DEPARTMENTAL WORKLOAD ADMINISTRATION USING GROUP FORECASTING IN UNIVERSITIES

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Abstract *¾ Workload assignment to departmental academic staff is an important activity that is based on the number of course groups necessary for a forthcoming semester. Knowledge of the numbers of students expected in each course is vital in determining the departmental teaching workload and achieving its planning and distribution. This knowledge leads to good resource planning and prevents any last minute changes to workload assignment of staff or opened course groups. Without such a facility, course group numbers may need to be changed based on student uptake or the lack of it. In this paper, a system developed for workload administration of a department is described. Experience with the system has shown that the effort in developing the system has been well worth it and its use has resulted in better utilization of academic staff resource as well as increase satisfaction of both the staff and students.*

Index Terms ¾ Academic decision support system, DSS, departmental workload administration, group forecasting.

INTRODUCTION

Workload assignment to departmental academic staff is an important activity within the academic calendar. This activity is based on the number of course groups necessary for the forthcoming semester. The number of students per group and student pass rates affect the their progress to the subsequent courses within the curriculum. The knowledge of the numbers of students expected to sign up for any potential course in the following semester is a piece of vital information in departmental workload planning and workload distribution. This knowledge results in good resource planning and prevents any last minute changes to workload assignment of staff or opened course groups. Without such a facility, course group numbers may need to be changed based on student uptake or the lack of it. This would result in closing some course groups, opening others and shifting staff workload; all with academic overheads.

Many universities around the globe have adopted 8 semester based bachelor programs as their educational time-scale. The main academic requirements for bachelor degree completion are the attainment of a minimum number of credit-hours and the achievement of a minimum cumulative grade point average such as 2.00 out of 4.00. In addition, some programs have additional requirements of residency, summer/practical training or non-credit courses. The curricula in many departments have pre-requisite chains necessitating the taking of courses in some prescribed order. This is necessary in order to make sure that students taking an advanced course have already completed courses incorporating more fundamental concepts necessary for the advanced course but not covered in that course due to course content requirements.

In departments where the numbers of new student intake change from year to year, or in which the student population is dispersed in terms of achievement levels, there is a need to open certain set of courses in order to provide a smooth path for student progress through the curriculum. Further, due to the semester-based system adopted, there may be varying needs for certain courses in each semester. Two approaches are broadly available for departments with a limited academic staff resource: 1) opening of all "must" courses every semester or 2) opening only courses which appear in a given semester (in alternate semesters). Both approaches have their advantages and disadvantages. It can be shown that the two approaches eventually lead to the same resource utilization. However, with the first alternative, students have the advantage of taking a failed course immediately in the following semester. In schools or departments with a high level of irregular-semester students, there is a need to establish or forecast the maximum number of students expected to join in a course if it is opened, or indeed determine the number of groups necessary for satisfying the student program requirements.

The use of computers and decision support systems (DSS) in academic decision-making and administrative use have previously been studied [1-9]. The use of DSS systems in academic planning and administration was studied in [5,6,9]. Murray and Le Blanc [9] propose the use of the DSS system specifically applied to academic advising based on analysis of past student performance and new course suggestions. In [4], a distributed computer system for data warehousing is presented by Ingham which could be used for institution wide outcomes assessment. In [5] Kassicieh and Nowak propose the use of a model-based DSS system by the decision-makers in demand forecasting and in

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resource planning and commitment. A more general use of a DSS system is proposed by Turban et al in [6] where both the financial aspects and student enrollment projections are proposed to be used by academic decision makers. The effect of student performance on graduation rates and on retention are studied through Markov chain analysis by Borden and Dalphin in [7]. It is shown that large changes in student performance levels are needed in order to impact retention and graduation rates to a modest extend. The effect of instructional practices, student preferences and their effect in student performance levels are studied by Belcheir et al in [8]. Application of DSS systems for academic performance evaluation for student and program assessment was proposed in [3]. All of the above relate to academic decision making in some form. However, none deal with the specific purpose of group-size forecasting that is the topic of this paper.

