An Academic Decision-Support System Based on Academic Performance Evaluation for Student and Program Assessment*

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Statistics plays an important role in assessment and evaluation of performance in academic environments. Universities need to have extensive analysis capabilities of student achievement levels in order to make appropriate academic decisions. Conversely, academic decisions will result in academic performance changes, which need to be assessed periodically and over spans of time. In this work, the different ways in which student performance data can be analyzed and presented for academic decision-making are investigated and a software package called the Performance-based Academic Decision-Support System (PADSS) is developed. The performance parameters chosen can be viewed at the individual student, department, school and university levels.

INTRODUCTION

STUDENT, department, program and faculty assessment are important steps in analyzing and discovering strengths and weaknesses of students and programs, planning and enhancing instruction and curriculum as well as evaluating and making decisions about students [1]. Evaluation is defined as the act of assigning merit or worth to something [1]. There is a need to do both in academic environments. Furthermore, it is necessary to repeat this process periodically, at the end of each semester and academic year as well as over a specified period of time in order to get a better idea. Indeed, some academic decisions do not lend themselves to comprehensive assessment within a very short time. There are different but related forms of evaluation in academia including assessment, outcomes measurement, retention and attrition measurements. Assessment is defined as determining the value, significance or extent of something. Outcomes studies are expected to concentrate more on academic and intellectual growth of students [2]. Assessment techniques have been discussed widely in the literature [1–11]. Both qualitative and quantitative assessment techniques are available [5]. Alternative forms of assessment including curriculum-based [4], portfolios [7], outcomes-based [9] performance-based assessment [11], and other means of testing students have also been developed.

A number of universities have set up measurement and evaluation units under instructional development offices and carry out senior student surveys as part of student outcome assessment [6]. These units are developing assessment models and are planning the use of results of these efforts to improve instruction and learning. The use of qualitative techniques based on student data available in university necessitate the use of data warehousing and mining techniques since these databases may be rather large and may be distributed [12–14]. In addition, decision-support systems [15, 16] have a place in presenting the data in a meaningful and useful way to the evaluators and administrators [17].

In order to gain an insight, assess and evaluate academic performance, there is a need to carry out statistical analyses at student, course, program, department, school and university levels. However, the data needs to be presented in an understandable form to start with. Detailed statistical testing and inferences can then be made. In this work we have aimed at providing a decision-support platform for academic administrators such that data is made available through the use of standard user interfaces, displays and graphs, as well as in tabular form. This is expected to minimize the time and effort needed to analyze pages of data since they are presented in similar forms for similar objectives.

Academic decisions may require extensive analysis of student achievement levels. Statistical data can also be used to see the results of important academic decisions. It is necessary to have measurements to make appropriate academic decisions on one hand, while on the other hand, there
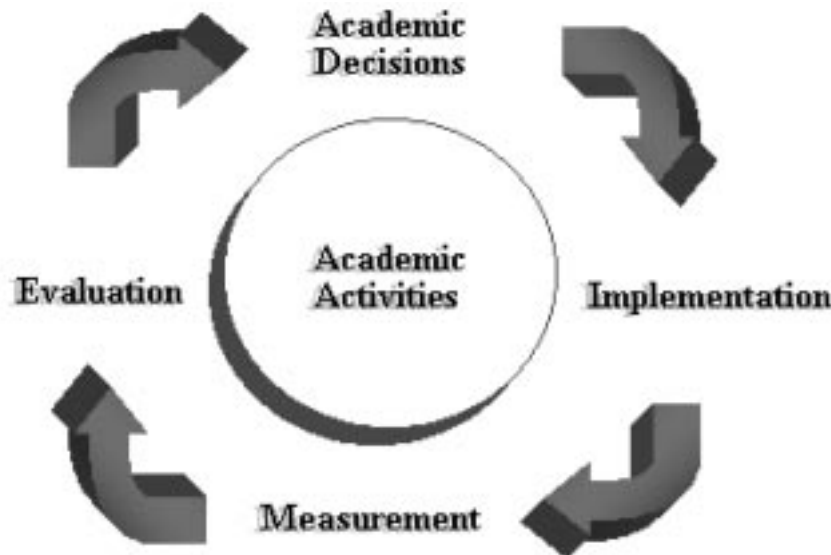
Fig. 1. Phases in academic decision making.

is a need to see the results of academic decisions by taking measurements. The decision, implementation, measurement, and evaluation mechanisms work like a chain one leading to the other. Their relationship is shown in Fig. 1.

