

Competence Based Management in Academics through Data Mining Approach

Pooja Tripathi

Professor, Inderprastha Engineering College, Ghaziabad, Uttar Pradesh, India.

* E-mail of the corresponding author : trippooja@gmail.com, poojatripathi_75@rediffmail.com

Abstract

Competence based Management through Data mining approach helps academia to improve research and academic decision making through uncovering hidden trends and patterns that predicts using a combination of explicit knowledge base, sophisticated analytical skills and academic domain knowledge. The paper proposes a framework for effective educational process using Data Mining techniques to uncover the hidden trends and patterns and making accuracy based predictions through higher level of analytical sophistication in students counseling process.

Keywords: Faculty; Faculty Assessment; Faculty; Competence Management; Data Mining; Patterns.

1. Introduction

The advanced networking infrastructure, new explorations in information technologies and personal connectivity to digital educational environments has made the collection, transfer, and dissemination of academics related information more accessible than at any other point in history.

The predictive power of Data Mining (Edelstein, 1997) comes from concepts of machine learning, pattern recognition, and statistics and it automatically extracts concepts to determine interrelations and patterns of interest from large databases. Data Mining has proven to be a powerful tool capable of handling decision making and forecasting techniques. Data Mining tools are extensively used in industries and corporates. The techniques and methods that are used in industries can be well connected to academia.

Academic institutions regularly generate huge data on students, faculty, staff that includes managerial systems, organizational personnel, lectures details and so on. This useful data serves as a strategic input to any academic institution for improving the quality of education process. Today in the changing global scenario where the knowledge and technology is expanding rapidly giving rise to the talent crunch, it is the need of the hour to find out the competencies that can help to adopt the individuals to remain competitive. Data Mining technique, is the least utilized technique for the human resource data, can be proved worthy if utilized for the knowledge management and dissemination. It can be utilized in every discipline of human resource management and in many such areas which are still untouched. The information retrieved through the data mining technique can be proved worthy in organizing and extending the generated information to the various stake holders of the academic institutions.

With academic institutions' severe budget expansions towards information technology infrastructure in order to compete with other institutions, it becomes even more important for the institutions to achieve success with benchmarking quality. Often the institutions come across several patterns in evaluations, courses taught, students' counseling and learning. These patterns if extracted by using Data Mining techniques will enhance data sharing analyze diversified student relationship management; predict student performances and success of programs etc by developing the departments in the academic institution. Information like what if analysis, predictive modeling, automated alerts, faculty interest tracking, subjects and areas tracking, etc. could be effectively and efficiently enhanced. Using these models one can find which faculty is likely to perform more knowledge transmission process, knowledge creation and knowledge service. By addressing these challenges, Data Mining ensures effective allocation of resources and staff, increases productivity without increasing the cost.

One of the objectives of the paper is to develop a holistic model for educational purpose using Data Mining techniques for exploring the effects of probable changes in processes related to competence management and performance assessment of the faculty. By doing so, the authors believe that the quality of students will be improved more efficiently and effectively. The model proposed in this paper, can help research community to know how academics benefit from large academic data. This model will be useful to help faculty for managing their classes, understand their students' learning and reflect on their teaching and to support learner reflection and provide proactive feedback to learners.. Data Mining can enable academic institutions to gain more comprehensive, integrative and reflexive view of the impact information technology by obtaining a better understanding around issues of information use and access, ultimately leading to improved knowledge sharing and effective decision-making.

This paper presents the role of Data Mining approach in institutional research towards effective competence management of the faculty in academics domain. The paper is organized as follows: Section II

presents the related research and a brief introduction to Data Mining techniques. Section III describes the educational process and parameters affecting the competencies required in the educational institutions. Section IV addresses the Data Mining approach in competence management process. Section V addresses the expected benefits. Section VI concludes the whole paper.

