Title:

Students' Performances in Mathematics Teacher Programs in North Carolina

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Authors:

Olusola Ademola Olaniyi, Ph.D (Main/Corresponding Author)

E-mail: solanike1@gmail.com

Co-Authors:

Olanike Oluwakemi Olaniyi, MS.

Oluwasemire Ayotunji Olaniyi, MS.

Serign Omar Lowe-Nicolas, MS.

Raymond Nwinkom Dumeh, Ph.D.

Adetokunbo Omotade Omojowo, BS.

Abstract

(Purpose) The purpose of this study was to examine the effect of math teacher program on students' performances in math teacher training programs in five selected colleges in North Carolina. **(Methodology)** This study collected 300 data (150 pre-tests and 150 post-tests) data of college students enrolled in the five selected colleges. The ANOVA and multiple comparison t-tests analyses showed that there were significant differences among students in the experimental group compared to those in the control group. **(Results)** Results indicate that there was a major role teaching pedagogy played in the performances of the students. **(Conclusions)** Results revealed that over a period of three years (2010 – 2013), there were more improvements in the performances of the students as they proceeded through the math teaching pedagogy at the experimental colleges than at the control college. **(Recommendations)** Educators could use the findings of this study as a platform to further study the relationship between high performance in math education and other courses taken throughout a student's college years.

Introduction

As the world economy becomes more complex and competitive, it is imperative that students in the United States strive for higher academic achievement. This is especially true for mathematics. Students need to be equipped with effective teachers in order to measure up to the global challenge. As such, states that aspire to be, and remain, economically viable and competitive must seriously address the quality of the education workforce and must also be greatly concerned about students' performances in math.

In recent years, teachers' knowledge of key subject content, especially mathematics, and the way mathematics is being taught have been a matter of increasing focus and concern for researchers as well as policy makers. As such, the implementation of the No Child Left Behind (NCLB) Act of 2001, signed into law by President George W. Bush on January 8, 2002, requires schools to target student assessment in the areas of reading and math to ensure students receive an effective education. NCLB requires teachers to demonstrate subject-matter competency through subject-matter majors, certification, or other means. Consequently, this directive has had an impact on teacher training in mathematics instruction. This act was meant to reauthorize the Elementary and Secondary Education Act (ESEA) by President Lyndon B. Johnson's War on Poverty in 1965. In addition to the goal of equal access to exceptional education afforded each child, the act also places demands on high standards and accountability from teachers on improving student proficiency level in mathematics [1].

With the many math training programs available, it is imperative to ascertain how students' performances in math are enhanced and achieved. It is essential to understand

how much learning of math is taking place in the United States Colleges. It is the opinion of the researchers that successful translation of a quality teacher training into students' performances in math is rare, but when it occurs, the impact on society may be substantial. In that regard, additional research is needed to further examine the relationship and impact math training program has on students' performances in mathematics.

While there have been several studies which suggested that teacher's licensure or certification, years of experience, and test scores play vital roles in influencing student achievement positively; most studies have failed to provide any predictive value of teacher credentials on the variance of teacher effects [2, 3]. Consequently, knowledge of the impact of teacher training on student achievement in math learning remains limited. Moreover, recent studies have also documented the essential role of quality teacher training in fostering student achievement; nonetheless, no consensus has been reached as to what factors further improve the quality teacher training that impacts student achievement. As such, how best to prepare new teachers has been a matter of discourse among researchers [4 - 6]. To further investigate these concerns, the study embarked upon exploring teacher training programs as it relates to students' performances in math.

According to Allen [4], quality teacher education is a fundamental component that guarantees delivery of an excellent academic curriculum; thereby making it an integral part of significant student academic achievement. Allen's [4] study demonstrated that quality education involves the methodology, skills, and policies put in place to efficiently equip prospective teachers with the needed expertise, right attitude, and necessary work ethic to effectively perform various classroom tasks.

Contrary to Allen's [4] study, Henard & Roseveare [7] developed a more modern definition of quality teaching. That is, quality teaching is the effective use of pedagogical techniques of salient factors such as curriculum, course content, guided independent study, project-based learning, collaborative learning, well-adapted learning environments, experimentation, feedback, effective assessment of learning, and student support services to produce learning outcomes for all students. Although the two terms "quality teacher education" and "quality teaching" defined by Allen [4] and Henard, et al. [7] respectively are slightly different, the two are closely interwoven and continues to be germane today. The relevance is that quality teaching can be viewed as the application of quality teacher education.

It is worth noting that there has been a seventy-two-year gap between the two studies and respective definitions. Nevertheless, both Allen [4] and Henard, et al. [7] still maintain that the student academic achievement requires teachers to employ more pedagogical techniques in the classroom. This is indicative of the quality teacher education training mentioned by Allen [4]. Another relevance of Allen's [4] definition of quality teacher education training for the twenty-first century is the fact that it agrees with the definitions provided by Aaronson, Barrow & Sander [8] and Anderson [9]; where both agreed that quality education is related to the quality of duty performed by the teacher, and that it has great impact on student achievement.

Several studies have also suggested that teachers could make a significant difference in student learning; however, no consensus has been reached yet on the significance of an individual teacher on student achievement [10 – 14]. Moreover, while several studies like [11, 15 – 16] suggest that teacher's licensure, or certification, years of

experience, and test scores matter in having a positive influence on student achievement. Other studies such as [8, 17, 21, 13].have failed to provide any predictive value of teacher credentials on the variance of teacher effects.

It is worth noting at this juncture that the uncertainty surrounding accurately knowing the impact of teacher training program on students' performances may be largely due to the following methodological challenges:

- A student's innate ability as well as other school factors plays vital roles in determining anticipated measured outcomes (teacher training and student achievement); isolation of productivity may be difficult. Moreover, the systematic assignment of students and teachers to classrooms may enhance the difficulty of obtaining an unbiased sample.
- Inherent problems on the characteristics of teachers in determining the effects of education and student achievement may exist. Such characteristics include motivation, intelligence, and subsequent classroom performance.
- Collection of accurate or detailed data about various education or training teachers receive may be difficult to obtain. Moreover, it is also of an arduous task finding a relationship between teacher training and student achievement.

Hypothesis Statement

The research hypothesis is that the students in math education program from selected colleges with math teacher programs would perform higher than those in math program in colleges without math education or teaching program.

Research Questions:

Question 1: Is there a difference between the means of the scores (students' performances in math) in all the colleges?

Question 2: Are there statistical significant differences in the performances of students in math education programs among the colleges in both the experimental and control groups?

No doubt, addressing all these concerns in a single research may be found increasingly onerous. However, this study addresses these challenges as well as presents new evidence of measuring quality teacher training (pre-college or college education) and its impact on student achievement.

Materials and Methods

This study compared the math teaching practice curricula and analyzed the pre-tests and post-tests of students majoring in math teaching programs at North Carolina State University (NCSU), East Carolina University (ECU), North Carolina Central University (NCCU), North Carolina Agriculture and Technical University (NCAT) and Shaw University (Shaw), which served as a control group. The random selection of the data reflects the various ability levels of students represented within each college. The choice of Shaw University as a control group was because it has a math program but not a math teacher education program. The study explored a relationship between teaching practice – a pedagogical component of teacher training – embedded in the math teacher program curricula; and the students' performances in standardized math assessments. The teaching practice represented the independent variable while students' performance represented the dependent variable.

Measures

In order to measure the performances of students in math teacher training programs, the study proposed to achieve this in two steps:

- First step: To perform multiple comparison tests of all pre-tests in order to know students' level of math knowledge that entered the program in each of the four colleges and compared with that of the fifth college, which is the control group.

- Second step: To perform multiple comparison tests of all post-tests in order to know students' performance in each of the four colleges and compared with that of the fifth college, which is the control group.

Descriptive statistics

Question 1: Is there a difference between the means of the scores (students' performances in math) in all the colleges?

Descriptive statistical data show the means and standard deviations of all pre-tests of 150 randomly selected students from five colleges in North Carolina. Of these, 120 students from NCSU, ECU, NCCU and NCAT were considered as an experimental group; while 30 students from Shaw University were considered as a control group.

A. Analyses of pre-tests from all the five colleges:

The first research question was answered by the analyses of the data in Tables 1 through 6 shown below. Table 1 below shows the summary of the descriptive statistics of the analysis. It shows that the means of the pre-tests of NCSU (M = 45.9) with (SD = 18.96); ECU (M = 43.6) with (SD = 16.13); NCCU (M = 51.7) with (SD = 16.81); NCAT (M = 52.6) with (SD = 14.68) and SHAW (M = 43.9) with (SD = 16.32). This depicts that the mean of pre-tests of students enrolled in math education program is 4.40% higher at NCSU; 0.76% lower at ECU; 17.68% higher at NCCU and 19.73% higher at NCAT; than the mean of those enrolled in a math program at Shaw (control).

Table 1: Means and standard deviations of pre-tests for all colleges in 2012 – 2013:

	NCSU	ECU	NCCU	NCAT	SHAW (Control)
Mean	45.86666667	43.6	51.7	52.6	43.93333333
(SD)	18.9640919	16.12579856	16.80753115	14.67956591	16.3220463
StdError	3.462354	2.944155	3.068621	2.68011	2.979984

Moreover, Figure 1 shows a pictorial representation of the means of pre-tests for all the colleges in 2012-2013. It is obvious from the graph that the mean of the students enrolled in math education program at NCAT is the highest.

