DECISION SCIENCE TECHNIQUES IN HIGHER EDUCATION ADMINISTRATION

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Abstract. This paper describes three actual applications of decision science techniques in solving education and administration problems at Universiti Utara Malaysia. They are the assignment of group projects to students, the determination of the most suitable candidate for student excellence award, and budget allocation for student activities. For each application, the problem environment is given followed by the description of the technique used to solve the problem. It is hoped that with these simple illustrations those who are unfamiliar with decision science will be aware of its great potential in solving managerial problems.

Keywords*: Decision science, higher education administration, mathematical programming, analytic hierarchy process.*

I. Introduction

The 1990's have seen the emergence of a new type of corporations in the United States. These firms have prospered as a direct consequence of developing and exploiting special skills in Decision Science (DS), also known as Management Science (MS) and Operations Research (OR), allowing them to gain and hold a competitive advantage in their marketplaces. In certain industries, a high level of DS sophistication has emerged; the very existence of firms in these industries depends not only on their marketing, financial, and human resource skills, but also on their ability to use the concepts, and tools of DS on a day-to-day basis (Bell, 1999). However, the same scenario cannot be found in Malaysia as yet, although the situation is improving.

A study conducted by Salleh Yahya in 1999 reveals that the factors faced by firms in applying decision science techniques are: (1) Managers lack of knowledge of DS techniques; (2) Managers in key position lack of knowledge of DS techniques; (3) Benefits of using DS techniques are not clearly understood by managers, and; (4) Managers are not exposed to quantitative techniques early in their training.

Realizing the fact that Malaysia is in need of more quantitative specialists in general and DS specialists in particular, Universiti Utara Malaysia (UUM) took the initiative to introduce a three year DS degree program that was the first in Malaysia, in September 1999, with the first intake of 45 students (Sains Pemutusan: UUM university tunggal tawar program, 2001).

The DS degree program requires its students to take many quantitative-based courses in which DS techniques are introduced and explored. The development of these DS techniques or models, include applying them to problems to generate solutions or recommendations. Using the problem scenario approach in teaching DS techniques helps to motivate the students by demonstrating not only how the procedure works, but also how it can contribute to the decision-making process. However, the stuff of DS can seem abstract, and students

sometimes have trouble perceiving the usefulness of these quantitative techniques covered in DS courses. Part of the problem is that examples used in books often do not seem realistic. Thus, examples must be made simple and applicable to facilitate the learning process (Taylor, 2002).

Sometimes, apart from giving examples from the industry, which may seem somewhat alien for the students, problems that students can relate to and get involved in solving them should also be given. The most logical choice would be problems in higher education or academic administrations as DS techniques and concepts have long been applied to solving these types of problems (Mustafa and Goh, 1996).

The purpose of this paper is therefore to describe our experience of applying DS techniques in solving problems at UUM, involving both the students and the teaching/administrative staff. In the following section, several related higher education management problems solved elsewhere using various DS techniques are discussed. Next, we illustrate three of our previous experiences in solving problems in UUM using DS techniques. Finally, in the last section, we describe a few problems that we are currently working on.

2. Literature Review

The uses of OR/MS/DS in higher education administration are aplenty with the most significant applications being in timetabling and classroom allocation, resource allocation, budgeting and financial planning, and assignment of students and faculty members to duties (Cheng, 1993; Mustafa and Goh, 1996). Some of the extensive reviews on these applications can be found in White (1987) and Mustafa and Goh (1996).

To illustrate, we list just a few studies under each type of application here.

2.I. Timetabling and classroom allocation

Rankin (1995) presented a memetic algorithm technique to generate an automatic timetabling system that could produce working timetables for a large department, which offers a range of undergraduate and postgraduate courses attended by some 500 students. A record system manual data collection and timetable editing supported the algorithm.

Erben and Keppler (1995) presented a genetic algorithm technique to solve a heavily constrained university weekly course-timetabling problem. The prototype timetabling system that was developed provided an interactive graphical user interface and was able to yield promising results.

