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Contents

Predicting students' final results through discriminant analysis

Julianti Kasih† & Sani Susanto‡

Maranatha Christian University, Bandung, Indonesia†
Parahyangan Catholic University, Bandung, Indonesia‡

ABSTRACT: As an academic advisor, a full-time lecturer has the duty to help students in setting up their study plan each semester so that they can perform with maximum efficiency. The aim of this research is to ascertain which subjects determine the students' final passing results. An academic advisor is expected to be able to predict the students' final passing results. In order to achieve this goal, discriminant analysis can be applied for this purpose. This particular analysis, based on students' results obtained in several subjects was applied in this research, and is outlined and presented as an example in this article.

INTRODUCTION

One of the important aims of higher education in the Republic of Indonesia is to prepare the academic participants (students) to become society members with academic and/or professional abilities that enable them to apply-develop-enrich the knowledge foundation in science, technology and the arts (The Government Regulation on Higher Education, the Republic of Indonesia, Nr 60, Year 1999) [1]. To achieve this objective, undergraduate students are assigned to several academic advisors (an informal translation for the Indonesian term *Dosen Wali*) throughout their years of higher education studies.

Academic advisors are lecturers or other faculty members and their main task is to foster students' academic and non-academic activities. With regard to students' academic activities, one of the duties of the academic advisor is to help students in setting up their study plans for each semester. Setting up a study plan includes providing guidance for students regarding how many subjects, and which subjects, to undertake. Through this advice, students are expected to obtain the best results at the end of their undergraduate study. The passing results in the Indonesian education system are classified into three grades: Extraordinary (*Cum Laude*), Very Satisfactory and Satisfactory.

This research aims to equip academic advisors with knowledge and tools required to provide guidance. As a case study, a certain research arena was chosen. For confidentiality reasons, the arena is called the Faculty of Information Technology, University X in Bandung, West Java, Indonesia. The academic transcripts of some alumni serve as *input data* for a multivariate technique called discriminant analysis.

OVERVIEW OF BACKGROUND THEORY

Discriminant analysis is a multivariate statistical technique used in statistics. This technique classifies an *object* into one among several *groups* based on its *attributes*. Discriminant analysis has three main objectives. First, to identify the *attributes* that discriminate among the groups. The second objective is to use the identified variables to develop some functions, called the *discriminant functions*, for computing some new variables or indices that will parsimoniously represent the differences among the groups. The third objective is to use the computed scores to develop a rule to classify future observations into one of the several groups [2].

In this research:

- Objects are the undergraduate students being studied;
- Based on the passing results, there are three possible groups of students, as mentioned previously:
  1 - Extraordinary (*Cum Laude*); 2 - Very Satisfactory; and 3 - Satisfactory;

- The students' attributes are their final marks in some subjects. In the Indonesian undergraduate education system, the final marks of a subject are classified into five groups, as follows: A (High Distinction), B (Distinction), C (Credit), D (Pass) and E (fail). Those results are scored as 4 (A), 3 (B), 2 (C), 1 (D) and 0 (E), respectively.

The discriminant analysis works as follows. First, based on the available students' attributes, this technique identifies those that discriminate among the groups. The corresponding attributes are subjects in the first four semesters that are related to the Information Technology discipline.

The reason is to allow advice from academic advisors to work as early as possible. Second, to use the identified attributes to develop two discriminant functions for computing two discriminant scores and to obtain a territorial map. Third, to plot the computed scores on the map to classify students into one of the several groups.

EXPERIMENT: THE RESULT AND INTERPRETATION

As mentioned earlier, the academic transcripts from some alumni served as *input data*. There were 146 transcripts available for this research. Each transcript contained the final marks of 31 subjects from the 1st until the 8th semester. The first four semesters were chosen as alumni or student attributes.

Those subjects were IF102 (Introduction to Computer Application), IF103 (Introduction to Information Technology), IF104 (Algorithms and Programming), IF105 (Basic Programming), IF106 (Informatics Mathematics), IF201 (English), IF202 (Linear Algebra and Matrices), IF203 (Computer Network) and IF205 (Archives and Access System). The discriminant analysis was performed through the use of SPSS 17.0 software. One of the results are the Canonical Discriminant Function Coefficients as represented in Table 1.

Table 1: Discriminant Functions Coefficients.

