

ANALYSIS OF THE ASSIGNMENT STRATEGIES OF ENGINEERING PREPARATORY YEAR STUDENTS TO DEPARTMENTS

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ABSTRACT

Students promoted from the preparatory year to the first year at the Faculty of Engineering, University of Alexandria are asked to write-in the ten available departments ordered according to their individual preferences. This data is used, together with the capacities of the departments, the academic achievements of the students and other special requirements to assign the students to the various departments, filling each department from the leading choices of the students in a descending order of achievement. This paper introduces a "dissatisfaction index" as a measure of the ability of different assignment strategies to satisfy and conform with the initial student choices. Three forms of the dissatisfaction index are introduced; the first accounts for the student choices only, the other two are 'weighted' by the achievements of the students. The student assignment data for the academic year 1992-1993 is used as a sample to test the introduced indices. Correlation between these indices and the achievements of these students at the first year final examinations a year later prove the validity of these measures. Finally, a two-stage assignment strategy is suggested. Hypothesized application of the suggested strategy to the selected sample shows that a drastic reduction of the dissatisfaction index is possible which may hopefully improve the academic performance of the students.

Keywords: Assignment Strategies, dissatisfaction Index.

1. INTRODUCTION

The program of study for the B.Sc. degree in Engineering at the Faculty of Engineering, University of Alexandria consists of four years of study preceded by a preparatory year. After the preparatory year, a student is admitted to one of the following ten academic departments to major in :-

1. Computer Science; CS,
2. Electrical Engineering; EE,
3. Mechanical Engineering; ME,
4. Nuclear Engineering; NE,
5. Architectural Engineering; AR,
6. Chemical Engineering; CH,
7. Textile Engineering; TEX,
8. Marine Engineering; MAR,
9. Civil Engineering; CE and
10. Production Engineering PE.

Due to capacity constraints of these departments, a student may not be admitted to the department of his first preference. Students are elected for admission in any of these departments according to the score they obtained in their preparatory year study and examinations. Some departments apply extra rules in the election of their students; these are the Architectural Engineering Department which uses a normalized special score that consists of 50% of the final preparatory year score and 50% of the score of a departmental aptitude test; the other department is the Production Engineering Department which requires that the student has passed the examination for Engineering Drawing.

The admission procedure requires the students to fill-in a form ranking all ten major departments in the order of their preference, starting with his most

preferred major. It is clear that a student elected for admission to the department of his i^{th} preference will be less dissatisfied than another student elected for admission to a department of his j^{th} preference for all $i < j$. Moreover, it has been observed that a student's academic performance in his department is highly affected by his level of dissatisfaction.

Admission data of September 1993 was used in the analysis and evaluation. The main characteristics of this sample is given in section 2.

This paper suggests some quantitative measures of dissatisfaction that can be used to evaluate different planning strategies. The suggested measures shall be presented in section 3.

Reliability of the suggested measures and their sensitivity analysis to variations in departmental capacities are presented in section 4.

Section 4.2 discusses a suggestion to adopt a two-stage admission procedure instead of the current single-stage procedure. The evaluation of the suggested procedure shows that it would enhance the feeling of satisfaction among the students and hence is expected to have positive effect on their future performance.

Finally, Conclusions and recommendations are presented in section 5.

2. SAMPLE DESCRIPTION

The sample used in the study consists of the entire student body (805 students), being promoted from the preparatory year in June 1993. Table 2.1 shows the grade distribution of these students.

The student choice counts (distribution) for the various departments are shown in Figures (2.1)(a) to (j) in number against choice of the 10 choices for all departments.

The skewness of these distributions range from +2.0668 (highly skewed to the right) for the Electrical Engineering Department (EE) to -1.8848 (highly skewed to the left) for the Nuclear Engineering Department (NE). Right skewness characterizes departments of high preference among students while left skewness represents departments of low preference among them.

The departments can be grouped in two subgroups; the first subgroup consists of the CS, EE, ME and NE

departments with skewness > 1 in absolute value. The first three departments in this subgroup have positive skewness, reflecting their high preference among the students, while the NE department has a high negative skewness that reflects its low preference among the students.

