Embedded Math Credit: Is there a relationship between NCLB's HQTC and secondary CTE students' outcomes?

John S. Gaal, Ed.D.
Director of Training & Workforce Development
Carpenters' District Council of Greater St. Louis and Vicinity

Embedded Math Credit: Is there a relationship between NCLB's HQTC and secondary CTE students' outcomes?

Overview

U.S. business leaders, politicians, educators, and others within the community have been inundated with reports that claim many of today's high school graduates are ill-prepared, from a functional literacy standpoint, to face the challenges posed by the global marketplace (Achieve, 2004; Brown et al., 2005; Friedman, 2005; and Judy & D'Amico, 1997). In an effort to ensure today's students are better prepared for a world of work that is driven by technology, U.S. Congress passed the No Child Left Behind (NCLB) Act at the behest of former President Bush in 2001. Consequently, school districts throughout the U.S. have responded to the accountability measures within NCLB by increasing public high school graduation requirements in the core subject areas (i.e., English, math, science, and social studies). To this end, other key areas that make-up the high school experience are scrambling to identify strategies that enhance improvement within the core subjects mentioned above. More specifically, secondary Career and Technical Education (CTE) programs in one Midwest State have experimented with state-sanctioned projects in the areas of math and language arts known as embedded credit. Wherein, for the purposes of this study, secondary area vocational and technical schools' CTE teachers develop teaching methods and strategies, in math, with the cooperation of academic teachers from their sending school districts. In so doing, it is expected that CTE students will be exposed to more math theory while in their CTE courses and additional practical math applications while attending their academic institutions. One version of the embedded math credit approach allows students seeking an additional math credit to request participation in the embedded coursework while attending the CTE institution and testing for the embedded credit at their sending school location under the direction of an accredited math teacher near the end of senior year.

Early aspects of research literature revealed that NCLB insisted that core subject areas be delivered only by highly-qualified teachers after the 2005-06 school year (OESE, 2005). To this end, NCLB defines a new highly-qualified teacher as one who possesses a state teacher's license, a bachelor's degree, and a related professional credential. With this in mind, there were secondary math and CTE teachers in one Midwest State who participated in the embedded math credit program who did not meet NCLB's definition of a new highly-qualified teacher. Therefore, the purpose of this study is to establish baseline data, in a scientific manner, that examines the relationship between traditional and non-traditional CTE programs' teachers' backgrounds and methods and their students' mathematical gains as measured by standardized pre- and post-tests. A mixed method / quasi-experimental approach was undertaken to establish criteria for the teachers and students (Kingsbury, 2006).

The math and CTE teachers' survey was developed based on the research literature, pre-tested, piloted-tested, and, eventually, launched, collected, and analyzed utilizing an online survey tool. Over 50 percent of the teachers from the two control groups and or one experimental group participated in the survey. From a descriptive standpoint, the respondents' backgrounds did not reveal notable differences between the control groups and or experimental group. Additionally, an inferential statistical method

found no significant difference between the teachers' methods utilized by the two control groups and or one experimental group.

Students from the two control groups and one experimental group are required to take a standardized math test within the first three months of their junior year and a post-test within the last three months of their senior year. ACT's WorkKeys Applied Math assessment was utilized as the pre- and post-test instrument. With the permission and cooperation of the participating schools' administrators, pre- and post-test data were gathered, analyzed, and, finally, reported in an aggregate manner. With respect to students' test score gains, an inferential statistical method found no significant difference between the two control groups and or one experimental group.

Introduction

By October 2005, based on a report addressing future workforce demands that was developed by representatives from education, business, industry, and labor, one Midwest State Board of Education adopted a requirement that all students beginning with the Senior Class of 2010 must earn 24 credits to graduate from public high schools versus the current 22 credits. In which, the minimum credit hours for core subjects were boosted upward from three credit hours in Language Arts to four; two credit hours in Math to three; two credit hours in Science to three; and two credit hours in Social Studies to three (MTEC-SOWR, 2004). Consequently, CTE administrators became concerned that there were fewer opportunities for CTE students to partake in CTE courses due to the additional academic demands brought on by the new policy. In addition, many CTE administrators felt former President Bush's NCLB's push for more academic accountability marginalized the positive impact and effectiveness of secondary CTE programs.