2. Motivation and Related work

Data mining is applicable to all sectors of business, like retail, banking, telecommunications, marketing, web mining, medicines etc. One can refer to (Adriaans and Zantinge, 2005; Fayyad, 1996; Han, 2002; Edelstein, 2000; Chang, 2000; Mobasher, Jain, Han and Srivastava, 1996; Baylis, 1999; Brossette et. al, 1998) for different applications of Data Mining. Data Mining is widely used in business context but its applications in academics is very much limited. This is the main motivation for our paper. The concept of Data Mining in academics is promising but still streamlining is required by relevance of proof and stereotypical analysis. Summary of findings in educational domain include (Luan, 2002; Petrides, 2004; Luan, 2001; Tsantis, 2001; Mostow, 2004; Merceron, 2005). Several commercial data mining tools like Clementine (Clementine, 2005), Weka (Weka, 2005), XLminer (XLminer, 2005), Illimine (Illimine, 2006) are available. But these are scarcely used in academics. There are tools (Zaiane, 2001; Merceron, 2005) dedicated at finding pedagogically relevant information in student work like TADA-Ed (Tool for Advanced Data Analysis in Education). Data Mining, in contrast is discovery driven. That is, the hypothesis is automatically extracted from the given data. The other reason is that Data Mining techniques tend to be more robust to messier real world data and is also usable by less expert users. (Delmater and Handcock, 2001) stressed on underlying predictive modeling which is a mixture of mathematics, computer science, and domain expertise. (Luan, 2001) has produced a high level view of the comparable features among Data Mining, Statistics and data warehouse based on analytical processing. To take advantage of the results, a system needs to be in place (Tsantis, 2001) for transforming new knowledge into successful models for teaching and learning to develop and improve student relationship management. (Luan, 2001) emphasizes on knowledge management for higher education and emphasizes the role of Data Mining in research, teaching and institutional research. But its application for the competence management of the faculty in academics is still very rare. We feel that if data mining approach is applied in the competence management process of the faculty in the educational institution will definitely give us fruitful results and will develop a process which can select the right candidate for the right job.

2.1 Techniques in Data Mining.

(a) Associations, Mining frequent patterns.

These methods identify rules of affinities among the collections. The applications of association rules include market basket analysis, attached mailing in direct marketing, Fraud detection, Department store floor/shelf planning etc. Association can be used to track students activities related to discipline programs, specializations and courses. It was introduced and applied by (Agarwal, Imielinski and Swami, 1993) and (Agarwal and Srikant, 1994). The goal of the association rules is to detect relationships or associations between specific values of nominal attributes in large data sets.

(b) Classification and Prediction.

The classification and prediction models are two data analysis techniques that are used to describe data classes and predict future data classes. The performance levels of the student can be classified as Good, Medium, or Poor. Using prediction, student's choice of specialization (ex. whether the student will opt one particular course or not) can be determined. To predict whether a student will show a certain type of behavior implies an assumption that the student belongs to certain type of student group and will therefore show a certain kind of behavior. The models of decision trees, neural networks based classifications schemes are very much useful in analyzing academic data. Decision trees are widely used in prediction and in exploration of datasets like looking at the predictors and values that are chosen for each split of the tree. Regression is often used as it is a statistical method used for numeric prediction. Student geographic, demographic and academic variables will be the main predicting factors. Cluster analysis and predictive modeling can be applied to study the increased rate of student enrollment process.

(c) Clustering

It is a method by which similar records are grouped together. Clustering is usually used to mean segmentation. An institution can take the hierarchy of classes that group similar students. Using clustering, students can be grouped based on educational background, age, areas of interest and specialization and so on. The aim of clustering is to create n-groups of students of homogeneous levels with respect to learning. Clusters of student/faculty satisfactory surveys are possible. (Hilgendorf and Erik, 1997) studied the role of clustering techniques in evaluating and implementing long-range planning for student retention and academic success. (Valadkhani Abbas and Worthington Andrew, 2005) examined clustering methods in context of Australian university academic databases.