In this paper, we describe a departmental workload administration system (DEWAS) that has the ability to forecast as well as predict the number of students expected in the potential courses for the following semester. The foundations of this work were laid down by earlier proposal of Deniz [1] and software development by Deniz and Yavuz [2]. Here, the basic system that analyses the student performance, generates the suggested-course list and calculates the expected group sizes of the forthcoming courses to be opened in the following semester is described. In this process, additional information regarding the student body expected to take each course is generated. A software package has been developed for implementing the ideas proposed in the system design. This software package is developed as a standalone package as well as a module within a broader departmental information system (DIS), which is perceived as an academic decision support system [1,2]. Furthermore, we report on the use of the system and present our experience with the system gained over the past several years.

This paper is organized as follows. In section 2 the general system requirements are analyzed. The system design and implementation is carried out in section 3. In section 4, results obtained from the system are presented and comments regarding their use are made. Finally, conclusions are presented in section 5.

SYSTEM REQUIREMENTS

The group and group size forecasting necessitates the analysis or prediction of student performance, determination of courses to be taken by each student, and the creation of group rosters [1,2]. The available recorded data is in the form of a student database that is kept by the registrar's office. Other known parameters of the system are the input from the departmental curricular program. These include the courses listed for given semesters, the pre-requisite chain and the list of courses to be opened in a given semester. In addition, the failure rates in courses can be given as an input. All of these inputs need to be made available to the program in the appropriate format [1,2].

The system is required to work in two modes:

1. *Forecast mode:* in this mode, the student performance in courses currently registered is not available. However, forecasting of expected student numbers in courses in the following semester is needed. This can be carried out in two forms:
   a) 100% pass rate: it is assumed that students taking a prerequisite course will all pass the courses taken (a nominal average pass grade of "C" is assumed in each course for all students temporarily) and will take the succeeding curricular program courses in the following semester. Although this is a rather optimistic approach, it gives the maximum upper bound of student numbers expected in a given course.
   b) x% pass rate: in calculating the number of expected students in a given course, the pass rate from a given pre-requisite course is assumed to be *x*% and evaluated accordingly. The values of *x* for different semester courses are to be given as an input to the system.
2. *Current mode:* in this mode, all the grade results for all courses of the department are readable from the registrar's database files. Hence, course suggestions can be made on actual student performance, standing and academic rules. The result of this operation will give maximum expected student numbers in course groups in the following semester. These numbers are expected to be quite close to the actual course group sizes since only students with special cases and program timetable clashes would not be able to take a given suggested course.

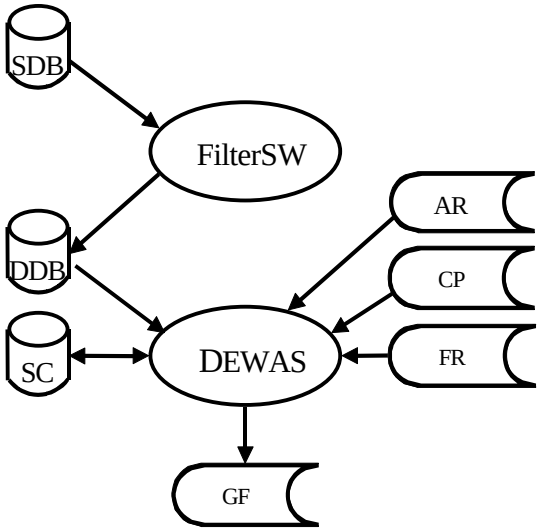
The system is required to carry out its work in the following steps. It should be noted that the forecasting and current modes of operation are significantly similar:

i. Filter the departmental student data from the registrar's general student database and create the necessary local (DEWAS) database files,
ii. For both the *forecasting* and *current modes* of operation do the following:
   a) Determine suggested courses for all departmental students based on the student performance in past semesters, academic rules, curricular program, pre-requisite course chain and the courses to be opened in the following semester.
   b) Generate the group forecasts using the suggested-courses file and using three factors: Failed (F: students taking and failing the course), Late (L: late semester course), and Current (C: current semester course) conditions. Students' "suggest
   to be taken are based on the credit hour points accumulated by the students which also indicates their "current" academic terms.
iii. For the x% pass rated *forecasting mode:* the above results are adjusted to reflect the failed student numbers

when calculating the total students expected to take a given course.