In an effort to address both academic accountability and the increase in core credit requirements for CTE students, a couple of this Midwest State's secondary CTE schools have experimented with a new method for the delivery of teaching math within their technical classrooms and shops: embedded math credit. Embedded math credit is more than a turn-key curriculum that teachers pull off the shelf and implement. Embedded math credit requires on-going support from school administrators, open-minded math and CTE teachers willing to work as a team to try new strategies, and a year-round focused professional development program (Dillard, 2004). Most importantly, embedded math credit benefits secondary CTE students by allowing those interested to earn dual-credit: One unit for their CTE course and one unit for the technical math covered within the CTE course concurrently.

Unfortunately, to this author's knowledge, science-based evidence does not exist to assist educational leaders in accepting or rejecting the adoption of the embedded math credit concept versus traditional teaching methods. Equally important, secondary CTE was been under attack by the former Bush Administration for several years for not providing evidence that CTE improves academic student learning. In fact, former President Bush on a number of occasions proposed cutting federal funding for CTE institutions in order to finance his NCLB efforts geared towards improving student accountability in areas of math and science (Cavanagh, March 15, 2006).

Problem Background

Since the late 1980s, economists and researchers have warned U.S. business, political, and educational leaders of an impending economic crisis related to a dearth in employees' functional workplace literacy skills or, in other words, a need for workers to improve their basic math, science, and reading skills (Gray, 2000; and Johnston & Packard, 1987). In addition, the results from numerous national and international standardized tests, measuring math and science knowledge, taken by U.S. high school students over the past few decades, support the skills' deficiency projections mentioned above (Boe & Shin, 2005; Cogan & Schmidt, 2002; Gregory & Clarke, 2003; Kelly, 2002; Kronholz, 2004; Lemke et al., 2005; NCES, 2005; Perie, 2005; and Silverberg et al., 2004). To be sure, Schoeff (2006) says, "Workers on the factory floor responsible for ensuring that steel meets specifications must be able to calibrate sophisticated equipment,

which requires math knowledge…but too often, the company finds that its employees lack those skills" (p. 46). Accordingly, on January 31, 2006, former President Bush reiterated a theme common among U.S. business leaders: U.S. high school students must improve their math and science knowledge in order to compete in today's global marketplace (Davis, 2006). In addition to expressing an interest in funding efforts to train more math and science teachers, the Bush White House proposed making grant monies available for targeting interventions that assist teachers in delivering research-based math instructional strategies that improve student accountability (Davis). Herein lays two problems: 1) What standards are in place to determine who is qualified to teach math; and 2) What standards are in place to determine that students are benefiting from new interventions?

With regards to teaching standards, NCLB defined a new highly-qualified teacher, as follows:

> a) Has obtained full state certification or passed the state licensing exam and does not have either of these requirements waived on an emergency, temporary, or provisional basis; b) Holds a minimum of a bachelor's degree; and c) Has demonstrated competency in the subject area(s) taught. (OESE, 2005, p. 2)

In essence, a qualified teacher must represent a balance between obtaining, delivering, and exhibiting knowledge. Fittingly, Keller (2006) notes recent findings indicate that in order to raise teacher quality one must look beyond academic background as a predictor of effective teaching. To this end, Cavanagh (March 8, 2006) cites an example of a Pittsburgh school district that utilizes systemic-change funds to develop teacher-leaders. Wherein, highly skilled math teachers were allotted time to assist struggling peers on matters of professional development (Cavanagh). Consequently, Cavanagh asserts that teachers who participate in focused professional development were able to establish a classroom culture that encouraged student discussion and investigation. However, some experts suggest that not enough data exists to determine whether these teachers improved their math content or pedagogy or whether student learning increased (Cavanagh).

