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Forming Maximally Diverse Workgroups: An Empirical Study

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1. Introduction

This work addresses two related important themes in business and business schools today: expanding diversity in the workplace and the increasing reliance on teams as an organizational structure.

The paper describes an approach for creating student work groups where the objective is to maximize within group diversity based upon multiple criteria. This approach is an extension of a heuristic-based multiple-criteria decision support system (MCADSS) developed in earlier work (Weitz and Jelassi [1992]); that system was successfully implemented, and is currently in use, at the European Institute of Business Administration (INSEAD) in Fontainebleau, France. The heuristic has been modified here to incorporate a different set of criteria, and to allow for students "placing out" of core courses. This paper discusses the modified system, its implementation at the Stern School of Business at New York University (NYU), and an empirical experiment evaluating the performance of the system.

2. Related Work

The student assignment problem may be generalized as the task of assigning a set of items to a limited number of entities, under a specified set of constraints, with the intent of maximizing some overall utility function. (The problem is related to other applications of assigning entities with multiple characteristics to one or more groups with the aim of maximizing diversity.) Related problems include assigning workers to jobs, court cases to judges, and salespeople to sales territories. Relevant academic applications include assigning students to courses, and exams to exam periods. Typically, mathematical programming and/or heuristic approaches are utilized. A thorough literature review is provided in Lakshminarayanan and Weitz [1994].

3. The Multi-Criteria Allocation Problem at NYU

Each fall semester typically 350-400 students enter the MBA program at the Stern School of NYU. Prior to the start of classes, each student is assigned to one of six "blocks"; students in a block take all required ("core") classes together. Students in each block are then assigned to groups; each group is composed of approximately six members who work together on group assignments. (For the spring semester, the problem is repeated on a smaller scale.) The objective of the MBA office is to maximize within-block and within-group diversity based upon the criteria of nationality, gender, undergraduate discipline, GMAT verbal, and GMAT quantitative scores (percentiles).

4. The Heuristic

The following discussion refers to assigning students to groups; the block assignment process is identical.

The basic MCADSS heuristic works by avoiding placing the most similar students in the same group. The first student, usually selected randomly, is placed in the first group. The heuristic then selects the student most similar to the first student and places him/her in the next group. (Computation of the similarity measure is discussed below.) The model continues in this fashion, at each iteration taking the student most similar to the previous student and placing him/her in the next group. (After a student is allocated to the last group, the "next" group is group one.)

The similarity measure may be based upon any criteria. At NYU the criteria of interest are: nationality, gender, discipline, GMAT verbal and GMAT quantitative. The first three characteristics are measured on a nominal scale. (For example, being Japanese is as different from being Korean as it is from being French.) The GMAT scores are directly represented as percentiles; that is, a difference in GMAT verbal scores between two students of 20% is twice the difference of 10%. The difference measure is obtained by summing the weighted contributions of all the criteria by which two students being compared differ. (The similarity measure is obtained by subtracting the difference measure from 100%.)

As stated earlier, the heuristic is embedded in a decision support system (DSS). (See Alter [1980] for a discussion of the characteristics of decision support systems.) MCADSS is menu-driven and includes facilities for data input and display, summary statistics, manually moving or exchanging students between blocks or groups, and verifying/respecifying weights. For a full discussion of the system, including details of the weighting scheme and DSS components of the system, see Weitz and Jelassi [1992]. Mathematical programming approaches, and differences between the INSEAD and NYU implementations are discussed in Lakshminarayanan and Weitz [1994].

5. NYU Implementation Results

The purpose of MCADSS is to provide administrators with solutions as good or better than those previously obtained manually, reduce the time required for the partitioning process, and provide the administrators with a means to measure the quality of alternate allocations. The overarching determinant of success, of course, is that the administrators should be happier working with MCADSS than without it.

Using MCADSS at NYU for the first time, for the entering class of the Fall of 1994, the block and group allocation process was reduced from several days to several hours. Training the administrator (including establishing the criteria weights) took an afternoon. (These results are comparable to those observed at the INSEAD implementation.) The administrator found the system easy to use; additionally, the administrator appreciated the confidence achieved by having a quantitative measure for how good the allocations were, and in particular how the solution quality varied when alternative solutions were tried (when experimenting by manually moving students between blocks or groups). Finally, the reduced solution time allowed for the allocation process to be done "just-in-time"; this was an important contribution as, with other academic programs, the incoming class roster varied right up until the start of classes.