Data sitting in databases are of little use unless they are processed, converted and expressed in intelligent ways to present decision-makers with valuable information. In universities, student records form the basis for a wealth of information as well as operations. In many universities, student-related databases are created and maintained by the office of the registrar. These databases include student personal data, course registration data for each semester, the student course performance data, advisor data, instructor data, instructor-course data and the departmental curriculum data amongst others.

The main concern of the registrar offices in universities is the administration of student records, registration and it's academic and financial implications, graduations and the application of the academic rules and regulations to all students. It is time consuming to make statistics gathering or detailed analysis of the available data. Academic administrators and departments on the other hand, need timely and accurate information on student performance for decision making. Academic decisions may have far reaching consequences on student performance. Implementation of such decisions may go into effect immediately or after a certain set date. Alternatively, such new decisions may only be applied to new entrants to the university. Furthermore, the results of such decisions and their implementation, for example the introduction of a 'semester repeat' system in a university, may need several years before its effects on student performance can be evaluated. Measurement needs to be continuous in order to provide continuous assessment. In the academic world this usually means periodical measurement

during or at the end of each term. Long-range accumulation of such measurements is usually needed.

CGPA performance, Academic Term/Time in University (ACT/TIU) ratio and student entry grades are the main qualitative requisites for the analysis of student achievement and assessment of departmental and university-wide performance. Obtaining these items as a list does not give meaningful results. Graphical capabilities need to be used to display/present the data as useful statistical charts and tables that help the user to see the effects of the decisions, performance changes with respect to time, improvements and the effect of the student achievements on the university performance.

In this paper, we present several different ways in which student performance data can be analyzed and presented for academic decision making. Also, we demonstrate the usefulness of an academic decision-support system (ADSS) in evaluating huge amounts of student-course related data. In addition we present the basic concepts used in the analysis and design of a specific DSS software package which is called the Performance-based Academic Decision Support System (PADSS).

RATIONALE AND OBJECTIVES

The system aim is to present academic decision-makers with a facility for the evaluation of academic performance as well as presenting them with a tool for organized information access. It is also aimed to shed new light on potentially new techniques that can be used in the evaluation of major 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 would be a complete package unlike most current systems, which necessitate manual data extraction and evaluation by users.
- Development of intelligent, object-based or object-oriented user interfaces for easy navigation and obtainment of required information from the databases.
- Development of a general database application programmers interface 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.

SYSTEMS ANALYSIS AND DESIGN

Systems analysis is a necessary part of development of every engineered software. The paradigm used in systems analysis and design is based on the hybrid of 'Prototype Paradigm' and the 'Waterfall Paradigm'. This is found to be useful for this particular development due to the complex nature of data to be presented. The particular methodology used for system development is the Structured Systems Analysis and Design Methodology (SSADM). By using the SSADM, data and control flow in a system can be determined and shown in the systems analysis phase. The PADSS system interacts with users and the various databases to produce, display, print or save the results obtained. The Data Flow Diagram (DFD) of Fig. 2 shows the main interaction types at near-conceptual level.

Control (1.1) transform of the first level DFD shows the Main Menu of the system. Presentation and Application (1.2) transform is under the control of transform 1.1; hence, the whole program runs under the control of transform 1.1. The latter transform accepts further user input once the first select command is entered at the display of the main menu. The presentation and application transform then obtains the data needed by the user and generates the necessary graphical display allowing the user to have various printing and file/clipboard action selections.

The system design is modular and allows the addition of necessary modules at a later stage to the software package. The system is GUI based and hence necessitates little input from the users, achieving results with mere mouse clicks. Object-based techniques have been used in developing the software.

