Finding the Correlation between Formative and Summative Assessments by Spearman's Correlation Coefficient: A Case Study

S.Rajalingam[1*] and Zeya Oo[2]

[1,2]School of Engineering and Science, Curtin University Sarawak,
Sarawak Campus, CDT 250, 98009, Miri, Sarawak, Malaysia

rajalingam@curtin.edu.my
zeya.oo@curtin.edu.my

Abstract – *Academic progresses of students are measured by using variety of statistical analysis techniques like central tendency, variability, percentiles and others. These measures help the teaching professionals to understand their student progress in their class. A relatively simple technique that can be used for exploratory data analysis is the Spearman rank correlation coefficient. In this paper the authors describe how the Spearman rank correlation coefficient can be used as a statistical tool to find out the correlation between two different types of assessments for a mathematics unit as a case study. This method is perhaps the simplest method for calculation of coefficient correlation. Is a non parametric technique for evaluating the degree of linear association or correlation between two independent variables. It is operates on the ranks of the data rather than the raw data. The case study result show that existence of a positive correlation of medium order between the formative and summative assessments. That is, increase in formative assessment the summative assessment also increase. In other words, some students who scored high in the formative assessment only managed to get medium scores in the summative assessment and vice versa.*

Keywords: Correlation, Formative and Summative Assessments, Coefficient, Hypothesis, Rank, and Data.

INTRODUCTION

Academic progresses of students are measured by using variety of statistical analysis techniques like central tendency (mean, median and mode), variability (range, quartile deviation, average deviation and standard deviation) and percentiles. These measures help the teaching professionals to understand their student progress in their class. At the same time technique like standard scores (Z scores and T scores) are useful in interpretation of the results of an examination (M.Bhandarkar, 2007). Therefore statistical measures and techniques are useful in evaluating the progress of students. A relatively simple technique that can be used for exploratory data analysis is the Spearman rank correlation coefficient (Thomas, 2001). In this paper the authors describe how the Spearman rank correlation coefficient can be used as a statistical tool

to find out the correlation between two different types of assessments for a mathematics unit.

The main author teaches Mathematics and Statistics for undergraduates. According to him some of the important questions are still yet to be answered. For example, why the students of equal ability differ in their achievements? Can student scoring good marks in mathematics also score good marks in physics? Do the marks scored in mathematics have any relationship to the marks scored in programming? These are some of the questions which strike his mind. According to him the teaching professionals can only find out the answers to these types of questions if they have adequate knowledge about correlation which exits among the various subjects or units. The authors also believe that knowledge of correlation is extremely essential to make the teaching and learning more effective.

Correlation -Interrelation between two variables is known as correlation which indicates how change in one variable affects the other variable. The correlation among more than two variables is a multiple correlation and correlation between two variables is a simple or liner correlation (Walpole et al, 2002). Correlation also can be divided into five different categories: Positive correlation, Perfect positive Correlation, Zero Correlation, Negative Correlation and Perfect Negative Correlation. There are three factors have to be considered in understanding the correlation. 1. The direction of correlation. (positive or negative), 2.The existence of correlation between the variables and 3.The extent of correlation. (High, Medium or Low) (M.Bhandarkar, 2007).

Coefficient of correlation - A constant which denotes the extent of correlation that exists between the two variables is known as coefficient of correlation. Since, the coefficient of correlation is a ratio, it has no unit. In general, coefficient of correlation is denoted by ρ *(rho)*. The limit of coefficient correlation extends from -1 to +1 where the positive or negative signs indicate the nature or direction of correlation. In statistics, the value of the correlation coefficient varies between +1 and -1. When the value of the correlation coefficient is $\pm$ 1, then it is said to be a perfect correlation between the two variables. As the value goes towards zero, the relationship between the two variables will be weaker (Myers et al, 2003). There are three types of correlation coefficients in statistics: Pearson correlation, Kendall rank correlation and Spearman correlation (William C. 2005). The case study in these paper focuses on Spearman Rank Difference Method.