The other subgroup includes the remaining six departments with skewness ≤ 0.531 in absolute value. These are the departments that enjoy nearly symmetric distribution of preference by the students. The Architectural Engineering Department (AR) has the least absolute skewness of 0.0074 with a distribution that is nearly flat.

Table 2.1. Grade Distributions for Students in the Sample.

Grade	Number	Percentage
Excellent	31	3.85
Very Good	63	7.83
Good	199	24.72
Pass	262	32.55
Carried Subjects	250	31.05
Total	805	100.00

A student choosing any of the highly preferred departments (CS, EE and ME) as, e.g., his 8^{th} or 10^{th} choice is very unrealistic in view of the overall student body preference. Such choices result from the fact that students are asked to write in 10 choices. Choices beyond the 5th choice for these departments can surely be considered as "outliers" and consequently can be eliminated from department choice distribution.

Analysis of the first five choices for the three highly preferred departments gives a more realistic inference about their relative preference. Table 2.2 shows the count, mean choice and skewness for these three departments based on the first five choices. It is clear that the order of preference of these departments is CS, EE and ME with skewness 2.4014, 1.2864 and 0.0895 respectively.

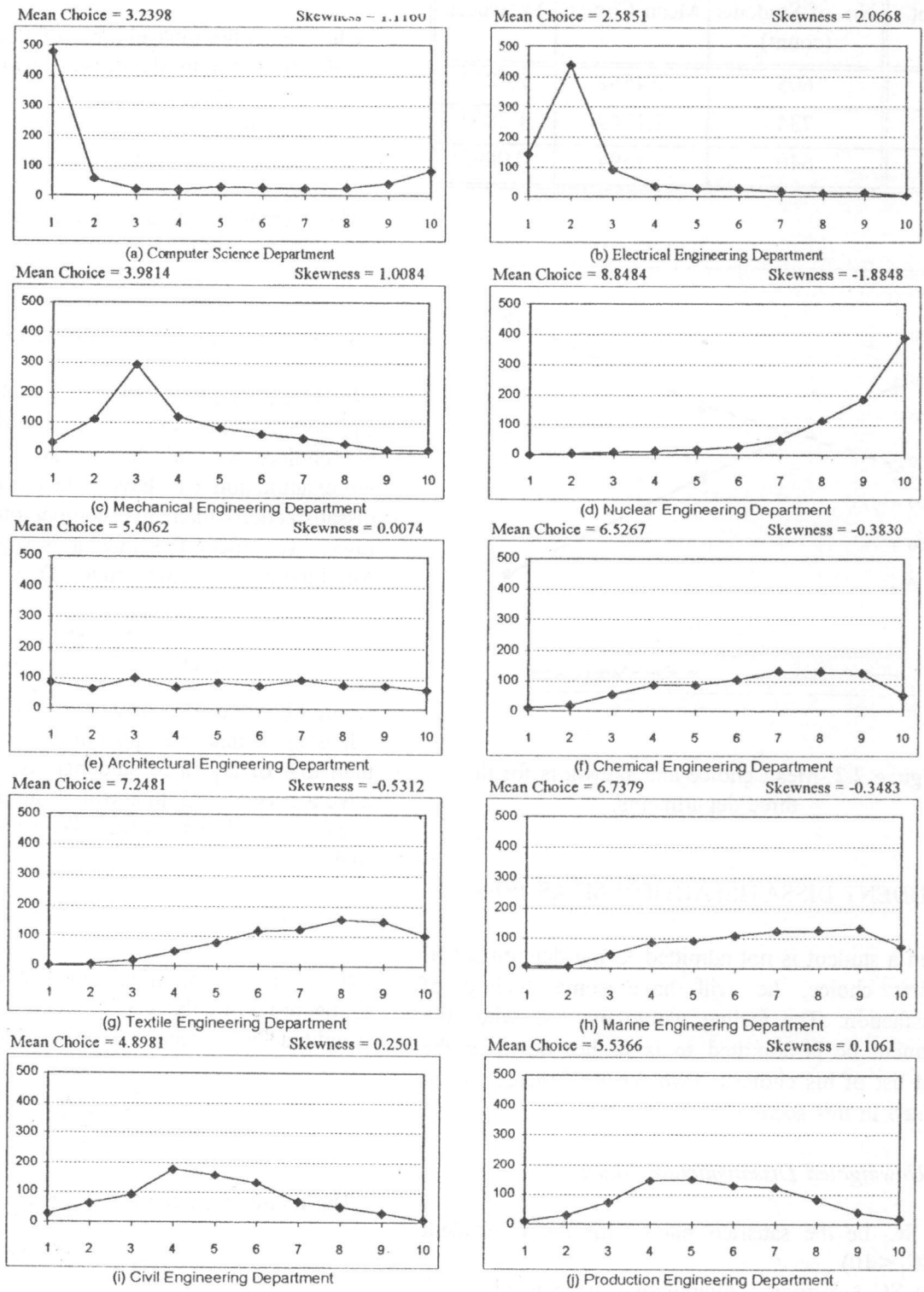


Figure 2.1 Student Choice Count Distributions

Table 2.2. Analysis of the First Five Choices.

Dept	No. of Students (count)	Mean Choice	Skewness
CS	605	1.4562	2.4052
EE	734	2.1349	1.2864
ME	640	3.1594	0.0895

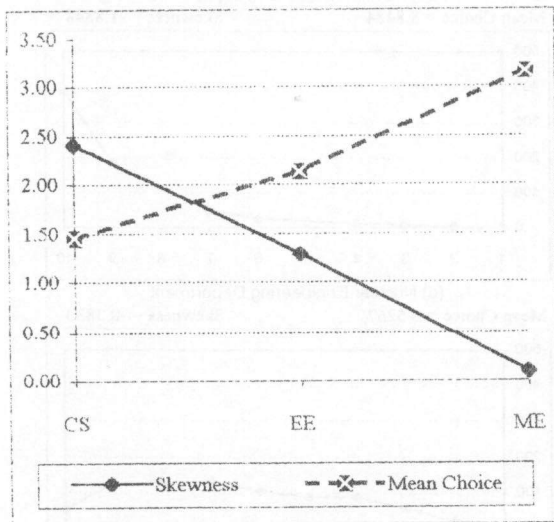


Figure 2.2. Mean choice and skewness for the three departments.

3. STUDENT DISSATISFACTION MEASURES

When a student is not admitted to the department of his first choice, he will have some feeling of dissatisfaction. The feeling would increase when the department he is admitted to is farther down in the ranked list of his choices. Two types of measures are presented in this section.