DATABASE MANAGEMENT

A purpose-designed application database is designed and implemented. The data available in the university databases are converted, calculated and sorted to form the core of the package database. This is done in order to have a maintainable standard database interface, to de-couple
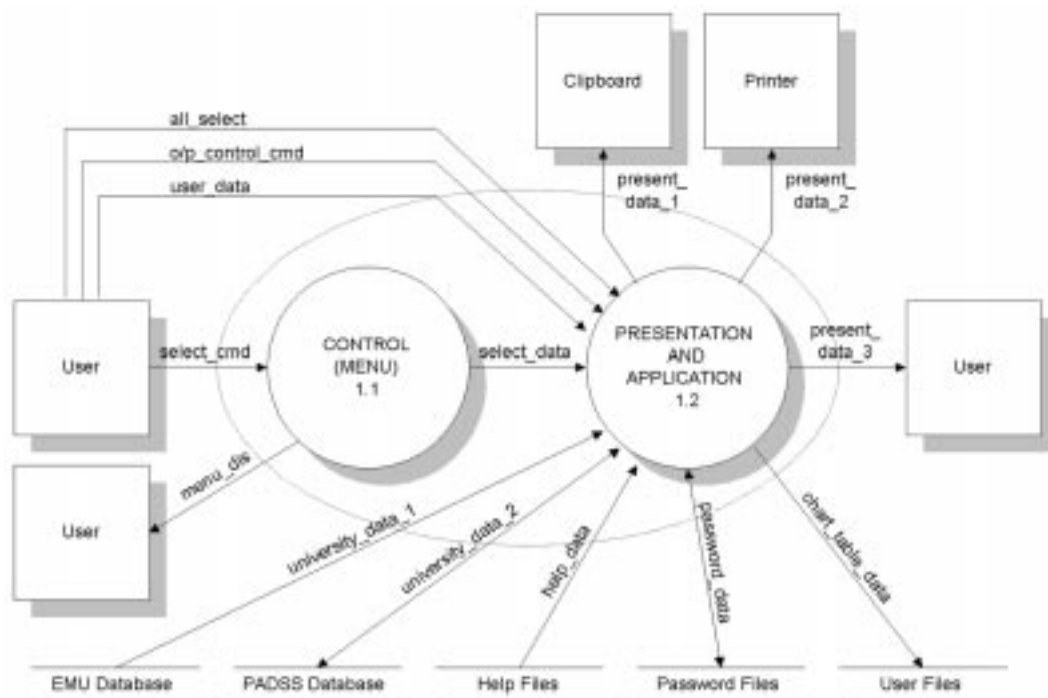

Fig. 2. Main interactions available within the PADSS package.

the development from local university databases and to provide a Database User Interface (DUI) or 'Database API' to which all other available database formats, from any university can be converted. Furthermore, with this technique ease and speed of access are the aims to be achieved.

While dealing with statistics, trying to give important decisions or trying to see the results of decisions the users must concentrate on their work; no one wants to be lost in a huge bulk of raw data. On the other hand, if anyone wants meaningful statistical results but does not know how to manage the raw data, it will take him/her a long while to learn the correct steps in using a general-purpose statistical and/or database package. Furthermore, all the data must be extracted, refined and analyzed using the same approach every time. The express aim is to grab all useful and necessary data and turn them into statistical information.

Data available in the university academic databases are not used directly, as these are not optimized for the purpose of this project. Two types of files are used to form the PADDS database. The necessary data from the database of the university are converted into text and MDB (Microsoft Database Format) files after applying the necessary calculations. As can be seen no new data type is produced. In many applications a new data file type is produced specially for the application. This feature has one big advantage; any other database or statistics program can use the PADDS database. There is no need to have any special application to convert, to see and to use the produced database. The reason for using the text and MDB file types is based on a simple logic. Text files are easily manageable and the MDB file type is native to many well-known programming languages; hence, there is no need to use any extra interface program to maintain compatibility.

From the user point of view, the usage of the PADDS program differs from any statistical package. In a statistical package, the user is much more closer to the database because he/she has to have the application package, read the database, make the necessary filtering and sometimes apply some formulae or rule to obtain the desired result. In that case all the results for an academic analysis need to be planned and placed in the application program.

MDB files are mostly used in transcript processing and listing, which requires indexed and huge data files. Text files contain almost all the data of the statistical charts and tables. The data in the text files is calculated during the update process, so there is no need to re-calculate the data during presentation. Usage of pre-calculated data increases the speed of chart construction. Also, these files are very small in size and any program can read them rapidly without any memory or swap space problem.