With respect to new innovations, Cavanagh (March 15, 2006) notes that NCLB's focus on academic rigor diminished the time allotted for career-related subjects in the high school and, therefore, encouraged new approaches to incorporating math into career-oriented lessons. The traditional team-teaching approach has transformed into teacher-sharing strategies that provide secondary CTE students academic content in a vocational context (Cavanagh). Herein, both CTE teachers and academic math teachers work before and after school to ensure their weekly math lessons are industry-relevant for their students. (Cavanagh). Equally important, Cavanagh asserts that this new mode of team-teaching assists CTE programs by addressing NCLB's requirement that core subjects (i.e., math or science) be taught by highly-qualified teachers and contribute to student accountability. Nevertheless, little, if any, science-based evidence exists to confirm or deny the effectiveness of these teaching methods towards improving student achievement; especially where course credit is granted to secondary CTE students successfully completing both the CTE and math portions of their coursework.

Importance and Purpose of the Study

In light of NCLB's focus on accountability, a study that helps examine the relationship between highly-qualified teachers' backgrounds and methods and their students' mathematical gains in area career and technical schools in a selected area of the Midwest can have important implications to many beneficiaries including States' School Boards of Education, States' Departments of Elementary and Secondary Education, school district superintendents, high school principals, career and technical center directors, math teachers, CTE teachers, CTE students, and business and industry. Findings from this study can assist educational leaders in identifying science-based methods of instruction that can lead to focused professional development for academic math teachers and CTE teachers while concurrently improving students' outcomes and awarding students course credits.

Furthermore, valuable information from this study will provide educational leaders a basis to accept or reject implementing standardized measures of student accountability, such as ACT's WorkKeys, as a means to curtail former President Bush's penchant to replace secondary CTE with so-called more rigorous math and science endeavors. However, the lack of evidence to support non-traditional credit-bearing methods of CTE math delivery speaks to the absence of sound research to base a meaningful response to this issue. In addition to addressing the need to leverage these findings as a matter of statewide educational policy, this study provides new and relevant input to the body of scholarly research that can drive the future of highly-qualified teachers and embedded math credit in CTE programs.

The primary purpose of this study is to examine the relationship between highly-qualified teachers' backgrounds and methods and their students' mathematical gains in secondary career and technical schools in a selected area of the Midwest. In general, what constitutes the need for highly-qualified teachers and what delineates highly-qualified math teachers' backgrounds and methods was derived from relevant literature on elementary and secondary educators and secondary CTE teachers in particular (Brewer, 2003; Darling-Hammond, 2004; Kaplan & Owings, 2003; Podgursky, 2005; Porter-Magee, 2004; Smith et al, 2005; Stone, 2005; and Wang & Lin, 2005). For purposes of this study, surveys queried secondary math and CTE teachers in two traditional (control groups) settings known as North County Tech (NCT) and South County Tech (SCT) and one non-traditional (experimental group) setting known as Cape Technical Center (CTC) to determine the perceived importance of selected characteristics of highly-qualified teachers found throughout contemporary literature. These findings were used to establish descriptive and inferential patterns that exist between secondary math and CTE educators from the traditional settings and non-traditional setting. In addition, a one-way analysis of variance (ANOVA) was performed to determine if a statistical significance exists between differences in gains on standardized mathematical assessments from CTE students exposed to traditional methods and CTE students exposed to non-traditional methods. To this end, this author's work addresses the following three research questions: 1) Do the educational backgrounds of secondary math and CTE teachers from traditional CTE institutions differ from those in a non-traditional setting?; 2) Do the teaching methods of secondary math and CTE teachers from traditional CTE institutions differ from those in a non-traditional setting?; and 3) Do the changes in students' WorkKeys

Applied Math scores from traditional CTE institutions differ from those in a non-traditional setting?

Methodology

The intent of this study is to determine if a relationship exists between highly-qualified secondary teachers' backgrounds and the methods they utilized and if these factors impacted students' gains as measured by standardized math test scores. For purposes of this study, the term highly-qualified teachers will be operationalized as those secondary teachers who teach the core academic of math and who meet NCLB's Highly-qualified Teacher criteria (HQTC) as mentioned below:

> a) Has obtained full state certification or passed the state licensing exam and does not have either of these requirements waived on an emergency, temporary, or provisional basis; b) Holds a minimum of a bachelor's degree; and c) Has demonstrated competency in the subject area(s) taught. (OESE, 2005, p. 2)

To this end, the author provides the following details on how the research data was collected, analyzed, and processed for both teacher and student participants.