SYSTEM DESIGN AND IMPLEMENTATION

The system model outline is depicted in Figure 1. Here, the student database is the existing student database available through the registrar's office. A filtering software provides automatic filtering and creation of the DEWAS database files also named the Departmental Database (DDB). The derived DEWAS database is the new database required by the software package for group size forecasting through the creation of the suggested courses (SC) database file.



SDB: students' database, DDB: departmental database, SC: suggested courses, AR: academic regulations, CP: curricular program, FR: failure rates, GF: group forecast.

FIGURE. 1
SYSTEM MODEL DESCRIPTION

The key to the operation of the system is the determination of the academic status of each student, current numbers of students taking given courses (calculated from student current semester course list) and calculating the number of students expected to take a given course based on academic rules and student success rates in the prerequisite courses. Curricular program, students' academic standing and current term, the number and type of successfully completed courses as well as the academic rules help determine the courses that each student must take in the following semester. Further, in determining the list of courses to be suggested for each student, the courses expected to be opened in the following semester need also be specified. In our example, the normal course load for students is five credited courses. Therefore, the software is designed to suggest five credited courses and any non-credited course according to the curricular program for each student.

In actual use, it is most desirable to be able to forecast the group sizes even before the exam results are known. This allows advance planning for the following term or indeed the academic year. However, in the absence of actual performance of students before the end of the term means that some form of failure (or pass) rates may well help forecast the group numbers more correctly. This is indeed the approach taken in the design and implementation of this software.

The failure rates (FR) for courses are obtained from a pre-entered data in the FR file. This is applied to the system and hence the numbers generated by the software in the course group size estimates are forecast based on the failure rate estimates. The resulting output is saved in a file called the group forecast (GF) file.

The system described above has been implemented using the "C" language. The database format used by the university for the student database was the proprietary DBF format. The Filtering software creates a departmental database in the same format. The DEWAS system creates its own database files mostly in the text format.

RESULTS AND COMMENTS

The system developed has been used since 1995 in some form or other. Table I shows the result of the software which lists the suggested courses to be taken by a given student. The results for all students are saved in an output file called the suggested-courses file. The suggested courses are listed in the order of course taking priority specified by academic rules. The "reason code" field in the table provides an explanation as to the reason why that particular course has been proposed. These are printed as reasons in open textual format by a code to text conversion operation at the time of print-out listing.

TABLE I
COURSES TO BE TAKEN BY A STUDENT IN SUGGESTED-COURSES FILE
Sample reason codes: 2: Failed, 13: Current, 15: Next

St.Id.#	Crs.Code	Ref.No.	Reason Code
….	….	….	…
990xxx	EE232	21142	2
990xxx	EE343	21153	2
990xxx	MATH273	21155	13
990xxx	HIST200	21156	13
990xxx	EE362	21164	15
990xxx	EE326	21182	15
….	….	….	…

Table II shows part of the results of forecast produced through assuming *x*% pass rates by the software. The table shows the total number of students expected in different courses as made up of components of failed (F), late (L) and current (C) reasoned contributions. The values of records 1-

4 show very low values for "C" reasoned students since no new student intake is expected during the summer session for which this table was obtained.

TABLE II
FORECAST REPORT BY THE SOFTWARE PACKAGE

				x% Pass Rates			
				Expect. No. of Stds.			
Rec	RefCode	CrsCode	Name	F	L	C	T
1	27111	CHEM101	General Chemistry	18	0	1	19
2	27112	EFL101	English I	8	0	1	9
3	27113	PHYS101	Physics I	16	0	2	18
4	27114	MATH150	Calculus & Pre-Cal.	21	0	2	23
5	27115	EEE111	Intr.to Computing	13	0	1	14
6	27116	TURK100	Intr. to Turkish	4	0	63	67
7	27121	EFL102	English II	27	0	25	52
8	27122	PHYS102	Physics II	28	0	44	72
9	27123	MATH106	Linear Algebra	28	0	40	68
10	27124	MATH152	Calculus II	29	0	36	65
…	…….	…….	……..	…	…	….	….

F: Number of students (#) still in "Fail status" in given course,
L: # who did not take the corresponding course on time.
C: # who are taking the corresponding course in its proper time.
T: Total # expected in the corresponding course.

