FAQs)	• Clusters of FAQs for various topics / subjects	• Efficient access to queries	• Clustering
Effective teaching methodologies used by faculty	• Clusters of teaching methodologies for various topics / subjects • Patterns of success of teaching methodologies	• Availability of efficient teaching methodologies • Prediction of effective teaching methodology for a topic / subject	• Clustering • Classification
Faculty Performance			
Courses taught by faculty	• Clusters of expertise of faculty	Assignment of courses to faculty	• Clustering
Results in courses taught by faculty	• Patterns of results based on pre defined parameters	• Evaluation of faculty • Assignment of courses to faculty • Design of strategies for faculty improvement • Awards and recognition to faculty	• Classification • Clustering
Research activity	• Patterns of research areas of faculty • Clusters of related research areas • Clusters of related research literature • Clusters of available guidance	• Identification of research areas • Prediction of research trends • Research guidance • Awards and recognition to faculty	• Classification • Prediction
Student feedback	• Patterns in student feedback based on pre-defined parameters • Patterns in competencies / skills most sought for	• Faculty recognition • Faculty counselling • Designing strategies for faculty improvement Career development plans	• Classification • Clustering
Peer rating	• Patterns of peer rating based on pre defined parameters • Patterns in skills most sought for • Patterns in missing / deficient skills	• Self improvement • Team work • Counselling	• Clustering • Classification
Administrative responsibilities carried out by the faculty	• Clusters of administrative responsibilities in functional domains Patterns of administrative responsibilities performed	• Assignment of responsibilities • Faculty skill development initiatives • Team work	• Clustering • Classification
Initiatives for self improvement and career development	• Patterns of self improvement and career development initiatives • Patterns of success rates of self improvement and career development initiatives	• Support for self improvement • Career Development plans	• Classification