The study consisted of a mixed-method design: cross-sectional and quasi-experimental methods. Herein, the survey employed the cross-sectional design method to collect background and methods data on math and CTE from three secondary institutions in the Midwest. Borg and Gall (1983) note that when a cross-sectional survey gathers data from a predetermined population versus a sample of that population the survey is referred to as a census. In addition, a quasi-experimental research approach was utilized to examine the convenience sampling of pre- and post-test CTE student test data. Accordingly, Isaac and Michael (1997) suggest that unlike with true experimental designs, the researcher undertaking quasi-experimental methods must understand the limitations that exist since conditions do not allow for control over all relevant variables.

This study involved a mixed-method research design applied to three participant groups. The survey research consisted of three stages. The first stage involved creating the survey instrument and pre-testing the instrument for accuracy, validity, and reliability. Herein, this author created a survey based on relevant research findings based on contemporary literature. Upon completion, the author field-tested the survey with nine educators (i.e., math teachers and CTE teachers) from four secondary schools across the geographic region impacted by this study. This group of educators provided feedback on the structure and content of the survey instrument presented. In turn, the author incorporated these educators' suggestions into the redesign of the survey instrument.

The second stage of development involved pilot testing the revamped survey instrument. Accordingly, Fink (2003) recommends pilot testing the survey instrument at a secondary school similar to the target population of this study. To this end, the author pilot tested the survey with a group of eight math and CTE teachers from one secondary school within the geographic region impacted by this study. Once again, the author solicited comments from the pilot test group but more importantly tracked the individual times required to complete the surveys in order to establish a mean time for instruction purposes in the third stage.

The third stage of this process involved surveying nearly 119 math and CTE teachers at the control group institutions: NCT and SCT and the experimental group institution: CTC. Additionally, the total above included surveys issued to nearly 12 secondary math teachers from the sending schools at the CTC. The total number of surveys collected and analyzed was 61. The teachers' background data collected were analyzed using descriptive techniques (i.e., frequency counts) in an attempt to establish trends between and among the control and experimental groups mentioned above. In addition, one quasi-experimental aspect of this study, a one-way ANOVA, was performed on the portion of the survey focused on teachers' methods wherein responses were measured on a Likert Scale. In so doing, this author attempted to determine whether or not a significant difference existed between and or within the experimental group's teachers' methods and the control groups' teachers' methods.

By means of a survey, NCT, SCT, CTC, and their sending schools provided the setting for investigating the backgrounds and methods of their entire population of math and CTE teachers. Access to these teachers was provided by cooperating with the superintendents and principals of all the school districts involved. Support for this study was obtained from these school leaders in advance. An online survey tool was developed and electronically mailed to all prospective math and CTE teachers expected to participate. Survey responses were completely anonymous. Electronic reminder messages were sent to encourage full participation. Participation was voluntary and all responses were kept confidential.

This cross-sectional design survey utilized in this study polled secondary math and CTE teachers to obtain data related to their personal and professional backgrounds. The assumption was that more than 30 percent of these targeted teachers would participate in order to obtain a multitude of perspectives and provide balanced and reliable results. In addition, this author assumed that the survey participants responded to all survey questions in an honest manner so that the results gathered have integrity. Finally, it is assumed that the proposed questions within the cross-sectional design survey instrument are valid and reliable based upon the contemporary literature and the pre- and pilot testing stages described earlier.

Another quasi-experimental aspect of this study entailed collecting and analyzing pre- and post-test WorkKeys Applied Math scores from secondary students attending NCT, SCT, and CTC. The statistical technique utilized was a one-way ANOVA. In so doing, this author attempted to determine whether or not a significant difference existed between and or within the experimental group's change in student math score gains and the control groups' student math score gains. The total population of these three student groups was 420 students.

Secondary CTE students selected for this study took the WorkKeys Applied Math in the beginning of the 2004-2005 school year as juniors and were re-tested with the WorkKeys Applied Math at the end of their 2005-2006 senior school year. Upon gaining approval from the chief school administrators from NCT, SCT, and CTC, access to these students' records was provided by means of the counselors at NCT, SCT, and CTC. The only data requested was WorkKeys Applied Math pre- and post test level and scale scores, gender, race, and program. To protect individual student identity, the author insisted on obtaining stripped data.