A CASE STUDY

The sample comprised 18 students who enrolled in the *Mathematics 277* unit semester 1, 2010 in their second year engineering programme in Curtin University of Technology Sarawak Campus, Sarawak, Malaysia. *Mathematics 277* is a core unit in the course of Bachelor of Electrical and Computer Engineering. Assessment details

are as follows: Formative Assessment (Online Quizzes and Assignments) is 40% and Summative Assessment (Final Exam) is 60%. The main author is the lecturer cum examiner for *Mathematics 277* unit and the score distribution for the formative and summative assessments raw score is given in the Table 1.

Objective of the study - The case study intended to find out is there any correlation between the students score in formative and summative assessment for *Mathematics 277* unit by computing the coefficient of correlation using Spearmen's rank method.

METHODOLOGY

Spearman's Rank Difference Method – This method is perhaps the simplest method for calculation of coefficient correlation. Is a non parametric technique for evaluating the degree of linear association or correlation between two independent variables. It is similar to Pearson's product moment correlation coefficient except that it operates on the ranks of the data rather than the raw data. Spearman's rank order correlation ρ (or rho) determines the relationship between two sets of ordinal data (usually paired) that initially appear in rank order or have been converted to rank order (Walpole et al, 2003). There are advantages to using Spearman's rank correlation coefficient over other common product moment correlation coefficients. It is a non parametric technique so it is unaffected by the distribution of the population. Because the technique operates on the ranks of the data it is insensitive to outliers and there is no requirement that the data be collected over regularly spaced intervals. It can be used with very small sample sizes and it is easy to apply.

There are three imported steps in the case study: 1.Compute the coefficient of correlation by Spearman's rank method, 2.Interpret the coefficient of correlation and 3. Perform the hypothesis test to test the significance of the correlation (Singaravelu and Sivasubramanian, 2010)**.**

Steps1: Computing Coefficient of Correlation by Spearman's Rank Method

- Each variable (formative and summative assessments scores) is ranked separately from lowest to highest (e.g. 1, 2, 3, etc). Ranks for the formative and summative assessments are denoted by R_1 and R_2 respectively.
- If two or more students obtain equal scores, then same rank was given to them. Therefore the average of the concerned rank is computed. It is an average of their ranks in the ascending order of the values. For example (Refer to Table 1), rank 9.5 (columnR_2) is given to students 3 and 4 by obtaining average of 9^{th} and 10^{th} rank.
- Calculate the difference *(D)* between two ranks by subtracting R_2 from R_1, i.e. $D = R_1 - R_2$. Take note that if the sum of differences $(\sum D)$ comes out to be zero, then we can conclude that the steps followed are correct.
- The differences are squared(D^2).

- All D^2 are summed up and the total is denoted by($\sum D^2$).
- Compute the value of Spearman's rank correlation coefficient ρ (rho) by using the equation 1(Myers et al, 2003; Maritz, 1981).

$$\rho = 1 - \frac{6\sum D^2}{N(N^2-1)} \qquad \text{(Equation 1)}$$

Where, ρ (rho) is Spearman's rank order correlation coefficient,
D is the difference between ranks for the two observations within a pair
N represents the total number of pair data.

Step 2: Interpretation of Coefficient of Correlation

Once the value of coefficient of correlation computed by using equation 1 the approximate interpretation of the correlation coefficient can be refer to Table 2.

Step 3: Hypothesis Testing

- We assume that there is no correlation between formative and summative assessment by saying that the null hypothesis is zero otherwise the alternative hypothesis that it is not equal to zero at the 0.05 level of significance.

  Null Hypothesis H_O: $\rho = 0$ vs Alternative Hypothesis H_A: $\rho \neq 0$
- Significance level $\alpha = 0.05$
- Find the Critical Value of Spearman's Rank Correlation by referring to Table 3.
- To determine whether the *rho* coefficient is statistically significant (e.g., reject the null hypothesis that the *rho* is zero), compare the calculated *rho* with *rho* value found in Table 3 corresponding to the two sets of data R_1 and R_2 .
- If the calculated *rho* is equal to or greater than the tabulated *rho*, reject the null hypothesis at the 5% level of confidence. If the calculated *rho* is less than the tabulated *rho*, fail to reject the null hypothesis (reject alternative hypothesis) at the 5% level of confidence.
- Conclusion: The rejection of the null hypotheses gives the conclusion that there is a significant correlation or linear relationship between the formative and summative assessments otherwise there was no correlation.