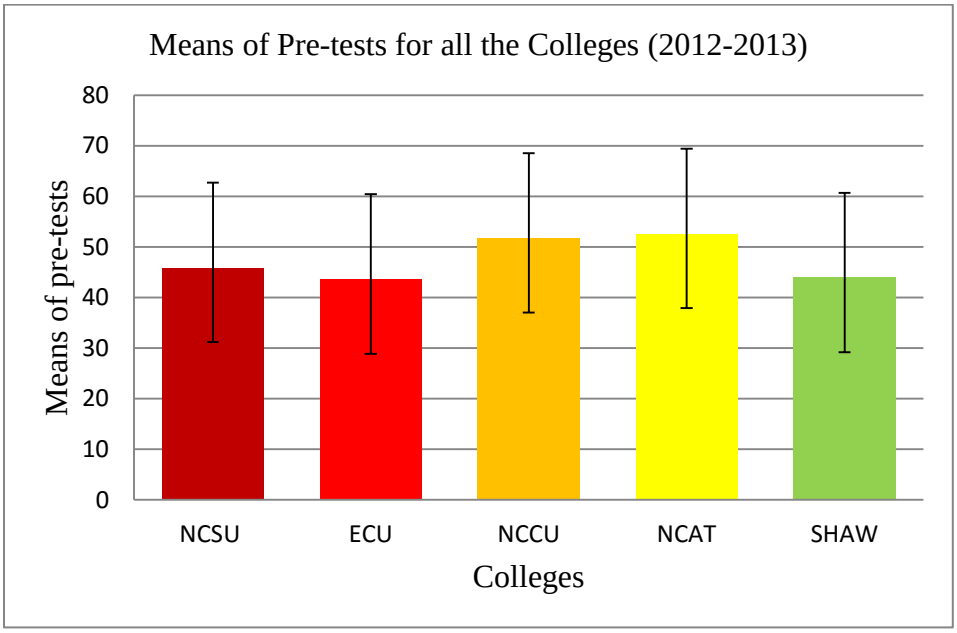

Fig. 1: Means of pre-tests for all the colleges (2012-2013)

Table 2 below shows the summary of the descriptive statistics of the analysis. It shows the means of the pre-tests of NCSU (*M* = 52.2) with (*SD* = 13.2); ECU (*M* = 49.1) with (*SD* = 12.0); NCCU (*M* = 45.1) with (*SD* = 13.5); NCAT (*M* = 49.1) with (*SD* =

12.2) and SHAW (M = 47.3) with (SD = 13.0). It further shows that the mean of pre-tests of students enrolled in math education program is 10.28% higher at NCSU; 3.73% higher at ECU; 4.65% lower at NCCU and 3.73% higher at NCAT; than the mean of those enrolled in a math program at Shaw (control). The means of pre-tests of students enrolled in math education program in both ECU and NCAT are the same.

Table 2: Means and standard deviations of pre-tests for all colleges in 2011 – 2012:

	NCSU	ECU	NCCU	NCAT	SHAW (Control)
Mean	52.2	49.1	45.13333333	49.1	47.33333333
(SD)	13.19979101	12.04402842	13.51559338	12.20330651	13.04457433
Std Error	2.409979	2.19089	2.464752	2.227405	2.373464

Moreover, Figure 2 shows a pictorial representation of the means of pre-tests for all the colleges in 2011-2012. It is obvious from the graph that the mean of the students enrolled in math education program at NCSU is the highest.

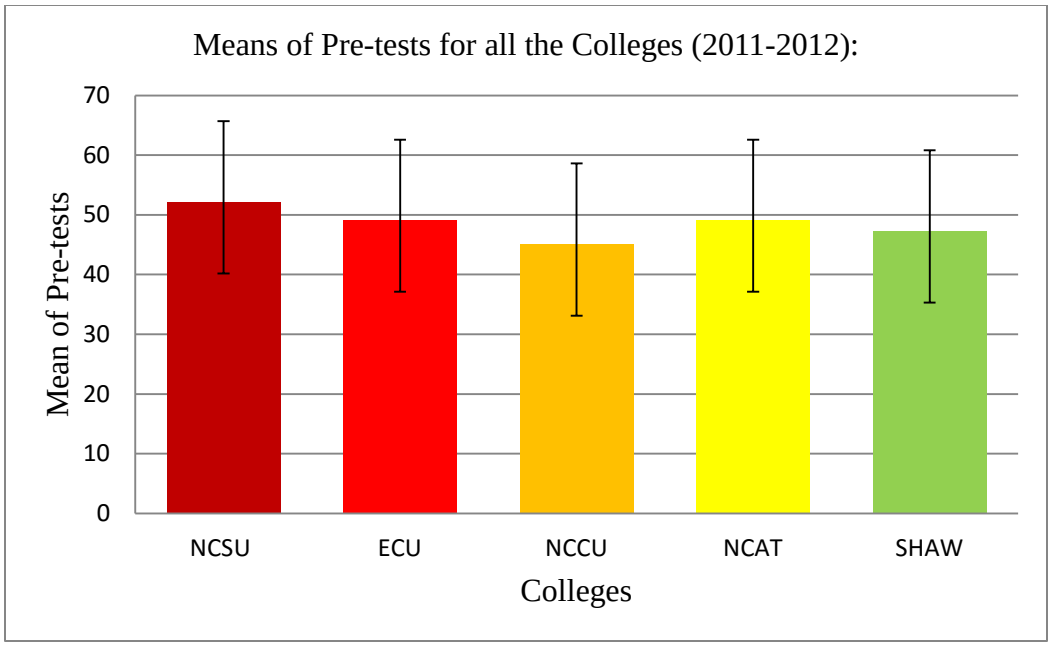

Fig. 2: Means of pre-tests for all the colleges (2011-2012)

Table 3 below shows the summary of the descriptive statistics of the analysis. Table 3 below shows the means of the pre-tests of NCSU (*M* = 51.4) with (*SD* = 15.32); ECU (*M* = 51.4) with (*SD* = 12.9); NCCU (*M* = 45.2) with (*SD* = 13.9); NCAT (*M* = 48.4) with (*SD* = 16.8) and SHAW (*M* = 40.9) with (*SD* = 18.3). It further shows that the mean of pre-tests of students enrolled in math education program is 25.75% higher at NCSU; 25.59% higher at ECU; 10.59% higher at NCCU and 18.34% higher at NCAT; than the mean of those enrolled in a math program at Shaw (control).

Table 3: Means and standard deviations of pre-tests for all colleges in 2010 – 2011:

	NCSU	ECU	NCCU	NCAT	SHAW (Control)
Mean	51.43333333	51.36666667	45.23333333	48.4	40.9

(SD)	15.32112207	12.94945967	13.93502987	16.78998059	18.26122706
Std Error	2.797241389	2.364237056	2.544176733	3.065417037	3.334028663

Moreover, Figure 3 shows a pictorial representation of the means of pre-tests for all the colleges in 2010-2011. It is obvious from the graph that the mean of the students enrolled in math education program at NCSU and ECU are practically the same.

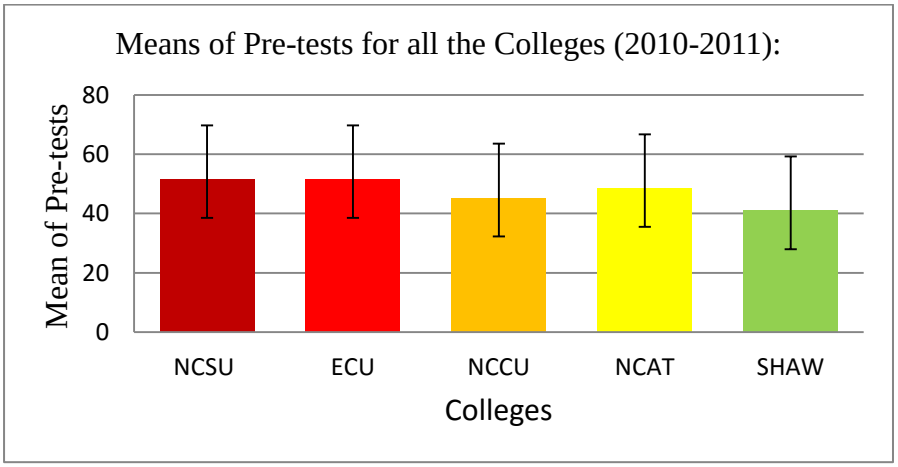

Fig. 3: Means of pre-tests for all the colleges (2010-2011)

B. Analyses of post-tests from all the five colleges:

In this section, the researcher analyzed the post-tests from all the five colleges. The descriptive statistical data show the means and standard deviations of all post-tests of 150 randomly selected students from five colleges in North Carolina. Of these, 120 students from NCSU, ECU, NCCU and NCAT were considered as an experimental group; while 30 students from Shaw University were considered as a control group.