The one-way ANOVA procedure utilized in this study examined two matters: aspects of teachers' methods and changes in students' pre-test scores and post-test scores. The assumption was that the data obtained provided a sufficient number of participants from each of the three secondary institutions involved. In addition, due to the small number of potential participants at each of the three locations mentioned above, it is assumed that the NCT, SCT, and CTC counselors provided the full array of scale scores available and only screened data for privacy concerns. Finally, this author assumes that data reported from the testing source, ACT (WorkKeys), is accurate and reliable.

Since the teacher population within this study represented only math and CTE teachers, the ability to generalize its results are limited to similar teaching populations. Likewise, findings pertaining to CTE students' math score gains may only be generalized to similar populations. In addition, WorkKeys pre- and post-tests assess workplace readiness skills and may not be generalized to other post-secondary readiness placement exams. Finally, the CTE student populations for this study mainly dealt with suburban and rural students and, therefore, the findings should not be generalized to urban students facing different socioeconomic conditions.

Findings

Survey Response: The teacher population surveyed included 119 participants as follows: 42 math and CTE teachers from NCT, 36 from SCT, and 41 from CTC and its sending schools. The overall response rate was 51 percent or 61 of 119 teachers from the control and experimental school systems participated. Wherein, NCT had 13 of 42 participate or 31 percent; SCT had 17 of 36 participate or 47 percent; and CTC had 31 of 41 participate or 76 percent. Of the 61 participants, 51 percent were females. However, when these data were disaggregated, NCT and SCT represent more than 60 percent females while CTC represents less than 40 percent females (See Table 1 and *Figure 1*).

Table 1

Frequency Distribution: Teacher Gender

Gender	Frequency	Percent
Female	31	51.0%
Male	30	49.0%
Total	61	100.0%

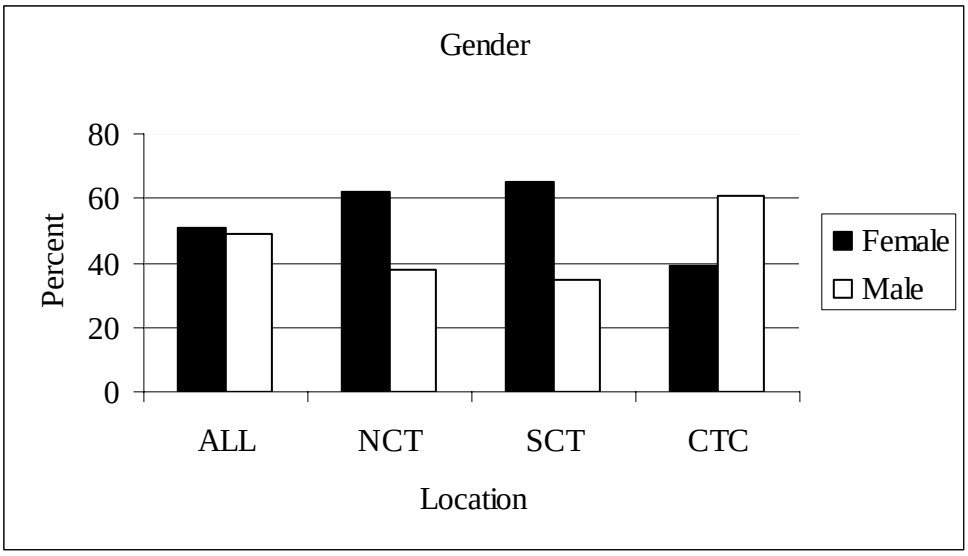

Figure 1. Frequency Distribution: Teacher Gender

Approximately 90 percent of this overall group was Caucasian. When these data were disaggregated, NCT had 85 percent Caucasian, 15 percent African-American, and zero percent Other participants; SCT had 88 percent Caucasian, six percent African-American, and six percent Other participants; and CTC had 94 percent Caucasian, zero percent African-American, and six percent Other participants (See Table 2 and *Figure 2*).

