USING AN ACADEMIC DSS FOR STUDENT, COURSE AND PROGRAM ASSESSMENT

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Abstract *¾ Decision-making necessitates accurate information to be available in a timely fashion. Too often information is not available to decision makers in a useful form or the available data has not been evaluated sufficiently to reveal hidden or crucial details. Universities need to have extensive analysis capabilities of student achievement levels in order to make appropriate academic decisions. Conversely, certain academic decisions will lead to changes in academic performance, necessitating periodic assessment for determining the effect of changes. In this work, a performance based academic decision support system employing data mining techniques is developed in order to extract useful information from raw data available in student databases. In addition, the different ways in which student performance data can be analyzed and presented for academic decision-making are studied. Application of the technique to student, course and program assessment is also investigated.*

Index Terms ¾ academic decision support system, assessment, data mining, performance statistics.

INTRODUCTION

Academic decision-making is a necessary part of university administration. Accurate and timely information is of paramount importance for informed decision making. Too often, the information is not available to decision makers in a useful form or the available data has not been evaluated sufficiently to reveal hidden or crucial details. Universities need to have extensive analysis capabilities of student achievement levels in order to make appropriate academic decisions. Conversely, certain academic decisions will lead to changes in academic performance, necessitating periodic assessment for the determination of the effect of changes.

The study of academic decision-making process, effective resource management, personnel administration, automation of student registration, factors determining retention, graduation and dismiss have always been of great interest to educationalists. More recently, the issue of assessment has been a hot research topic. Various academic decision support systems (DSS) for academic planning, evaluation, advising and comparison have previously been proposed [1]-[7]. Kassicieh and Nowak [1] investigate the model-based DSS for allowing the decision-maker to plan and respond quickly to changes in academic environments. These include changes in admission policies, forecasts of student demand for particular courses, effects of introduction of different majors, program standards and modified GPA requirements, as well as some other well-defined changes. Turban *et al.* [2] review various approaches for use of DSS in academic administration. Modeling and simulation of student profile changes to determine retention and graduation rates using Markov chain analysis has been studied by Borden *et al.* [3]. Prediction and analysis of freshmen retention has been investigated within the context of cognitive, affective and psychomotor domains by Zhang and Richarde [4]. Bailey *et al.* [5] developed a model for predicting student retention. The use of a DSS for academic advising has been investigated by Murray and Le Blanc [6]. Performance evaluation of academic departments in a university in terms of productivity and quality has been the topic of research by Lopes *et al.* [7] for possible resource allocation amongst departments.

Student performance data contain a wealth of hidden information. It is necessary to mine this information from raw data available in the student databases. An academic decision support system employing data mining techniques needs to be employed for consistent and standardized analysis of such data. Student performance data can yield valuable information about many related fields; the course and semester grade distributions for single or multiple terms, the regularity of students, regularity according to semesters, CGPA distributions at graduation, satisfactory/unsatisfactory status, time for program completion, retention levels, absent/dismissed status are but some examples.

If student intake to engineering programs is from a wide-ranging background, students may experience different difficulties as may be indicated by the loss of regularity at different semesters or as a result of different courses. Identification of particular problems experienced by groups of students is helpful in determining bottlenecks in the program. This in turn may help to identify courses that must be given additional attention or in determining the adequacy of program admission requirements. Pre-requisite level of knowledge of students for success in certain courses can be better identified in this manner.

In this work, the different ways in which student performance data can be analyzed and presented for academic decision-making are investigated. A software package called the Performance based Academic Decision Support System (PADSS) is designed and developed for this purpose. The software system makes extensive use of

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standard graphical displays for presenting the results. This allows the comparison of different programs with each other in terms of program success and student performance using standard interfaces. Although the technique is very general, it is especially useful in comparing different engineering programs within an engineering school. Statistical information on attrition rates, retention levels, program completion rates and durations can be obtained. Furthermore, grade distributions in any course in a university for any period of time can be obtained and compared with similar courses in other departments. This helps the assessment of different courses within a curriculum. Student graduation performance versus entry qualifications for any department or school can be obtained as well as grade distributions for all the courses offered in any program in the university. Overall term-based performance of students in a program can be assessed and compared in this manner. Performance of an individual student can be tracked through the presentation of transcript-based information using a search facility. In general, the performance parameters chosen can be viewed at the individual student, department, faculty/school and university levels. In short, it is an aid in the assessment of student, course, program and department.