Table 4 below shows the summary of the descriptive statistics of the analysis. It shows that the means of the post-tests of NCSU (M = 80.9) with (SD = 10.00); ECU (M = 78.5) with (SD = 8.96); NCCU (M = 83.5) with (SD = 7.00); NCAT (M = 86.1) with (SD

= 6.13) and SHAW (*M* = 74.6) with (*SD* = 9.64). Moreover, it further shows that the mean of post-tests of students enrolled in math education program is 8.49 % higher at NCSU; 5.32% higher at ECU; 11.98% higher at NCCU and 15.51% higher at NCAT; than the mean of those enrolled in a math program at Shaw (control).

Table 4: Means and standard deviations of post-tests for all colleges in 2012 – 2013:

	NCSU	ECU	NCCU	NCAT	SHAW (Control)
Mean	80.86666667	78.53333333	83.5	86.13333333	74.56666667
(SD)	10.00942085	8.962501703	6.996304443	6.134882363	9.637152725
Std Error	1.827461862	1.636321452	1.277344588	1.120071153	1.759495313

Moreover, Figure 4 below shows a pictorial representation of the means of post-tests for all the colleges in 2012-2013. It is obvious from the graph that the mean of the students enrolled in math education program at NCAT is the highest.

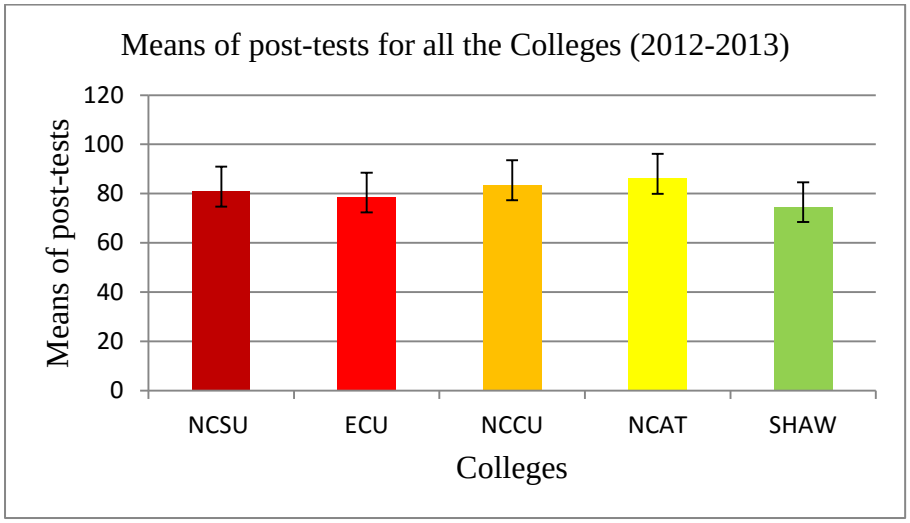

Fig. 4: Means of post-tests for all the colleges (2012-2013)

Table 5 below shows the summary of the descriptive statistics of the analysis. It shows that the means of the post-tests of NCSU (*M* = 88.1) with (*SD* = 5.34); ECU (*M* = 87.2) with (*SD* = 4.94); NCCU (*M* = 77.8) with (*SD* = 8.25); NCAT (*M* = 84.0) with (*SD* = 6.80) and SHAW (*M* = 76.8) with (*SD* = 11.73). It also further shows that the mean of post-tests of students enrolled in math education program is 14.62% higher at NCSU; 13.54% higher at ECU; 1.30% higher at NCCU and 9.37% higher at NCAT; than the mean of those enrolled in a math program at Shaw (control).

Table 5: Means and standard deviations of post-tests for all colleges in 2011 – 2012:

	NCSU	ECU	NCCU	NCAT	SHAW (Control)
Mean	88.06666667	87.23333333	77.83333333	84.03333333	76.83333333
(SD)	5.336493317	4.938821117	8.246559715	6.79494403	11.72995968
Std Error	0.974305923	0.901701244	1.505608926	1.240581374	2.141587838

Moreover, Figure 5 shows a pictorial representation of the means of post-tests for all the colleges in 2012-2013. It is obvious from the graph that the mean of the students enrolled in math education program at NCSU is the highest, closely followed by that of the ECU.

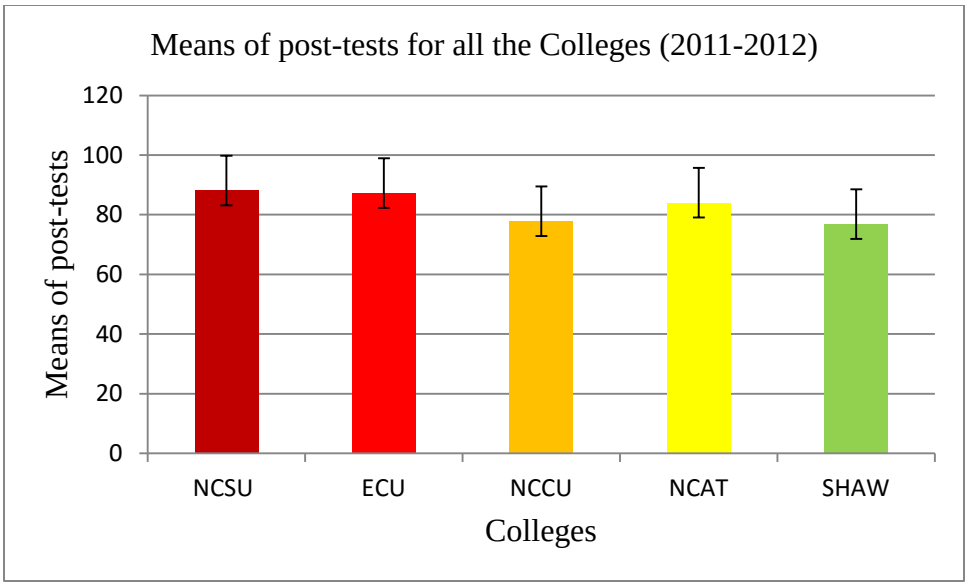

Fig. 5: Means of post-tests for all the colleges (2011-2012)

Table 6 below shows the summary of the descriptive statistics of the analysis. Table 6 below shows the means of the post-tests of NCSU (*M* = 85.5) with (*SD* = 6.80); ECU (*M* = 83.9) with (*SD* = 6.00); NCCU (*M* = 80.4) with (*SD* = 8.87); NCAT (*M* = 84.2) with (*SD* = 7.70) and SHAW (*M* = 76.17) with (*SD* = 10.86). It further shows that the mean of post-tests of students enrolled in math education program is 12.21% higher at NCSU; 10.20% higher at ECU; 5.60% higher at NCCU and 10.59% higher at NCAT; than the mean of those enrolled in a math program at Shaw (control).

Table 6: Means and standard deviations of post-tests for all colleges in 2010 – 2011:

	NCSU	ECU	NCCU	NCAT	SHAW (Control)
Mean	85.46666667	83.93333333	80.43333333	84.23333333	76.16666667
(SD)	6.80128453	5.993866597	8.869487927	7.704380005	10.86304502

Std Error	1.241738986	1.094325314	1.619339537	1.406620907	1.9833116

Moreover, Figure 6 shows a pictorial representation of the means of post-tests for all the colleges in 2010-2011. It is obvious from the graph that the means of the students enrolled in math education program at NCSU, ECU, NCCU and NCAT are not too far from each other but that of NCSU appears to be the highest.

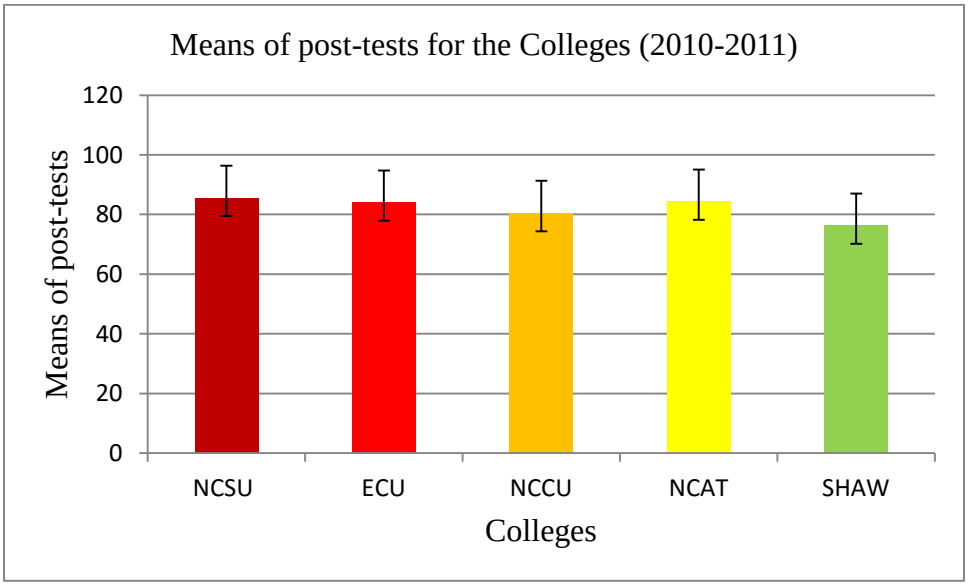

Fig. 6: Means of post-tests for all the colleges (2010-2011)

Inferential statistics

Question 2: Are there statistical significant differences in the performances of students in math education programs among the colleges in both the experimental and control groups?

