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Rule Based Expert System with an Object-Oriented Database for an Educational Institute

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Abstract - Using intelligent computer systems systems technology to support the academic advising process offers many advantages over the traditional advising. Proper channeling of institutional resources leads to increased performance and better outcomes in order to meet the competitive edge. A crucial feature of educational institutions is that they consist of many processes each requiring the combination of various skills at different proficiency levels. A robust institutional advising system must reflect the need for development in the institution and cater to methods to achieve increased usage. In this paper a rule based expert system for guiding Management and employees of an educational institute is designed and developed. The system is supported with an object-oriented database, and the interactions with the system are performed through a friendly graphical user interface. An overview of the system's model and a description of its structure are presented. The system is expected to result in successful computerized intelligent decision support software that is easy to maintain modify, and extend.

***Keywords* - Artificial Intelligence, Rule-Based Expert System, Object- Oriented Software Development, Academia, Educational institutions.**

1. Introduction

The processes of engineering education are immensely demanding in terms of skills and competency. The growing number of institutions offering engineering courses and the increasing performance requirements of the stakeholders has increased competition and the need for better outcomes. In order to achieve this, the institutions need to perform better. Competency is a key resource that all institutions possess and proper channeling of the institutional resources can help to achieve the performance requirements and meet the competitive edge.

A crucial feature of engineering institutions is that they consist of many functions and processes, each requiring the combination of various skills at different proficiency levels. This implies that people in the institutions need to possess and develop multiple competencies for personal and institutional survival. This paves the way to recognize the need for resources management in EIs. In educational institutions human resource alone greatly contributes towards the success of the institution. Engineering institutions formulated on the basis of the competency of their employees, particularly faculty can achieve the competitive edge. The institutions employ people possessing a variety of qualifications with different proficiency levels. The question is what value is added to the services they deliver through the effective use of their abilities. The institutions have to precisely identify the requirements based on institutional goals and job profiles and the gap that exists between the expected and available level of proficiencies. Based on the data, the institutions need to modulate themselves to design strategies in order to develop the missing capabilities and adapt the existing ones to the required proficiency levels.

The aim of this paper is to explore the competency management in engineering education from a knowledge management perspective in order to achieve easy integration of the proficiencies required in the academia and their mapping to academic processes. Comprehensive knowledge of the availability and requirement of the expertise is critical to the overall performance of the organization.

2. Research Approach and Findings

The research literature related to Institutional management was studied extensively. It helped us to comprehend the need for management in educational institutions. Selecting a suitable design is a difficult and time consuming task because many factors contribute towards taking the accurate decision. In addition, due to the 'knowledge explosion' that we observe in all fields, more and more models are designed and introduced based on the society and business needs. The will of the employees or the 'feeling' that a person likes a specific model is not enough to give the result that the targeted one is suitable. Even for 'smart' employees (with expertise in computer) it is a difficult task to choose the correct and most suitable one.

A suitable model for any educational institute is the one that fits the management's requirements, employee's aptitudes, skills, preferences, subjects that he/she likes, and the career type that he/she loves. Artificial intelligence methods like Expert Systems can help and save time in this domain because an ES can provide a fast expert advice based on the captured and modeled knowledge in its knowledge base component as addressed in the next section

A review of relevant literature in accordance to the objectives of this paper were explored and adopted in order to solicit the right information needed for the analysis. In accordance to the goals of this research/project, the design- based research methodology was employed to carry out this research. This is because design-based research is a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development and implementation based on collaboration among researchers and practitioners in real-world settings and leading to contextually-sensitive design principles and theories. Design research was developed as a way to carry out formative research to test and refine educational designs based on principles derived from prior research. Consistent with the design research framework, this research will be carried out in some of the following five steps:

a) *Awareness of the Problem(s)*: Identify the problem(s) by analyzing the deficiencies of the existing systems and describe how to make improvements.
b) *Suggestion:* Review the related literature and previous research. Describe how the system can be designed and implemented with feasible, optimized solutions.
c) *Development:* Develop and implement the proposed application(s)/system(s) according to the suggested solutions.
d) *Evaluation:* Evaluate and experiment the partially or fully successful implementations according to the functional specification.
e) *Conclusion:* Discuss and draw conclusions based upon findings in the process of system design as well as the evaluations.