6. Integer Bound

The heuristic creates good quality solutions (as judged by the administrators), but does not provide mathematically optimal solutions. In order to quantify the performance of the heuristic, an upper bound for the optimal solution was calculated, and an empirical test was performed using NYU data. This upper bound (integer) solution was realized by considering the calculation for the average difference metric for a group (and thereby for an entire allocation). For each of the S members in a group, there are $(S-1)$ pairwise differences which may be calculated. The average of these $S(S-1)$ differences comprises the average group difference; the average of all the group differences in a particular partition is the difference metric for the partition. A maximum bound may therefore be determined by considering the matrix of pairwise differences between all students, and calculating the difference metric using the largest $(S-1)$ differences for each student. Clearly this method does not guarantee a feasible solution; however it does provide an upper bound on a feasible solution.

7. The Experiment

In order to evaluate the performance of the heuristic an experiment was conducted. The experiment was based on forming groups from blocks using the NYU data set, and proceeded in the following manner. First, the list of students was randomized. Then, the first 60 students were selected. The heuristic was applied to this set of students, starting with the first student in the set, with ten groups of size six formed. The average within-group difference for each of the six groups was calculated; the average of these six within-group differences provides a measure of the quality of the solution reached by the heuristic, starting with that particular student. The process was then repeated on this (60 student) dataset an additional 59 times, each time starting the heuristic with a different student. The minimum (worst), maximum (best) and average of the 60 average difference

measures was then calculated; these provide a gauge for the performance of the heuristic on this set of students for this number of groups. The entire process was then repeated for the next 60 students, and so on until the list of students was exhausted.

Additional results are reported here for the 360 student six group (block) problem (corresponding with block formation at NYU).

Summary results are presented below.

Group Formation Experiment:

Number of students in each set = 60

Number of groups formed in each set = 10

set	best	worst	average	integer bound	% diff. average heuristic & bound
1	0.5231	0.5113	0.5186	0.7437	30.27
2	0.4533	0.4390	0.4467	0.7323	39.00
3	0.4311	0.4187	0.4252	0.7050	39.68
4	0.4660	0.4495	0.4590	0.7220	36.42
5	0.4735	0.4627	0.4698	0.7071	33.56
6	0.4881	0.4765	0.4831	0.7283	33.67
avg	0.4725	0.4596	0.4671	0.7231	35.43
std dev	0.0314	0.0322	0.0321	0.0150	3.61

Block Formation Experiment:

Number of students: 360

Number of groups (blocks) formed: six

1 0.4932 0.4381 0.4387 0.6858 36.03

8. Discussion of Results

It should be noted that the real determinant of solution quality is the opinions of the decision makers using the DSS. However the experiment does indicate the following: 1) There was no statistically significant difference between the performance of the best and worst heuristic results. 2) At worst, the heuristic is generally within 35% of the optimal solution. 3) Solution quality does not appear to degrade as the number of students increases. (The heuristic was coded in C, runs on a personal computer, and solution times are measured in minutes.)

9. Conclusions and Future Research

This research builds upon previous work demonstrating the utility of the MCADSS heuristic for creating maximally different student work groups based upon multiple criteria. It was shown here that the MCADSS heuristic is robust enough to be

successfully replicated in a second, somewhat different academic environment. Additionally an empirical experiment was performed indicating that the heuristic is robust with respect to starting student. Finally, the heuristic was shown to generally perform within 35% of the upper bound optimal solution.

There are several fertile areas for future work in this area. First is the possibility of exploring mechanisms by which the heuristic may be modified, and its performance improved, with little increase in computing resources. Second, alternative heuristics developed for other, related problems can be contrasted empirically with the MCADSS (or modified MCADSS) heuristic. MCADSS has proven itself to be a powerful and robust approach for this application; exploring its potential in other areas may prove rewarding. Finally, additional work is anticipated towards determining the behavior of the bound as parameters vary, and towards developing sharper optimal bounds.

References

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