An inferential statistical analysis of data is provided in this section to answer the second research question. Tables 7 through 12 depict the results of the ANOVA Single Factor pre- and post-tests of randomly chosen thirty graduates of the mathematics education program from each of the five colleges (totaling 150 students), for three consecutive academic years: 2012-2013, 2011-2012 and 2010-2011. In addition, ad-hoc multiple comparison t-tests were performed for all significant ANOVAs. Each test was based on the null hypothesis that there is no significant difference between the pre- and post-tests. That is, the difference between the pre- and post-test mean scores was less than or equal to zero $\left(H_0 : \mu_S \leq 0\right)$. However, the alternative hypothesis was that there is a significant difference between the pre- and post-tests. That is, the difference between the pre- and post-test mean scores was greater than zero $\left(H_A : \mu_S > 0\right)$. It should be noted that all the tests are based on an alpha level of significance of 0.05, that is $\left(\alpha = 0.05\right)$; except when Benferroni adjustment [18 – 20] ($\alpha_{BonferroniCorrection} = \frac{\alpha}{n} \Rightarrow \frac{0.05}{5} = 0.01$ was used in the ad-hoc multiple comparison t-tests.

A. Interpretation of the pre and post-tests using ANOVA Single Factor Tests for Means

ANOVA Single Factor Tests were used to compare the pre-test mean differences of the five colleges – NCSU, ECU, NCCU, NCAT and SHAW – for academic year 2012-2013. Data in Table 7 indicate there were statistical significances among the colleges. The results of the ANOVA depict difference in the pre-tests of students of NCSU (M = 45.9), ECU (M = 43.6), NCCU (M = 51.7), NCAT (M = 52.6) and SHAW (M = 43.9); (F [4, 145] = 2.01, $p > 0.05$).

Table 7: Summary of ANOVA for pre-tests for the year (2012-2013):

SUMMARY

Groups	Count	Sum	Average	Variance
NCSU	30	1376	45.86667	359.6368
ECU	30	1308	43.6	260.0414
NCCU	30	1551	51.7	282.4931
NCAT	30	1578	52.6	215.4897
SHAW	30	1318	43.93333	266.4092

ANOVA

Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	2227.227	4	556.8067	2.011483	0.095913	2.434065
Within Groups	40138.03	145	276.814			
Total	42365.26	149				

ANOVA Single Factor Tests were used to compare the post-test mean differences of the five colleges – NCSU, ECU, NCCU, NCAT and SHAW – for academic year 2012-2013. Data in Table 8 indicate there were statistical significances among the colleges. The results of the ANOVA depict difference in the post-tests of students of NCSU (*M* =

80.9), ECU (M = 78.5), NCCU (M = 83.5), NCAT (M = 86.1) and SHAW (M = 74.6); (F [4, 145] = 8.30, $p < 0.05$).

Table 8: Summary of ANOVA for post-tests for the year (2012-2013):

SUMMARY

Groups	Count	Sum	Average	Variance
NCSU	30	2426	80.86667	100.1885
ECU	30	2356	78.5	80.32644
NCCU	30	2505	83.5	48.94828
NCAT	30	2584	86.13333	37.63678
SHAW	30	2237	74.56667	92.87471

ANOVA

Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	2390.973	4	597.7433	8.302574	4.66×10^{-6}	2.434065
Within Groups	10439.27	145	71.99494			
Total	12830.24	149				

ANOVA Single Factor Tests were used to compare the pre-test mean differences of the five colleges – NCSU, ECU, NCCU, NCAT and SHAW – for academic year 2011-2012. Data in Table 9 indicate there were statistical significances among the colleges. The results of the ANOVA depict difference in the pre-tests of students of NCSU (M = 52.2), ECU (M = 49.1), NCCU (M = 45.1), NCAT (M = 49.1) and SHAW (M = 47.3); (F [4, 145] = 1.24, $p > 0.05$).

Table 9: Summary of ANOVA for pre-tests for the year (2011-2012):

SUMMARY

Groups	Count	Sum	Average	Variance
NCSU	30	1566	52.2	174.2345
ECU	30	1473	49.1	145.0586
NCCU	30	1354	45.13333	182.6713
NCAT	30	1473	49.1	148.9207
SHAW	30	1420	47.33333	170.1609

ANOVA

Source of Variation	SS	df	MS	F	p-value	F critical
Between Groups	812.36	4	203.09	1.236776	0.097932	2.434065
Within Groups	23810.33	145	164.2092			

Total	24622.69	149				

ANOVA Single Factor Tests were used to compare the post-test mean differences of the five colleges – NCSU, ECU, NCCU, NCAT and SHAW – for academic year 2011-2012. Data in Table 10 indicate there were statistical significances among the colleges. The results of the ANOVA depict difference in the post-tests of students of NCSU (M = 88.1), ECU (M = 87.2), NCCU (M = 77.8), NCAT (M = 84.0) and SHAW (M = 76.8); (F [4, 145] = 13.44, $p < 0.05$).

Table 10: Summary of ANOVA for post-tests for the year (2011-2012):

SUMMARY

Groups	Count	Sum	Average	Variance
NCSU	30	2642	88.06667	28.47816
ECU	30	2617	87.23333	24.39195
NCCU	30	2335	77.83333	68.00575
NCAT	30	2521	84.03333	46.17126
SHAW	30	2305	76.83333	137.592

ANOVA

Source of Variation	SS	df	MS	F	p-value	F critical
Between	3275.467	4	818.8667	13.43995	2.42×10^{-9}	2.434065

Groups						
Within Groups	8834.533	145	60.92782			
Total	12110	149				

ANOVA Single Factor Tests were used to compare the pre-test mean differences of the five colleges – NCSU, ECU, NCCU, NCAT and SHAW – for academic year 2010-2011. Data in Table 11 indicate there was no statistical significance between NCSU (M = 51.4) and ECU (M = 51.4). The results of the ANOVA depict no difference in the pre-tests of students of NCSU (M = 51.4) and ECU (M = 51.4); but a difference in the pre-tests of students of NCCU (M = 45.2), NCAT (M = 48.4) and SHAW (M = 40.9); (F [4, 145] = 2.47, $p < 0.05$).

Table 11: Summary of ANOVA for pre-tests for the year (2010-2011):

SUMMARY

Groups	Count	Sum	Average	Variance
NCSU	30	1543	51.43333	234.7368
ECU	30	1541	51.36667	167.6885
NCCU	30	1357	45.23333	194.1851
NCAT	30	1452	48.4	281.9034
SHAW	30	1227	40.9	333.4724

ANOVA

Source of Variation	SS	df	MS	F	p-value	F critical
Between Groups	2397.733	4	599.43333	2.472938	0.047059	2.434065
Within Groups	35147.6	145	242.3972			
Total	37545.33	149				

ANOVA Single Factor Tests were used to compare the post-test mean differences of the five colleges – NCSU, ECU, NCCU, NCAT and SHAW – for academic year 2010-2011. Data in Table 12 indicate there were statistical significances among the colleges. The results of the ANOVA depict difference in the post-tests of students of NCSU (M = 85.5), ECU (M = 83.9), NCCU (M = 80.4), NCAT (M = 84.2) and SHAW (M = 76.2); (F [4, 145] = 6.34, $p < 0.05$).

Table 12: Summary of ANOVA for post-tests for the year (2010-2011):

SUMMARY

Groups	Count	Sum	Average	Variance
NCSU	30	2564	85.46667	46.25747
ECU	30	2518	83.93333	35.92644
NCCU	30	2413	80.43333	78.66782
NCAT	30	2527	84.23333	59.35747

SHAW	30	2285	76.16667	118.0057

ANOVA

Source of Variation	SS	df	MS	F	p-value	F critical
Between Groups	1716.44	4	429.11	6.343747	9.86×10^{-5}	2.434065
Within Groups	9808.233	145	67.64299			
Total	11524.67	149				

B. Ad-hoc tests for significant ANOVA from Table 8 (post-test 2012-2013):

In this section, Ad-hoc multiple comparison t-tests were performed for the significant ANOVA observed in Table 8 above. Bonferroni adjustment [18 – 20] was used for these tests since five multiple variables are involved in the comparison unless otherwise stated. That is, $\alpha_{BonferroniCorrection} = \frac{\alpha}{n} \Rightarrow \frac{0.05}{5} = 0.01$ was used.

From Table 8, a t-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and ECU – for academic year 2012-2013. Data in Table 8A below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCSU students displayed a higher rate of achievement (M = 80.9) than their counterparts at

ECU (M = 78.5), (t[58] = 0.95, p > 0.01). Therefore, the result was not statistically significant.

