IOSR Journal of Research & Method in Education (IOSR-JRME)
e-ISSN: 2320–7388,p-ISSN: 2320–737X Volume 7, Issue 5 Ver. IV (Sep. – Oct. 2017), PP 28-43
www.iosrjournals.org

Correlation between Difficulty and Discrimination Indices of MCQs Type A in Formative Exam in Anatomy

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Abstract: *Difficulty (D) and discrimination (P) indices are the factors used to assess the typical of MCQs type A in the examination. The plan of this study knows the correlation between the (D) and (P) and the standard of MCQs informative examination in Anatomy. There were 580 MCQs items, taken from six exams for medical female students conducting in the Najran University department of anatomy. The relationship between them determined by a Pearson correlation using SPSS-PC version 20.0. Distribution of items: very difficult; 9 (3.5%): 75 (37.5 %), difficult;2 (1%):14 (7.8%), average; 45 (22.5%): 6 (3%), easy; 2 (1.1%): 29 (14.5%) and very easy; 1 (0.6%): 27 (13.5%).Poor discrimination; 61 (30.5%): 13 (7.2%), acceptable; 0(0%):19 (10.6%), good; 0 (0%): 7 (3.5%), very good; 0 (0%): 9 (5%) and excellent; 14 (7%): 64 (32%).The coefficient "r" (r = 0.509, P = (0.000) < 0.01, r = 0.181, P = (0.072) > 0.01, r = 0-.059, P = (.560) > 0.01, r = 0.260, P = (0.009) < 0.01, r = 0.490, P = (0.000)< 0. and r = 0.372, P = (0.000) < 0.01.Our finding has a widely positive correlation between (D) and (P) indices.*

Keywords: *Item analysis, Difficult index, Discrimination index, formative test, Single best response type MCQ.*

Date of Submission: 13-09-2017 Date of acceptance: 28-09-2017

I. Introduction

Formative examinations are part of the instructional process which helps to modify teaching and learning while they are happening. Timely modification can be made to improve knowledge. Knowledge of students can be assessed by MCQs dates to 1960 .After 1999, in medical sciences, use of MCQs has been diversified to departmental, university and competitive examinations. Informative examinations MCQs help to understand the strength, weakness, gaps in knowledge, and provide feedback to teachers on their educational actions [1,2,3].

Evaluation is an important component of a teaching-learning curriculum. A significant application of evaluation is for continued monitoring of learning activities for giving a feedback to students and teachers. Today Multiple Choice Questions (MCQs) is the most commonly used tool for assessing the knowledge capabilities of medical students.However it is said that MCQs emphasize recall of factual information rather than conceptual understanding and interpretation of concepts[4]. There is more to writing good MCQs than writing good questions. Properly constructed MCQs can assess higher cognitive processing of Bloom's taxonomy such as interpretation, synthesis and application of knowledge, instead of just testing recall of isolated facts [5,6]. Designing good MCQs is a complex, challenging and time consuming process. Having constructed and assessed, MCQs need to be tested for the standard or quality .Item analysis examines the student responses to individual test items (MCQs) to assess the quality of those items and test as a whole[7]. It is a valuable yet relatively simple procedure performed after the examination that provides information regarding the reliability and validity of a test [8]. Thus item analysis assesses the assessment tool for the benefit of both student and teacher.

Item analysis is a process which examines students, responses to individual test items in order to assess the quality of those items and quality of the test as a whole. It is of great help in improving the quality of items which may be used again in subsequent tests. It also nurtures a thought in the mind of the instructor to improve the skill in the construction of test items, and also helps identify course content which needs greater emphasis or clarity .Nonetheless, it also provides feedback to teachers to instill changes in the standard of teaching. The item statistics can help find out poor items which need improvement or deletion. It allows any aberrant items to be given attention and reconstructed. Although some basic form of item analysis of the MCQ tests might have been carried out routinely there has been no evidence that the data generated have been used to help develop or select subsequent MCQ items [9,10].

There was a wide distribution of item difficulty indices (8.57 to 95.71) and discrimination indices

(-0.54 to 0.8).The mean difficulty index (P) was 52.53 + 20.59 and mean discrimination index was 0.30+ 0.18. On average, about23% of the MCQ items were easy (P >70%), while about 15%were difficult (P <30%). The remaining 62% items were within acceptable range (30 to 70%). In all 4% of the items showed negative discrimination and 21% of the items exhibited poor discrimination. The remaining 75% of the items were in the range of acceptable to excellent discrimination. The discrimination index exhibited slight positive correlation with difficulty index (r = 0.191, P=0.003<0.01. (The maximal discrimination (D=0.6-0.8) was observed with moderately easy/difficult items (P = 40% - 60%) [11].

Difficulty index of 31(62%) items was in the acceptable range (p value 30-70%), 16(32%) items were too easy (p value >70%) and 3(6%) items were too difficult (p value <30%). Discrimination index of 26 (52%) items was excellent (d value>0.35), 9(18%) items was good (d value 0.20-0.34) and 15(30%)items were poor (d value<0.2%). A total of fifty items had 150 distractors. Amongst these, 53(35.3%)were nonfunctional distractors, 38(18.6%) were functional distractors and 69(46.06%) had nil responsive. not attempted by any student. On the basis of non-functional distractors, distractor effectiveness of each item was assessed. Inter-relationship between these indices was analyzed [12].

The items were categorized in their discrimination indices based on [13]Ebel (1972) guidelines on CT item indices. As a rule-of thumb, any item discrimination index of 0.2 or higher is acceptable [14](Brown, 1983; [15] Crocker and Algina, 1986.(Among the seventy items analyzed, forty-nine (70%) were found with index level of 0.2 or higher and were able to discriminate good and weak students. [16]Lin et al., (1999) in item analysis of registered nurse licensure examination in Taiwan held in 1996 found that 23 out of 80 (29%) MCQ items on Basic Medical Sciences had discrimination indices less than 0.2.

Pearson correlation between difficulty and discrimination indices showed that discrimination index correlate poorly with difficulty index (r = -0.325). The correlation is significant at 0.01 level (2-tailed).Negative correlation signifies that with increasing difficulty index values, there is decrease in discrimination index. Negative correlation between difficulty and discrimination index indicated that with increase in difficulty index, there is decrease in discrimination index. As the test items get easier, the discrimination index decreases, thus it fails to differentiate weak and good students [17].

Same observation was reported by Si-Mui Sim et al., (2006) in their study, Mitra et al., (2009)showed that the discrimination index correlated poorly with the difficulty index (r= -0.325). The negative correlation signified that with increasing difficulty index values, there was a decrease in the discrimination index indicating that low performance students were more likely to get the correct answer. As the items got easier (above 75%), the level of discrimination index decreased consistently.

Pearson correlation between difficulty and discrimination indices showed that discrimination index correlate poorly with difficulty index (r = -0.453). The correlation was significant at 0.000 level (2-tailed). Negative correlationsignifies that with increasing difficulty index values, there is decrease in discrimination index. When the data was entered in Microsoft illustration a dome shaped relationship was displayed (Figure 4.9). Initially, the discrimination power increased with the level of difficulty of the items, until it reached a plateau (discrimination index of about 0.28 with the maximum 0.65) with difficulty indices of about 0.50(extending up to 0.70) and then began to decline with further increase in difficulty indices. The discrimination power of the items with difficulty indices 0.10 and 1.0 were zero [18].