Steps that must be taken to develop an expert system were also reviewed and adopted. These steps are enumerated below:

- Define the problem
- Evaluate alternative solutions
- Verify and expert system solution
- Estimate the payoff
- Choose an expert system tool
- Perform the knowledge engineering
- Build the knowledge base
- Develop the software
- Test and validate the system
- Maintain the system

3. Proposed Framework of the System

Management in engineering institutions consists of the activities as follows:

1. Defining the right requirements based on the organizational and management goals, objectives, strategies and functional domains.
2. Evaluating the current scenario present in the institution and identifying the missing one (Resources and staff required).
3. Developing and procuring the required resources and recruiting the individuals for requirements that are missing through trainings, QIPs and developmental activities.
4. Monitoring the performance of people for compliance to the identified system.

Based on the activities of management of an institute, we proposed a model which consists of four stages, which aim at the continuous enhancement and development of the institution and its members (employees and students as well).

The first phase in institutional management aims to provide the institution with an extensive list of requirements in order to its quality in accordance with the institutional strategies for meeting goals and targets. The second phase is the evaluation phase which encompasses the assessment of the current state of resources and staff available in the institution and the level of each required. A gap analysis may be required at this stage to identify the difference in the available and the required resources and staff and the redundancy in the existing scenario.

The identification of the missing and the redundant components will clearly contribute towards the next phase of development and enhancement of working in the institution. The third phase aims at activities towards fulfilling the existing gap in institute. This includes providing for the missing staff, enhancing the existing ones to the required proficiency level and re-directing the redundant to new directions. This can be achieved through recruitments, training and development programs.

The monitoring phase ensures that the model developed and working is maintained. A mechanism comprising of feedback and evaluation can be adopted to achieve this.

Feedback must be given at regular basis and should lead to required training, development and guidance. Evaluation is the outcome of feedback on performance at any point of time. It reinforces the need for additional development and refinement to perform a job. The combination of these in the required will facilitate the people to perform their jobs with proficiency and will contribute towards the overall development of the institute as a whole.

4. Implementation of the Framework

Fig 1. Shows an expert system based layered architecture for the proposed framework to facilitate the identification, storage mapping and development of the institutional 'Expert System Advisor'. The first layer depicts the knowledge identification and knowledge gathering process for the competency domains, functional activities and the required and available competencies. The knowledge gathering is achieved through the medium of people, study of documents and observation of processes. The second layer describes the storage of knowledge in a knowledge repository.