The following observations are made regarding the values presented in course group-sizes. First, the column F in T indicates the number of repeating students in the class and hence the make of the group. This is very useful for instructors giving the lectures. Second, class rosters can be obtained with a little more effort from the suggested courses file and the DEWAS database system. This helps in finding out about the background of each and every one of the students in the class, including their performance in the pre-requisite courses and their general academic standing. Third, the general accuracy of the forecasts is approximately 85-95% on the final group numbers. This could be improved using some of the system extension ideas proposed below.

A number of extensions are thought possible for the system developed. First, the forecasting of the student successes in courses could be made on an individual basis rather than collectively as is the case in the present configuration. To help in this, additional term-time information such as mid-term exam results, quiz results and attendance reports may be added to the database regarding each student's current performance as the term unfolds. This would then give more accurate results on group sizes.

Second, the forecasting of group sizes for courses with more than one pre-requisite could be improved by analysis of past performance statistics. A better understanding of student performance in a number of courses may help better estimation of their performance in the following courses.

Third, a learning system may be incorporated which would then be able to (i) accumulate pass rate statistics for each course over the years and update the mean pass rate index after every semester, and (ii) predict individual student performance in a given course based on student profile; for example the performance in mathematics courses may be used as a good index for successes in a number of following engineering science and design courses.

Fourth, time-table clashes may be used in forming the suggested courses list. Some service courses as well as departmental courses are assigned fixed time slots in the weekly program. If two or more such courses are to be taken by the student, then these could be checked for clashes and new courses could be suggested if the academic rules allow it for a given student.

Finally, the above system can be used in student advising, student self-assessment of progress as well as in pre-registration of next semester's courses with suitable extensions. Indeed, the department has been using the Departmental Information System (DIS) described in [2] for pre-registration of students in the past few years successfully.

CONCLUSIONS

In this paper we have described a method for forecasting course group sizes using pass rate data as the main contributor to group size formations after the academic rules and regulations. The system is very easy to use and gives a broad indication as to the expected maximum group sizes for all the courses in the curriculum that are indicated to be opened in the following semester. Our experience with the system has shown that the effort extended in developing the system has been well worth it; it has been of great help in determining the number of course groups necessary for the following semester and allowing advanced planning of workload distribution amongst academic staff. This has resulted in reducing the administrative effort needed in the organization, better utilization of our academic staff resource as well as giving better satisfaction to both the staff and students; leading to a much better organized departmental course-group formation and pre-registration activity.

APPENDIX

Academic Rules for Course Suggestion

In this appendix the academic rules regarding course registration are detailed with a view of explaining the design of the software program for determining the list of courses to be taken by the students in the following semester.

I. Rules regarding the number and type of courses to be taken by students:

- Students need to pass from 40 credited and 4 non-credited courses and obtain a CGPA ≥ 2.00 out of 4.00 in order to qualify for graduation. They need to take all the courses in the first and second academic terms in the

order specified in the curriculum. In semesters 2-8, courses can only be taken if the pre-requisite courses have already been taken and the minimum grade of "D-" obtained.
- The normal course load of each student is 5 credited courses per semester. At most one course may be dropped in the case a student has not achieved the CGPA value of ≥ 2.00.
- The grades "A", "A-",…, "C+", "C" are the normal passing grades for credited courses and "S" is the passing (satisfactory) grade for the non-credited courses. On the other hand, grades "C-", "D+", and "D" are "conditional passing grades", and "D-", "F", and "NG" (null-grade) are failing grades for credited courses and "U" (un-satisfactory) is the failing grade for non-credited courses. "W" is the grade assigned for withdrawn courses. The "I" (incomplete) grade is assigned to courses when the course-work or exams are missing for final evaluation. This grade needs to turn into one of the grades given above, except the grade "W" and "NG".

II. Precedence rules regarding the selection/assignment of courses to be taken by students:
- The courses with a grade of "D-", "F", "NG", "U", and "W",
- The courses not taken from the previous academic terms,
- The courses not taken from the current academic term,
- Other appropriate courses.

III. Rules regarding "*academic warning*":
- A student will receive an *academic warning* if in a given semester (s)he obtains a CGPA lower than the CGPA limit set for the specified academic terms by the Senate of the University,
- A student in receipt of first academic warning may register to at most two new courses,
- A student in receipt of two or more consecutive academic warnings can not register to any new course. In this case, Rules II apply and for remaining courses, the student takes courses that have been passed conditionally.

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