한국수학교육학회지 <수학교육>
1991. 6. 제 30권 제 1호 59 - 66

Journal of the Korea Society of Mathematical Education
June 1991: Vol. 30, No.1, 59-66

Students' Degree Project as an Efficient Test Discriminator

E. C. Nduka

Department of Mathematics and Statistics,
University of Port Harcourt,
Port Harcourt, Nigeria

ABSTRACT. This paper considers the problem of determining how degree examinations' project which consumes a very significant time of the student and his supervisor affect his overall degree performance and sifts among students of varying performance; particularly at the university level. A survey sampling method for data collection and techniques for analysis are discussed and results show degree project as a poor discriminator.

1. Introduction

Every examination has as its pivot the assessment of performance by examinees, hence it is of much interest to the educational planners, researchers, students and the nation at large.

We set out to present a methodology for assessing the value of academic work in the various faculties in a university system particularly the degree thesis and its structural characteristics.

Since students' degree project costs a lot of time and money both to the student, his supervisor and often times his department or faculty; the time and efforts expended in carrying out project is unproportional to that in other courses of equal weight and importance. This is not glossing over the fact that degree project helps to widen a student's research horizon in his further work.

We wish to provide a basis for tackling the following pertinent questions:

(i) Does degree project up-grade students performance in degree examinations?
(ii) Is project a good discriminator among students of differing academic ability?

2. Sampling

2.1 Survey Sampling for Data Collection

Our knowledge, attitudes and actions are based and often guided to a very large extent on samples, Cochran (1977). This holds sway in every day life and almost in all scientific research.

Bearing in mind the glaring advantages of survey sampling over the entire population:- cost - reduction, increased speed, precision and scope ; a study of this nature would require designing suitable sampling techniques.

We would take for granted that a university structure is made up of faculty of studies and within it we have departments offering various courses. Also courses are graded either on four or five point Grade Point Average (GPA). Under this configuration, any faculty(ies) or department(s) not offering degree projects or not grading such are exclued to prevent its chance of falling into the required sample.

The data for this study were collected from the Examinations Department of the six "first generation" universities sampled (Ibadan, Nsukka, Ahmadu Bello, Ife, Lagos, Benin), NUC (1975): the target population consisting of all the lists of final year students over the peried 1985-1989.

Stratified random sampling which increases precision and necessitates making inferences on any desired stratum and also monitor any interaction in the set up is used. The frame consists of the lists and the GPA's of students in each department within various faculties over the period 0 study.

Here a two-stage stratified random sampling is used, first stratification is based on the faculties; then faculties are sub-stratified into departments from which a simple random sample of the students were selected. This arrangement is obvious because faculties have different modes of assessing degree project performance; and also its "difficulty levels" and other criteria may differ from faculty to faculty and department to department. Above all, the number of departments and students in each faculty are unequal. The GPA's are standardized to the four point scale of the University of Nigeria (1985).

2.2 Choice and Allocation of Sample Size

Undoubtedly, the GPA's would differ between faculties and within faculties; so the corresponding variance scores would differ. Also the cose (time) of obtaining data for each department would differ because of the nature and set up in various departments and faculties. The variance scores for each faculty in the respective years would be

$$S_{ijl}^2 = \frac{\sum_{ijl}(x_{ijl} - \bar{x}_{i..})^2}{N_{ij} - l}$$

$i = (1, s)$, $j = (1, m)$, $l = (1, p_i)$.
N_{ji} is the number of students in faculty j in the i^{th} year.
$\bar{X}_{i..}$ is the cumulative GPA in the ith year.

We now estimate and obtain the sample size due each faculty in the respective years which is

$$n_{ji} = \frac{\sum_j N_{ji}^2 S_{ijl}/W_{ji}}{N_{ji}^2 D + \sum_j N_{ji} S_{ijl}^2}$$

W_{ji} is the faculty weight ($= N_{ji}/\sum_j N_{ji}$)
D is bound on the error of estimation.

We make an optimum allocation of each n_{ji} to the various departments based on the differing linear cost function of obtaining data from each faculty:

$$n_j(k)i = C\left(\frac{(N_{ji}N_{ji}S_{ijl})}{\sum_j N_{ji}S_{ijl})}\right)$$

where

$$C = \begin{cases} t_0 \sum_j t_{ji}\sqrt{n_{ji}} & (t \text{ as travel time}) \\ t_0 & \text{is the overhead cost.} \end{cases}$$

Having estimated the sample sizes due each faculty and then departments, a simple random sample of the desired sizes was taken from each department. These now become the subjects for our experimentation.

2.3 Method For Data Collection

The most ideal method for this comparative study would be to examine the sampled students in the given year coupled with their degree project report and thereafter re-examine them without their doing any project. This is not feasible in a system where no student would offer himself up for such exercise.

The ideal comparison would require that a number of pairs of final year students of substantially equal motivation and ability in each department be selected, one member of each pair would then be randomly chosen and would be offered project while his matched partner served as a control Siegel (1956). Practically, this mode would be problematic for two reasons: one is in a department where students must do project before graduating and the other is hat emotions could be evoked in either group of the students as to what may seem discriminatory, differential or preferential treatment regardless of their performance in the examination.