The rest of this paper is organized as follows. In section 2, the issues of data warehousing, mining and the use of some of the ideas in PADSS are discussed. In section 3, the aims, objectives and capabilities of PADSS are discussed. Sections 4, 5 and 6 provide a look at student, course and program/department assessment issues respectively. Finally, the conclusion is presented in section 7.

DATA WAREHOUSING, MINING AND PADSS

Data warehousing is applicable when large data repositories need to be considered. Such databases may be formed by the accumulation of years of student, course and program data. A well-designed data warehouse supports an assessment environment by automating the collection of data and its analysis [8]. Data mining is the popular term used for *knowledge discovery* in databases [9]. Its tools allow the discovery of trends, patterns and correlations within data repositories invaluable in strategic decision-making. All data-mining applications have the common aims of detection, interpretation, and prediction of qualitative or quantitative patterns in data [10]. Deriving qualitative assessments from quantitative data is an important challenge for data miners. Many large organizations are now utilizing some form of data mining in their business operations. Credit card companies, super-store chains, e-commerce companies are using data mining techniques to find out about customer preferences, relationship between socioeconomic status and purchasing habits, etc. Stock exchanges use data mining techniques for identifying correlations in suspected company operations.

Student databases at universities can be very large, depending on the number of students enrolled. Indeed, past student data may also be of interest in many data mining or statistical operations. Hence, many universities have all past and present students in the same database or in multiple, related databases. At its present development level, PADSS has some built-in data mining capabilities; it allows the filtering and presentation of data in suitable forms and graphical representations (visualizations) more easily understandable by users. Derivation of the qualitative inferences is left to the educational expert or the administrator. The software is amenable for improvement to include additional "data-mining" concepts such as induction, querying, approximation, compression and search. Data warehousing is also available through the design of a local Database Application Programmers Interface (API) and extension of the design to the client-server architecture.

RATIONALE AND CAPABILITIES OF PADSS

The aim in the design and development of the PADS System is to equip academic decision-makers with a tool for organized information access, enable easier assessment of academic performance and shed a new light on potentially new techniques suitable for the evaluation of main academic decisions. The above may be achieved with the following objectives:

- Analysis and design of a new academic performance evaluation criteria,
- An in-depth understanding and demonstration of the parameters affecting academic performance in universities,
- Analysis, design and development of a software system suitable for general university environments using the semester based education system. This system is a complete package unlike most current systems, which necessitate manual data extraction and evaluation,
- Development of intelligent user interfaces for easy navigation and gathering of required information from the databases,
- Development of a general Database API for future adaptation to other universities,
- Design and development of a modular object based/oriented software package providing solutions to the ideas proposed above,
- Demonstration of powerful techniques for achieving the aims of the project.

A number of major goals have been achieved in this work. For example, it has been demonstrated that academic environments are amenable to data mining techniques and that a wealth of information is available provided data sitting in databases are processed in an intelligent way. Novel proposals for academic performance evaluation criteria have been put forward, for example the distribution of student CGPA at graduation and the ratio of Academic Term/Time

of terms in University (ACT/TIU). Novel techniques for displaying data have been proposed; for example, display of number of students versus academic term and terms spent at the university on a departmental basis. The notions of average, better than average, and worse than average performance for such students have also been proposed. The PADSS software is an object based software package which provides a flexible and sophisticated environment for presenting the ideas proposed as well as having the flexible infrastructure for future expansion. This package facilitates the analysis by providing a user-friendly environment, useful graphical charts, easily readable tables, opportunity of adding different points of view to the analysis, and sharing of information. The examples of the graphical capabilities are shown in Figures 1 and 2.

