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Comparing Two Examination Results using Means of Sample Means and Control Charts

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Abstract
Some examination candidates submit their scripts first, sometimes, for recognition as being brilliant, and some do for not knowing what to write. However, some equally submit last because they want to dot i's and cross t's. The objective of this research is to compare the results of both the earliest and latest submissions with the aim of finding out whether or not there is a significant difference between the two. The examination results of students of the Departments of Accounting, Business Administration and Industrial Relations and Personnel Management of the Faculty of Business Administration and the Department of Mathematics, Faculty of Science, University of Lagos were compared using means of sample means and two statistical quality control charts. The results showed that, generally, the early submissions seemed to be an indication of being more brilliant than the last submissions in the Faculty of Business Administration. In the Mathematics Department, however, the last to submit appeared to be more brilliant.
Keywords:measures of brilliance, statistical quality control, two-sample test, ordered-data-control charts, time sequence of exam-script submission, competition assessment

1.0 introduction

1.1 Background of the Study: Factors Influencing Performance in an Examination- Time spent on the Examination

An examination is a method of assessing a candidate's level of knowledge in a field of study. The examination may be either an impromptu one or a prepared one. Hence, a candidate may be either occasional or regular. In this study the students of the University of Lagos are focused.

For ages an examination time has been associated with the length of time of teaching the course in a specified period of time, for example, the number of hours of teaching the course in a week, three hours for a three-unit course, say. That is, an examination of a three-unit course takes three hours generally speaking. It is common knowledge that students finish and submit the examination scripts to the invigilator at various times in the course of the examination. The scripts are marked and the results are released.

The questions are: Does first submission connote brilliance? Does last submission signify mediocrity? In the main, the research seeks factors influencing students' performance in an examination positively or otherwise using earliest submissions and latest submissions of answer scripts in an examination hall as a case study based on means of sample means in statistical quality control. Statistical quality control is the use various statistical techniques to decide whether or not a manufactured product has met a pre-stated quality level.

Examinations are important activities in all educational establishments all over the world. The performance of an examinee is a function of many variables. Ogundeji and Okafor (2009) used empirical Bayes' model to estimate proportion of "above-average performance of university graduates". Using data from various faculties in the University of Lagos (henceforth Unilag), it was estimated that the proportion of "above-average performance of university graduates" is 72%, i.e. this is the proportion or percentage of those students who are eligible for further studies out of all the university graduates results analyzed.

Okafor and Essan (2003) carried out MAT 840 examination-results analysis as a response to a challenge from some quarters in Unilag that the failure of students was intolerably high. One of the reasons advanced for the failure was that the affected faculties relaxed the admission requirements for mathematics at that time. Only ordinary pass at the ordinary level of the G.C.E. was required. Summarily the background knowledge of a student is an influencing factor to performance in an exam.

Ntekim (2007) examined the teaching of idioms in selected secondary schools in Lagos using the English Language Curriculum, the English teachers's lesson plans and students' performance in identifying idioms and their ability to provide explanations to selected idioms. One of the reasons highlighted for students' failure was that they hardly had enough opportunity to practise the idioms they were taught.

Onyishi (2007) pointed out that failure in exams resulted from the following factors: inadequately trained

teachers, lazy and over-pampered students.

In his own contribution Akinbode (2006) stated that students failed English exams because they were always afraid of making mistakes, not having self-satisfied and qualified teachers, the government that did not employ qualified teachers, parents' failure to monitor their children's progress.

Ahani, Ogundeji, Abass and Okafor (2009) used logistic models to find out that the final-year GPA of the granduands has significant effect among all the variables considered for predicting students' performance with data from eight faculties in Unilag.

Fasasi (2006)'s reasons for failure in an exam include a lack of infrastructure, limited commitment to work by teachers, and low work force.

The writer's over thirty years' teaching and examining experience also shows that success of students in an exam depends on points that include:
i. The number of questions to be answered in a specified time
ii. The level of difficulty of the questions
iii. Conducive examination hall
iv. Sitting arrangement
v. Effective and efficient invigilation
vi. Exam malpractice situation
vii. The level of preparedness by the students.
vii. The quality of the teaching of the subject

In the reviewed literature, no one talks about the time allocated to examinations vis-à-vis time of submission of the answer scripts by the students: submitting first and submitting last and the difference between the two sets of marks for the two groups. It is viewed in this paper that such an issue needs to be examined with the objective of ascertaining who is better: the first students to submit their answer scripts or the last ones to submit.