Subjects	Function	
	1	2
IF102 (Introduction to Computer Application)	0.481	1.767
IF103 (Introduction to Information Technology)	0.858	-0.638
IF104 (Algorithms and Programming)	0.663	-0.334
IF105 (Basic Programming)	0.589	-0.128
IF202 (Linear Algebra and Matrices)	0.223	0.831
(Constant)	-9.255	-5.865

Table 1 indicates that students' final marks in the following five subjects - IF102 (Introduction to Computer Application), IF103 (Introduction to Information Technology), IF104 (Algorithms and Programming), IF105 (Basic Programming), and IF202 (Linear Algebra and Matrices) significantly determined their passing results.

This result demonstrates the fulfilment of the first objective of discriminant analysis. This table also indicates the two discriminant functions obtained: DF-1 and DF-2, and further demonstrates the fulfilment of the second objective of the discriminant analysis. The equations of the two functions are:

$$DF\text{-}1 = 0.481\ IF102 + 0.858\ IF103 + 0.663\ IF104 + 0.589\ IF105 + 0.223\ IF202 - 9.255 \qquad (1)$$
$$DF\text{-}2 = 1.767\ IF102 - 0.638\ IF103 - 0.334\ IF104 - 0.128\ IF105 + 0.831\ IF202 - 5.865 \qquad (2)$$

For future students, once the researchers acquire the final marks of the five significant subjects, each student will obtain two scores from the two discriminant functions. Another result from the discriminant analysis is the territorial map as presented in Figure 1.

Once the point with the coordinate (DF-1, DF-2) is plotted, the location of this point on the map is obtained. This location indicates where a future student will be in one of the three groups. This result demonstrates the fulfilment of the third objective of discriminant analysis, which enables an academic advisor to predict the final passing results of a student, and this is the main aim of this research.

Let assume that a student has obtained the following results: A, B, B, C and C in the following subjects: IF102, IF103, IF104, IF105 and IF202, respectively. Hence, this student will obtain the following two scores:

$$DF\text{-}1 = 0.481(4) + 0.858(3) + 0.663(3) + 0.589(2) + 0.223(2) - 9.255 = -1.144 \qquad (1)$$
$$DF\text{-}2 = 1.767(4) - 0.638(3) - 0.334(3) - 0.128(2) + 0.831(2) - 5.865 = 11.423 \qquad (2)$$

In the territorial map depicted in Figure 1, the point (-1.144, 11.423) lies in Area 2, which indicates that just from the academic result of his/her first three semesters, this student is predicted to obtain the final results of Very Satisfactory at the end of the study.