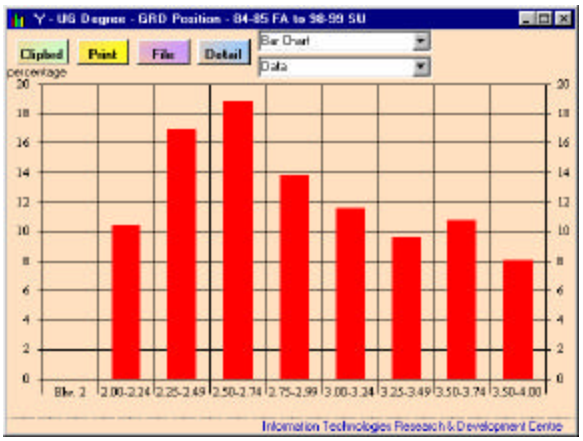

FIGURE. 1
DATA GRAPHING CAPABILITIES OF THE PADSS SOFTWARE.

The package is designed with many useful features like the 'Toolbox' feature, which allows the developers to add future packages easily and 'student search engine' which helps the user to find personal and academic information about any student recorded in the university database. Finally, the update ability for data used, allows the use of new data added to the university database during each new academic semester.

Types of Analyses Available

The types of analyses made available by the PADSS software are listed below:

1. Analysis of students in 'graduated position' with respect to CGPA and ACT/TIU.
2. Analysis of students in 'undergraduate or postgraduate position' with respect to CGPA.
3. Analysis of students in 'dismissed, transferred or absent' (DTA) position with respect to CGPA and ACT/TIU. Figure 3 shows an example DTA display. As it can be seen, the majority of students (78%) in the DTA position have unsatisfactory academic standing.
4. Detailed departmental analysis of undergraduate or postgraduate students:
   4.1 Analysis with respect to ACT/TIU
   4.2 Analysis according to 'worse, regular or better' position with respect to ACT/TIU. Figure 4 depicts an example of this information using pie-chart.

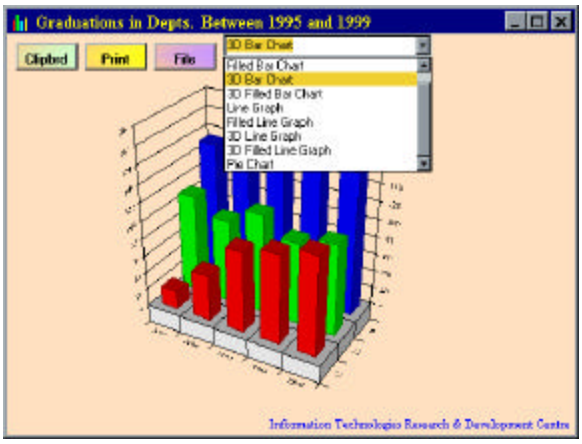

FIGURE. 2
GRAPHICAL DISPLAY HANDLING CAPABILITIES OF THE PADSS SOFTWARE.

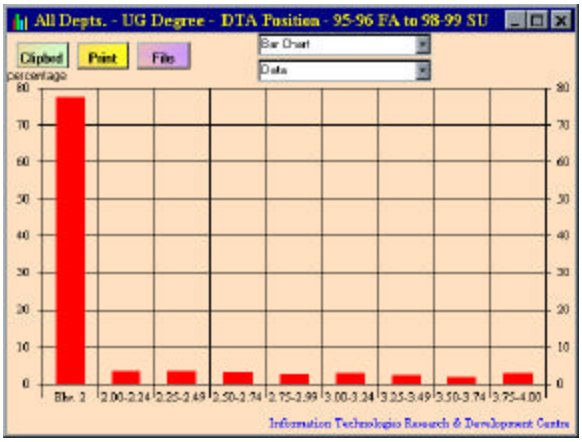

FIGURE. 3
CGPA DISTRIBUTION OF STUDENTS DISMISSED/TRANSFERRED OR ABSENT FROM UNIVERSITY BETWEEN YEARS 1995-99.

5. General Analysis
   5.1 University population with respect to semesters for a range of years. Figure 5 shows the university population change between the dates 1995-99
   5.2 Registrations with respect to years and departments
   5.3 University-wide CGPA based academic standing
   5.4 University-wide ACT/TIU based academic standing An example display is shown in Figure 6
   5.5 State of a course based on grade distribution (for a given number of semesters)
   5.6 University/department-wide, number of graduates
   5.7 University-wide grade interval distribution for all courses.