2.0 Methods

The methods used in this study are the means of sample means, Shewhart's individual observation-control chart using SPSS and a proposed order-statistics-control chart to analyze the marks of the two samples in every exam hall concerned in a First-Semester Examination at the University of Lagos, Nigeria.

2.1 Means of sample means

Take m samples each of size n for variable x. Then, the sample mean is $\bar{x} = (\sum x_i)/n$ …….(1)

and the mean of sample means is $\bar{\bar{x}} = (\sum \bar{x})/m$ ……..(2)

Similarly, take m samples each of size n for variable y. Then, the sample mean is $\bar{y} = (\sum y_i)/n$ ….(3)

and the mean of sample means is $\bar{\bar{y}} = (\sum \bar{y})/m$ ……..(4)

The relative sizes of the sample means and the means of sample means are observed for conclusions.

2.2 Using Statistical Quality Control Methods of Analysis

Using statistical quality control charts (SQCC) in assessing examination results or students' performance started relatively recently as found in William D. Schafer,
Bradley J. Coverdale, Harlan Luxenberg, Ying Jin (20011). In the paper Shewharts control limits and consequently control charts :

Upper Control Limit = $\mu x + 3\sigma x$
Baseline = μx
Lower Control Limit = $\mu x - 3\sigma x$

were used in a large-scale assessment program. In that program Maryland in U. S. A. tested all students in grades 3, 5, and 8 using a performance assessment format in reading, writing, math,
science, language usage, and social studies. The state was advised

by a group of nationally recognized psychometricians to help reach a decision, and in later years the group was informed when the results were judged unusual, using SQCC.

In the present study control charts are also used to determine the significance or otherwise of the difference between two sets of examination results. Schafer(2011) did not display any control chart. Control charts are displayed in this study to make the results more meaningful.
In that case we consider the sample means, but as if they were just in one group, then, apply the following methods:

2.2.1 Shewhart's individual-observation-control chart using SPSS
The means of sample means will be subjected to Shewhart,s individual observation-control limits through the use of the Statistical Package for Social Sciences (SPSS)

Upper Control Limit x = $\bar{x}$ + 3σ

Lower Control Limit x = $\bar{x}$ - 3σ

Where $\bar{x}$ is the sample mean of variable x and σ is the population standard deviation of x

2.2.2 A proposed ordered-data- control chart limits of individual observations (Alabi-Labaika, 2011):
Order statistics is the arrangement of a data set from the smallest to the highest (Hogg and Craig, 1978; Kottegoda and Rosso, 1997) .
Statistical control charts are methods of verifying whether or not a manufactured product has met a pre-manufacture set quality level to satisfy the customers (Burr, 2005; Adekeye, 2000; Gupta,2011). These ideas form the basis for the following control limits developed by Alabi-Labaika (2011):

Upper Control Limit x = $\bar{x}$ + (y_n - y_{b+1})

Lower Control Limit x = $\bar{x}$ - ($y_b - y_1$)

where in an ordered data set y_b is the value of the order statistic just before the partitioning-criterion, the sample mean, $\bar{x}$, in this case; y_{b+1} =the order statistic coming after the partitioning criterion.

The decision rule is, once there is a test value outside the control limits, then, the test values are not statistically controlled. That is, they are not homogeneous, thus the null hypothesis that there is no significant difference is rejected and the alternative hypothesis that there is a significant difference is accepted. The chart is used to guide subsequent production. This is now applied to students examination marks to decide who is more brilliant: the first students to submit or the last ones to submit their answer scripts to the invigilator in an examination hall?

3.0 Results and Discussion
The populations of study students are those in the Faculties of Science and Business Administration in the First Semester 2009/2010 Undergraduate Examinations at the University of Lagos. The resulting data consist of seven examinations in each of the Departments of Mathematics, Accounting, Business Administration and Industrial Relations and Personnel Management(IRPM) randomly selected. In each exam in a hall the first ten scripts to be submitted and the last ten scripts to be submitted to the invigilators were recorded. After marking, their results were collected and analyzed as two independent samples using sample means and means of sample means, the parametric individual-control chart of Shewhart and that of Alabi-Labaika (2011) for testing for significant difference or otherwise between the two samples in the next tables 1-4.