Consequently, the mostly practical approach would be to calculate each of the sampled student's degree GPA-X_{ijkl} and re-calculate it when his degree project score has been removed -Y_{ijkl}. The student serves as his own control!

3. Analysis

We would assume that the students' GPA's (X_{ijkl}, Y_{ijkl} as most test scores) are drawn from approximately normally distributed population, Hogg & Craig (1982).

3.1 Paired-Comparison t-Test

The paramentric technique for analysing such data from two related samples is to apply a t-test to the difference mean scores to know if degree project really up-grades performance in degree examinations. The test statistic is

$$t = \frac{\bar{d}_{i\ldots} - u_{di\ldots}}{(S^2_{di}/m)^{\frac{1}{2}}} \sim t_{m-l}(\alpha)$$

S^2_{di} is the variance of the "difference" GPA's $(= \sum(d_{ijkl} - \bar{d})^2/m - 1)$

$$d_{ijkl} = X_{ijkl} - Y_{ijkl}$$

X_{ijkl} is the GPA of the ℓth sampled student of the kth department within the jth faculty in the ith year.
α is a chosen type I error. The hypothesis of interest is

$$H_0 : U_{di} = 0, \quad H_1 : U_{di} > 0.$$

We shall reject H_0 in favour of H_1 if $t > t_{m-1}(\alpha)$, and accept otherwise. (See Table 1)

3.2 Sing-Rank Test

The t-test would show what happens on the average in the faculties, and not what happens to sampled individual students. Here we would investigate what happens to each sampled individual examinee through d_{ijkl}'s and if $d_{ijk\ell}$'s are symmetric about zero.

If $\min(d_{ijkl}) > 0$, shows that it up-grades individual performance in the faculties.
If $\min(d_{ijkl}) < 0$, it down-grades.
If $\min(d_{ijkl}) = 0$ shows no effect.
This is to check if few sampled students are instrumental to average performance.
The sign-rank test (its asymptotics) is

$$Z = \frac{S^+_{Nj(k)} - ES^+_{Nj(k)}}{\sqrt{\mathrm{Var}(S^+_{Nj(k)})}} \sim N(0,1)$$

$ES^+_{Nj(k)}$ is expected value $(= \frac{1}{4}\{N_{j(k)}(N_{j(k)}+1) - t_0(t_0+1)\})$.
Var $S^+_{Nj(k)}$ is variance value

$$(= \frac{1}{24}\{[N_{j(k)}(N_{j(k)}+1)(2N_{j(k)}+1) - t_0(t_0+1)(2t_0+1)]^{-\frac{1}{2}} \sum_i (t_i^3 - t_i)\}).$$

S^+_N is the sum of positive ranks
t_0 is the number of zero differences in each group
t_i is the number of tied differences in each group
The hypothesis to be tested is
$H_0 : d_{ijkl}$ is symmetric about zero
$H_1 : d_{ijkl}$ is not symmetric about zero, and we would reject H_0 if $Z \notin [Z_{1-\alpha/2}, Z\alpha/2]$, $\notin$ is not in (see Table 2)

Table 1: Results of Difference - Test

Faculty	$\bar{d}$	s_d	t	$t_{.05}(m-1)$	Decision on H_0
Agriculture	0.078	0.122	4.475	2.01	Reject
Arts	0.047	0.138	2.890	2.02	"
Education	0.039	0.145	2.509	1.99	"
Engineering	0.035	0.179	1.771	2.00	Accept
Medical Sciences	0.075	0.145	4.626	2.01	Reject
Physical Sciences	0.034	0.118	2.305	2.00	"
Social Sciences	0.039	0.141	2.780	1.98	"

The table suggests that project upgrades performances in degree examinations except for the faculty of Engineering.

Table 2: Results of Minimum d_i and Sign-Rank Tests.

Faculty	Z-values	$Z_{.05}$	Decision on H_0	Minimum d_i
Agric.	4.19		Reject	0.060
Arts	3.45		"	0.004
Education	2.72		"	-0.016
Engineering	2.47	1.67	"	-0.030
Medical Sciences	4.53		"	0.034
Physical Sciences	3.22		"	0.004
Social Sicences	10.01		"	0.012

The table suggests that degree project does not upgrade individual performances in Education and Engineering; and it is not symmetric about zero.

3.3 Degree Project Discrimination

The two discriminators of degree project would be (in this case) its difficulty index and discriminating power. Difficulty index measures the level of easiness or difficulty of scores. For the sharpest discrimination among examinees, a test should be about 0.5 in difficulty. In practice, a test of difficulty index between 0.4 and 0.6 is preferred to that outside them, Ohuche & Akeju (1977).
The Discriminating Power measures the extent to which a test sifts among examinees differing in performance. Descrimination measures is such that good students perform very well, aberage students moderately and bad students poorly.

The Algorithm

Steps

I Assign the "Top" 25% of the examinees (those who score A or maximum grade) to N_T.