Relationship between Item difficulty (p) and discrimination power index (d) for each test item was determined by Pearson correlation analysis. The difficulty indices and discrimination indices are most often reciprocally related. The relationship between "p "and "d" is not linear but is somewhat dome shaped. Pearson correlation coefficient "r" calculated as -0.3711 showing a moderate negative relationship between values of Dv and Dp. This negative correlation signifies that as the difficulty index increased discrimination index also increase but to an optimum value only after which discrimination power decrease with the increase in difficulty level. This suggested that the easier items (>0.80) or too difficult items (<0.20) poorly discriminate between the superior and inferior examinees [19].

The result of the work showed that most of the test items fall in the acceptable range of difficulty index and discrimination index. However, 17 of the test items was excluded due to very high or very low difficulty level and poor discrimination power. Purposive sampling was adopted for this study and 100 B.Ed. Physical Science students were taken from private B.Ed. Colleges in Pondicherry, India. A test of 100 items was used for data collection. Using the findings relationship between the difficulty index of each item and the corresponding discrimination index is carried out using the Pearson correlation formula. From the analysis, it was found that item discrimination power increased with the increase in difficulty value but got decreased for very easy and very difficult test items [20].

II. Method and material

The MCQ type A items were created by female teachers and vetted by reviewer committee department for content accuracy every year. The vetted questions were selected by the female departmental head (test was administered by the researcher himself for data collection) and formatted for an examination paper.

Current study, 6 test MCQs taken from the past 2 year for anatomy first term and second term examinations, at first term two levels three and five and two papers exam and term two only level four and one paper exam were analyzed. Each examination was carried out at the end of the term. A varied number students appeared for each the examination. Each term the examination covered different topics, grouped generally according to the systems. However, some repetition of the questions did not occur. Each MCQ consisted of a stem and five responses and the students were asked to select one correct answer from these five choices.

There were 580 MCQs items, taken from six exam for medical female students conducting in Najran University –department of anatomy and analyzed for level of difficulty and discrimination indices. The MCQ papers contained 100 expect one paper exam contained 80 questions drawn from different regions. It formed a part of 2½ hours MCQ paper to be answered each question in 1 ½ minutes. A correct response to an item was awarded 1.0 mark and the wrong one zero, no negative marks allotted. The results of students performance in these MCQ tests were then used to determine the level of difficulty P- value (difficult index) and power of discrimination (discrimination index) using SPSS-PC statistical software version 20.0.

Interpretation

Difficulty Index (P) if:

≤ 0.20	Very difficult (should be revised)
0.21 – 0.30	Difficult (retained in the Q. bank)
0.31 – 0.69	Average (retained in the Q. bank)
0.70 – 0.80	Easy (revised before re-use)
≥ 0.81	Very easy (discarded or carefully reviewed)

Discrimination Index (D) if:

D = Negative	Defective item / Wrong key
D < 0- 0.19	Poor discrimination
D between 0.2-0.29	Acceptable discrimination
D between 0.3-0.39	Good discrimination
D =0.4	Very good discrimination
D > 0.4	Excellent discrimination

III. Statistical Methods

Statistical analysis was performed by SPSS-PC statistical software version 20.0 (Statistical Package for the Social Sciences). Correlation between the item difficulty index and discrimination index values for all items was determined using Pearson correlation analysis, descriptive frequency and crosstabs and correlation probabilities a P value, $p < 0.01$ (2-sided) was considered to indicate statistical significance. The Pearson correlation is a parametric measure of correlation for two variables. It measures both the power and the direction of a linear relationship. If one variable X is an exact linear function of another variable Y, a positive relationship exists if the correlation is +1.0 and a negative relationship occurs if the correlation is -1.0. If there is no linear predictableness between the two variables, the correlation is 0.0. The following guidelines have been proposed table III-1:

Table III-1 guidelines Coefficient, r

	Coefficient, *r*	
Strength of Association	Positive	Negative
Small	0.1 to 0.3	-0.1 to -0.3
Medium	0.3 to 0.5	-0.3 to -0.5
Large	0.5 to 1.0	-0.5 to -1.0

IV. Result

The following tables and figures shows the findings of the relationship between difficulty and discrimination indices (item analysis) which methods to assess the quality of test items (questions). The item

difficult is simply the percentage of students who answer an item correctly and item discrimination indicate to the ability of an item to distinguish among students on the basis of how well they recognize the material being tested. Table 1 explains the distribution of difficulty items of anatomy 1 exam term one in 2016 and 2017 years and each exam consist of 100 items. The number of items very difficult; 75 (37.5 %) and 3 (1.5 %), difficult;2 (1%) and 8 (4%), average; 6 (3%) and 33 (16.5%), easy;4 (2%) and 29 (14.5%), very easy; 13 (6.5%) and 27 (13.5%).Table 2 shows the frequency of discrimination items. The poor discrimination; 61 (30.5%) & 41 (20.5%), Acceptable; 20 (10%) & 0 (0%), good; 1 (0.5%) & 0 (0%), very good; 4 (2%) & 0 (0%),excellent14 (7%) and59 (29.5%) of anatomy-1 (2016-2017) respectively.

Table 1 Interpretation of Difficulty Index Frequency of Anatomy-1Exam 2016

Interpretation of Difficulty index	Frequency %		Relative Frequency %
	Anatomy -1 exam 2016	Anatomy -1 exam 2017	
P ≤ 0.20	75 (37.5%)	3 (1.5%)	78 (39%)
P between 0.21 – 0.30	2 (1%)	8 (4%)	10 (5%)
P between 0.31 – 0.69	6 (3%)	33 (16.5%)	39 (19.5%)
P between 0.70 – 0.80	4 (2%)	29 (14.5%)	33(16.5%)
P > 0.81	13 (6.5%)	27 (13.5%)	40 (20%)
Total	100 (50%)	100 (50%)	200 (100%)

P Value: Difficult index

Table 2 Interpretation of Discrimination Index Frequency of Anatomy-1Exam 2017

Interpretation of Discrimination index	Frequency %		Relative Frequency %
	Anatomy -1 exam 2016	Anatomy -1 exam 2017	
D < 0- 0.19	61 (30.5%)	41 (20.5%)	102 (51%)
D between 0.2-0.29	20 (10%)	0 (0%)	10 (5%)
D between 0.3-0.39	1 (0.5%)	0 (0%)	1 (0.5%)
D = 0.4	4 (2%)	0 (0%)	4 (2%)
D > 0.4	14 (7%)	59 (29.5%)	73 (36.5%)
Total	100 (50%)	100 (50%)	200 (100%)

D: Discrimination index

Table 3 shows the distributions of difficult and discrimination items in anatomy -2 (2016-2017). The very difficult 9 (3.5%) & 20 (10%), difficult 8 (4%) & 14 (7%), average 41 (20.5%) & 45 (22.5%), easy 24 (12%) & 6 (3%) and very easy 18 (9%) & 15 (7.5%). Table 4 explains the following distribution of discriminate items: poor discrimination;22 (11%) &29 (14.5%),acceptable;4 (2%) & 10 (5%), good; 7 (3.5%) & 0 (0%), very good; 3 (1.5%) & 0 (0%) and excellent;64 (32%) & 51 (25.5%) respectively.