3. Education Process and Competence Management

Fundamentally, academic goal of each academic institution is the same i.e. to facilitate individual (and hence social) learning. In the case of professional education (e.g. management education, engineering education), the academic goal gets refined to produce a professional through learning focused to a given stream or profession. To obtain this goal, excellence in all spheres becomes paramount which in turn requires quality and competent faculties as well as the process. Process of selecting a candidate as a faculty, and its training development in the organization defines the level of quality of an institution. In order to maintain a desired level of quality, institutes strive to adopt rigorous methods of selection and competence management process at each stage in addition to their core process of education delivery. The role of academic institutions is to induct students into desired culture and to transmit the societal way of life under the guidance of faculties. So there is a need for developing a system which can take care of various skills that should be developed in the faculties so that they can provide necessary guidance for the development of the students. Table1 below provides the various attributes of the competencies of the faculty which can be groups into various trades such as personality ability knowledge and skills. All these faculty trades that include innate and acquired aspects can be represented as a pyramid built on the foundation of inherent talents incorporating the types of skills and knowledge that can be acquired through learning efforts and experience.

Table 1 Competency Models for the Faculty

<u>Personality</u>	<u>Ability</u>	<u>Knowledge</u>	<u>Skills</u>
Assertiveness	Mental Ability	Technical & Practical	Basic Communication
Competitiveness	Divergent Thinking	knowledge of the	Problem solving skills
Self Sufficiency	Quantitative Reasoning	subject	Presentation skills
High Emotional	Learning	Latest trends & research	Coaching / Training
Stamina	Creativity	related to the subject	skills
High Energy Level	Innovativeness		

A competency model describes the combination of knowledge; skills & characteristics needed to effectively perform a role in an organization and is used as a human resource tool for the selection, training and development, appraisal and succession planning. Identifying and mapping these competencies is a complex process. In any educational institutions determining whether the workforce possesses the abilities for its success is indeed difficult. Academic institutes are trying to develop competency models to help them identify the essential knowledge, skills and attributes needed for successful performance in a job by keeping the organization mission and strategy in mind. Fig 1 below describes the various steps involved in linking HR process to organization strategy by keeping all the points required for the candidate competence and performance management process in any educational institutions with respect to their goals and vision.

The system is based on two structures: the competency catalogue and the learning outcome in academia. The competence catalogue describes the competency models of the institution, as this is defined by the human resources director. Each competency is composed of various behavior indicators which correspond to various proficiency levels. The process of analyzing the competency gap between the competencies possessed by an academia and those required for effectiveness in job role is the following: The head of the department analyzes competencies and proficiency level the employee.

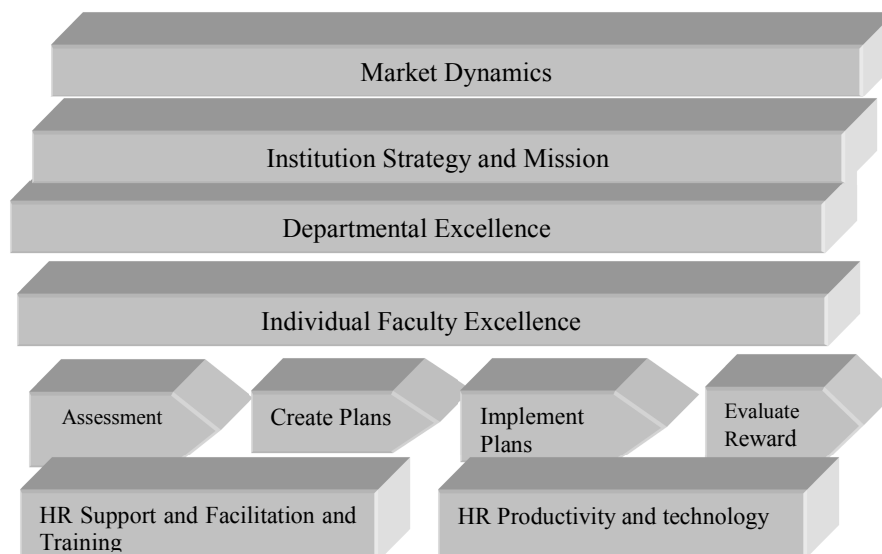


Fig 1 System Approach to Competence Based Development to Educational Institution

The competencies and the competency levels of the job role that the faculty should have is already entered, the system is able to compare one by one the corresponding competency available in the faculty and the competency levels and create a relevant report. It also provides the faculty with the learning objects required in order to further develop the competencies that are required in his/her current role and the succession planning.