2.2. Resource allocation

Hemaida and Hupfer (Winter 1994/1995) presented a goal-programming model to efficiently allocate faculty resources at the University of Southern Indiana. The goals to be achieved were (1) to assure coverage of the required course hours, (2) to maintain a faculty split of 80 percent full-time and 20 percent part-time, (3) to maintain a 65 percent terminal degree coverage rate of full-time faculty, and (4) to minimize cost.

Riztman, Bradford and Jacobs (1979) presented a large mixed-integer goal-programming model to look at an office-layout-planning problem where the major objective was the equitable reassignment of offices to teaching and administrative staff members in academic departments within a college.

2.3. Budgeting and financial planning

Ghosh, Pal, and Basu (1992) implemented a lexicographic goal programming model with integer variables, in order to assign financial resources to four departments of the same university, in order to adjust their teaching and administrative to the teaching burden foreseeable for the next academic year.

Caruthers and Wentworth (1997) presented a few forecasting models to forecast a number of interacting internal and external variables such as demographic trends, economic conditions, and broad social priorities before any university budget planning process begin.

2.4. Assignment of students and faculty members to duties

Lawrence, Lawrence and Reeves (1983) presented a goal-programming model to assign teaching personnel to courses.

Reeves and Hickman (1992) presented a multi-criteria, mixed-integer, linear-programming model for assigning I00 MBA students to approximately 20 summer field study project teams. The objectives of the study were to maximise student preferences and to maximise team quality and interest levels while balancing the foreign/non-foreign student mix across team assignments.

The applications above vary not only in terms of the type of problems involved, but also the techniques used to solve the problems, which include both optimization and heuristic approaches. In the next section, we will discuss three applications that we personally conducted.

3. Past Applications in UUM

So far, we have completed three actual applications of decision science techniques in solving education and administration problems at UUM. They are the assignment of group projects to students, the determination of the most suitable candidate for student excellence award, and budget allocation for student activities.

3.1. Application 1: The assignment of group projects to students (Engku and Razamin, 2004)

The objective of this study was to develop a suitable mathematical programming model to assign students to group projects so that the students' overall total preference could be maximized. At the same time, the lecturer also wanted to ensure two things:

i) A balanced gender/race mix proportions across teams to enhance gender/racial integration, and

ii) A balanced highly motivated and less well-qualified students' proportions across team to ensure that all groups have equal chances of doing well in their respective project.

At the beginning of the semester, the lecturer had already generated six projects each for each of these five subtopics: (1) Knapsack (2) Bin-packing (3) Traveling salesman (4) Assignment (5) Job-shop scheduling.

To solve the problem, the first step was to ask each student to fill in an AHP-questionnaire to determine the student's weight preference for each of the subtopic. Next, a 0-1 integer-programming model was developed. The model's objective function and constraints were as described below:

Objective Function: Maximize students' preference
Subject to:
Constraint 1: Each student must be assigned to a project.
Constraint 2: Each project must be assigned to either 4 or 5 students.
Constraint 3: Each group must consist of a combination of both male and female student members.
Constraint 4: Each group must consist of a combination of both, Malay and either Chinese or other student members.
Constraint 5: Each group must have an average group CGPA of between $LB\xi$ and $UB\xi$

The model was then solved using *LINDO 6.1* and the optimal solution was obtained and implemented on the students.

3.2. Application 2: The determination of candidate for student excellence award (Bahtiar, Engku and Nor Idayu, 2003)

This study discussed how AHP was applied to help two groups of decision makers, namely the administrative group and the student population, in choosing the best graduating student from the Faculty of Quantitative Sciences (FQS) to be awarded for academic excellence during the 2003 university convocation. A total of six criteria had been identified as suitable criteria for the selection process. The criteria were: (1) Cumulative grade point average; (2) Participation in on-campus activities; (3) Participation in off-campus activities; (4) Self-discipline; (5) Communication skill; (6) Attitude.

The AHP-output from both groups resulted with the following weight distribution for each criterion.

Table 1: Weights for criteria for each group

Criterion	Administrative Group	Student Population
I	0.358	0.331
2	0.164	0.129
3	0.085	0.074
4	0.186	0.186

5	0.057	0.160
6	0.150	0.120
Total	**1.000**	**1.000**

These criteria with their respective weight distribution were then used to evaluate three potential candidates.