Table 3 Interpretation of Difficulty Index Frequency of Anatomy-2Exam

Interpretation of Difficulty index	Frequency %		Relative Frequency %
	Anatomy -2 exam 2016	Anatomy -2 exam 2017	
P ≤ 0.20	9 (3.5%)	20 (10%)	29(14.5%)
P between 0.21 – 0.30	8 (4%)	14(7%)	22(11%)
P between 0.31 – 0.69	41 (20.5%)	45(22.5%)	86(43%)
P between 0.70 – 0.80	24 (12%)	6(3%)	30 (15%)
P >0.81	18 (9%)	15 (7.5%)	33 (16.5%)
Total	100 (50%)	100 (50%)	200 (100%)

P Value: Difficult index

Table 4 Interpretation of Discrimination Index Frequency of Anatomy-2Exam

Interpretation of Discrimination index	Frequency %		Relative Frequency %
	Anatomy -2 exam 2016	Anatomy -2 exam 2017	
D < 0- 0.19	22 (11%)	29 (14.5%)	51 (25.5%)
D between 0.2-0.29	4 (2%)	10 (5%)	14 (7%)
D between 0.3-0.39	7 (3.5%)	10 (5%)	17 (8.5%)
D = 0.4	3 (1.5%)	0 (0%)	3 (1.5%)
D > 0.4	64 (32%)	51 (25.5%)	115 (57.5%)
Total	100 (50%)	100 (50%)	200 (100%)

D: Discrimination index

Table 5 displays distribution difficult items and table 6 shows the distribution of discrimination items Frequency of anatomy3 exams (2016-2017). Very difficult;22 (12.2%) & 40 (22.2%), difficult; 12 (6.7%) &14 (7.8%), average; 43 (23.9%)& 35 (19.4%), easy;2 (1.1%) & 4 (22%), very easy; 1 (0.6%) & 7 (3.9%) and

table 6 shows: poor discrimination; 13 (7.2%) & 31 (17.2%),acceptable; 11 (6.1%) & 19 (10.6%), good: 4 (2.2%)&5 (2.8%), very good; 8 (4.4%) & 9 (5%) and excellent discrimination; 44 (24.4%) &36 (20%) respectively.

Table 5 Interpretation of Difficulty Index Frequency of Anatomy3Exam

Interpretation of Difficulty index	Frequency%		Relative Frequency%
	Anatomy -3 exam 2016	Anatomy -3 exam 2017	
P <& = 0.20	22 (12.2%)	40 (22.2%)	62(34.4%)
P between 0.21 – 0.30	12 (6.7%)	14(7.8%)	26(14.4%)
P between 0.31 – 0.69	43 (23.9%)	35(19.4%)	78(43.3%)
P between 0.70 – 0.80	2(1.1%)	4(22%)	6(3.3%)
P >0.81	1 (0.6%)	7 (3.9%)	8(4.4%)
Total	80 (44.4%)	100 (55.6%)	180 (100%)

P Value: Difficult index

Table 6 Interpretation of Discrimination Index Frequency of Anatomy3Exam

Interpretation of Discrimination index	Frequency %		Relative Frequency %
	Anatomy -3 exam 2016	Anatomy -3 exam 2017	
D < 0- 0.19	13 (7.2%)	31 (17.2%)	44 (25.5%)
D between 0.2-0.29	11 (6.1%)	19 (10.6%)	30 (7%)
D between 0.3-0.39	4 (2.2%)	5 (2.8%)	9 (8.5%)
D = 0.4	8 (4.4%)	9 (5%)	17 (1.5%)
D > 0.4	44 (24.4%)	36 (20%)	80 (57.5%)
Total	80 (44.4%)	100 (55.6%)	180 (100%)

D: Discrimination index

Very difficult Questions (Q) should be revised, difficult & average retained in the Q bank, easy QQ revised before re-use and very easy QQ discarded or carefully reviewed.

The following figures show data crostabulation between difficult and discrimination indices. (Figure 1) displayed poor discrimination more than anther at a level very and difficult items while excellent discrimination more than others at a level very easy items that mean decrease the difficulty index with increase discrimination that indicated to the positive relationship between them.

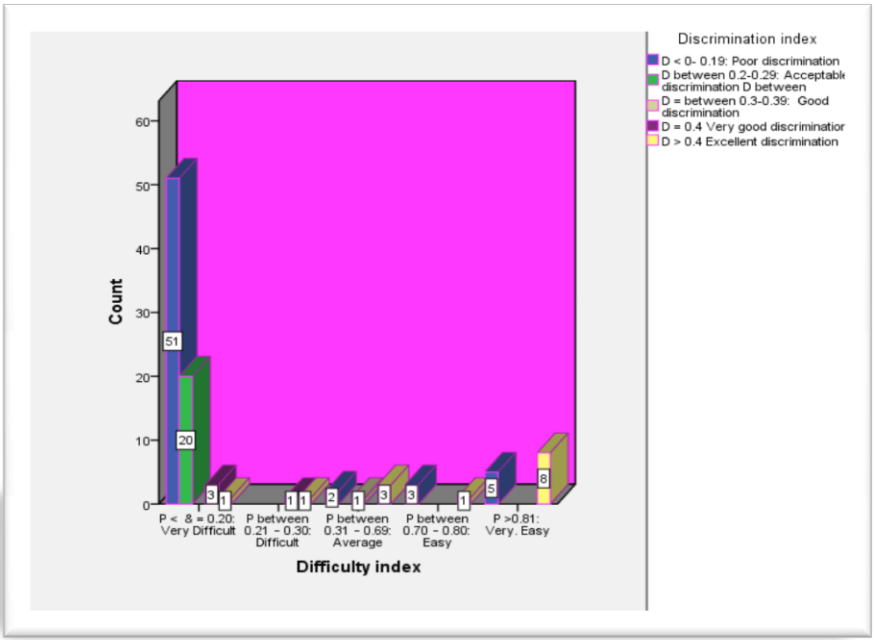

Figure 1 Crosstabulation of Difficult and Discrimination Indices of Anatomy- 1Exam 2016

Figure 2 shows excellent discrimination more at level average, easy, very easy, difficult and very difficult items, however the poor discrimination items more in level average, easy, very easy, difficult and very difficult these distributions indicated to negative correlation.

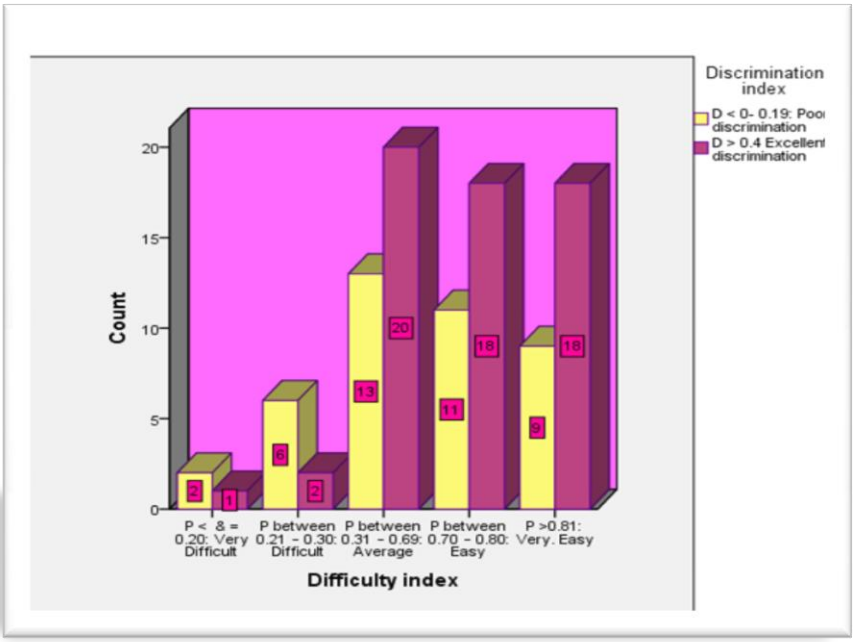

Figure 2 Crosstabulation of Difficult and Discrimination Indices of Anatomy -1 exam 2017

Figure 3 explains the excellent discrimination items more than anther at all levels of difficult items that indicates to negative relationship between two variables.