ACHIEVEMENTS AND RESULTS

The general environment

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. An object-based software package has been designed and developed called the Performance-based Academic Decision Support System, 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 different point of views to the analysis, and sharing of information. 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, update ability of the data used by the package has been developed, allowing 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 Cumulative Grade Point Average (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' position with respect to CGPA and ACT/TIU.
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.
5. General Analysis:
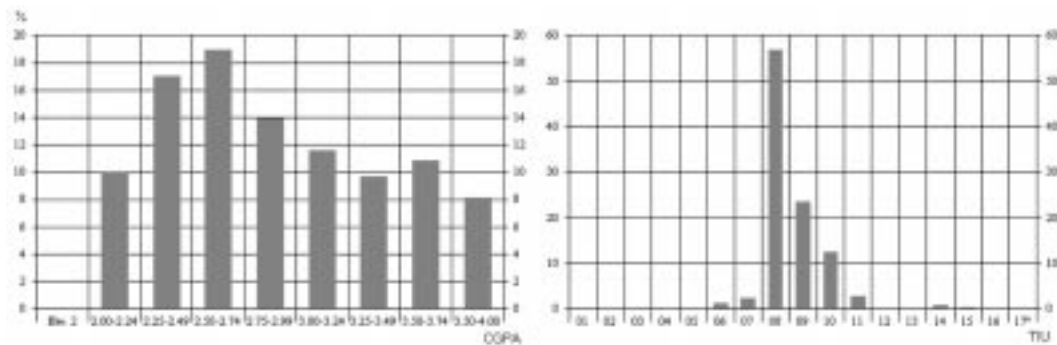   5.1. University population with respect to semesters for a range of years;

Fig. 3. CGPA and ACT/TIU comparison.

5.2. Student registrations with respect to years (and departments);

5.3. University Wide CGPA based academic standing;

5.4. University Wide ACT/TIU based academic standing;

5.5. State of a course based on grade distribution (for a given number of semesters);

5.6. University-wide and department based, number of graduates;

5.7. University wide grade interval distribution for all courses.

Statistics for academic decision making

CGPA and ACT/TIU comparisons can be examined using statistical charts. Student performances can be assessed based on the ACT/TIU ratio achieved by the student as well as the more traditional CGPA value attained at graduation. Students may graduate with good CGPA values but they may not necessarily be 'regular'. This is especially true in assessing 'early' as well as 'late' graduations. Figure 3 is a combined graph showing the distribution of CGPA standing of students at graduation against the time taken to graduate in terms of the number of semesters taken. It can be examined to illustrate the issue of regularity. In Fig. 3, the performance of students at graduation is well distributed with a median at the 2.50–2.74 value. The majority of students (approx. 57%) are found to graduate in 8 terms. If this graph was one where students needed on the average 10 semesters or more, then perhaps one would look for a correlation between the grade distribution and the time taken to graduate. These two factors can be used to compare 'performance' of two or more different departments in terms of their student performances.

The effect of changes in academic sufficiency levels can be examined by examining the regularity ratio of the students. Figure 4 examines regularity after a change in academic sufficiency level in 1996 (e.g. application of no-grade (NG) mark in evaluations). As well as new sufficiency level applications, changes in the academic system can affect regularity ratio. Here, the 'regular', 'better than regular' and 'worse than regular' student numbers are shown as a percentage of the total registered students for years 1992–99 for the university.

Figure 5 illustrates the situation after a change in the academic system in a given university in 1992. Here, the 'probation or term repeat system' is lifted and the academic 'warning' and 'attention' system is introduced. The net effect of the academic decision is found to be the reduction of the percentage of students in the satisfactory condition to fall quite rapidly from approximately 68% to 43% by 1995 and then return to 50% level in the middle of 1996. The general 'loss' of university-wide academic standing in terms of CGPA status is matched by an increase in the number of regular students in terms of ACT/TIU, from around 48% to 52% in the same period. For a regular student, the value of the ratio ACT/TIU is expected to be 1. Hence, marginal gain in the average 'time to graduate' has been matched by a marginal decrease in the general CGPA standing of students at graduation.
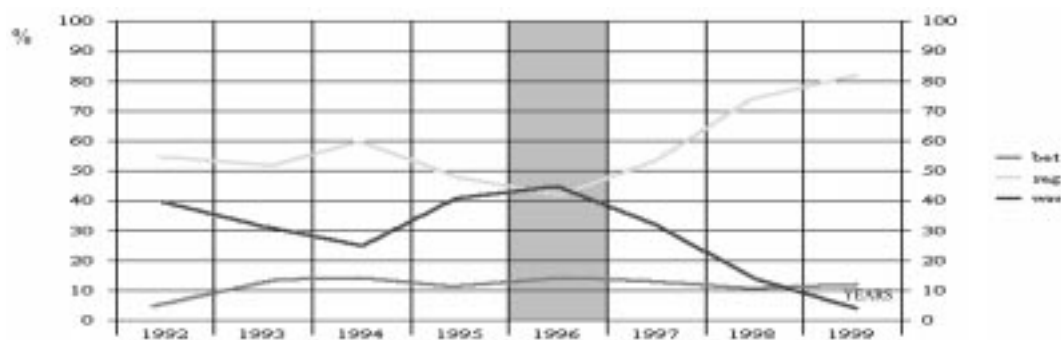