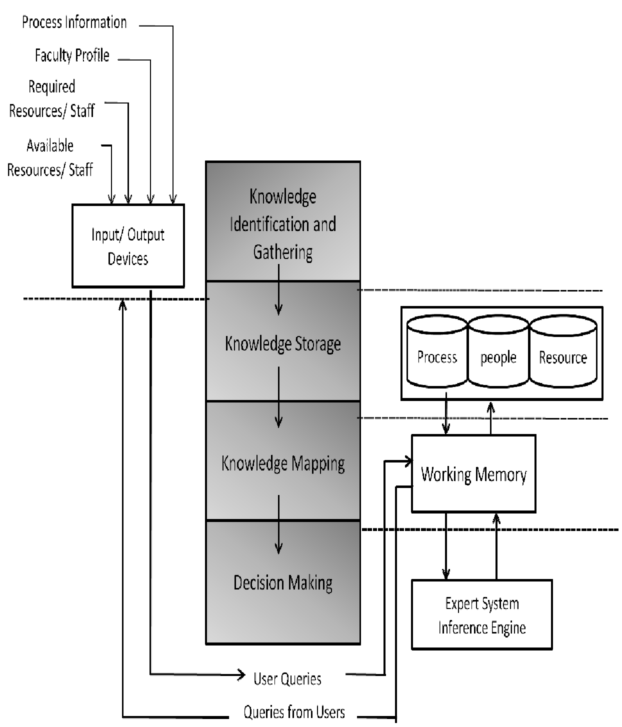

Fig 1 Architecture of Proposed Expert System

The knowledge repository is organized and maintained by knowledge engineers and consists of information on people, processes and competencies and represents all the knowledge in the required domains. Additionally, the knowledge gained in the first layer is filtered and structured to be represented in the repository in the form of rules and facts in the second layer. The third layer is the mapping layer for mapping the knowledge to people and processes and performing a gap analysis to identify the missing resources and people. The missing resources and people that are required for further enhancement of an educational institute are identified and noted, This is achieved by applying facts and rules to the knowledge repository. The fourth layer is the decision making layer using the expert system inference engine to derive the solutions for institutional enhancement and development, monitoring and rewards and recognition, career planning succession planning and institutional planning.

5. The Developed Expert System

5.1 The OO Database (OODB)

Developing an efficient database structure is an important objective in database design. Much of the work in creating a successful database is in the modeling. The database of the developed system is modeled as an OODB in which the main class is of 'users' which may be management persons, employees or students. (Figure 2-5).

The OO structure allows each user to be modeled as an object, and the database to be constructed as a collection of these objects. This structure gives more flexibility to each major to have whatever attributes and behaviors required for identifying it while maintaining the integrity of the system as a whole. In addition, adding more users or its attributes (or fields) is a straightforward process.

The current prototype system contains the following users mainly exist in any educational institute in India. Employees in an institution can be teaching or supporting. Teaching employee can be institutional Head, Departmental Heads, Professors, Assistant Professor, Subject Co-coordinator and other staff related with teaching in the institute like visiting faculties, subject expert etc.. Supporting staff can be Lab technician, office staff and others. Each user in the database is also described by its own list of attributes and skills values required. Note that employees data (e.g., first name, last name, e-mail address, designation, department, years of experience , expertise in subjects etc,) are saved in the database because one of the recommended future works on the system is to make it an online Internet-based system, thus saving employee' data can help in retrieving past consultations for registered users.

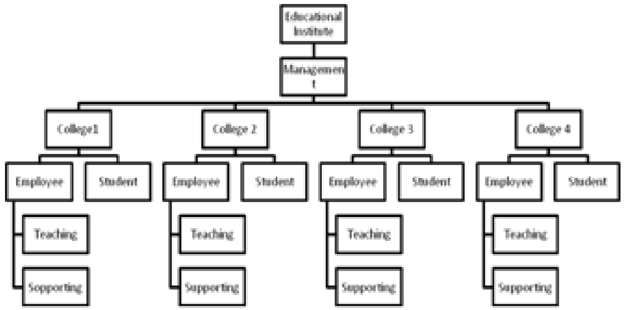

Fig 2 The Object Hierarchy of an Educational Institute

Management will be able to access the record of any employee of any institute. Besides this, they will also be able to have access to other records, like admission details, infrastructure, placement details and any other records which they want to access. They are at topmost level and will be able to access any record which may not be available to any employees and of course to students.

Employees of the institute (if the employee is institutional Head) will be allowed to access all the data pertinent to that institute. Departmental Heads can access information concerning their departments, whereas others will be allowed limited access which will be relevant to them.

Students are allowed to access only those records which will be important for them like timetable, syllabus, academic calendar etc.