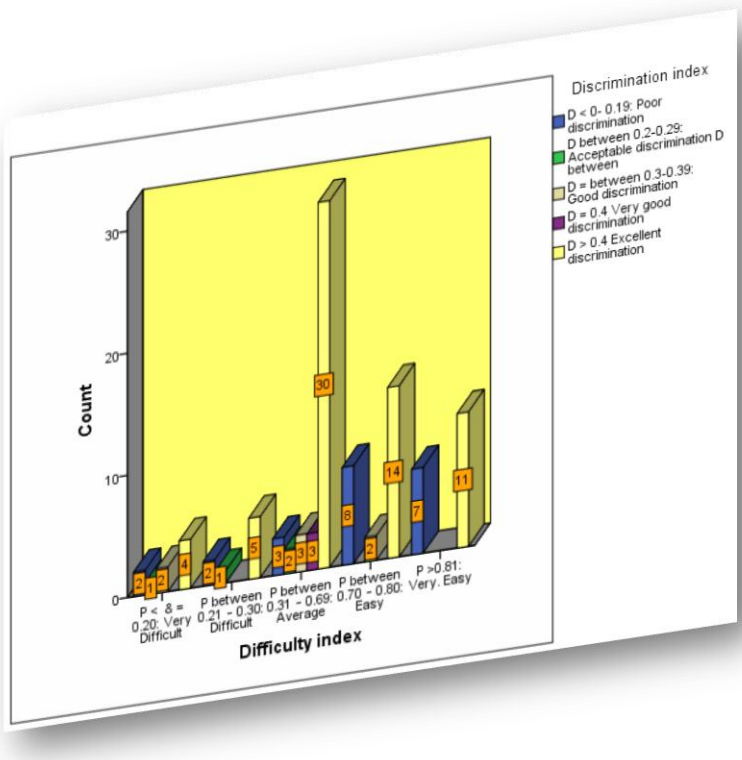

Figure 3 Crosstabulation of Difficult and Discrimination Indices of Anatomy- 2 Exam 2016

Figure 4 shows the poor discrimination items more than others at levels of very difficult items that indicates to relate together.

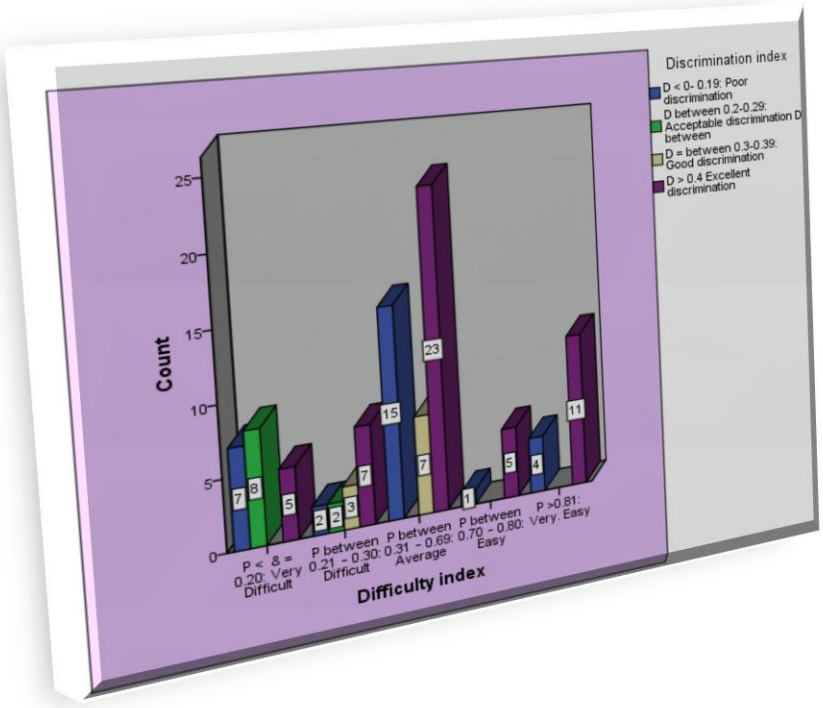

Figure 4 Crosstabulation of Difficult and Discrimination Indices of Anatomy- 2 Exam 2017

Figure 5 displayed poor and acceptable discrimination items common more than others at a level very difficult items that mean difficult index decrease and discrimination index increase that to indicates too positive correlation.

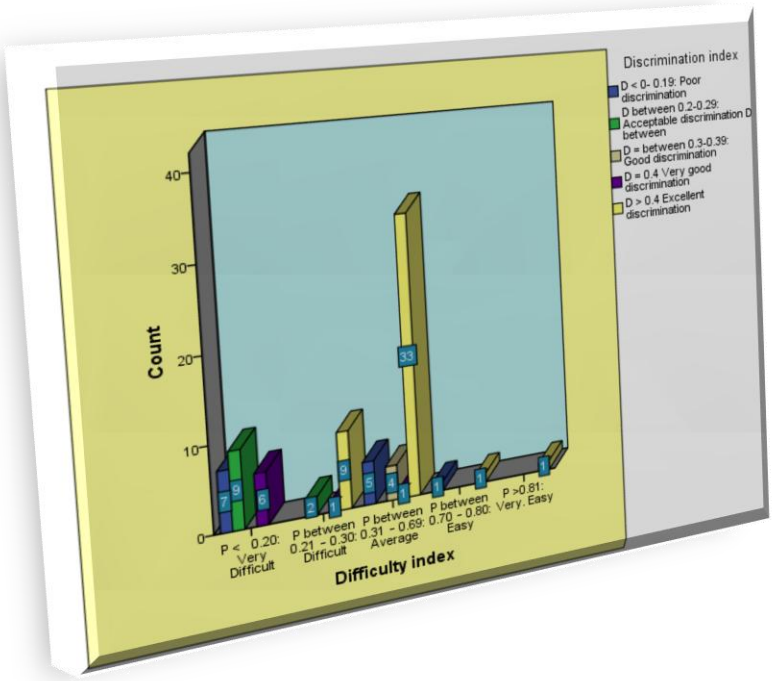

Figure 5 Crosstabulation of Difficult and Discrimination Indices of Anatomy -3 Exam 2016

Figure 6 explained poor discrimination items more than anther at very difficult that mean difficult index decrease while discrimination index increase this indicates a positive relationship.