From equations 1 and 2

$\bar{x}$ = (∑xi)/n = 241/10= 24.1 , etc.,

$\bar{\bar{x}}$ = (∑$\bar{x}$)/m = (24.1 +22.6 +46.4 + 31.2 + 57.4 +27.2 +67.1 +)/7 = 39.42

From equations 3 and 4

$\bar{y}$ = (∑yi)/n = 380/10=38

Then, the sample mean is $\bar{y}$ = (∑y_i)/n ….(3)

and the mean of sample means is $\bar{\bar{y}}$ = (∑$\bar{y}$)/m = (38+44 +61.6+ 43+45.6 +38.8 + 43.3)/7= 44.49

Comparing the two means of sample means 39.42 for X and 44.49 for Y, show that Y values are generally higher than X values. So the last students to submit their answer scripts seem to be more brilliant than the first to submit in a mathematics examination.

The Departments of Accounting, Business Administration, and Industrial Relations and Personnel Management(IRPM) in the Faculty of Business Administration are similarly considered in the next tables.

$\bar{x}$ = $(\sum xi)/n$ = 241/10= 845/10 = 84.5, etc.,

$\bar{\bar{x}}$ = $(\sum \bar{x})/m$= (84.5 +70+74+63+29+58.1+32.9/7=58.86

$\bar{\bar{y}}$ =(76+ 59+ 49+46+36+54+46)7=52.29

showing that X values are higher than Y's.

Consequently, the first students to submit their examination scripts seem to be cleverer than those that submit last in Accounting examinations.

$\bar{x}$ = $(\sum xi)/n$ = 712/10=71.2 , etc.,

$\bar{\bar{x}}$ = $(\sum \bar{x})/m$ = (71.2+78.2+66.3+63.9+56.5+48.5+59.6)/7= 63.46. **So X values are generally higher than Y values.**

Then, the sample mean is $\bar{y}$ = $(\sum y_i)/n$ ….(3)

and the mean of sample means is $\bar{\bar{y}}$ = $(\sum \bar{y})/m$ ……

$\bar{y}$ = $(\sum yi)/n$ = 632/10=63.2, etc.,

$\bar{\bar{y}}$ = $(\sum \bar{y})/m$ = (63.2+75.7+59+61.5+51.4+50.3+47.5)/7 = 58.37

Hence, it seems that better students submit their scripts first.

$\bar{x}$ = $(\sum xi)/n$

$\bar{\bar{x}}$ = $(\sum \bar{x})/m$ =(50.2+74.5+53.1+64.8+62.3+64.8+57.2)/7= 60.99

$\bar{y}$ = $(\sum y_i)/n$ and the mean of sample means is $\bar{\bar{y}}$ = $(\sum \bar{y})/m$ =(55.5+69.3+….52.2)/7 = 56.59

So X values are generally higher than Y values.

Using means of sample means

From Table 5 the students that first submit (X) generally have higher means of sample means than those that submit last(Y) in the Departments of Accounting, Business Ad ministration, and IRPM of the Faculty of Business Administration , University of Lagos.

The reverse, however, is the case in the Department of Mathematics in the Faculty of Science, University of Lagos. The mean of sample means for the first to submit is lower than that for the last to submit.

3.3 Using Statistical Quality Control Methods of Analysis

Again, consider the sample means, but as if they were just in one group:

58.86 63.46 60.99 39.42; 52.29 58.37 56.59 44.9

The data are approximate integers and duplicated to be comparable for two methods using n=16

Ordered as : 39 44 52 57 58 59 61 63
39 44 52 57 58 59 61 63

A proposed ordered-data control chart (ODCC) limits of individual observations (Alabi-Labaika, 2011):

Upper Control Limit x = $\bar{x}$ + ($y_n - y_{b+1}$)
Lower Control Limit x = $\bar{x}$ - ($y_b - y_1$)
UCL=Upper Control Limit
LCL= Lower Control Limt
UCL = 60
Mean = 54
LCL = 41.

The ordered-data-control chart (ODCC) is figure 1.

Figure 1 is to be compared with Shewhart's individual observation-control chart by SPSS in figure 2.

For Shewhart's individual-control chart the results are:

UCL =58.38
Mean = 54.13
LCL = 49.87
See Figure 2.

