

Application of Mahalanobis Distance to Determine the Dynamical Nature of Academic Stress, Self-efficacy in Mathematics and Anxiety in Mathematics

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ABSTRACT: Present work is dealt with the application of Mahalanobis Distance to measure the difference among dependent variables Academic Stress, Self-efficacy in Mathematics and Anxiety in Mathematics for two groups of higher secondary level students. Five different dichotomous groups (consisting ten independent variables) of students are considered for this study. Mahalanobis Distance is applied to compare the dynamical nature of three dependent variables considered as a branch. It is found that there is no significant difference in dynamical nature of three dependent variables for different groups of independent variables.

Key Words: Mahalanobis Distance, Academic Stress, Self-efficacy, Anxiety, Mathematics.

I. INTRODUCTION

Mahalanobis Distance (MD) is playing a very important role in differentiating characteristics in different field like anthropology, physics Precision Medicine, Clustering, Image Processing, Classification, Neurocomputing, etc. for last few decades. At present this distance is used for educational studies where dynamical measure of a group of variables are taken into account for two groups of learners or single group of learners where a bunch of variables are taken in two different situations.

II. LITERATURE REVIEW

In MD a measure of distance between groups in terms of multiple characteristics is used. P C Mahalanobis projected this measure in 1936 (Mahalanobis, 1936) in the context of his studies on racial likeness. Following works such as Cochran and Rubin (1973), Rubin (1976, 1979, 1980), McLachlan (1999), Bedrick et al. (2000), Xiang et al. (2008), Rosenbaum (2015), Diedrichsen, Provost and Zareamoghaddam

(2016), Cristani and Murino (2018), Toma (2019), Imani (2019) and Etherington (2019) are some evidence from such fields. Ahmed et. al. (2019) and Sen and Pal (2020) applied this distance in educational studies for achievement analysis. Present work is a description of the process by which one can calculate MD for the purpose of more generalised and powerful educational measurement. Present work is an extension of the work done by Mahato and Sen (2021) where five pair of independent variables sex, class, family type, residence and stream are considered. To test null hypotheses for each variable, t-test and Mann-Whitney U Test are administered. But for present work our aim is to determine the dynamical nature of three dependent variables Academic Stress, Self-efficacy in Mathematics and Anxiety in Mathematics together.

III. OBJECTIVES

Objective of this study is to compare different groups with respect to three dependent variables i.e. Academic Stress, Self-efficacy in Mathematics and Anxiety in Mathematics taken together as a group of variables. There are ten groups i.e. Boys, Girls, Urban, Rural, Joint family, Nuclear family, Class XI, Class XII, Science and Arts. We are going to determine whether there is a significant difference between Boys vs Girls, Urban vs Rural, Joint family vs Nuclear family, Class XI vs Class XII and Science vs Arts.

IV. HYPOTHESES

One may consider the following hypotheses to compare three dependent variables i.e. Academic Stress, Self-efficacy in Mathematics and Anxiety in Mathematics for different groups as follows:

H₀₁: There is no significant difference between boys and girls on Academic Stress, Self-efficacy in

Mathematics and Anxiety in Mathematics taken together as a unit.

H₀₂: There is no significant difference between urban and rural students on Academic Stress, Self-efficacy in Mathematics and Anxiety in Mathematics taken together as a unit.

H₀₃: There is no significant difference between joint family and nuclear family on Academic Stress, Self-efficacy in Mathematics and Anxiety in Mathematics taken together as a unit.

H₀₄: There is no significant difference between class XI students and class XII students on Academic Stress, Self-efficacy in Mathematics and Anxiety in Mathematics taken together as a unit.

H₀₅: There is no significant difference between science students and arts students on Academic Stress, Self-efficacy in Mathematics and Anxiety in Mathematics taken together as a unit.

V. METHODOLOGY

Scales used:

- Academic Stress Scale (ASS):

$\Delta^2 = (X - Y)^T \Sigma^{-1} (X - Y)$ Where X and Y are the column vectors (means of each variables for two groups) and Σ is pooled covariance matrix of two groups of data.

$$\text{Mahalanobis Distance} = \left[(X - Y)^T \Sigma^{-1} (X - Y) \right]^{\frac{1}{2}}$$

Pooled Covariance Matrix

$$\Sigma = [n_1 \Sigma_1 + n_2 \Sigma_2] / N$$

Where Σ_1 and Σ_2 be the Covariance Matrices, n_1 and n_2 be the sample size for first and second group respectively and $N = n_1 + n_2$.