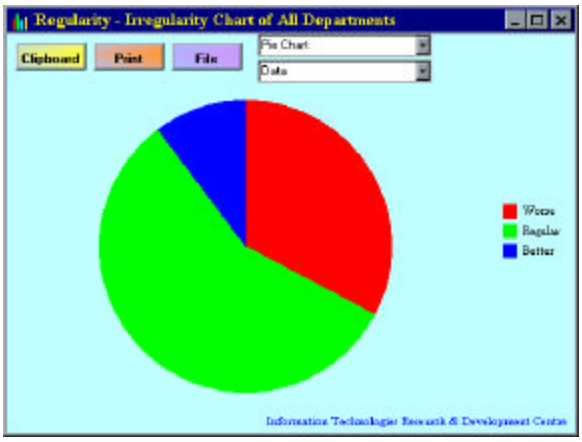

FIGURE. 4
REGULARITY CHART FOR THE UNIVERSITY BETWEEN THE YEARS 1995-99.

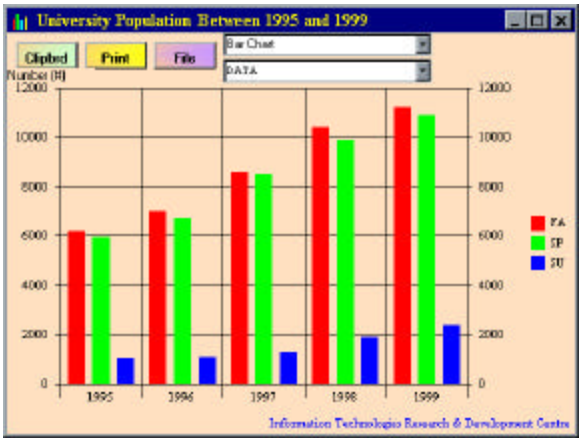

FIGURE. 5
STUDENT POPULATION CHANGE BETWEEN THE YEARS 1995-99.

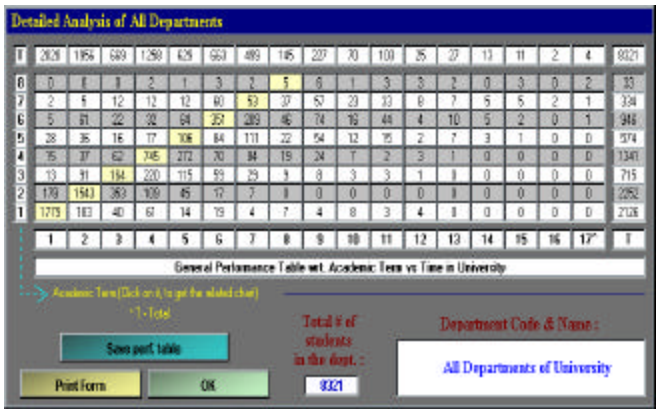

FIGURE. 6
ACT VS. TIU CHART FOR THE UNIVERSITY FOR ACADEMIC YEAR 1999-00.

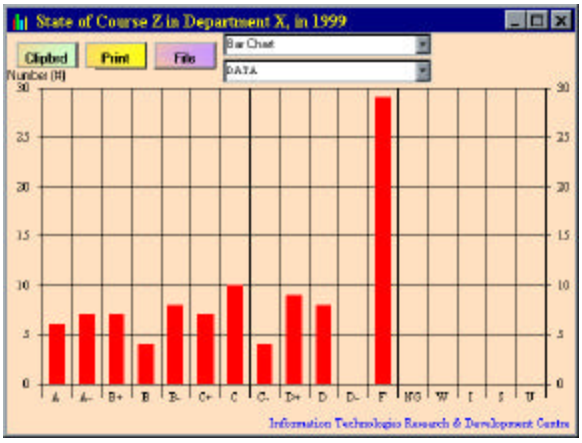

FIGURE. 7
DISTRIBUTION OF LETTER GRADES FOR THE FIRST YEAR COURSE (Z) IN DEPARTMENT X FOR ACADEMIC YEAR 1999-00.

The following are features desirable but not available in PADSS:

- Course evaluations by students have so far not been integrated into the software. However, this information is available at the university and can easily be incorporated into the software
- Outcomes assessment is not carried out: neither the data collection nor analysis is available in this version
- Staff assessment is limited to seeing the performance of course given by a staff member.