RESULT AND DISCUSSION

Correlation - The Table 1 shows that total sum of *D*s ($\sum D$) are equal to zero therefore can confirm that the ranks are calculated correctly. The Spearman rank correlation coefficient (ρ) calculated by two methods where the ρ equal to 0.53 was calculated by using the equation 1is given below.

$$\rho = 1 - \frac{6(458.50)}{18(18^2-1)} = 0.53$$

and the ρ equal to 0.522 was given by the SPSS output Table 4. Both values are almost same and only different in term of decimal point.

Table 1: Distribution of Scores and Rank for Formative and Summative Assessment

N	Formative Assessment (40%)	R_1	Summative Assessment (60%)	R_2	$D = R_1 - R_2$	D^2
1	39.09	2.00	27.50	4.00	-2.00	4.00
2	39.77	1.00	34.00	1.00	0.00	0.00
3	35.62	12.00	24.00	9.50	2.50	6.25
4	34.69	15.00	24.00	9.50	5.50	30.25
5	34.42	16.00	17.00	14.00	2.00	4.00
6	35.57	13.00	17.50	13.00	0.00	0.00
7	35.94	11.00	16.50	15.00	-4.00	16.00
8	38.68	3.00	26.00	5.50	-2.50	6.25
9	38.41	5.00	25.50	7.00	-2.00	4.00
10	36.40	9.00	28.50	2.50	6.50	42.25
11	37.95	7.00	26.50	5.50	1.50	2.25
12	37.03	8.00	13.00	16.00	-8.00	64.00
13	38.03	6.00	12.50	17.00	-11.00	121.00
14	35.50	14.00	9.50	18.00	-4.00	16.00
15	38.55	4.00	28.50	2.50	1.50	2.25
16	30.68	17.00	23.00	11.00	6.00	36.00
17	26.30	18.00	24.50	8.00	10.00	100.00
18	36.28	10.00	22.00	12.00	-2.00	4.00
					$\sum D = 0.00$	$\sum D^2 = 458.50$

Table 2: Interpretation of Coefficient of Correlation

Value of *r (rho)*	Correlation
0.00	Zero Correlation
0.00 to 0.19	Negligible Correlation
0.20 to 0.39	Low Correlation
0.40 to 0.59	Correlation of medium order
0.60 to 0.79	Good or High Correlation
0.80 to 0.89	Very Good or Very High Correlation
0.90 to 0.99	Excellent or Highest Order Correlation
1.00	Perfect Ideal Correlation

Table 4: Computer output from SPSS

Correlations

			Summative Assessment	Formative Assessment
Spearman's rho	Summative Assessment	Correlation Coefficient	1.000	.522*
		Sig. (2-tailed)	.	.026
		N	18	18
	Formative Assessment	Correlation Coefficient	.522*	1.000
		Sig. (2-tailed)	.026	.
		N	18	18

*. Correlation is significant at the 0.05 level (2-tailed).

Table 3: Table for the Critical Value of Spearman's Rank Correlation (one – tailed)

Table for Critical Values of Spearman's Rank Correlation Coefficient (one-tailed)