Table 2
Frequency Distribution: Teacher Ethnicity

Ethnicity	Frequency	Percent
Caucasian	55	90.0%
African-American	3	5.0%
Other	3	5.0%
Total	61	100.0%

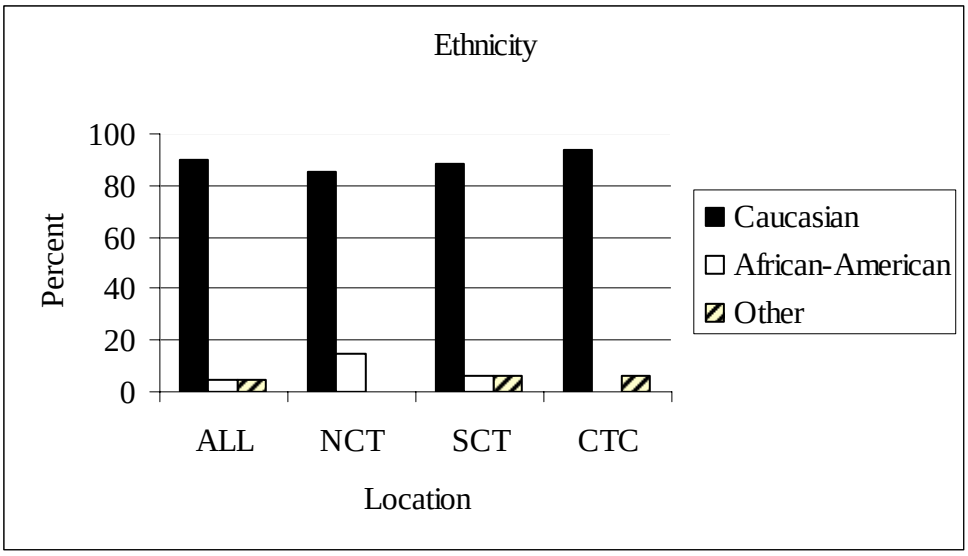

Figure 2. Frequency Distribution: Teacher Ethnicity

More than 50 percent of this overall group fell into the six to 20 years experience range. Nevertheless, when these data were disaggregated, 15 percent of NCT's participants fell into the less than six years age range, 46 percent were in the six to 20 years experience range, and 38 percent were in the above 20 years experience range; 18 percent of SCT's participants fell into less than six years experience range, 65 percent were in the six to 20 years experience range, and 18 percent were in the above 20 years experience range; and 19 percent of CTC's participants fell into less than six years experience range, 52 percent were in the six to 20 years experience range, and 29 percent were in the above 20 years experience range (See Table 3 and *Figure 3*).