3.1 Unweighted Dissatisfaction Index

Let SC_i be the satisfied choice for the i^{th} student ($1 \leq SC_i \leq 10$)

Then $SC_i - 1$ gives a quantitative measure of the i^{th} student dissatisfaction level.

The admission policy can be evaluated with the dissatisfaction index:

$$D_1 = \frac{\sum (SC_i - 1)}{n} \quad (3.1)$$

where n is the total number of students.

and D_1 is simply the average student dissatisfaction level.

It is clear that:-

$$0 \leq D_1 \leq 9 \quad (3.2)$$

The average satisfied choice for a given policy is :-

$$D_1 + 1$$

3.2 Weighted Dissatisfaction Index

If the satisfied choice for two students are the same, e.g. both students were admitted to department of their 3rd choice, then the student who has a higher score in the examination will have a deeper (higher) feeling of dissatisfaction than his companion whose score is lower. To reflect this fact, it is suggested to adopt a weighted dissatisfaction index D_2 given by:-

$$D_2 = \frac{\sum (SC_i - 1) G_i}{n} \quad (3.2)$$

where G_i is the percentage score of the i^{th} student.

It is clear that the upper bound of D_2 is much less than that of D_1 since students with $SC_i = 10$ usually have a very low G_i that will be approximately 50% or even lower. Consequently D_2 cannot exceed $(10-1)(0.5) = 4.5$, (i.e.):-

$$0 \leq D_2 \leq 4.5 \quad (3.4)$$

If the dissatisfaction feeling of the good students are to be more highly valued, then a more appropriate weighted dissatisfaction index would be :-

$$D_3 = \frac{\sum (SC_i - 1) G_i^2}{n} \quad (3.5)$$

The range of values for D_3 will be:-

$$0 \leq D_3 \leq 2.25 \quad (3.6)$$

These measures are used in policy evaluation and sensitivity analysis presented in the next section.

4. ANALYSIS OF THE ADMISSION POLICY

4.1 Results and Sensitivity Analysis

Table 4.1. Number of Students Admitted in Each Department Under Each Strategy.