Authors considered the scale used by Viqar (2012) which was developed by Mustafa (2003) to find out academic stress.

- Mathematics self-efficacy and anxiety questionnaire (MSEAQ):

To find out Student's perception of Mathematics self-efficacy and anxiety, the scale MSEAQ is used which was developed by May (2009).

Let us also consider the scores of five different dichotomous variables i.e. sex (boys and girls), class (XI and XII), family type (joint and Nuclear), residence (urban and rural) and stream (science and arts) for this study. Dependent variables are Academic Stress, Self-efficacy in Mathematics and Anxiety in Mathematics.

Now our purpose is to find out a generalize measure to calculate the difference between two branches (three variables in each branch). The Mahalanobis Distance is the measure which may be used for this purpose.

Mahalanobis Distance may be calculated by the rule stated as:

VI. RESULTS AND DISCUSSIONS

Independent variable	Frequency	Dependent variable	Mean
Boys	146	Academic Stress	51.22
		Self-efficacy	42.91
		Anxiety	36.21
Girls	84	Academic Stress	51.55
		Self-efficacy	43.60
		Anxiety	39.06
Urban	146	Academic Stress	49.70
		Self-efficacy	42.90
		Anxiety	37.24
Rural	84	Academic Stress	54.19
		Self-efficacy	43.61
		Anxiety	37.26
Joint family	94	Academic Stress	46.63
		Self-efficacy	42.99
		Anxiety	35.78
Nuclear family	136	Academic Stress	54.60
		Self-efficacy	43.28
		Anxiety	38.26

Class -XI students	164	Academic Stress	49.30
		Self-efficacy	43.87
		Anxiety	36.63
Class-XII students	66	Academic Stress	56.39
		Self-efficacy	41.41
		Anxiety	38.77
Streams -Science	166	Academic Stress	51.39
		Self-efficacy	43.69
		Anxiety	36.23
Streams -Arts	64	Academic Stress	51.22
		Self-efficacy	41.80
		Anxiety	39.89

Table1. Necessary descriptive statistics for calculating MD.

Table1 shows the descriptive statistics required for calculating MD. We have to compare different groups to test the hypotheses H_{01} to H_{05} by calculating MD. Although there are three dependent variables, we can calculate t value to compare either Academic Stress or Self-efficacy in Mathematics or Anxiety in Mathematics for two different groups.

Beauty of MD is that, it can compare two or more than two variables as a unit of variables.

Dichotomous independent variables	Boys vs Girls	Urban vs Rural	Joint vs Nuclear family	Class XI vs XII	Science vs Arts
MD	0.3142	0.2625	0.4671	0.4521	0.3807

Table2: MD for three dependent variables Academic Stress or Self-efficacy in Mathematics or Anxiety in Mathematics.

Table2 represents the MD between dichotomous variables. Values of MD show that the differences are insignificant in nature. So, there is no significant difference in dynamical nature of the dichotomous groups when three dependent variables (Academic Stress + Self-efficacy in Mathematics + Anxiety in Mathematics) together act as a branch.

VII. CONCLUSION

If we take dependent variables one by one and test the difference for two independent variables, for example, Academic Stress between boys and girls, it shows the difference for that particular variable. But it fails to cover the dynamical nature of the three dependent variables taken at a time. MD has the power to compare a set of dependent variables and gives an output of a single number which represent the distance. Here, all the distances are less than 1. So, dynamical natures of the groups are almost similar.

Here the unit is Academic Stress and Self-efficacy in Mathematics and Anxiety in Mathematics. MD is a number which represent the difference as a distance.

Following relation may be considered to determine the nature of relationship represented by MD.

If, $0 \leq MD < 1$, difference is insignificant.

If, $1 \leq MD < 2$, difference is significant.

If, $MD \geq 2$, difference is strongly significant.

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