Canonical Discriminant Function 2

```
        -8,0      -6,0      -4,0      -2,0       ,0       2,0       4,0       6,0       8,0
        +---------+---------+---------+---------+---------+---------+---------+---------+
    8,0 +                                                 23                            +
    |                                                     23                            |
    |                                                     23                            |
    |                                                     23                            |
    |                                                     23                            |
    |                                                     23                            |
    6,0 +         +         +         +         +      23+      +         +         +    +
    |                                                     23                            |
    |                                                     23                            |
    |   2                                                 23                            |
    | 1122                                                23                            |
    |  1122                                               23                            |
    4,0 +   1122  +         +         +         +    23  +      +         +         +    +
    |       1122                                        23                              |
    |       1122                                        23                              |
    |        1122                                       23                              |
    |         1122                                      23                              |
    |          1122                                     23                              |
    2,0 +        + 1122    +         +         +     23  +      +         +         +    +
    |             112                                   23                              |
    |              122                                  23                              |
    |               1122                                23                              |
    |               1122                                23                              |
    ,0 +        +        + 1122+     + +  23   +         +      +         +         +    +
    |               1122                        23                                      |
    |               1122                        23                                      |
    |                1122    23                                                         |
    |                 1122   23                                                         |
    |                 112  23                                                           |
    -2,0 +        +         +    **  1223   +         +      +         +         +       +
    |                            113                                                    |
    |                            13                                                     |
    |                            13                                                     |
    |                            13                                                     |
    |                            13                                                     |
    -4,0 +         +         +         +     + 13    +         +      +         +        +
    |                                     13                                            |
    |                                     13                                            |
    |                                   13                                              |
    |                                   13                                              |
    |                                   13                                              |
    -6,0 +         +         +         +         13  +         +      +         +        +
    |                                         13                                        |
    |                                         13                                        |
    |                                         13                                        |
    |                                         13                                        |
    |                                         13                                        |
    -8,0 +                                      13                                       +
        +---------+---------+---------+---------+---------+---------+---------+---------+
        -8,0      -6,0      -4,0      -2,0       ,0       2,0       4,0       6,0       8,0
```
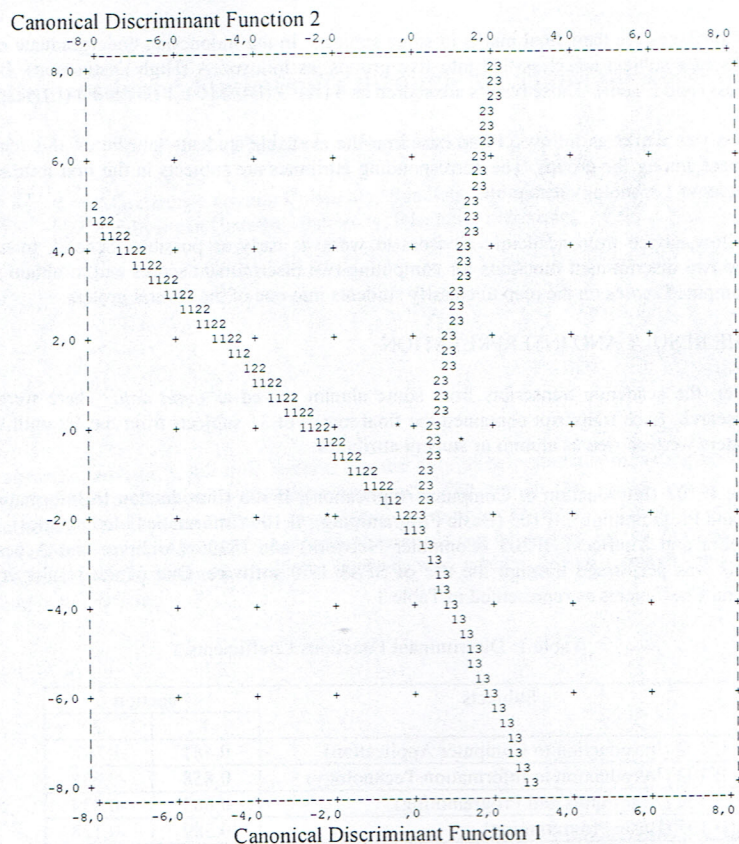
Canonical Discriminant Function 1

Figure 1: The territorial map.

Table 2 presents the accuracy of the discriminant analysis. Out of 146 alumni:

- Four (4) graduates with final passing results 1 (Extraordinary), three (3) of them classified correctly and one (1) incorrectly classified as results 2 (Very Satisfactory);
- 99 graduates with final passing results 2 (Very Satisfactory), 65 of them classified correctly and 10 and 23, were incorrectly classified as 1 (Extraordinary) and 3 (Satisfactory), respectively;
- 43 graduates with final passing results 3 (Satisfactory), three (3) of them classified correctly, and five (5) incorrectly classified as results 2 (Very Satisfactory).

Hence, out of 146 cases, 106 were classified correctly, which means the accuracy of the application of the discriminant analysis is 72.6%.

Table 2: The accuracy measurement of the Discriminant Analysis.

			Predicted Group Membership			
		Results	1.00	2.00	3.00	Total
Cross-validated	Count	1.00	3	1	0	4
		2.00	10	65	24	99
		3.00	0	5	38	43
	%	1.00	75.0	25.0	0.0	100.0
		2.00	10.1	65.7	24.2	100.0
		3.00	0.0	11.6	88.4	100.0

CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

This research demonstrates that discriminant analysis helps academic advisors to predict the final passing results of a student based on his/her performance in some subjects in the early stage (the first four semesters) of their study in higher education. This sort of facility enables academic advisors to assist students in setting up their study plans each semester in order for them to perform maximally.

The subject of further research may include the investigation of the prediction of the final passing results, which might be based on a data mining task called classification. Classification is performed through a technique called decision trees. It is envisaged that the authors of this article will undertake such research in the not too distant future.

ACKNOWLEDGEMENT

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