Department	Strategy "A"		Strategy "B"		Strategy "C"	
	Capacity	Admitted	Capacity	Admitted	Capacity	Admitted
CS	30	30	30	30	30	30
EE	200	200	220	220	230	232
ME	150	150	165	165	173	173
NE	25	3	25	3	25	3
AR	50	47	50	47	50	47
CH	120	85	120	75	120	72
TEX	50	26	50	21	50	18
MAR	30	30	30	30	30	30
CE	250	193	250	174	250	160
PE	40	40	40	40	40	40
Total	945	805	980	805	998	805

Three different capacity levels were analyzed and resulting admission strategies evaluated. The first strategy "A" used the base capacity levels as suggested by the Faculty Council. It was found that the CS, EE, ME, MAR and PE departments were filled to suggested capacity. In strategy "B"; the capacity of the two large departments (EE and ME) were increased by 10% while in strategy "C" their capacities were increased by 15%.

Table 4.1 shows the number of students admitted in each department under each strategy. It is clear from the table that the five above mentioned departments are still filled up to capacity. Further capacity increases of the same magnitudes are also expected to be exhausted. In addition, the table shows that more than 50% of the students who immigrated to these departments came from the Civil Engineering Department.

The average dissatisfaction indices for the three strategies are given in table 4.2-a. The percentage variation for strategies "B" and "C" with respect to "A" are shown in table 4.2-b. It is clear that the variations of the three indices are very close to each other. This means that the discriminatory characteristics of the three indices are approximately the same.

Table 4.2-a. Average Dissatisfaction Indices

Strategy	Average Dissatisfaction Index		
	D ₁	D ₂	D ₃
A	1.470	0.873	0.528
B	1.366	0.816	0.492
C	1.298	0.770	0.469

Table 4.2-b. Percentage Variation in Average Dissatisfaction Indices.

Strategy	Average Dissatisfaction Index		
	D ₁	D ₂	D ₃
A	-	-	-
B	7.1%	6.5%	6.8%
C	11.7%	11.8%	11.2%

It was shown in section 3.1 that the mean choice is $D_1 + 1$. However, taking D_1 as a dissatisfaction index is unfair to the good students since it does not take the score of the students into consideration; it gives students with very low scores the right to be as demanding as the best students and causes the system to be equally concerned about their satisfaction. A fair system should be concerned with the satisfaction of students with high scores much more than those with low scores.

Dissatisfaction indices D_2 and D_3 (specified by equations 3.2 and 3.3), take the students' scores into consideration. The effect is more pronounced in D_3 where the dissatisfaction of a student is weighted by the square of the percentage of his score.

Figure (4.1) shows the choice satisfied under the three strategies "A", "B" and "C". The detailed distribution of choices satisfied for students admitted to each department is shown in table 4.3, together with the corresponding dissatisfaction indices. Achievement percentages (score percentages) for the next year of the admitted students are also given in the last column of Table 4.3.

Table 4.3. Distribution of Choice Satisfied for Each Department (Strategy "A").

Dept.	Choice Satisfied										Total No. of Students	Dissatisfaction Indices			Average % score a year later	
	1	2	3	4	5	6	7	8	9	10		D ₁	D ₂	D ₃		
CS	30											30				75
EE	39	152	9									200	0.85	0.61	0.44	63
ME	23	45	73	10								151	1.46	0.91	0.57	60
NE	1	1	1									3	1.00	0.55	0.31	55
AR	26	13	8									47	0.622	0.39	0.25	62
CH	11	13	27	22	11	1						85	.14	1.20	0.67	60
TEX	4	4	7	5	5	1						26	2.23	1.21	0.65	58
AMR	7	3	6	10	3	1						30	0.07	1.18	0.67	57
CE	29	45	50	39	23	6	1					193	0.02	1.12	0.62	56
PE	9	6	13	12								40	1.70	1.03	0.62	61
Totals	179	282	194	98	42	9	1					805	1.470	0.876	0.528	Average

The Pearson product moment correlation coefficient between the complement of the dissatisfaction indices $D_{n-max} - D_n$ and the average score achieved a year later was evaluated, where:-

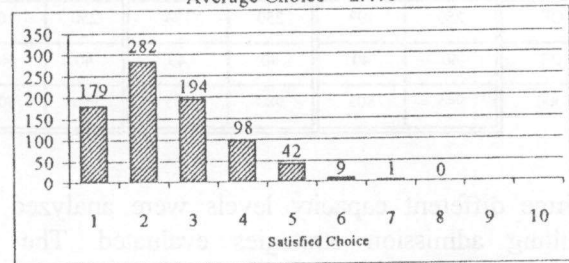
D_{n-max} is the maximum theoretical value of any of the three indices (see equations 3.2, 3.4 and 3.6);
 D_n is the actual measured dissatisfaction index.