3.1 Data View

The conceptual view of the functional architecture (see fig 3) describes the development of the knowledge flow in any educational institute. This also includes the proactive use of the data to assist the administration, team heads, employees (teaching and non teaching) in tracking and assessing the performance. It also helps to develop the knowledge base that can provide the information required for handling the changing requirements of the enterprise to develop competencies and resources accordingly. Hence, it will provide the technique to manage the competencies strategically. The layered approach provides the facility of separating the data gathering and the data manipulation. The first layer describes the data gathering process through different mediums such as employees (faculties, staff team heads), registrar, administration and other competencies gathering tools. The second layer describes the knowledge base. It is developed by the discussion from domain experts and knowledge engineer. The third layer describes the inference engine used to develop the reasoning based on cases and experiences to reach to solutions as suggested by different domain experts. It helps to do evaluation and assessment and provides information required for the trainings and developments of the employees, resources etc.

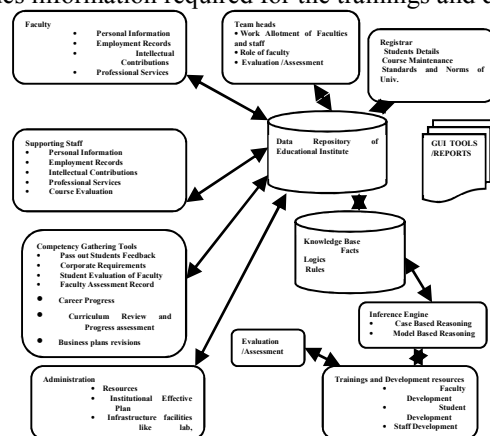


Fig 3 Functional Architecture for the educational Institution

3.2 Information Value Chain

Figure 4 exhibits the value chain of Information processing and utilization in education process in general and competence management in specific. Every institution invests on their offerings to nurture students' talents and abilities. Hence our focus is how to best manage the competence process for faculty to improve the teaching learning process design so that the quality of students coming out of the institution can be improved. There are various methods to assess the right candidate to perform the right job; the data mining model should assist the institution to take decision on the assessment and the competence enhancement of the faculty.

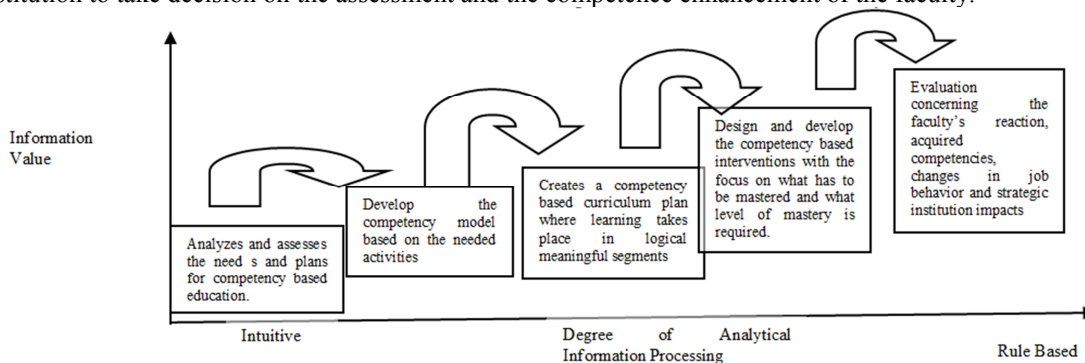


Fig.4 Information value chain processing for decision making in Competence management

4. Research Methodology

The research has explored various steps for the development and validation of the instrument used for the

competence management. In order to construct the measuring scale, firstly it was necessary to identify the important roles performed by faculties within educational institutions. The process begins by undertaking a literature search to ascertain previous work in the field, and delineate the number of conceptual variables to be investigated. In an attempt to obtain more comprehensive picture of the importance of these determinants, a series of academic committee reviews were undertaken. A total of ten directors from ten educational institutions were invited to participate in the academic committee interview. The academic committee has suggested that the various areas of the faculty work environment have a serious impact on the faculty work attitudes. In particular, three main job characteristics were conjectured to positively influence the faculty role in the academic institutions:

1. Knowledge Transmission: mainly considering the teaching and learning process.
2. Knowledge Creation: mainly ability to use initiatives for research, sponsored projects and publications.
3. Knowledge Service: mainly the services offered to the society for the knowledge up gradation through various collaborative meetings.