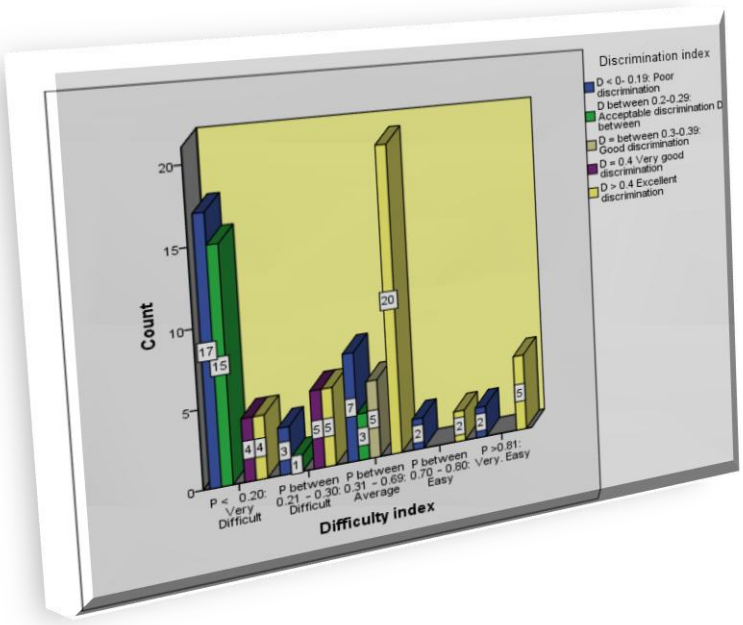

Figure 6 Crosstabulation of Difficult and Discrimination Indices of Anatomy-3 Exam 2017

Table 7 and following figures show correlation between difficult and discrimination indices. Table 7 explains the items of six anatomy exams and displayed relationship of difficulty and discrimination indices. The strength of association (coefficient, r)of items: anatomy -1 (2016);r = 0.509, P =(0.000)<0.01and its large positive correlation, anatomy -1 (2017); r =0.181,P = (0.072)<0.01its small negative correlation, anatomy -2 (2016); r = 0-.059, P = (.560) > 0.01 its large negative correlation, anatomy -2 (2017); r = 0.260,P = (0.009) < 0.01 its small positive correlation, anatomy -3 (2016); r = 0.490, P = (0.000) < 0.01 its medium positive correlation and anatomy -3 (2017); r = 0.372,P = (0.000) < 0.01 its medium positive correlation refers table III-1 above and the following figures supported these data analyses.

Table 7 Correlation Between Difficulty and Discrimination Indices of MCQs Type A in Formative Exam in Anatomy

MCQs type A in formative exam	Significant at the 0.01 level (2-tailed)		Coefficient
	Difficulty index	Discrimination index	(r)
Anatomy 1 2016	0.000	0.000	0.509**
Anatomy 1 2017	0.072	0.072	0.181
Anatomy 2 2016	0.560	0.560	-0.059
Anatomy 2 2017	0.009	0.009	0.260**
Anatomy 3 2016	0.000	0.000	0.490**
Anatomy 3 2017	0.000	0.000	0.372**

**. Correlation is significant at the 0.01 level (2-tailed).

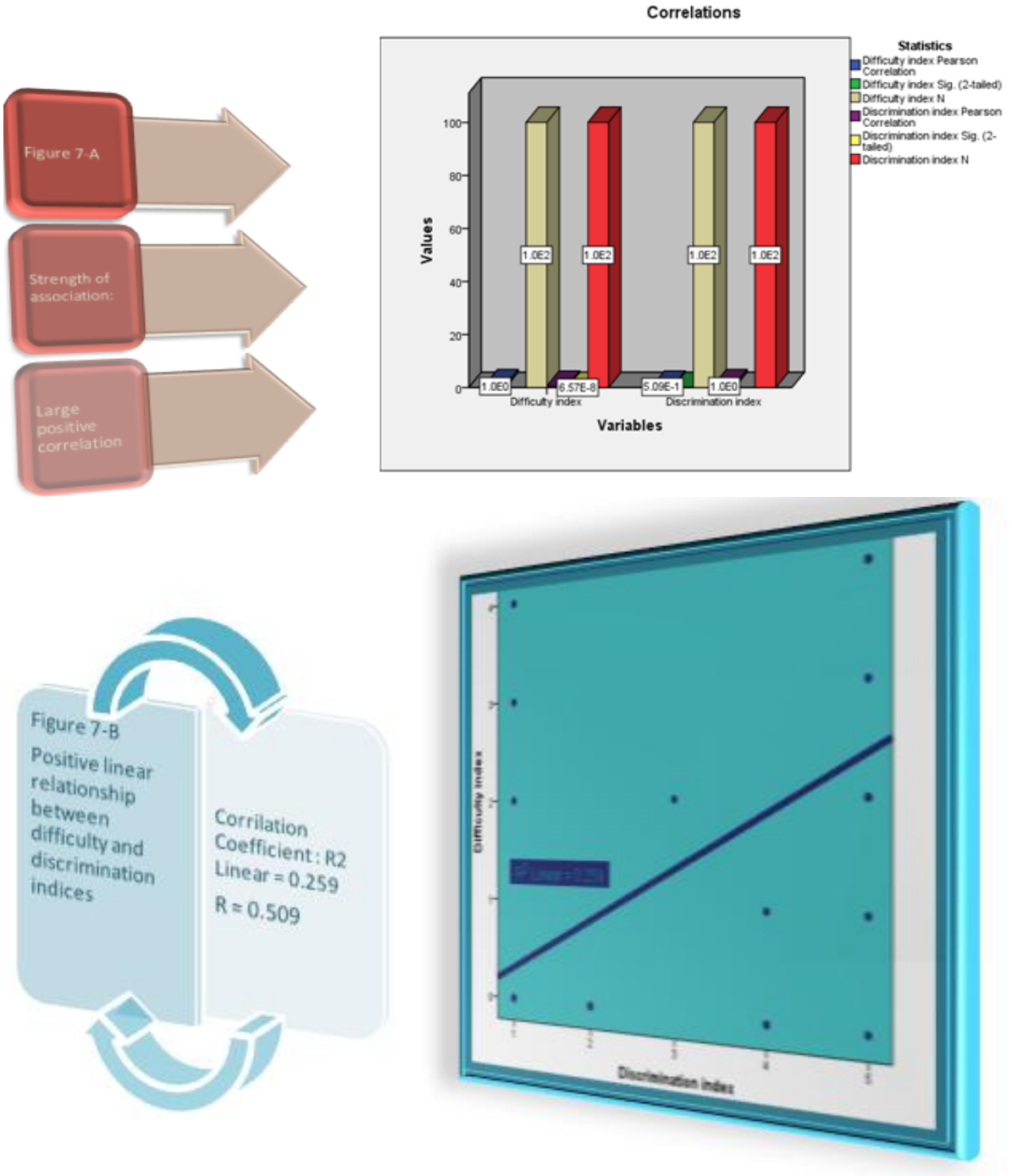

Figure 7 (A &B) Strength of Association Between Difficult and Discrimination Indices Anatomy- 1 2016