N	alpha = 0.05	alpha = 0.025	alpha = 0.012	alpha = 0.005
5	0.900	-	-	-
6	0.829	0.886	0.943	-
7	0.714	0.786	0.893	-
8	0.643	0.738	0.833	0.881
9	0.600	0.683	0.783	0.833
10	0.564	0.648	0.745	0.794
11	0.523	0.623	0.736	0.818
12	0.497	0.591	0.703	0.780
13	0.475	0.566	0.673	0.745
14	0.457	0.545	0.646	0.716
15	0.441	0.525	0.623	0.689
16	0.425	0.507	0.601	0.666
17	0.412	0.490	0.582	0.645
18	0.399	0.476	0.564	0.625
19	0.388	0.462	0.549	0.608
20	0.377	0.450	0.534	0.591
21	0.368	0.438	0.521	0.576
22	0.359	0.428	0.508	0.562
23	0.351	0.418	0.496	0.549
24	0.343	0.409	0.485	0.537
25	0.336	0.400	0.475	0.526
26	0.329	0.392	0.465	0.515
27	0.323	0.385	0.456	0.505
28	0.317	0.377	0.448	0.496
29	0.311	0.370	0.440	0.487
30	0.305	0.364	0.432	0.478

The two variables are said to be positively correlated because of the positive sign (+ 0.53). The value of 0.53 shows that the strength of the linear relationship between the two variables are medium order. Therefore we can interpret that any increase or decrease in one variable also can causes increase or decrease respectively in the other variable.

Hypothesis Testing – The calculated $\rho = 0.53$ and from Table 3, the tabulated *rho* correlation coefficient of 0.476 is required for statistical significance at the 0.025 level of significance in the two-tailed test with N = 18. The calculated *rho* is clearly greater than the tabulated *rho.* Therefore we reject the null hypothesis at the 5% level of confidence. The rejection of the null hypotheses gives the conclusion that there is a significant correlation or linear relationship between the formative and summative assessments.

CONCLUSIONS AND RECOMMENDATIONS

The value of $\rho = +0.53$. The value of *rho* is positive and of medium order, indicating the existence of a positive correlation of medium order between the formative and summative assessments. That is, increase in formative assessment the summative assessment also increase. In other words, some students who scored high in the formative assessment only managed to get medium scores in the summative assessment and vice versa. While $\rho = +1.00$ represents a perfect positive correlation between the two sets of ranks R_1 and R_2, the difference $\Delta\rho = 0.47$ gives a rough

estimate of the proportion of students whose ranks R_1 and R_2 failed to correlate as explained above.

The most important disadvantage of rank difference method is that it is useful only if the number of scores N is less than 30. If N is more than 30, this method is not useful. The method becomes complicated as the number of scores increases. Another disadvantage is that the data there is loss of information when the data are converted to ranks and if the data are normally distributed, it is less powerful than the Pearson correlation method. In that case, the Peason's Product Moment Method is recommended for calculation of coefficient of correlation.

REFERENCES

M.Bhandarkar (2007). *Statistics in Education,Neelkamal* Publication: Neelkamal Publications Pvt.Ltd. ISBN 8183161030

Maritz. J.S. (1981). *Distribution-Free Statistical Methods*, Chapman & Hall. ISBN 0-412-15940-6. (page 217)

Myers, Jerome L.; Arnold D. Well (2003). *Research Design and Statistical Analysis* 2nd Edition . Lawrence Erlbaum. pp. 508. ISBN 0805840370.

Thomas D. Gauthier. *Detecting Trends Using Spearman's Rank Correlation Coefficient.* Environmental Forensics, Volume 2, Issue 4, December 2001, Pages 359-362

Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, Keying Ye., (2002) .*Probability & Statistics for Engineers & Scientists* , 7th Edition, Publisher: Prentice Hall.

A.Singaravelu and Sivasubramanian (2010). *Statistics and Numerical Methods,* 5th Edition, Publisher: Meenakshi Agency

William C. Rinaman (2005). *Exploring Statistics with SPSS*, http://web.lemoyne.edu/~rinaman/LABMANUAL.HTML

Biodata

S. Rajalingam is currently working as a senior lecturer at the Curtin University, Sarawak Campus and pursuing a PhD in Applied Mathematics (by research) at University Malaysia Sabah, expected to complete in year 2012. He has wilst working experience in manufacturing industries in engineering field and in education industries as an Engineering Mathematics Lecturer. The subjects that he had taught range from the first year up to the postgraduate level. He received Best Lecturer Award and Student Choice Award for School of Engineering & Science in Year 2009 and 2010 respectively.