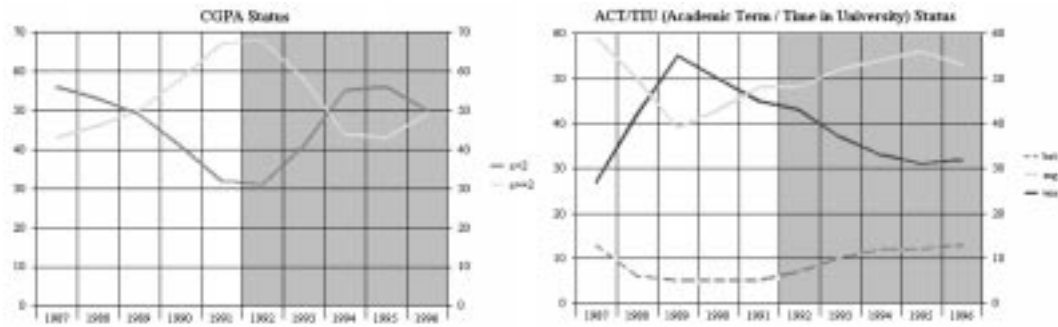Fig. 4. Effect of changes in academic sufficiency levels.

Fig. 5. Effect of changes in the academic system.

This in turn has increased the distribution of CGPA values near the 2.00–2.25 mark for most departments.

The general standing of students in a given department can be analyzed using a well constructed ACT/TIU table. This is shown in Fig. 6. This table summarizes the current performance of any given department; here the department X is analyzed. Students are placed in respective academic terms (ACT) in the Y axis direction, while they are also located according to the number of academic terms spent at the university (TIU). This novel technique allows the clear display of regular, better than regular and worse than regular students. It also identifies the semesters in which student regularity is broken, perhaps due to one or more difficult courses in the curriculum. Hence, it allows closer scrutiny of the effects of semester-based courses on the student population. This table can be obtained for different departments, or for the whole school or university and compared with each other for additional information.

Individual courses can be analyzed for any specific period in terms of grade distributions. This is depicted in Fig. 7. Here, the grades distribution analysis is carried out for course CRS 422 for the period 1990–1996. Any grading policy changes may easily be indicated especially due to staff changes, hence allowing tracking of general performance of students in a particular course. This also allows a simple course assessment process for the administrator.

GENERAL ASSESSMENT OF THE DEVELOPED SYSTEM

The PADSS system developed is named the Eastern Mediterranean University Academic Statistical Analysis (EMUASA) software. In this section we evaluate the system developed from the point of view of ease of use, usage, adaptability, expandability, ease of data update and cost to operate.

The system design has been carried out with ease of use being one of the highest criteria in the design of the software. It has an extremely user-friendly Graphic User Interface (GUI). This allows the obtainment of all statistics and information with a few mouse clicks. All selections are given as a combo-box presentation allowing point and click operation. The only place for user data entry is when using the student search engine. Here the

Detailed Analysis of X Department

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17^	T
8	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	3
7	0	0	2	0	0	1	0	0	0	1	2	0	0	0	1	0	0	7
6	4	0	0	1	0	7	2	0	0	0	0	0	0	0	0	0	0	14
5	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	3
4	2	2	3	12	5	1	0	0	0	0	0	0	0	0	0	0	0	25
3	0	1	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	8
2	3	19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
1	31	11	4	4	0	2	2	2	2	2	1	1	0	0	0	0	0	62

General Performance Table wrt. Time in University vs Academic Term

---> Academic Term (Click on it, to get the related chart)

[Save perf. table] [Print Form]

[OK]