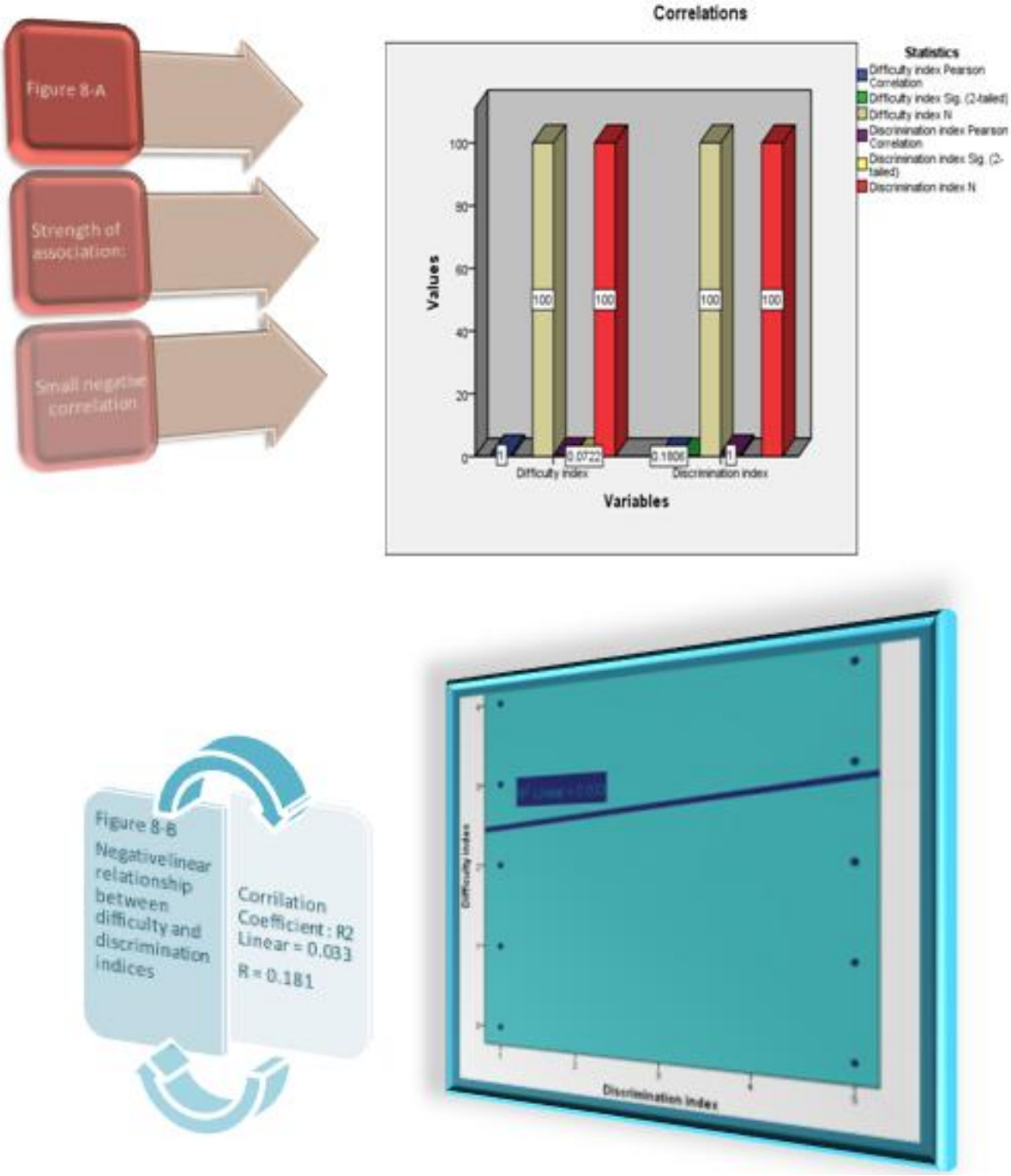

Figure 8 (A &B) Strength of Association Between Difficult and Discrimination Indices Anatomy-1-2017

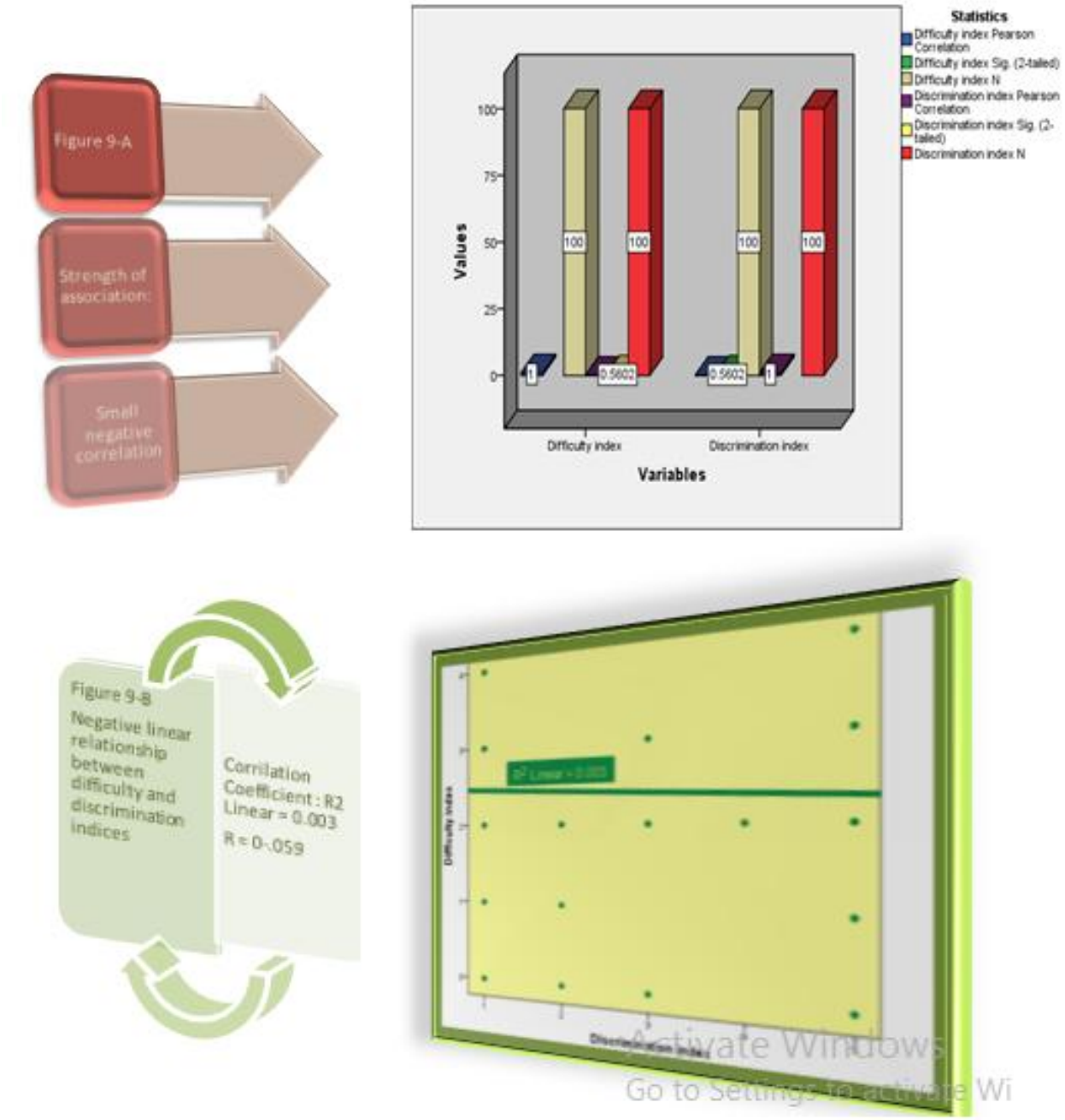

Figure 9 (A&B) Strength of Association Between Difficult and Discrimination Indices Anatomy -2-2016