3.3. Application 3: Budget allocation for student activities (Engku and Nor Aishah, 2004)

This paper described the application of 0-1 multi-objective integer programming model in helping student bodies at residential colleges in UUM in general and the student body at Kolej A, specifically, in coming up with a proper strategy to decide what type of annual college activities to be undertaken based on the amount needed to run each activity, some specific requirements for the limits of activities that can be undertaken, and two conflicting objective functions, namely: (O1) maximizing students' preference and (O2) maximizing management's preference towards achieving the best residential college award. We utilized the AHP technique to get the data for the weights in O1, and the points decided by the university panel in O2.

The AHP output for weights determined by students on their preference for activities under various portfolios and activity levels are as given in Table 3 and Table 4 respectively.

Table 2: Weights for Each Portfolio Given by AHP

Portfolio	**Weight (%)**
P1: Education & Communication	12
P2: Sports & Recreation	16
P3: Spiritual	12
P4: Cultural & Arts	14
P5: Infrastructure & Services	10
P6: Information	9
P7: Entrepreneur	13
P8: Academic & Training	14
Total	**100**

Table 3: Weights for Each Activity Level Given by AHP

Level	**Weight (%)**
L1: International/National	5
L2: State	15
L3: University	38
L4: College/Block	42
Total	**100**

Meanwhile, the model constraints were:

Constraint 1: Total budget available.

Constraint 2: The requirement that there should be at least two activities from each portfolio.

Constraint 3: The requirement that there should be at least one and at the most three activities at national/international level.

Constraint 4: The requirement that there should be at least two and at the most four activities at state level.

Constraint 5: The requirement that there should be at least three activities at university level.

The models were then solved using *LINDO 6.1* and the optimal solution for each model was obtained and compared. The results helped the student body make an unbiased decision by including the students' preference into account while reducing the influence of the student body representatives and make a proper planning in terms of budget allocation.

All the three applications above involved both the students and administrative/teaching staff in the decision-making process and actually successfully implemented. Spurred by the success of these applications, we proceed with a few more applications and the applications are described in the following section.

4. Current Work and Conclusion

This paper described actual applications of DS techniques in three higher education administration problems. They are the assignment of group projects to students, the determination of the most suitable candidate for student excellence award, and budget allocation for student activities at UUM. The main objectives for these illustrations are twofold: (1) To provide a means for the existing DS students and potential DS students alike, to assess the impact of DS techniques on higher education administration and (2) To encourage administrators in higher education administration as a whole, and in UUM in particular, to consider utilizing DS techniques in their decision-making process as the potential and advantages have been proven as illustrated in various success stories in literature.

As a conclusion, we would like to share with readers some other problems involving the applications of DS techniques that we are currently working on.

i. The university course timetabling.
Objective 1: To maximize total faculty preference (1 ½ + 1 ½ hour teaching slots)
Objective 2: To minimize total travel distance for teaching staff in every faculty
(Proposed technique: people sequential and people utility heuristic)

ii. The selection of students for events during university English month.
Objective 1: To maximize total student preferences.
Objective 2: To maximize total chances of winning.
(Proposed technique: AHP and integer programming)

iii. The conference paper scheduling.
Objective 1: To have an equal total participants in each parallel session.
Objective 2: To maximize total paper presenter preferences.

(Proposed technique: AHP and goal programming)

iv. The determination of first career path for decision science students.
Objective 1: To determine factors and weight for each factor that influence students' job selection.
Objective 2: To determine which job sector is the most suitable for each decision science student based on the factors and weight for factors given in Objective 1.
(Proposed technique: AHP)

v. The university library budget allocation.
Objective 1: To have an equitable budget share among faculties
Objective 2: To maximize total faculty preferences
Objective 3: Ti minimize cost
(Proposed technique: AHP and goal programming)

Most of these problems require inputs from students, thus making them a part of the decision-making process. With their direct involvement, it is hoped that students will be aware and appreciate the potential of DS techniques in solving managerial problems. These exact problems may not exist in the organizations where these students will be working at. However, the logical approach to problem solving embodied in these illustrations is valuable for all types of jobs in all types of organizations.

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