STUDENT ASSESSMENT

The academic success of students are generally measured in terms of the grade point average (GPA) and the cumulative grade point average (CGPA) points they have earned at the end of each semester and at graduation respectively. In cases where a fixed number of credits have been set as program completion requirements, the expected duration of "normal" graduation is known in advance. In such cases, student performances can be compared not only by their CGPA points but in addition by using the time that was taken to graduate. We have called this the ACT/TIU ratio, where the ACT is the academic term and the TIU is the time in university (i.e. the time spent in the university) in terms of the number of semesters registered in a given program. Student performances can be compared using this temporal value. The PADSS system allows the search of a student by student-id, surname or name, displays the traditional semester based course performance, current courses registered, the GPA and the CGPA values obtained by the student as well as the ACT/TIU ratio. This value is indicated for each registered or graduated student.

COURSE ASSESSMENT

In assessing a course we need to ask the following questions:

- Is the course achieving its aims in passing on the desired concepts in the course material to the students in such a way that students can follow the next related course without any problems.

- Are the prerequisite courses specified for this course adequate for the students in understanding all the concepts in this course.
- Are the evaluation techniques used for this course adequate to measure how much of the key concepts have been learnt by students.
- Is the course balanced out well in studying the course-material. This may be considered in terms of the time spent on different topics and concepts or in terms of the theoretical and laboratory work, the number and types of homework, term-projects etc.
- How difficult is this course found, as indicated by:
  - The mean grade point obtained by students in a given semester
  - The distribution of grade points obtained by students in a given semester
  - The mean repetition rate of the course
- How does this course compare with other courses in the curriculum in terms of its "perceived difficulty" by students.
- Is there any way of determining the reasons of the "perceived difficulty" level of the course.
- Is there a consistent distribution of marks in the evaluation of students.

The first two questions raised above relate to good curriculum design. The third relates to good evaluation techniques appropriate for the course material, and the correct evaluation of the learning of key concepts. The fourth point raised relates to the delivery techniques of the material. These questions are not readily amenable to assessment using performance statistics. However, questions 5-8 may be answered using performance statistics of students. We have tried to address these issues to some extend. In assessing a course, we may make use of the following performance statistics:

- Distribution of grades for a given course for a semester or for a number of semesters. An example of this is given in Figure 7 which shows the grade distribution for a first year course in department X.
- Distribution of grades for all the courses offered by a department
- Course grade-point and letter averages for a given semester
- Departmental grade-point and letter averages for a given semester

Additional insight into points 1-2 raised above can be obtained by using performance statistics as follows. It is possible to find out how well the students obtaining the "average grade - C", have performed in the following course. If they perform very badly consistently in the subsequent related courses, then various questions need to be answered. We have not followed this avenue in this paper any further.

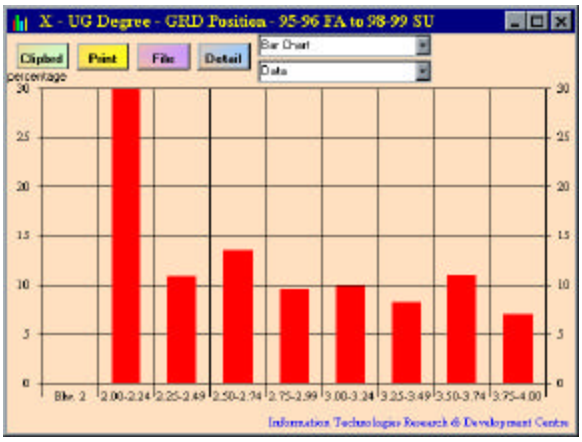

FIGURE. 8
DISTRIBUTION OF CGPAS AT GRADUATION FOR DEPARTMENT X FOR ACADEMIC YEARS 1995-99.

PROGRAM/DEPARTMENT ASSESSMENT

In departments where only one program is available these are synonymous. However, if multiple programs are run, then each program can be evaluated in a similar manner. Departmental assessment can be carried out using several major performance statistics:

- Department mean and standard deviation of the CGPA value at graduation averaged over all graduates
- Departmental mean and standard deviation of time needed by all students to graduate
- Distribution of CGPA values at graduation. Figure 8 shows the distribution of CGPA values for Department X for academic years 1995-99.
- Regularity chart for students registered to a given department. An example of this is given in Figure 9.