The results of the correlation test are given in table 4.4, the calculated values of the Pearson correlation coefficient show a highly significant correlation between the complements of the dissatisfaction indices (which may be called *satisfaction* measures) and the achievements of the students. This means that a satisfied student achieves better performance as expected. The better performance of the students of the departments with a high right skew may also be a result of their better score.

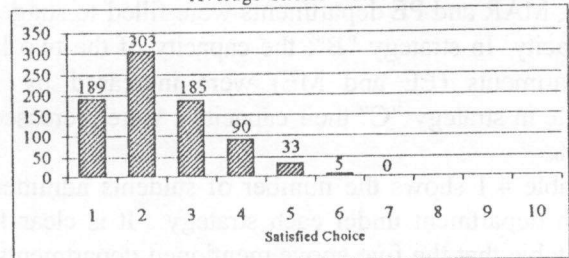
Table 4.4. Correlation Factors Between Complements of Dissatisfaction Indices and Student Achievements a Year Later.

Dissatisfaction Index	Pearson Correlation Coefficient
D ₁	0.7326
D ₂	0.7253
D ₃	0.7158

Strategy "A": According to Faculty Council Resolution
 Average Choice = 2.470



Strategy "B": Electrical Eng & Mechanical Eng Depts Increased by 10%
 Average Choice = 2.366



Strategy "C": Electrical Eng & Mechanical Eng Depts Increased by 15%
 Average Choice = 2.298

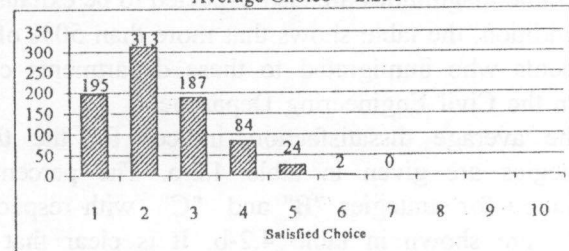


Fig 4.1 Distribution of Choice Satisfied

4.2 Two-Stage Policy

The present procedure of admission calls upon the students to order the ten departments according to their individual preferences. *Without loss of optimality, a student can do this ordering independent of his score and/or departments' capacities or history of minimum scores admitted to the various departments.* A student needs to make an intelligent decision only if he is allowed to write a number of choices less than the total number of departments. For example if he is allowed to list only five choices, then he must choose them carefully and he cannot do that without proper consideration of his score, the overall distribution of the students' scores and department capacities. In addition to proper ordering of his choices, he must try to guarantee his admission in at least one of the departments he has chosen. The upper bound of the dissatisfaction index D_1 is always less than the number of choices by one.

The suggested two-stage admission policy allows the students to write in only five choices. The first stage will be limited to those students with scores equal to or above the median score (usually about 60%). Results of this stage will be announced together with the number of seats that are still available in each department after the first stage. Students with scores less than the median score will write in their choices in the second stage in view of the results of the first stage and in due consideration of their scores.

Table 4.5. Two Stage Dissatisfaction Index D_1

Strategy	D_1	% age Variation
A	0.92	-
B	0.89	3.26%
C	0.89	3.26%

Under this policy, it is clear that the upper bound of D_1 is 4. Table 4.5 shows the two stage dissatisfaction index D_1 for the three strategies "A", "B" and "C". The percentage variation is reduced to less than half the values corresponding to the one stage policy. However, the dissatisfaction index itself is reduced by more than 30% as shown in table 4.6.