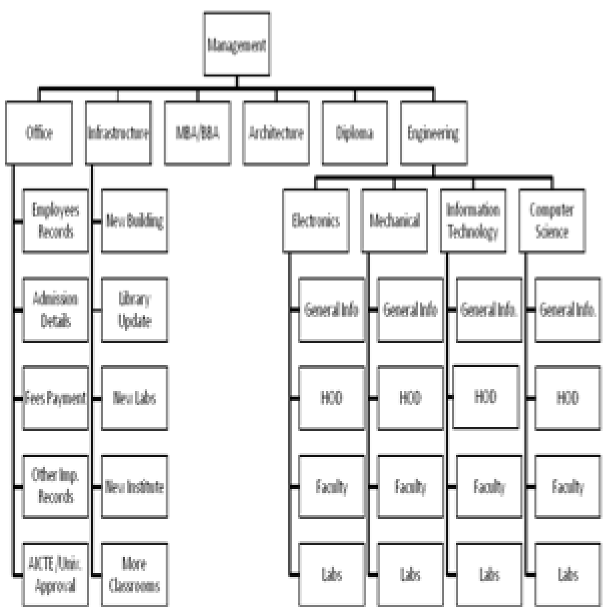

Fig 3. Database model for Management

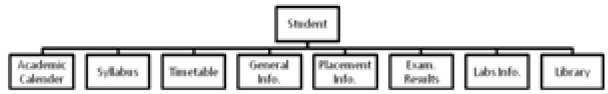

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Fig 4. Database model for Student

5.2 The Rule-Based Knowledge Base (RBKB)

The If-Then rules of the rule-base can be classified into two categories :(1) Institutional Requirements Rules, and (2) Employees Preferences and Skills Rules. Institutional Requirements rules are rules that are concerned with the academic conditions that the universities and institutes apply to accept employees in various positions in the institute depending on their qualifications and experience.

As an example of this rule category, consider the following illustrative rule written in English:

Rule1:

If: An employee' has completed Graduation in Electronics Engineering but has done masters in Computer Engineering

Then: Add the following information, the employee allowable Department where he will be working will be the branch in which he/she has completed Masters.

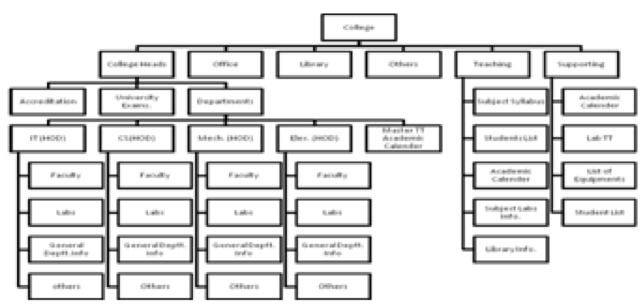

Fig 5. Database Model for College Head

As noticed from the example above rule is applicable when a person has done graduation and Masters in two different fields, institutional rules suggests designating employee in a department where his master's expertise may be put to use. Otherwise in case the area of graduation and masters are same then such disputes did not occur.

Of course at times, the above mentioned traditional rules do not work alone in giving the ES consultation results; they are supported with the second category of rules which are Employee Preferences and Skills Rules.

These rules as the name suggests- consider the preferences and skills values of employees and attempt to match them with the skills and attributes values required for teaching in a department.

As an example rule from this second category of rules consider the following rule:

If: An employee has done graduation and masters in two different branches and he has experience in teaching subjects relevant to his graduation degree, also institute needs faculty for teaching those subjects:
Then: Depending on his preference and teaching skills, he may be considered as a member of his preferred department From the above discussion it is clear that the objective of employee Preferences and Skills Rules is to attempt to understand the preferences and skills of the employee who is consulting the expert system and match them with the skills and attributes required by the institute within the allowable list (the list resulting from applying the first category of If-Then rules) in order to filter out the list and produce the list of 'suggested options' for the employee.

5.3 The Inference Engine

Kappa-PC expert system development environment supports rule-based reasoning as well as the micro-managing of the reasoning process using classical programming techniques and list processing through Kappa-PC Application Language (KAL). Major-Selection's inference engine uses both If-Then rules processing and list processing techniques. List processing is an important feature of Kappa-PC that is used in the developed system because a large portion of system reasoning depends on forming and processing lists as explained in the previous subsection.

There are three main steps performed in the inference process of determining the suggested majors. In Step 1 University and Institutional Requirements Rules are applied in order to form the list of allowable rules (Like Department where an employee can be appointed, Designation etc. which has to be accepted without violating university and Institutional 'traditional' requirements).
Step 2 applies employees Preferences and Skills Rules (based on user's answers to system questions) in order to assign the inferred values of a user skills and preferences.