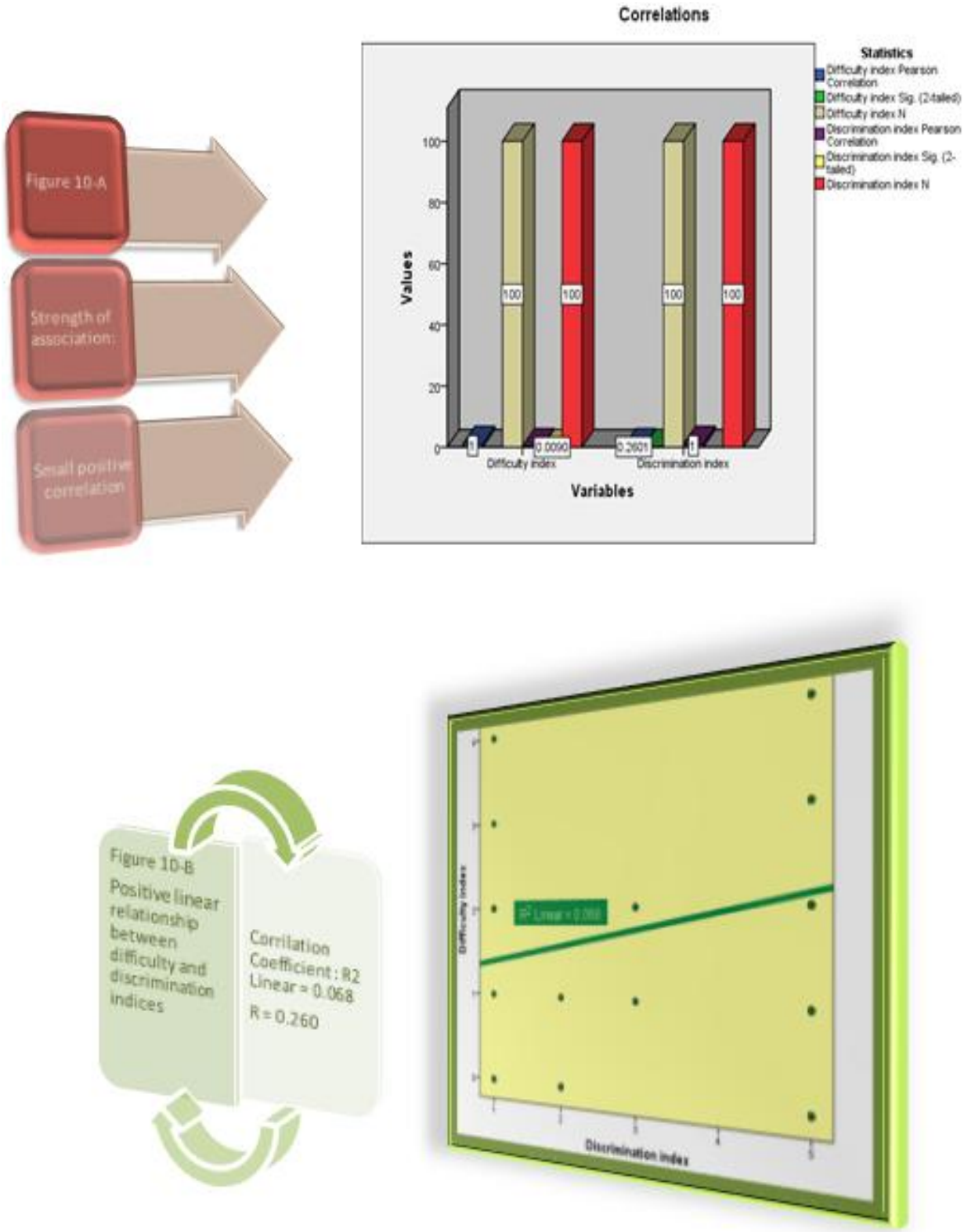

Figure 10 (A &B) Strength of Association Between Difficult and Discrimination Indices Anatomy- 2-2017

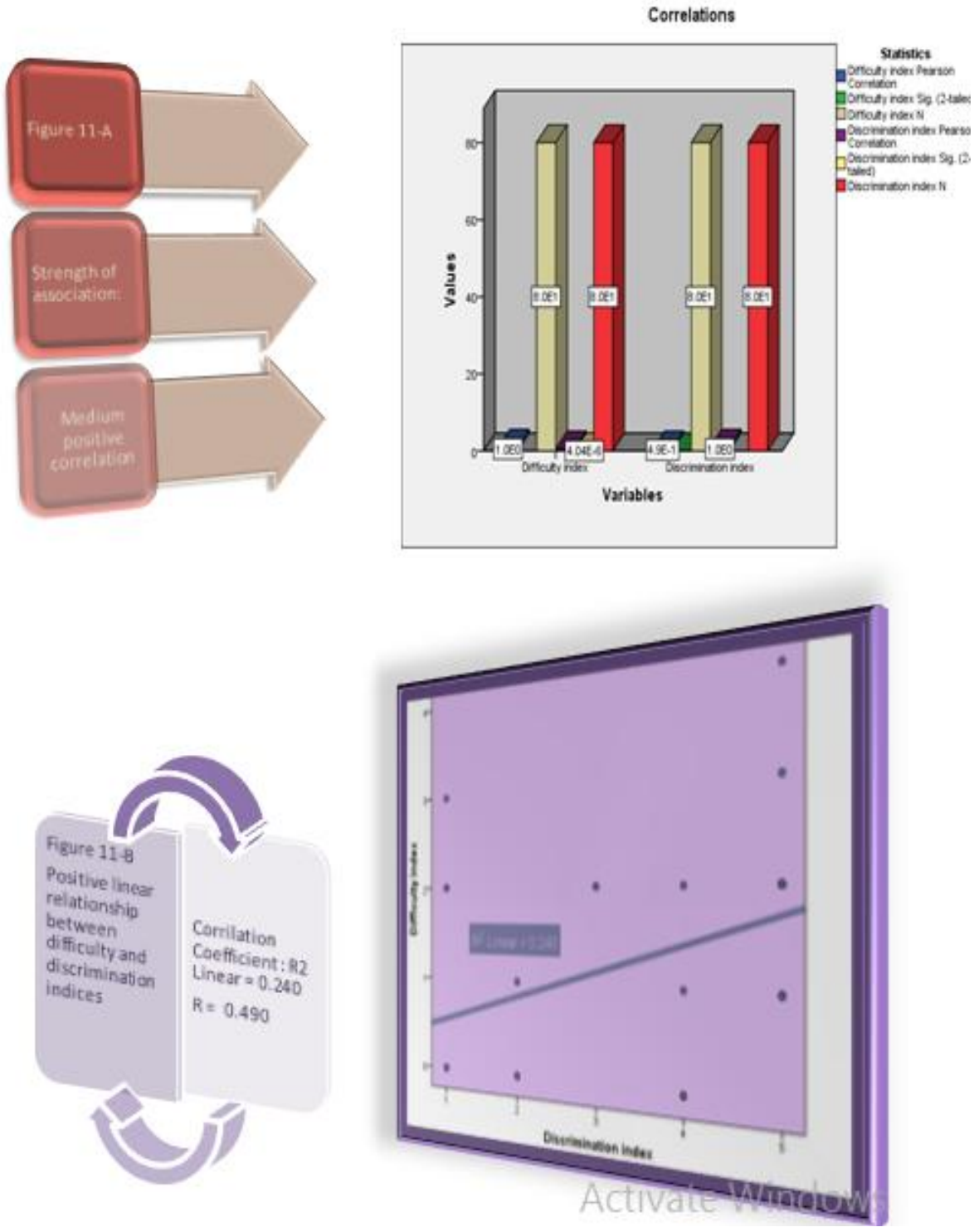

Figure 11 (A &B) Strength of Association Between Difficult and Discrimination Indices Anatomy- 3-2016