Additional, discussions with heads and deans of the colleges through the academic committee meetings led to several broad components. Specially, competence management within the educational institution seemed to have at least four dimensions;

1. Personality behavior dimension which reflect the demand for the quality services.
2. Knowledge dimension which reflects the need for the required educational qualification etc.
3. Skills which assesses the services performed by the faculty.
4. Ability dimension that reflects the various projects initiatives.

These factors were subsequently transformed in to items presented as statements in the questionnaire. The literature review together with the academic committee interview provided the basis for generating items for inclusion in the draft questionnaire. The draft questionnaire consisted of two sections A and B. Section A consisted of questions pertaining to respondent profile. Whereas section B contained question related to different aspects of the competencies required for the services offered by the faculty with different perspectives such as knowledge, behavior, administration and the research in order to understand the various aspects of jobs satisfaction, job characteristics, and personality factors. Findings of the academic committee led to the development of items tapping each of the dimensions of the construct. All the items in section B were presented randomly as statements on the questionnaire with the same rating scale used through out. The items were measured on a five point Likert- type scale that varied from 1= strongly disagree to 5= strongly agree.

Prior to conducting the major survey, a pilot study was administered so as to pretest the validity and reliability of variable measures contained in the draft instrument. About 5 colleges selected randomly from the complete list of selected colleges participated in the pilot study. The pilot instrument was directed to key respondents representing the colleges and all the completed questionnaires were inspected, and scale items that were not stable or consistent were modified or deleted from the test instrument. The revised questionnaire was subsequently submitted to domain experts (practitioners, academicians) for feedback before being administered on a full scale survey. They proposed that items with common themes or similarities were to be regrouped and redrafted. Data had been collected for the period of two months, and the sampling procedure used for the study was census.

Dimensionality of the faculty competence management

The dimensional structure of faculty competence management was hypothesized and assessed through the following steps. First, based on an examination of the literature and information gathered through an academic committee and expert panels. Second, four independent dimensions as discussed above encompass the major components of the domain of the competence management in academic institution.

Normality test of distribution for the four dimensions

The distribution measures how the respondent responds to the items or questions posed in the instruments. A good item should portray the responses as normally distributed with the skewness close to zero. A method using skewness and kurtosis was used to examine the normality of the data. The value of this statistics is zero when the data are normally distributed, and a skewness value more than twice its standard error is taken to indicate the departure from normality.

Reliability Test

In this study, the internal- consistency was used to evaluate the consistency of the responses for the four dimensions of the faculty competence management. All the coefficient values meet the required prerequisite, thereby demonstrating that all the four dimensions are internally consistent and have satisfactory reliability values in their original form.

Validity Tests

Face validity and content validity

Given that the questionnaire had been appropriately designed through a comprehensive review of relevant literature then fine tuned bases on academic committee findings and suggestions from various experts, both the face and the content validation of the questionnaire was ensured.

5. Data mining application in Faculty Competence Management process

Data understanding is the important stage of Data Mining model. This process starts with initial data collection pertaining to competence management of the faculty. This phase addresses the data quality problems to discover first insights into the data and to detect interesting subsets to form hypothesis for hidden information. Descriptive Statistics can be used for data auditing.