II Assign the "Bottom" 25% (those who score C or minimum grade) to N_B,

III Use $\gamma_{diff} = \frac{N_T+N_B}{N/2}$, $0 \leq \gamma_{diff} \leq 1$ to determine the difficulty index

IV Use $\gamma_{dis} \frac{N_T}{\text{"Top" } 25\%} - \frac{N_B}{\text{"Bottom" } 25\%}$, $-1 \leq \gamma_{dis} \leq 1$ to determine the discriminating power.

V Repert I, II, III and IV until the number of examinees are exhausted.
N is the number of examinees in each faculty.
If $\gamma_{diff} \in [0.4, 0.6]$ shows that the examination itself is of average difficulty (standard).

If $\gamma_{diff} < 0.4$ shows a below average (substandard) examination
If $\gamma_{diff} > 0.6$ shows an above average (superstandard) examination.
The more γ_{dis} approaches 1, the sharper the discriminating power of degree project.
If γ_{dis} approaches zero, it shows project as a low (poor) discriminator.
If γ_{dis} approaches - 1 indicates that students with low degree performance do better in project than those with high degree performance.

Table 3: Results of Difficulty Index and Discriminating Power.

		N_T	N_B	γ_{diff}	γ_{dis}
Argic.	"Top" 25%	6	–	0.04	0.08
	"Bottom" 25%	–	0		
Arts	"Top" 25%	36	–	0.28	0.22
	"Bottom" 25%	–	24		
Education	"Top" 25%	30 30	–	0.16	0.14
	"Bottom" 25%	–	12		
Engineering	"Top" 25%	36	–	0.24	0.10
	"Bottom" 25%	–	24		
Med. Sciences	"Top" 25%	30	–	0.23	0.05
	"Bottom" 25%	–	24		
Phy. Sciences	"Top" 25%	18	–	0.25	-0.13
	"Bottom" 25%	–	30		
Soc. Sciences	"Top" 25%	18	–	0.08	0.08
	"Bottom" 25%	–	6		
All	"Top" 25%	174	–	0.18	0.07
	"Bottom" 25%	–	120		

The above suggests that degree project has low difficulty and discriminating power. The negative discriminating power in Physical Sciences tends to indicate that those with low degree performance do better in degree project than those whose degree performance is better.

Theorem. *If* $\gamma_{diff} \in [0.4, 0.6]$, *then* $\gamma_{dis} \to 1$.

Proof: (sketch). Let $N = N_T + N_B + N'$
where N' is the number of examinees not in N_T of N_B.

$$\Rightarrow \gamma_{diff} = \frac{N - N'}{0.5N}$$

for $\gamma_{diff} = 0.4$ (say).

$$\frac{N - N'}{N} = 0.2$$

$$\Rightarrow N' = 0.8N$$

Also

$$\gamma_{dis} = \frac{N_T}{\text{"Top" } 25\%} - \frac{(N - N' - N_T)}{\text{"Bottem" } 25\%}$$

Scores are assumed normal, thus number of "Top" 25% and "Bottem" 25% do not differ significantly.
i.e. number of "Top" 25% $\approx$ number of "Bottom" 25% $= K$ (say).

$$\Rightarrow \gamma_{dis} = \frac{N_T - N + N' + N_T}{K} = \frac{2N_T - 0.2N}{K}$$

But $N_T + N_B < N$

$$\text{"Top"}25\% + \text{"Bottom"}25\% << N$$

i.e.

$$K << N.$$

Hence

$$\gamma_{dis} = \frac{2N_T - 0.2N}{K} \to 1$$

Since $\max(\gamma_{dis}) = 1$.
It follows similarly for $\gamma_{diff} = 0.6$.

4. Summary And Conclusion

Degree project generally up-grades students performances in degree examination among the Nigerian universities. This may well be expected since no student sampled failed in project examinations. Its level of difficulty and discrimination is rather low. Since this is the situation, it calls to question the rationale for the students' time, effort and money being expended in carring out project studies.

As the difficulty index and discriminating power act as "inbuilt" checks and balances in the sense that it confides in and convinces the university administration the reliability of the quality of its examinations; and on the part of the students a measure of self assessment and placement, the degree project examinations should be restructured towards raising the present levels of difficulty index and discriminating power. This could be achieved by weighting project topics assigned to students.

ACKNOWLEDGEMENT

The author acknowledges the invaluable contributions made by Dr. C.C. Agunwamba of the Department of Statistics, University of Nigeria, Nsukka.

References

1. Academic Calendar, The University of Nigeria, Nsukka.
2. Cochran, W. G., "Sampling Techniques," John Wiley & Sons Inc., 1977, p. 1.
3. Hogg, R. V. & Craig, A. T., "Introduction to Mathematical Statistics, 4th Ed," Macmillan Pub. Coy, Inc., 1978, p. 112.
4. Ohuche, R. O. & Akeju, S. A., "Testing and Evaluation in Education," African Education Resources Pub., 1977, pp. 111–114.
5. Siegel, S, "Non-Parametric Statistics for the Behavioural Sciences," McGraw Hill Book Co. Inc., 1956, p. 61.