Figure 2: Shewhart's Individual Control Chart for the Means of Sample Means of Examination Scores

Comparing the two figures shows that Figure 1 rejects 6 out of 16 values i.e., probability of acceptance is 10/16, but Figure 2 rejects 10 , i.e., an acceptance probability of 6/16. One of the reasons for this difference in acceptance is that Figure 1 is a nonparametric control chart based on no probability distribution; but Figure 2 is a parametric control chart based on the normal probability distribution. When the normal distribution assumption fails as a result of the nature of the data under test, then, Figure 1 should be preferred, otherwise prefer Figure 2.

The decision rule is, once there is a value outside the control limits, then, the test values are not statistically controlled. That is, they are not homogeneous. So, from the quality-control charts (Figures 1 and 2), some of the test values are outside the control limits meaning that that there is a significant difference between the two sets of scores. This means that the first set X to submit answer scripts seemed to be better than the last set Y to submit in this research. This decision tallies with that made with means of sample means.

Contributions to knowledge in this work include using control charts, originally meant for manufactured products, to analyze examination results, comparing results of analysis by means of sample means with those for control charts, initiating a new area of study: using submission time in an examination to decide the levels of intelligence of students.

4.0 Conclusion

The analysis of data collected from the Faculty of Business Administration using the means of sample means and two statistical quality control methods showed that there is a significant difference between the marks of the first students to submit and the marks of the last students to submit their examination scripts to the invigilator in an examination hall. The higher sample means and means of sample means belong to the first to submit. So, the first sets of students to submit their examination scripts in an exam hall were likely to be more brilliant than those sets that submitted last. On the contrary, the means of sample means of the Department of Mathematics in the Faculty of Science supported the argument that the better students submitted their scripts last.

Further Research: Similar research efforts are needed in other departments and faculties to know whether or not the answer to the main question of this research depends on faculties or departments or both.

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Table 1Math Dept

Course Code	1	1	2	2	3	3	4	4	5	5	6	6	7	7	
	X	Y	X	Y	X	Y	X	Y	**X**	**Y**	**X**	**Y**	**X**	**Y**	
	0	12	10	13	17	38	15	29	35	15	1	2	39	0	
	1	13	12	33	17	54	15	40	43	21	1	21	49	15	
	4	17	12	40	34	55	18	40	51	26	5	40	60	19	
	12	30	16	40	46	56	20	40	54	41	7	40	60	27	
	15	31	20	45	46	62	23	40	61	48	10	43	63	40	
	16	50	21	47	51	62	26	42	62	57	22	45	74	42	
	23	50	24	47	56	65	40	43	63	58	43	47	75	48	
	50	53	33	50	56	70	40	46	64	61	43	48	79	75	
	57	62	36	53	60	73	55	50	67	64	55	50	86	80	
	63	62	42	67	81	81	60	60	74	65	85	52	86	87	
Total	241	380	226	435	464	616	312	430	574	456	272	388	671	433	

Table 2: Dept. : Accounting

S/N	1		2		3		4		5		6		7	
Code	FBA110		BUS211		ACC310		ACC310		ACC311		BUS410		ACC410	
	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
1	27	48	46	33	48	0	29	28	0	24	49	42	10	22
2	84	64	63	41	58	41	48	32	17	28	55	43	12	22
3	85	67	68	41	71	41	52	40	24	29	57	50	14	28
4	90	67	70	44	72	51	60	41	31	32	58	52	19	40
5	90	80	70	60	77	54	64	45	31	34	58	55	30	41
6	90	81	73	63	78	54	66	48	32	38	59	55	42	45
7	92	81	73	71	81	55	75	51	33	41	60	58	50	46
8	92	85	73	76	83	61	75	56	38	44	60	58	50	56
9	97	92	80	77	84	65	78	56	38	46	60	62	51	63
10	98	95	82	81	85	71	86	61	41	46	65	68	51	95
Total	845	760	698	587	737	493	633	458	285	362	581	543	329	458
Mean ACC	84.5	76	69.8	58.7	73.7	49.3	63.3	45.8	28.5	36.2	58.1	54.3	32.9	45.8