Major Data Mining Techniques	Patterns
Clustering	<p>Faculties having similar characteristics. Grouping top performers.</p> <p>Analysis of faculties' attrition. Groups of faculties most likely to leave.</p> <p>Segments related to retirement facilities, compensations, benefits, allowance</p>
Classification and Prediction	<p>Predicting faculties learning outcome in an enterprise.</p> <p>Predicting the likelihood of success in a HR Process.</p> <p>Predicting the percentage accuracy in faculties' performance.</p> <p>Analyze forecast and model information to quantify human capital assets.</p> <p>Classifying the recruiting process.</p> <p>Predicting faculties' attrition rates.</p> <p>Prediction of what type of faculties most likely to leave, most likely to shift, most likely to take particular assignments.</p> <p>Predicting faculties' behavior, attitude. Predicting demand projections by seasonal variations.</p> <p>Predicting the Performance progress throughout the performance period.</p> <p>Identifying the best profile for different faculties. Prediction to find what factors will attract new faculties.</p> <p>Classify trends of movements through the organization for successful/unsuccessful employee sets.(useful in recruitment management)</p> <p>Information on faculty hired from particular source has a higher value.</p> <p>Quick prediction on large enterprise faculty records. Categorization of people leaving by job type.</p> <p>Scores of individual faculty in risk category predicted to voluntarily leave.</p>
Association	<p>Association of training undertaken with various types of faculty and performance scores, individually and in teams.</p> <p>Association of faculty work profiles to the most appropriate programs/jobs</p> <p>Association of faculty team building and leader ships approaches.</p> <p>Association of faculty attitude with performance.</p> <p>Association and analysis of staff movements</p> <p>Application tracking mechanism in recruiting process.</p> <p>Identify patterns in faculty benefit selections.</p> <p>Association of strategic enterprise objectives to faculty performance results.</p>
Data Mining using other inter-disciplinary methods	<p>Standardizing training methods, task performance monitoring in career management, monitor work flow route tasks.</p> <p>Provides summary information: various multidimensional summary reports.</p> <p>Statistical summary information (data central tendency and variation).</p> <p>Use historical data to build models of fraudulent behavior and use Data Mining to help identify similar instances.</p> <p>Summaries of employee population, compensation, turn over rates and other HRM elements.</p>

In academic institutions there are many diverse yet interesting databases available ranging from students, faculty, courses, administration to research and consultancy, infrastructure facilities etc. Balancing the data like performing faculty to non performing faculty members much important. The main components here can be

faculty demographic data, their academic levels, and descriptive statistics (relevant without noise and missing values). During data preparation, the complete dataset is prepared for final data modeling techniques.

6. Conclusion

Data Mining intersects technology, information, academic practices through efficient models, analyzes the diversified faculty relationship management, assesses the competences of the faculty and their performance management, skill management etc. It is the predictive ability that distinguishes Data Mining from other one-dimensional data management applications. The power of Data Mining to target interesting snapshots or markers empowers academic users in making proactive, knowledge-driven decisions based on markers found within the data. This model will be useful to help deans and heads of the departments for managing their faculties, understand their students' learning and reflect on their teaching and to support learner reflection and provide proactive feedback to faculties. It is clear that recognition of high quality institutional research by professors and staff is dealt for faculty competence management and their performance assessment. Since the number of colleges have significantly grown over the period of years, it becomes prudent to look at how teaching and learning have changed. The institutions have been making substantial investments for their computing infrastructure to meet their goals. With the increasing competition in the market, institutions are under pressure to improve their performance. Human Resource (HR) professionals are looking for a newer tool to align it with HR strategies. In this regard the tools, which can be adopted widely by institutions to align their growth strategies and HR strategies, are 360 degree feedback, assessment centers and competency mapping.

In this paper, we have presented a model using Data Mining approach for academics. This will be useful to help institutions for managing competencies of the faculties, performance assessment, understand the students' learning and provide proactive feedback to learners.

7. Expected Benefits

Without an effective way to manage and query the education data, collected information about faculty often go underutilized. Parts of a collection can remain untapped for years, and the larger it grows, the more difficult its management becomes. Unfortunately, improving this usually comes at a cost—at a time when budget cuts have forced most programs to reduce spending, any plan for improving management must include how those improvements can increase efficiency and drive down costs in the long run.

Data Mining techniques enhance the information management. The success of a particular organization can be rated using prediction of the market requirement and developing the team to cater that market challenges. Thus, enhancing the overall learning outcome. We can identify the group of personnels who are more likely to leave a particular organization.

The proposed process improves process by identifying the potential personnel who have the strongest prospects and also forecasts demand for new talents required. The benefits include deeper understanding of patterns previously unseen using current available reporting capabilities. Further prediction allows the institution an opportunity to act before personnel leaves and can do succession planning strategically. The institutions can know the resource allocation with confidence gained from knowledge.

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