Total # of students in the dept. : 145

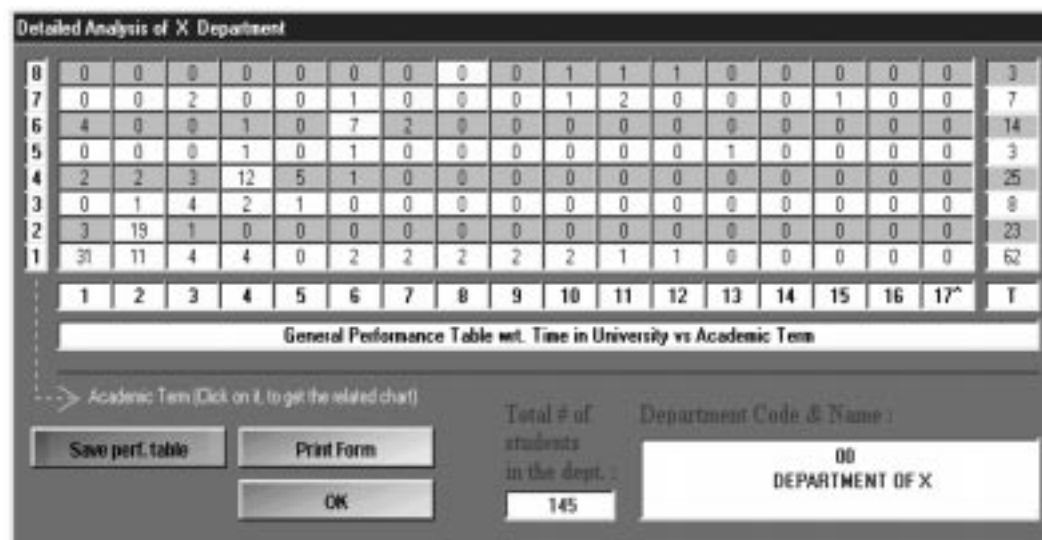Department Code & Name : 00 DEPARTMENT OF X

Fig. 6. General performance table with respect to ACT/TIU.
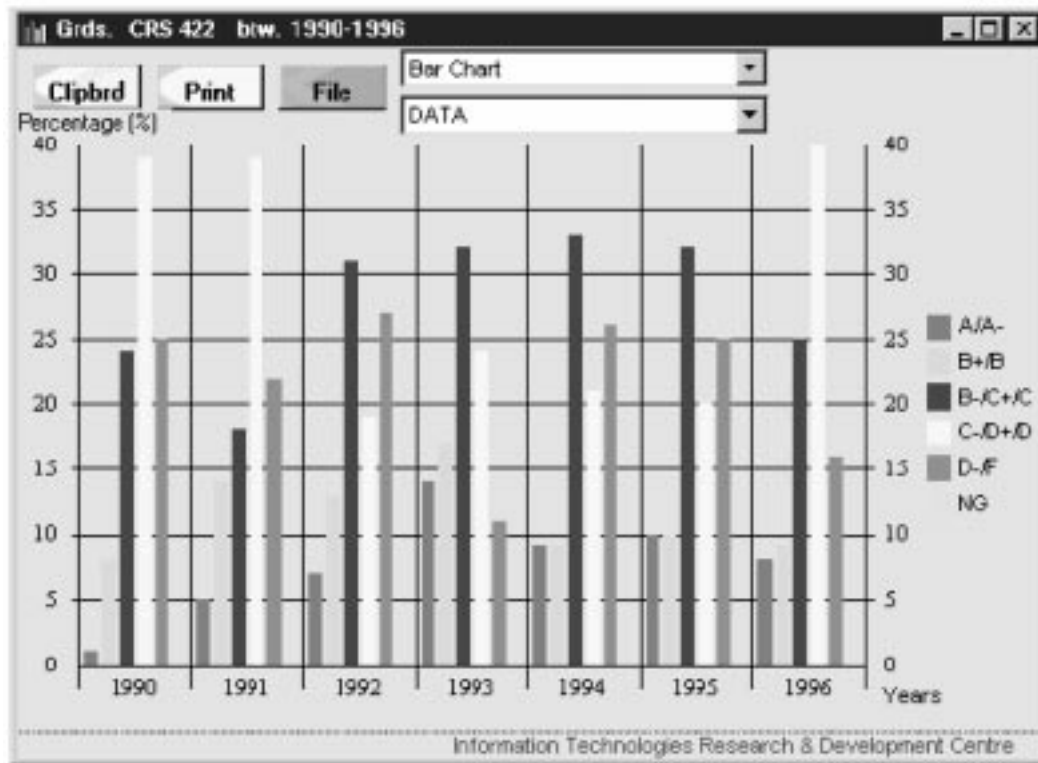
Fig. 7. Grade distribution of a given course in any period of time.

student name, surname or student number can be entered alternatively to find the records of the desired student.