Table 3

Dept:	Bus Admin														
S/N	1		2		3		4		5		6		7		
Code:	FBA	110	FBA	110	BUS	210	BUS	211	BUS	212	BUS	310	BUS	410	
Item 1.	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	
1	48	26	42	48	48	45	65	48	42	36	40	31	67	42	
2	62	56	48	51	59	45	55	62	53	41	40	40	49	37	
3	62	63	68	68	59	52	73	70	54	46	46	46	54	37	
4	63	63	74	73	66	57	74	45	55	50	47	48	57	42	
5	66	64	85	81	68	61	63	65	55	50	48	50	58	44	
6	66	64	90	83	68	61	47	68	57	50	50	51	60	49	
7	80	64	91	87	70	64	76	45	60	56	50	52	60	52	
8	83	68	95	88	73	64	69	70	62	61	51	60	62	53	
9	84	76	97	88	75	66	53	63	62	62	55	62	63	57	
10	98	88	92	90	77	75	64	79	65	62	58	63	66	62	
Total	712	632	782	757	663	590	639	615	565	514	485	503	596	475	
Mea n BUS	71.2	63.2	78.2	75.7	66.3	59	63.9	61.5	56.5	51.4	48.5	50.3	59.6	47.5	Total

Table 4: Dept.: IRPM

SN	1		2		3		4		5		6		7	
Code	ECN111		FBA110		BUS 210		BUS 211		IRP 310		IRP311		IRP 410	
Item	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
1	37	40	48	48	40	32	73	40	40	32	50	44	45	40
2	37	44	60	55	57	41	58	40	60	46	59	50	52	40
3	42	45	67	63	59	43	59	40	60	46	61	51	52	48
4	51	57	68	68	61	50	60	73	63	50	62	54	55	50
5	51	57	71	71	66	59	73	38	65	55	62	54	56	50
6	53	59	74	73	66	61	58	73	70	60	64	61	60	50
7	55	60	81	76	73	61	68	61	70	63	67	61	60	52
8	57	61	87	76	73	66	60	53	73	72	73	62	60	58
9	59	62	91	80	75	66	79	57	84	73	74	71	61	61
10	60	70	98	83	75	80	74	40	85	80	76	74	71	73
Total	502	555	745	693	531	517	648	582	623	510	648	582	572	522
MeanIRP	50.2	55.5	74.5	69.3	53.1	51.7	64.8	58.2	62.3	51	64.8	58.2	57.2	52.2

Table 5: Means of Sample Means

	Mean of Sample Means	Mean of Sample Means
Department	First to Submit (X)	Last to Submit(Y)
Accounting	58.86	52.29
Business Administration	63.46	58.37
Industrial Relations…(IRPM)	60.99	56.59
Mathematics	39.42	44.9

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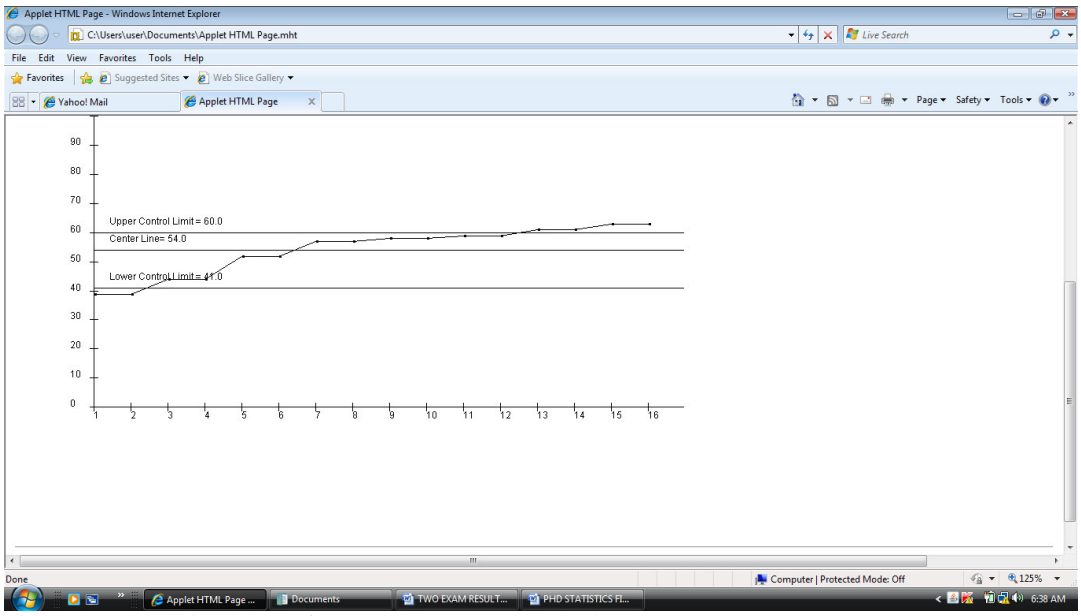

Figure 1: Ordered-Means- of Sample Means-Control Chart

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