Table 4.6. Dissatisfaction Index for the One and Two Stage Policies

Strategy	D_1	D_1	% age Variation
	1 Stg Plcy	2 Stg Plcy	
A	1.470	0.92	37.4%
B	1.366	0.89	37.8%
C	1.298	0.89	31.4%

5. CONCLUSIONS AND RECOMMENDATIONS

Three dissatisfaction indices were suggested as evaluation yardsticks for admission strategies. The first index does not take student scores into consideration. This index evaluates a student's dissatisfaction level simply as the choice satisfied (fulfilled) minus one. For the second index, this quantity is weighted by percentage student score. Finally, the third index, the quantity is weighted by the square of the percentage student score.

It has been found that the weighted indices are very reliable and have almost the same discriminatory characteristics. The effect of student score is highly pronounced in the values of the third index, and is more realistic.

It has also been found that the student achievements a year later, is highly correlated with the complement of the dissatisfaction index. The Pearson correlation coefficients for the three indices ranged from 0.7158 to 0.7326. This high level of correlation ensures the validity of the suggested indices as highly powerful discriminants.

A two stage admission policy has been suggested. The first stage is limited to students with a minimum score equal to or greater than the median score which is usually about 60%. In other words, only half the students are allowed to participate in the first stage of admission. The student is allowed to write-in only five choices of the 10 available departments. After announcing the results of this stage, together with the number of seats still vacant in each department, the rest of the students are called to write in their choices selected from those departments that still have available seats.

This two-stage policy results in a very good

enhancement of the student dissatisfaction level. The computed value of the unweighted dissatisfaction index has been reduced by more than 30%.

The two-stage admission policy can of course be extended to a multi-stage policy in which the optimal number of stages can be determined by a statistical study of the performance of the students after the final preparatory year examination.

Finally, it is recommended that the marginal cost of increasing the capacity of the highly preferred (usually full) departments should be evaluated taking in consideration national manpower needs of the different engineering specializations. This would lead to objective planning of the capacities of the departments and consequently enhances the student satisfaction levels and their future achievements and contribution to the welfare of the society.

	B	C
	0.87	0.71

CONCLUSIONS AND RECOMMENDATIONS

These dissatisfaction indices were suggested as evaluation variables for admission strategies. The first index does not take student scores into consideration. This index evaluates a student's dissatisfaction level simply as the number of preferred departments minus one for the second index. This quantity is weighted by the percentage student score. Finally, the third index quantity is weighted by the square of the student score.

It has been found that the weighted indices are very reliable and have almost the same distribution characteristics. The first of student score is highly pronounced in the values of the third index and is more reliable.

It has also been found that the student achievement a year later is highly correlated with the comparison of the dissatisfaction index. The Pearson correlation coefficient for the three indices ranged from 0.717 to 0.758. The high level of correlation confirms the validity of the suggested indices as highly potential distribution.

A two stage admission policy has been suggested. The first stage is limited to students with a minimum score equal to or greater than the median score which is usually about 60%. In other words only a 1/2 of the students are allowed to participate in the first stage of admission. The student is allowed to write in only two choices of the 19 available departments. After announcing the results of this stage, together with the number of seats still vacant in each department, the second stage of the students are called to write in their choices selected from those departments that still have available seats.

It is shown in table 4.5 that the dissatisfaction index for departments for a sample of 10 is shown in table 4.5. The first stage is limited to students with a minimum score equal to or greater than the median score which is usually about 60%. In other words only a 1/2 of the students are allowed to participate in the first stage of admission. The student is allowed to write in only two choices of the 19 available departments. After announcing the results of this stage, together with the number of seats still vacant in each department, the second stage of the students are called to write in their choices selected from those departments that still have available seats.

The suggested two-stage admission policy allows the student to write in only two choices. The first stage is limited to those students with scores equal to or greater than the median score (usually about 60%). Results of this stage will be announced together with the number of seats still available in each department after the first stage. Students with scores less than the median score will write in their choices in the second stage in view of the results of the first stage and in the consideration of their scores.

Table 4.5. Two Stage Distribution Index D₂

Department	D	W age Variation
A	0.92	0.84
B	0.87	0.76
C	0.82	0.68

It is clear that the upper bound of the dissatisfaction index for the two-stage dissatisfaction index for the three strategies "A", "B" and "C". The percentage variation is reduced to less than half the value corresponding to the one stage policy. However, the dissatisfaction index itself is reduced by more than 30% as shown in table 4.6.