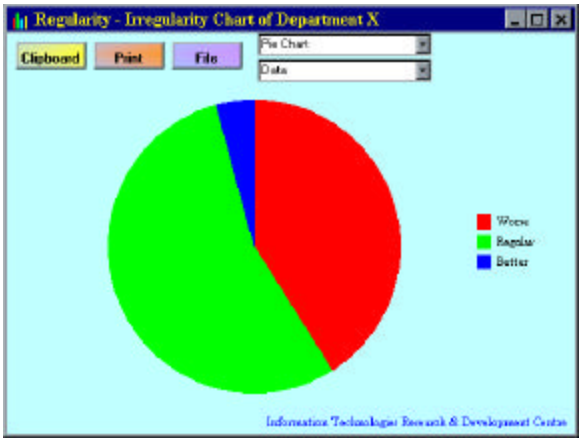

FIGURE. 9
REGULARITY CHART FOR DEPARTMENT X BETWEEN THE YEARS 1995-99.

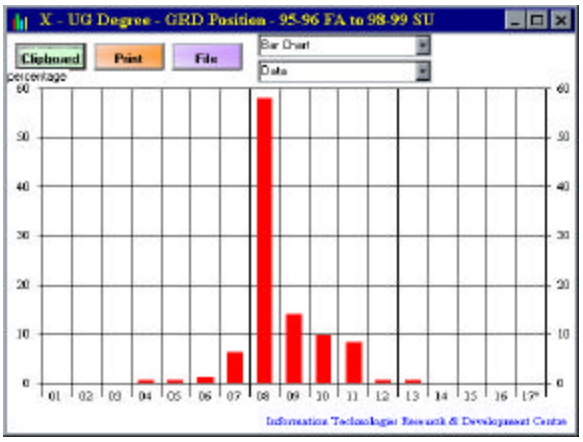

FIGURE. 10
DISTRIBUTION OF NUMBER OF TERMS TO GRADUATE FOR DEPARTMENT X BETWEEN THE YEARS 1995-99.

- Distribution of time needed to graduate by all graduates of the department. An example of this is shown in Figure 10.
- Distribution of the Dismissed/Transferred/Absent students.
- Distribution of CGPA values of currently registered students.
- Departmental mean and standard deviation of the CGPA value averaged over all registered students.
- Departmental mean and standard deviation of ACT/TIU of all registered students
- Semester based departmental grade average from all courses.
- Course repetition (failure) rates.
- CGPA at entry/CGPA at exit value for all students.

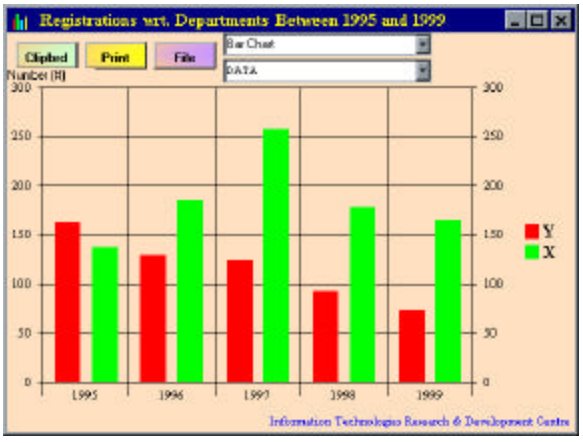

FIGURE. 11
COMPARISON OF NUMBER OF REGISTRATIONS TO DEPARTMENTS X AND Y BETWEEN THE YEARS 1995-99.

In addition to the above, different sets of data can be combined to be viewed together for comparison. For example registrations to and graduations from different departments can be viewed at the same time on the same graph. An example of this is given in Figure 11, where the number of registrations to department X and Y are compared over the time period of 1995-99.

CONCLUSION

In this study, we have shown different ways in which student performance statistics can be used to obtain information which may be used in assessing the individual student, course, program and the department in terms of their performances. A number of data warehousing and data mining concepts are applied in obtaining the required results. Whereas most systems reported in the literature lack actual data, PADSS is currently able to deliver extensive data for analysis. The challenge is two pronged: firstly, interpretation of the masess of results obtainable from the system and secondly, having the qualitative assessment process to be integrated more with the software process.

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