Table 8A: *t*-Test – Two-Sample Assuming Equal Variances (NCSU vs. ECU)

	NCSU	*ECU*
Mean	80.86667	78.53333333
Variance	100.1885	80.32643678
Observations	30	30
Pooled Variance	90.25747	
Hypothesized Mean Difference	0	
df	58	
t Stat	0.95122	
P(T<=t) one-tail	0.17272	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.34544	
t Critical two-tail	2.663287	

From Table 8, a t-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and NCCU – for academic year 2012-2013. Data in Table 8B below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCSU students displayed a higher rate of performance or achievement (M = 80.9) than their counterparts at NCCU (M = 78.5), (t[58] = 0.95, p > 0.01). Therefore, the result was not statistically significant.

Table 8B: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. NCCU)

	NCSU	*NCCU*

Mean	80.86667	78.53333333
Variance	100.1885	80.32643678
Observations	30	30
Pooled Variance	90.25747	
Hypothesized Mean Difference	0	
df	58	
t Stat	0.95122	
P(T<=t) one-tail	0.17272	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.34544	
t Critical two-tail	2.66329	

From Table 8, a t-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and NCAT – for academic year 2012-2013. Data in Table 8C below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCAT students displayed a higher rate of performance or achievement (M = 86.1) than their counterparts at NCSU (M = 80.9), (t[58] = -2.46, p > 0.01). Therefore, the result was not statistically significant.

Table 8C: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. NCAT)

	NCSU	*NCAT*
Mean	80.86667	86.13333333
Variance	100.18851	37.63678161
Observations	30	30
Pooled Variance	68.91264	
Hypothesized Mean Difference	0	
df	58	
t Stat	-2.45715	
P(T<=t) one-tail	0.00851	

t Critical one-tail	2.39238
P(T<=t) two-tail	0.01702
t Critical two-tail	2.66329

From Table 8, a t-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and SHAW – for academic year 2012-2013. Data in Table 8D below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCSU students displayed a higher rate of performance or achievement (M = 80.9) than their counterparts at SHAW (M = 74.6), (t[58] = 2.48, p > 0.01). Therefore, the result was not statistically significant.

Table 8D: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. SHAW):

	NCSU	*SHAW*
Mean	80.86667	74.56667
Variance	100.18851	92.87471
Observations	30	30
Pooled Variance	96.53161	
Hypothesized Mean Difference	0	
df	58	
t Stat	2.48343	
P(T<=t) one-tail	0.00796	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.01592	
t Critical two-tail	2.66329	

From Table 8, a t-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – ECU and NCCU – for academic

year 2012-2013. Data shown in Table 8E below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCCU students displayed a higher rate of performance or achievement (M = 83.5) than their counterparts at ECU (M = 78.5), (t[58] = – 2.39, p > 0.01). Therefore, the result was not statistically significant.

Table 8E: t-Test – Two-Sample Assuming Equal Variances (ECU vs. NCCU)

	ECU	*NCCU*
Mean	78.53333	83.5
Variance	80.32644	48.94828
Observations	30	30
Pooled Variance	64.63736	
Hypothesized Mean Difference	0	
df	58	
t Stat	-2.39259	
P(T<=t) one-tail	0.009995	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.01999	
t Critical two-tail	2.66329	

From Table 8, a t-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – ECU and NCAT – for academic year 2012-2013. Data in Table 8F below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCAT students displayed a higher rate of performance or achievement (M = 86.1) than their counterparts at ECU (M = 78.5), (t[58] = – 3.83, p < 0.01). Therefore, the result was statistically significant.

Table 8F: t-Test – Two-Sample Assuming Equal Variances (ECU vs. NCAT)

	ECU	*NCAT*
Mean	78.53333	86.13333
Variance	80.32644	37.63678
Observations	30	30
Pooled Variance	58.98161	
Hypothesized Mean Difference	0	
df	58	
t Stat	-3.83267	
P(T<=t) one-tail	0.000157	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.000314	
t Critical two-tail	2.66329	

From Table 8, a t-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – ECU and SHAW – for academic year 2012-2013. Data in Table 8G below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that ECU students displayed a higher rate of performance or achievement (M = 78.5) than their counterparts at SHAW (M = 74.6), (t[58] = 1.65, p > 0.05). Therefore, the result was not statistically significant.

Table 8G: t-Test – Two-Sample Assuming Equal Variances (ECU vs. SHAW)

	ECU	*SHAW*
Mean	78.5	74.56667
Variance	80.32644	92.87471
Observations	30	30
Pooled Variance	86.60057	
Hypothesized Mean Difference	0	

df	58
t Stat	1.650863
P(T<=t) one-tail	0.052086
t Critical one-tail	2.392377
P(T<=t) two-tail	0.104172
t Critical two-tail	2.66129

From Table 8, a t-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCCU and NCAT – for academic year 2012-2013. Data in Table 8H below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCAT students displayed a higher rate of performance or achievement (M = 86.1) than their counterparts at NCCU (M = 83.5), (t[58] = – 1.55, p > 0.01). Therefore, the result was not statistically significant.

Table 8H: t-Test – Two-Sample Assuming Equal Variances (NCCU vs. NCAT)

	NCCU	*NCAT*
Mean	83.5	86.13333
Variance	48.94828	37.63678
Observations	30	30
Pooled Variance	43.29253	
Hypothesized Mean Difference	0	
df	58	
t Stat	-1.55005	
P(T<=t) one-tail	0.063285	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.12657	
t Critical two-tail	2.66329	

From Table 8, a t-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCCU and SHAW – for academic year 2012-2013. Data in Table 8I below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCCU students displayed a higher rate of performance or achievement (M = 83.5) than their counterparts at SHAW (M = 74.6), (t[58] = 4.11, p < 0.01). Therefore, the result was statistically significant.

Table 8I: t-Test – Two Sample Assuming Equal Variances (NCCU vs. SHAW):

	NCCU	*SHAW*
Mean	83.5	74.56667
Variance	48.94828	92.87471
Observations	30	30
Pooled Variance	70.91149	
Hypothesized Mean Difference	0	
df	58	
t Stat	4.10867	
P(T<=t) one-tail	0.0000410867	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.000126571	
t Critical two-tail	2.66329	

From Table 8, a t-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCAT and SHAW – for academic year 2012-2013. Data in Table 8J below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCAT students displayed a higher rate of performance or achievement (M = 86.1) than their

counterparts at SHAW (M = 74.6), (t[58] = 5.55, $p < 0.01$). Therefore, the result was statistically significant.

Table 8J: t-Test – Two Sample Assuming Equal Variances (NCAT vs. SHAW):

	NCAT	*SHAW*
Mean	86.1	74.56667
Variance	37.63678	92.87471
Observations	30	30
Pooled Variance	65.25575	
Hypothesized Mean Difference	0	
df	58	
t Stat	5.54555	
P(T<=t) one-tail	0.000000377412	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.000000754824	
t Critical two-tail	2.66329	

C. Ad-hoc tests for significant ANOVA from Table 10 (post-test 2011-2012)::

In this section, Ad-hoc multiple comparison t-tests were performed for the significant ANOVA observed in Table 10 above. Bonferroni adjustment [18 – 20] was used for these tests since five multiple variables are involved in the comparison unless otherwise stated. That is, $\alpha_{BonferroniCorrection} = \frac{\alpha}{n} \Rightarrow \frac{0.05}{5} = 0.01$ was used.

From Table 10, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and ECU – for academic

year 2011-2012. Data in Table 10A below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCSU students displayed a higher rate of performance or achievement (M = 88.1) than their counterparts at ECU (M = 87.2), (t[58] = 0.63, p > 0.01). The result was not statistically significant.

Table 10A: t-Test – Two Sample Assuming Equal Variances (NCCU vs. ECU):

	NCSU	*ECU*
Mean	88.06667	87.23333
Variance	28.47816	24.39195
Observations	30	30
Pooled Variance	26.43506	
Hypothesized Mean Difference	0	
df	58	
t Stat	0.62773	
P(T<=t) one-tail	0.26632	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.53264	
t Critical two-tail	2.663287	

From Table 10, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and NCCU – for academic year 2011-2012. Data in Table 10B below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCSU students displayed a higher rate of performance or achievement (M = 88.1) than their counterparts at NCCU (M = 77.8), (t[58] = 5.71, p < 0.01). The result was statistically significant.

Table 10B: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. NCCU):

	NCSU	*NCCU*
Mean	88.06667	77.83333
Variance	28.47816092	68.00575
Observations	30	30
Pooled Variance	48.24195	
Hypothesized Mean Difference	0	
df	58	
t Stat	5.706244	
P(T<=t) one-tail	0.000000206753	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.000000413507	
t Critical two-tail	2.663287	

From Table 10, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and NCAT – for academic year 2011-2012. Data in Table 10C below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCSU students displayed a higher rate of achievement (M = 88.1) than their counterparts at NCAT (M = 84.0), ($t[58] = 2.56$, $p > 0.05$). The result was not statistically significant.

Table 10C: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. NCAT):

	NCSU	*NCAT*
Mean	88.06667	84.03333333
Variance	28.47816	46.17126
Observations	30	30
Pooled Variance	37.32471	
Hypothesized Mean Difference	0	
df	58	
t Stat	2.55689	

P(T<=t) one-tail	0.00660
t Critical one-tail	2.392377
P(T<=t) two-tail	0.01320
t Critical two-tail	2.66329

From Table 10, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and SHAW – for academic year 2011-2012. Data in Table 10D below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCSU students displayed a higher rate of achievement (M = 88.1) than their counterparts at SHAW (M = 76.8), (t[58] = 4.77, $p <$ 0.01). The result was statistically significant.