Step 3 is the matching and filtering step that generates the list of suggestions based on comparing the values of employee skills and preferences with the values of the skills and attributes required. A skill is considered satisfied if its value for the user is equal to or greater than its value required at university/Institute, otherwise the skill is considered unsatisfied. Test fields can have the values Satisfactory, Unsatisfactory, or Unknown (the Unknown value is assigned to a test field in case the user's skill or preference value is not determined; which is the case if he skips some ES questions without answering them (see Figure 8). The user is always encouraged to answer as much questions as possible in order to reduce the Unknown test values. At the end of this step, all answers having some (one or more) "Unsatisfactory" test values are excluded from entering the suggested list, and that have either all Satisfactory tests or combination of Satisfactory and Unknown tests enter the suggested list with the one having more Satisfactory values ranked higher in the list. The process of looping over the generated lists, comparing, and filtering them is achieved using KAL codes containing the powerful Kappa-PC's function 'EnumList' which is able to loop over all the elements of its argument list using a dummy variable (X for example) to perform an expression for each element in the list (X is matched with each element in the list in turn and is used in the action expression of EnumList).

6. The User Interface and Sample Consultation

The Interaction between the users and the expert system is supported through a friendly graphical user interface running under Windows environment. Figure 6 shows the current main screen of the system where various options (or buttons) are displayed. The Button "Data Input " is used for updating and adding new information in the system and the button "Information Kiosk" displays the information required by varied members as per their requirement and also as per their level of authorization. The user can see the user manual and get more help on using the system by clicking the "Help" button, or exit the system by selecting the "Exit" button. The main option here is "Data Input" from which a new user is directed to several successive screens asking for the user's data requested by the system (Fig-7).

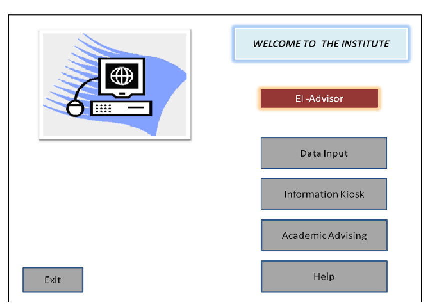

Fig 6. The Main screen of EI Advisor

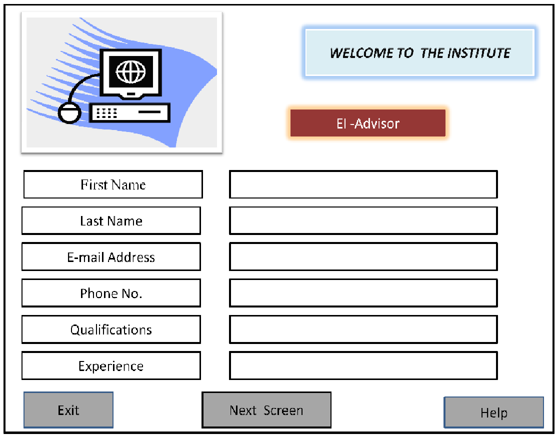

Fig 7. Simple User Data Input Screen

After all user data input screens, the user is prompted to answer several successive questions through which user's skills and preferences are extracted as shown in Fig 8.This will mainly be useful for such users whose Graduation and Post Graduation are in two different branches.

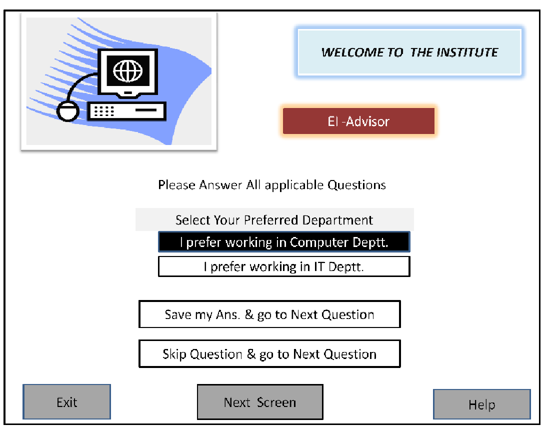

Fig 8. Sample Question Screen for Determining Preferences

At the end of the consultation the ES presents the list of suggested Departments (a ranked list) and the list of allowable Departments as shown in Fig 9. Presenting both lists on one screen gives some sort of 'explanation' to the user since the user can easily recognize the Departments that were excluded from the list of allowable one based on his/her skills and preferences (detected from user's answers).