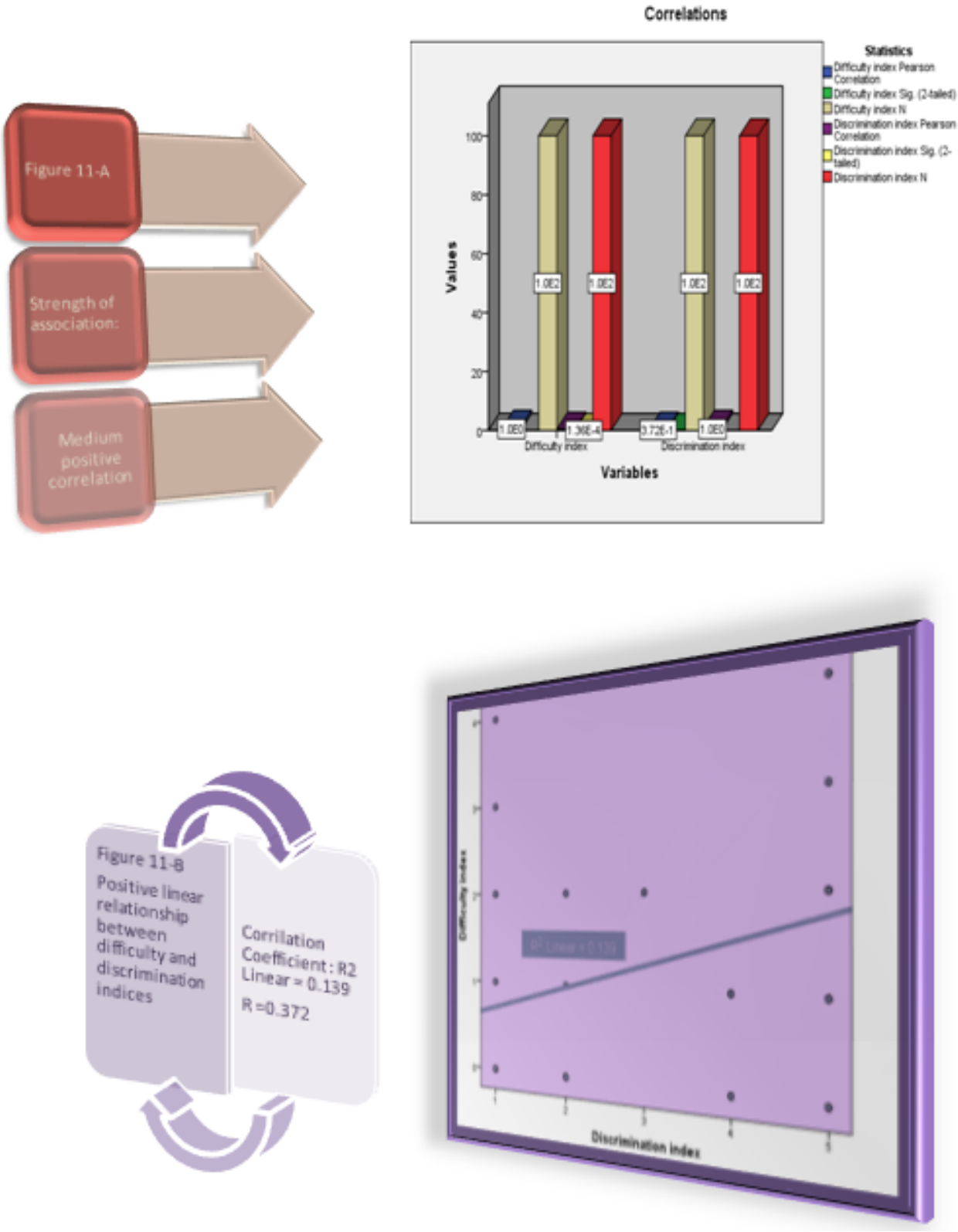

Figure 12 (A &B) Strength of Association Between Difficult and Discrimination Indices Anatomy- 3-2017

V. Discussion

The outcomes of this study indicate the significance of item analysis (difficulty and discrimination indices) for determining the quality and validity of individual exam item in constructing a more reliable exam. The current study was conducted with the similar aim to previous studies above. In this study the items of anatomy -2 (2017); r = 0.260, P = (0.009) < 0.01 its small positive correlation same opinions were reported by Sushma S. Pande, et al. (2013) in their study on correlation between difficulty & discrimination indices of MCQs informative exam in Physiology; the discrimination index exhibited a slight positive correlation with the difficulty index (r = 0.191, P=0.003<0.01). In this study the items of anatomy -1 (2017); r = 0.181, P = (0.072) > 0.01 its small negative correlation and items of anatomy -2 (2016); r = -0.059, P = (.560) > 0.01 its large negative correlation same observation was reported by Si-Mui Sim et al., (2006) in their study, Mitra et al., (2009) showed that the discrimination index correlated poorly with the difficulty index (r= -0.325), Suruchi S (2014) reported that Pearson correlation coefficient r calculated as -0.3711 showing a moderate negative relationship between values of Dv and Dp and also similar finding Md Ahsan and et al. (2016) found the discrimination index correlate poorly with difficulty index (r = -0.453). This could have been due to poor understanding of difficult topics, obscurity in expressions of the questions or even unfitting key or personal difference in forming the questions and may also be due to dissimilarities in students' intelligence level. We found the strength association between item difficulty index or the p –value is defined as the percentage of examinees selecting the answer to the item correctly and the item discrimination index is a basic measure of the validity of items of anatomy -1 (2016); r = 0.509, P = (0.000) < 0.01 and its large positive correlation, the items of anatomy -3 (2016); r = 0.490, P = (0.000) <0.01 its medium positive correlation and the items of anatomy -3 (2017); r = 0.372, P = (0.000) < 0.01 its medium positive correlation; i.e. these exams characterized by validity and reliability and we did not find a similar finding in this part of our study. In our study the widely held items of anatomy exams satisfied the criteria of acceptable difficulty and good discrimination, which means the MCQs designed were of good quality. Easy and difficult items had the highest discriminative ability. Very easy and very difficult items showed poor discrimination. Even bad discrimination was observed in very difficult items.

VI. Conclusion

Our finding of the study reveals that anatomy test items with good discrimination coefficient have a widely positive correlation between difficulty (D) and discrimination (P) indices. Item analysis (parameter D and A)improves exams and give it reliability and validity, which functions as implement to evaluate students and instructional quality.

Acknowledgements

Many pleasures and appreciation owed to many people who contributed knowingly and indirectly to this work, gratitude to all authors who cited who their work in this research. Many thanks and appreciations go to everyone who encouraged and supported the ideas of this work.

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Dr. Itedal Abdelraheem Mohamed Ahmed . "Correlation between Difficulty and Discrimination Indices of MCQs Type A in Formative Exam in Anatomy." IOSR Journal of Research & Method in Education (IOSR-JRME) , vol. 7, no. 5, 2017, pp. 28–43.