Table 10D: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. SHAW)

	NCSU	*SHAW*
Mean	88.06667	76.83333
Variance	28.47816	137.592
Observations	30	30
Pooled Variance	83.03506	
Hypothesized Mean Difference	0	
df	58	
t Stat	4.774452	
P(T<=t) one-tail	0.00000631633	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.0000126327	
t Critical two-tail	2.663287	

From Table 10, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – ECU and NCCU – for academic

year 2011-2012. Data in Table 10E below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that ECU students displayed a higher rate of achievement (M = 87.2) than their counterparts at NCCU (M = 77.8), (t[58] = 5.36, $p < 0.01$). The result was statistically significant.

Table 10E: t-Test – Two-Sample Assuming Equal Variances (ECU vs NCCU)

	ECU	*NCCU*
Mean	87.23333	77.83333
Variance	24.39195	68.00575
Observations	30	30
Pooled Variance	46.19885	
Hypothesized Mean Difference	0	
df	58	
t Stat	5.356214	
P(T<=t) one-tail	0.000000762606	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.00000152521	
t Critical two-tail	2.66329	

From Table 10, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – ECU and NCAT – for academic year 2011-2012. Data in Table 10F below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that ECU students displayed a higher rate of achievement (M = 87.2) than their counterparts at NCAT (M = 84.0), (t[58] = 2.09, $p > 0.01$). The result was not statistically significant.

Table 10F: t-Test – Two-Sample Assuming Equal Variances (ECU vs NCAT)

	ECU	*NCAT*
Mean	87.23333	84.03333
Variance	24.39195	46.17126
Observations	30	30
Pooled Variance	35.28161	
Hypothesized Mean Difference	0	
df	58	
t Stat	2.08652	
P(T<=t) one-tail	0.02067	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.04134	
t Critical two-tail	2.66329	

From Table 10, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – ECU and SHAW – for academic year 2011-2012. Data in Table 10G below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that ECU students displayed a higher rate of achievement (M = 87.2) than their counterparts at SHAW (M = 76.8), ($t[58] = 4.48$, $p < 0.01$). The result was statistically significant.

Table 10G: t-Test – Two-Sample Assuming Equal Variances (ECU vs. SHAW)

	ECU	*SHAW*
Mean	87.23333	76.83333
Variance	24.39195	137.592
Observations	30	30
Pooled Variance	80.99195	
Hypothesized Mean Difference	0	
df	58	
t Stat	4.47567	

P(T<=t) one-tail	0.0000181
t Critical one-tail	2.39238
P(T<=t) two-tail	0.0000362
t Critical two-tail	2.66329

From Table 10, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCCU and NCAT – for academic year 2011-2012. Data in Table 10H below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCAT students displayed a higher rate of achievement (M = 84.0) than their counterparts at NCCU (M = 77.8), (t[58] = -3.18, $p < 0.01$). The result was statistically significant.

Table 10H: t-Test – Two-Sample Assuming Equal Variances (NCCU vs. NCAT)

	NCCU	*NCAT*
Mean	77.83333	84.03333
Variance	68.00575	46.17126
Observations	30	30
Pooled Variance	57.08851	
Hypothesized Mean Difference	0	
df	58	
t Stat	-3.17807	
P(T<=t) one-tail	0.001189	
t Critical one-tail	2.39238	
P(T<=t) two-tail	0.002378	
t Critical two-tail	2.66329	

From Table 10, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCCU and SHAW – for

academic year 2011-2012. Data in Table 10I below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCCU students displayed a higher rate of achievement (M = 77.8) than their counterparts at SHAW (M = 76.8), (t[58] = 0.38, p > 0.01). The result was not statistically significant.

Table 10I: t-Test – Two-Sample Assuming Equal Variances (NCCU vs. SHAW)

	NCCU	*SHAW*
Mean	77.83333	76.83333
Variance	68.00575	137.592
Observations	30	30
Pooled Variance	102.7989	
Hypothesized Mean Difference	0	
df	58	
t Stat	0.38199	
P(T<=t) one-tail	0.351933	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.703865	
t Critical two-tail	2.663287	

From Table 10, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCAT and SHAW – for academic year 2011-2012. Data in Table 10J below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCAT students displayed a higher rate of achievement (M = 84.0) than their counterparts at SHAW (M = 76.8), (t[58] = 2.91, p < 0.01). The result was statistically significant.

Table 10J t-Test – Two-Sample Assuming Equal Variances (NCAT vs. SHAW)

	NCAT	*SHAW*
Mean	84.03333	76.83333
Variance	46.17126	137.592
Observations	30	30
Pooled Variance	91.88161	
Hypothesized Mean Difference	0	
df	58	
t Stat	2.909135	
P(T<=t) one-tail	0.002565	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.005131	
t Critical two-tail	2.663287	

D. Ad-hoc tests for significant ANOVA from Table 11 (pre-test 2010-2011):

In this section, ad-hoc multiple comparison t-tests were performed for the significant ANOVA observed in Table 11 above. Bonferroni adjustment [18 – 20] was used for these tests since five multiple variables are involved in the comparison unless otherwise stated. That is, $\alpha_{BonferroniCorrection} = \frac{\alpha}{n} \Rightarrow \frac{0.05}{5} = 0.01$ was used.

From Table 11, a *t*-test of two samples assuming equal variance was used to compare the pre-test mean differences of two colleges – NCSU and ECU – for academic year 2010-2011. Data in Table 11A below show the relationship between the performances of the two colleges. The results of the pre-hoc t-test show that NCSU students displayed the same rate of performance or achievement (M = 51.4) as their counterparts at ECU (M = 51.4), (t[58] = 0.02, p > 0.01). The result was not statistically significant.

Table 11A: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. ECU):

	NCSU	*ECU*

Mean	51.43333	51.36667
Variance	234.7368	167.6885
Observations	30	30
Pooled Variance	201.2126	
Hypothesized Mean Difference	0	
df	58	
t Stat	0.018202	
P(T<=t) one-tail	0.49277	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.98554	
t Critical two-tail	2.663287	

From Table 11, a *t*-test of two samples assuming equal variance was used to compare the pre-test mean differences of two colleges – NCSU and NCCU – for academic year 2010-2011. Data in Table 11B below show the relationship between the performances of the two colleges. The results of the pre-hoc t-test show that NCSU students displayed a higher rate of performance or achievement (M = 51.4) than their counterparts at NCCU (M = 45.2), (t[58] = 1.64, p > 0.01). The result was not statistically significant.

Table 11B: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. NCCU):

	NCSU	*NCCU*
Mean	51.43333	45.23333
Variance	234.7368	194.1851
Observations	30	30
Pooled Variance	214.4609	
Hypothesized Mean Difference	0	
df	58	
t Stat	1.639696	
P(T<=t) one-tail	0.053241	
t Critical one-tail	2.392377	

P(T<=t) two-tail	0.106482
t Critical two-tail	2.663287

From Table 11, a *t*-test of two samples assuming equal variance was used to compare the pre-test mean differences of two colleges – NCSU and NCAT – for academic year 2010-2011. Data in Table 11C below show the relationship between the performances of the two colleges. The results of the pre-hoc t-test show that NCSU students displayed a higher rate of performance or achievement (M = 51.4) than their counterparts at NCCU (M = 48.4), (t[58] = 0.73, p > 0.01). The result was not statistically significant.

Table 11C: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. NCAT):

	NCSU	*NCAT*
Mean	51.43333	48.4
Variance	234.7368	281.9034
Observations	30	30
Pooled Variance	258.3201	
Hypothesized Mean Difference	0	
df	58	
t Stat	0.730948	
P(T<=t) one-tail	0.233877	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.467753	
t Critical two-tail	2.663287	

From Table 11, a *t*-test of two samples assuming equal variance was used to compare the pre-test mean differences of two colleges – NCSU and SHAW – for

academic year 2010-2011. Data in Table 11D below show the relationship between the performances of the two colleges. The results of the pre-hoc t-test show that NCSU students displayed the same rate of performance or achievement (M = 51.4) as their counterparts at SHAW (M = 51.4), (t[58] = 0.02, p > 0.01). The result was not statistically significant.

Table 11D: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. SHAW):

	NCSU	*SHAW*
Mean	51.43333	51.36667
Variance	234.7368	167.6885
Observations	30	30
Pooled Variance	201.2126	
Hypothesized Mean Difference	0	
df	58	
t Stat	0.018202	
P(T<=t) one-tail	0.49277	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.98554	
t Critical two-tail	2.663287	

From Table 11, a *t*-test of two samples assuming equal variance was used to compare the pre-test mean differences of two colleges – ECU and NCCU – for academic year 2010-2011. Data in Table 11E below show the relationship between the performances of the two colleges. The results of the pre-hoc t-test show that ECU students displayed a higher rate of performance or achievement (M = 51.4) than their counterparts at NCCU (M = 45.2), (t[58] = 1.77, p > 0.01). The result was not statistically significant.