The software has not yet entered widespread use. However, two different configurations have been developed. The first one is a standalone version and the second one is the client-server version. The advantage of the client-server version is that a central database can be maintained which will be updated centrally and all client user names and passwords can be controlled at the server side, hence allowing security and confidentiality.

The software is highly adaptable and expandable due to its modular nature of design based on software engineering principles. Additional functionality can be added using the Toolbox section, while adaptability to other university databases is provided by the use of a novel Database API. In this way, any university database can be filtered and interfaced to the EMUASA software using the API facilities provided.

The data update is the most time consuming operation within the software. As the data update involves the pre-filtering and formation of the new EMUASA database, it takes a rather long time. However this is well worth waiting for since the database access is then almost instantaneous even for the most difficult search operations.

There is no cost to operate the software as it can be used by non-experts. The only cost foreseen is in the maintenance of the client-server version of the software. This will need the attention of an operator in order to manage access, privileges, user profiles and data update over the network.

CONCLUSIONS

An integrated approach to the academic decision-support system design has been demonstrated which includes administrative and planning features as well as statistical analysis of performance features. The importance and wealth of information that can be extracted from student registration and grades databases has been shown. An extremely useful and critically important tool for general university performance analysis has been proposed, designed and developed that provides a great insight to the effects of major academic decisions. Examples of these are the implementation or removal of a 'Repeat (Probation) System', or changing the 'Entry Requirements' or the 'Examination Type' for entry to the university. Definition and use of general performance indices for global use have been made. These include ACT/TIU ratio, distribution of grades at graduation and during education, ACT/TIU table and the scatter diagram for entry/graduation CGPA values. Display of information in certain useful formats and forms have been proposed and implemented. These include the display of ACT/TIU according to semesters and the average, better than average and worse than average graphs.

It is thought that the PADSS software can be implemented in the management information system (MIS) of the university allowing sharing of information between administrative staff over the campus and local area networks automatically and in real-time without making any data update

process necessary. Furthermore, it can be distributed to other universities and sharing of information between universities regarding their students, decisions and results of their decisions can be achieved over the Internet.

The client-server version of the system will be reasonably cheap to maintain as it will have a client system that will require little support, and a server system that will have automatic data updating if the server is linked to the university MIS system. As student records databases are usually well established in registration systems, they will provide the most up-to-date data to the users of client-server based PADDS system. The standalone version of the system will require centralized distribution of student records databases in a secure manner. It will also require each user to update the student records databases at the beginning of each semester on individual workstations. This will be time-consuming, will need more computing support as the user-base expands and less flexible in terms of upgrading of local databases. Its main advantage would be the independence from the rest of the university MIS system and hence allow easier portability.

PADSS has shown us the potential of academic data mining and the use of academic decision-support software. We have however only scratched at the surface of the different ways this data can be analyzed, interpreted and used in the assessment of student, learning, program success and the effectiveness of teaching. Hence, there is a need for in-depth and detailed analysis of existing university data to expose information in forms not utilized so far; this is certainly within the capabilities of the designed software system.

PADSS is capable of helping to assess the attainment of program educational objectives. Several educational objectives including for example the attainment of higher levels of learning of course material as made evident by the attainment of better grades in a series of (or all) courses, steady distribution of grades in a given course for a given number of years, increasing the student CGPA attainment at graduation and increasing of the retention rates may be followed through a number of years using the PADSS software. A powerful combination would be the use of the PADSS software in junction with the outcomes measurement techniques to obtain qualitative as well as quantitative comparison capabilities.

It is expected that one way of achieving wider usage in the university is the use of the PADS system at the faculty/school and departmental levels as standalone systems. Once the user-base is achieved and the usefulness is appreciated, the client-server version of the software can then be adapted to the university MIS system allowing general adoption and much wider usage at university level.

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