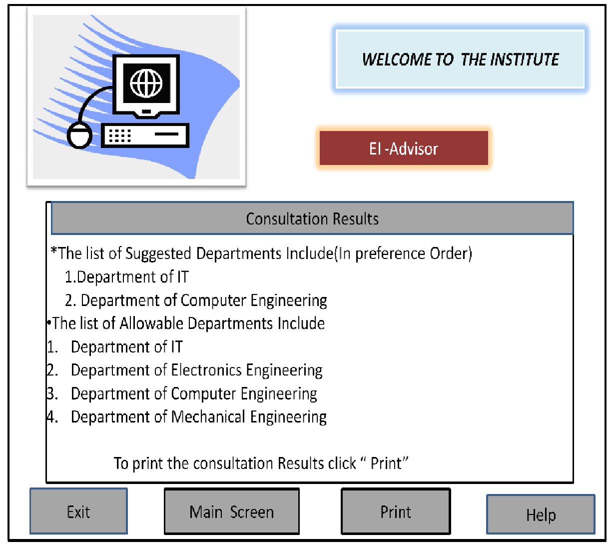

Fig 9. Sample Result Consultation Screen

7. Expected Benefits of the EI-Advisor

Some of the applications and expected benefits include:

- Administration: Every educational institute need to deal with complex problems on a day to day basis. Problems with budgeting, staff and planning are just a few difficulties they face every day. During budget cuts, the administrator must decide what items to cut and how much. Should staff be removed or more staff needs to be recruited in a particular department. They also need to decide how much money is needed for infrastructure development/ Lab set up etc. The advisor could be helpful in assisting the administrator in making these decisions.
- Staff Management: In hiring, promoting and placement of staff, an expert system advisor might be helpful. By using criteria, such as qualifications required for the job and experience, an expert system could be used to assist in decision making. The advisor would suggest which staff members should receive raises, disciplined or dismissal.
- Planning: The advisor using information from patters and material usage could help plan for remodeling or creating new facilities. The system would help to decide the location of class rooms, labs, departments etc. their size capacity so as to enhance the usage of resources.
- Technical Services: More efforts have been in developing the advisor applications for technical services. The focus of research efforts are witnessed in the areas of location of departments, office, principal chamber, workshop etc.

- Guidance to Students: The advisor would guide the students where there lectures will be conducted, information of the syllabus and the labs. They can also note the tentative examination schedule from academic calendar, besides being aware of the timetable. Also final and pre-final year students can gather information about campus placement from the advisor.
- Guidance to Departmental Heads/ Staff: The advisor will assist the heads in deciding subject allotment to staff members in a particular semester, by putting suggestions from past records. Staff members of any department teaching any subjects will be able to access the list of available books in library for their subjects. They can also recommendation for any other books required.
- Integration: It will integrate the institutional development process to the business strategies and will enable the institution to quickly respond to its goals
- It will help to create a culture that rewards rather than punishes mistakes
- It will help to take decisions under uncertainty considering complex preferences. It will help the management to take the decision/advices by considering all the possibilities required for the management in the organization by tracking the skills of the employees working.

8. Conclusion and Future Work

In this paper a prototype expert system supported with an object-oriented database for the management of an educational institute has been proposed and developed. The system provides the management, staff and students with a useful decision support tool for quick and easy search and selection. The system has a graphical user interface and simple menus. The architecture used in the design of the system will result in a successful software system that is easy to maintain, modify, and extend. The concept has been integrated with expert systems approach for decision making and if implemented will yield benefits to define changes in the overall development of the institution and growth of the individual faculty. It also promises fair appraisals and succession processes resulting in job satisfaction for all employees. Many parts of the system can be improved further and some issues deserve future work, among them:

1. Being a prototype system only regular students and staff are currently included, therefore others (like students taking admission directly to 2^{nd} year from Diploma) can be added in the future developments of the system.
2. The system can be improved by making it an internet-based system so users can access it online and regis ter in the system and be able to save and retrieve their past consultations results.

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