Table 11E: t-Test – Two-Sample Assuming Equal Variances (ECU vs. NCCU):

	ECU	*NCCU*
Mean	51.36667	45.23333
Variance	167.6885	194.1851
Observations	30	30
Pooled Variance	180.9368	
Hypothesized Mean Difference	0	
df	58	
t Stat	1.765951	
P(T<=t) one-tail	0.041333	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.082667	
t Critical two-tail	2.663287	

From Table 11, a *t*-test of two samples assuming equal variance was used to compare the pre-test mean differences of two colleges – ECU and NCAT – for academic year 2010-2011. Data in Table 11F below show the relationship between the performances of the two colleges. The results of the pre-hoc t-test show that ECU students displayed a higher rate of performance or achievement (M = 51.4) than their counterparts at NCAT (M = 48.4), ($t[58] = 0.77$, $p > 0.01$). The result was not statistically significant.

Table 11F: t-Test – Two-Sample Assuming Equal Variances (ECU vs. NCAT):

	ECU	*NCAT*
Mean	51.36667	48.4
Variance	167.6885	281.9034
Observations	30	30
Pooled Variance	224.796	
Hypothesized Mean Difference	0	
df	58	

t Stat	0.766338
P(T<=t) one-tail	0.223292
t Critical one-tail	2.392377
P(T<=t) two-tail	0.446583
t Critical two-tail	2.663287

From Table 11, a *t*-test of two samples assuming equal variance was used to compare the pre-test mean differences of two colleges – ECU and SHAW – for academic year 2010-2011. Data in Table 11G below show the relationship between the performances of the two colleges. The results of the pre-hoc t-test show that ECU students displayed a higher rate of performance or achievement (M = 51.4) than their counterparts at SHAW (M = 40.9), ($t[58] = 2.56$, $p > 0.01$). The result was not statistically significant.

Table 11G: t-Test – Two-Sample Assuming Equal Variances (ECU vs. SHAW):

	ECU	*SHAW*
Mean	51.36667	40.9
Variance	167.6885	333.4724
Observations	30	30
Pooled Variance	250.5805	
Hypothesized Mean Difference	0	
df	58	
t Stat	2.560828	
P(T<=t) one-tail	0.006533	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.013067	
t Critical two-tail	2.663287	

From Table 11, a *t*-test of two samples assuming equal variance was used to compare the pre-test mean differences of two colleges – NCCU and NCAT – for academic year 2010-2011. Data in Table 11H below show the relationship between the performances of the two colleges. The results of the pre-hoc t-test show that NCAT students displayed a higher rate of performance or achievement (M = 48.4) than their counterparts at NCCU (M = 45.2), (t[58] = -0.79, $p > 0.01$). The result was not statistically significant.

Table 11H: t-Test – Two-Sample Assuming Equal Variances (NCCU vs. NCAT):

	NCCU	*NCAT*
Mean	45.23333	48.4
Variance	194.1851	281.9034
Observations	30	30
Pooled Variance	238.0443	
Hypothesized Mean Difference	0	
df	58	
t Stat	-0.79491	
P(T<=t) one-tail	0.214953	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.429906	
t Critical two-tail	2.663287	

From Table 11, a *t*-test of two samples assuming equal variance was used to compare the pre-test mean differences of two colleges – NCCU and SHAW – for academic year 2010-2011. Data in Table 11I below show the relationship between the performances of the two colleges. The results of the pre-hoc t-test show that NCCU students displayed a higher rate of performance or achievement (M = 45.2) than their

counterparts at SHAW (M = 40.9), (t[58] = 1.03, p > 0.01). The result was not statistically significant.

Table 11I: t-Test – Two-Sample Assuming Equal Variances (NCCU vs. SHAW):

	NCCU	*SHAW*
Mean	45.23333	40.9
Variance	194.1851	333.4724
Observations	30	30
Pooled Variance	263.8287	
Hypothesized Mean Difference	0	
df	58	
t Stat	1.033253	
P(T<=t) one-tail	0.152887	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.305775	
t Critical two-tail	2.663287	

From Table 11, a *t*-test of two samples assuming equal variance was used to compare the pre-test mean differences of two colleges – NCAT and SHAW – for academic year 2010-2011. Data in Table 11J below show the relationship between the performances of the two colleges. The results of the pre-hoc t-test show that NCAT students displayed a higher rate of performance or achievement (M = 48.4) than their counterparts at SHAW (M = 40.9), (t[58] = 1.66, p > 0.01). The result was not statistically significant.

Table 11J: t-Test – Two-Sample Assuming Equal Variances (NCAT vs. SHAW):

	NCAT	*SHAW*
Mean	48.4	40.9

Variance	281.9034	333.4724
Observations	30	30
Pooled Variance	307.6879	
Hypothesized Mean Difference	0	
df	58	
t Stat	1.655967	
P(T<=t) one-tail	0.051565	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.10313	
t Critical two-tail	2.663287	

E. Ad-hoc tests for significant ANOVA from Table 12 (post-test 2010-2011):

In this section, ad-hoc multiple comparison t-tests were performed for the significant ANOVA observed in Table 12 above. Bonferroni adjustment [18 – 20] was used for these tests since five multiple variables are involved in the comparison unless otherwise stated. That is, $\alpha_{BonferroniCorrection} = \frac{\alpha}{n} \Rightarrow \frac{0.05}{5} = 0.01$ was used.

From Table 12, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and ECU – for academic year 2010-2011. Data in Table 12A below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCSU students displayed a higher rate of performance or achievement (M = 85.5) than their counterparts at ECU (M = 83.9), (t[58] = 0.93, $p > 0.01$). The result was not statistically significant.

Table 12A: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. ECU):

	NCSU	*ECU*
Mean	85.46667	83.93333
Variance	46.25747	35.92644
Observations	30	30
Pooled Variance	41.09195	
Hypothesized Mean Difference	0	
df	58	
t Stat	0.926411	
P(T<=t) one-tail	0.179036	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.358071	
t Critical two-tail	2.663287	

From Table 12, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and NCCU – for academic year 2010-2011. Data in Table 12B below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCSU students displayed a higher rate of performance or achievement (M = 85.5) than their counterparts at NCCU (M = 80.4, (t[58] = 2.47, p > 0.01). The result was not statistically significant.

Table 12B: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. NCCU):

	NCSU	*NCCU*
Mean	85.46667	80.43333
Variance	46.25747	78.66782
Observations	30	30
Pooled Variance	62.46264	
Hypothesized Mean Difference	0	
df	58	

t Stat	2.466557
P(T<=t) one-tail	0.008309
t Critical one-tail	2.392377
P(T<=t) two-tail	0.016618
t Critical two-tail	2.663287

From Table 12, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and NCAT – for academic year 2010-2011. Data in Table 12C below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCSU students displayed a higher rate of performance or achievement (M = 85.5) than their counterparts at NCAT (M = 84.2), (t[58] = 0.66, p > 0.01). The result was not statistically significant.

Table 12C: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. NCAT):

	NCSU	*NCAT*
Mean	85.46667	84.23333
Variance	46.25747	59.35747
Observations	30	30
Pooled Variance	52.80747	
Hypothesized Mean Difference	0	
df	58	
t Stat	0.657322	
P(T<=t) one-tail	0.256787	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.513574	
t Critical two-tail	2.663287	

From Table 12, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCSU and SHAW – for academic year 2010-2011. Data in Table 12D below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCSU students displayed a higher rate of performance or achievement (M = 85.5) than their counterparts at SHAW (M = 76.2), (t[58] = 3.97, $p < 0.01$). The result was statistically significant.

Table 12D: t-Test – Two-Sample Assuming Equal Variances (NCSU vs. SHAW):

	NCSU	*SHAW*
Mean	85.46667	76.16667
Variance	46.25747	118.0057
Observations	30	30
Pooled Variance	82.13161	
Hypothesized Mean Difference	0	
df	58	
t Stat	3.974417	
P(T<=t) one-tail	0.0000989	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.000198	
t Critical two-tail	2.663287	

From Table 12, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – ECU and NCCU – for academic year 2010-2011. Data in Table 12E below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that ECU students displayed a higher rate of performance or achievement (M = 83.9) than their

counterparts at NCCU (M = 80.4), (t[58] = 1.79, p > 0.01). The result was not statistically significant.

Table 12E: t-Test – Two-Sample Assuming Equal Variances (ECU vs. NCCU):

	ECU	*NCCU*
Mean	83.93333	80.43333
Variance	35.92644	78.66782
Observations	30	30
Pooled Variance	57.29713	
Hypothesized Mean Difference	0	
df	58	
t Stat	1.790801	
P(T<=t) one-tail	0.039272	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.078544	
t Critical two-tail	2.663287	

From Table 12, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – ECU and NCAT – for academic year 2010-2011. Data in Table 12F below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCAT students displayed a higher rate of performance or achievement (M = 84.2) than their counterparts at ECU (M = 83.9), (t[58] = -0.7, p > 0.01). The result was not statistically significant.

Table 12F: t-Test – Two-Sample Assuming Equal Variances (ECU vs. NCAT):

	ECU	*NCAT*

Mean	83.93333	84.23333
Variance	35.92644	59.35747
Observations	30	30
Pooled Variance	47.64195	
Hypothesized Mean Difference	0	
df	58	
t Stat	-0.16833	
P(T<=t) one-tail	0.433453	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.866906	
t Critical two-tail	2.663287	

From Table 12, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – ECU and SHAW – for academic year 2010-2011. Data in Table 12G below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that ECU students displayed a higher rate of performance or achievement (M = 83.9) than their counterparts at SHAW (M = 76.2), (t[58] = 3.43, $p < 0.01$). The result was statistically significant.

Table 12G: t-Test – Two-Sample Assuming Equal Variances (ECU vs. SHAW):

	ECU	*SHAW*
Mean	83.93333	76.16667
Variance	35.92644	118.0057
Observations	30	30
Pooled Variance	76.96609	
Hypothesized Mean Difference	0	
df	58	
t Stat	3.428709	
P(T<=t) one-tail	0.000561	
t Critical one-tail	2.392377	

P(T<=t) two-tail	0.001122
t Critical two-tail	2.663287

From Table 12, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCCU and NCAT – for academic year 2010-2011. Data in Table 12H below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCAT students displayed a higher rate of performance or achievement (M = 84.2) than their counterparts at NCCU (M = 80.4), (t[58] = -1.77, p > 0.01). The result was not statistically significant.

Table 12H: t-Test – Two-Sample Assuming Equal Variances (NCCU vs. NCAT):

	NCCU	*NCAT*
Mean	80.43333	84.23333
Variance	78.66782	59.35747
Observations	30	30
Pooled Variance	69.01264	
Hypothesized Mean Difference	0	
df	58	
t Stat	-1.7716	
P(T<=t) one-tail	0.040857	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.081715	
t Critical two-tail	2.663287	

From Table 12, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCCU and SHAW – for academic year 2010-2011. Data in Table 12I below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCCU

students displayed a higher rate of performance or achievement (M = 80.4) than their counterparts at SHAW (M = 76.2), (t[58] = 1.67, p > 0.01). The result was not statistically significant.

Table 12I: t-Test – Two-Sample Assuming Equal Variances (NCCU vs. SHAW):

	NCCU	*SHAW*
Mean	80.43333	76.16667
Variance	78.66782	118.0057
Observations	30	30
Pooled Variance	98.33678	
Hypothesized Mean Difference	0	
df	58	
t Stat	1.666389	
P(T<=t) one-tail	0.050514	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.101028	
t Critical two-tail	2.663287	

From Table 12, a *t*-test of two samples assuming equal variance was used to compare the post-test mean differences of two colleges – NCAT and SHAW – for academic year 2010-2011. Data in Table 12J below show the relationship between the performances of the two colleges. The results of the post-hoc t-test show that NCAT students displayed a higher rate of performance or achievement (M = 84.2) than their counterparts at SHAW (M = 76.2), (t[58] = 3.32, p < 0.01). The result was statistically significant.

Table 12J: t-Test – Two-Sample Assuming Equal Variances (NCAT vs. SHAW):

	NCAT	*SHAW*

Mean	84.23333	76.16667
Variance	59.35747	118.0057
Observations	30	30
Pooled Variance	88.68161	
Hypothesized Mean Difference	0	
df	58	
t Stat	3.317592	
P(T<=t) one-tail	0.000786	
t Critical one-tail	2.392377	
P(T<=t) two-tail	0.001572	
t Critical two-tail	2.663287	

Table 13 below summarizes all the multiple comparison t-tests of the pre-tests and post-tests of the colleges that display significant differences among colleges as well as the years they occurred.

Table 13: Summary of Multiple Comparisons t-tests among the colleges

Pre-test	Post-test
2012-2013: • None	2012-2013: • ECU vs. NCAT (Table 8E) • NCCU vs. SHAW (Table 8I) • NCAT vs. SHAW (Table 8J)
2011-2012: • None	2011-2012: • NCSU vs. NCCU (Table 10B) • NCSU vs. SHAW (Table 10D) • ECU vs. NCCU (Table 10E)

	• ECU vs. SHAW (Table 10G) • NCCU vs. NCAT (Table 10H) • NCAT vs. SHAW (Table 10J)
2010-2011:: • None	2010-2011: • NCSU vs. SHAW (Table 12D) • ECU vs. SHAW (Table 12G) • NCAT vs. SHAW (Table 12J)

Results

The analyses of the ANOVA tests generally revealed statistical significances among the five colleges for the post-tests of 2012-2013; post-tests of 2011-2012; pre-tests of 2010-2011 and post-tests of 2010-2011. While ANOVA showed that there existed significant differences among the five colleges, it failed to identify specifically, where the differences existed. Thus, there was a need for another test - multiple comparison t-tests which revealed specific colleges that exhibited statistical differences. Thus, the "none" significant differences observed in the pre-tests of the five colleges under investigation within the three consecutive years (2010 – 2013); indicated that students that enrolled in the math education programs in the colleges were equally prepared for college work.

The multiple comparison tests indicated that statistical significances occurred for the post-tests of 2012-2013 between (ECU vs. NCAT, NCCU vs. SHAW and NCAT vs.

SHAW); post-tests of 2011-2012 between (NCSU vs. NCCU, NCSU vs. SHAW, ECU vs. NCCU, ECU vs. SHAW, NCCU vs. NCAT and NCAT vs. SHAW) and post-tests of 2010-2011 between (NCSU vs. SHAW, ECU vs. SHAW and NCAT vs. SHAW).

In 2012-2013, the findings from Tables 8I and 8J respectively revealed that the means of post-test scores of NCCU $\left(M_{NCCU} = 83.5\right)$ and NCAT $\left(M_{NCAT} = 86.1\right)$ are each greater than the mean score of SHAW $\left(M_{SHAW} = 74.6\right)$.

In 2011-2012, the findings from Tables 10D, 10G and 10J respectively revealed that the means of post-test scores of NCSU $\left(M_{NCSU} = 88.1\right)$, ECU $\left(M_{ECU} = 87.2\right)$ and NCAT $\left(M_{NCAT} = 84.0\right)$ are each greater than the mean score of SHAW $\left(M_{SHAW} = 76.8\right)$.

In 2010-2011, the findings from Tables 12D, 12G and 12J respectively revealed that the means of post-test scores of NCSU $\left(M_{NCSU} = 85.5\right)$, ECU $\left(M_{ECU} = 83.9\right)$ and NCAT $\left(M_{NCAT} = 84.2\right)$ are each greater than the mean score of SHAW $\left(M_{SHAW} = 76.2\right)$.

All these indicated that students in the experimental group performed much better than those in the control group. It also indicated that there was a major role teaching pedagogy played in the performances of students in the four colleges (experimental group) compared to those in the fifth college (control group). Moreover, the results revealed that over a period of three years (2010 – 2013), there were more improvements in the performances of the students as they proceeded through the math teaching pedagogy at the four experimental colleges (NCSU, ECU, NCCU, NCAT) than at the control college (SHAW).

Discussion and Conclusion

Limitations of the Study

During the study, there were certain limitations that surfaced. As stated by Anderson [22], tests are estimates rather than exact measures of a student's knowledge and skills. Thus, the constraints of a testing environment peculiar to all standardized assessments that make it impossible to assess students' true performance, may be a set of limitations for the study.

According to Henard & Roseveare [23], quality teaching is the use of pedagogical techniques to produce learning outcomes for students. However, the actual curriculum design and individual initiatives in the delivery of quality math education instruction in the classroom were not addressed or accounted for in this study.

The students in the study were limited to only five colleges from North Carolina. Data were only analyzed for students who enrolled in math education programs in the five colleges. As such, the results may not have been a proportional representation of all the colleges of education in the state. Another limitation was that the area – the effect or impact of teacher education program on students' learning of math – focused on by the researcher was only perceived as significant to the study. There was also another limitation in the sense that the researcher only examined one type of math course (not

different types) taken by the students in three consecutive years. The rigor in data collection by the researcher from all the colleges was another limitation.

Implications for further study

Based on the research findings, it is apparent that it is the responsibility of the instructional leader to ensure that students are career ready by providing access to engaging relevant curriculum, pedagogy and instruction; which are indicative of higher performance over the period of three years. Future studies could determine if increasing enrollment of students in math education programs would subsequently increase retention and in turn, improve students' performance.

The findings in this study demonstrated mostly, a statistical significance between pre- and post-tests of students in the math education programs. Since the study is focused on math education as opposed to other content areas in general, future studies may choose to focus on one geographical region and target a greater number of colleges in order to look at each content area individually. Also, a future study could examine the gender of students enrolled in math education program in the four colleges versus their performances throughout the program.

Another option for future researchers to consider is how professional development impacts teachers' teaching practices. The issue of student aptitude and motivation for enrolling in math education programs needs to be considered in future studies as well. Such a study would administer pre-tests that measure aptitude and interest in math to see how predictive they are to future enrollment, retention, graduation as well as performance.

As these five colleges, other colleges in the state of North Carolina as well as across the nation continue to strive for excellence in math education proficiency; effective math education curriculum will continue to be a matter of discourse in future researches. Therefore, the findings of this study can serve as a platform for depicting the relationship between high performance in math education and other courses taken throughout a student's college years.

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