Table 3
Frequency Distribution: Teacher Experience

Years	Frequency	Percent
<6	11	18.0%
6-20	33	54.0%
>20	17	28.0%
Total	61	100.0%

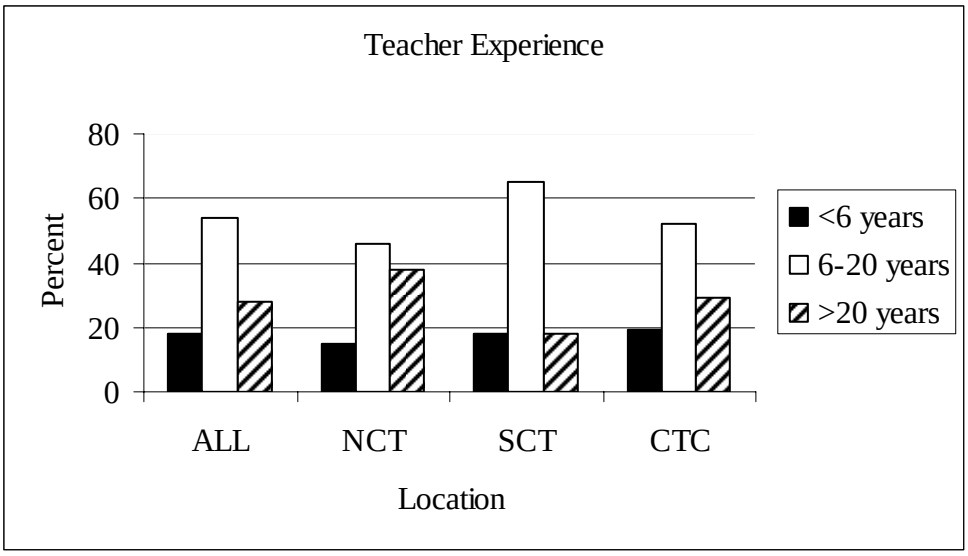

Figure 3. Frequency Distribution: Teacher Experience

Research Question One: Do the educational backgrounds of secondary math and CTE teachers from traditional CTE institutions differ from those in a non-traditional setting?

Only 43 of the 61 overall participants or 70 percent earned Bachelor's Degrees. Wherein, nine percent of these teachers obtained Primary, Middle, or Secondary School majors without math concentrations; 14 percent earned Primary, Middle, or Secondary School majors with math concentrations; 28 percent obtained degrees in Math, Engineering, or Science; 26 percent obtained degrees in Career and Technical Education (CTE); and 23 percent obtained degrees in Other fields. However, upon closer inspection, the largest concentration of majors for NCT participants was in Math, Engineering, or Science-related fields while SCT's largest concentration was in the areas of Math, Engineering, or Science and CTE but CTC's largest concentration was in the areas of Primary, Middle, or Secondary School Education with a concentration in math and Math, Engineering, or Science (See Table 4 and *Figure 4*).

Table 4

Frequency Distribution: Teacher Bachelor Degree Major

Type	Frequency	Percent
Education without Math	4	9.0%
Education with Math	6	14.0%
Math / Engineering / Science	12	28.0%
CTE	11	26.0%
Other	10	23.0%
Total	43	100.0%

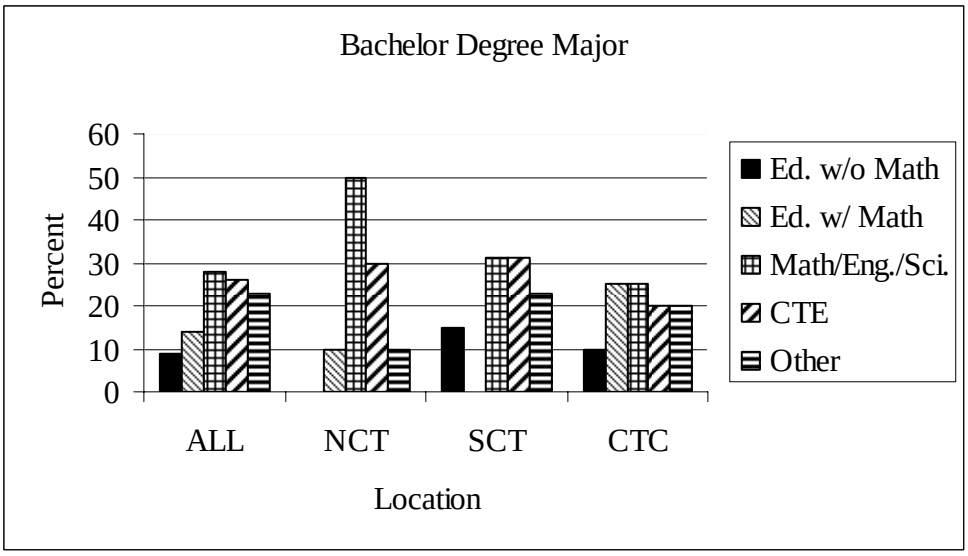

Figure 4. Frequency Distribution: Teacher Bachelor Degree Major

Overall, approximately 98 percent of the 60 teachers who responded held some sort of teaching license or certification. Nevertheless, when these data were disaggregated, only 92 percent of NCT's teachers obtained a teaching license or certification versus the 100 percent compliance at both SCT and CTC. More importantly, further investigation revealed that eight percent of NCT's teachers held temporary or provisional certifications while 12 and 13 percent of the teachers in the SCT and CTC systems fell into the same category, respectively (See Table 5 and *Figure 5*).

Table 5
Frequency Distribution: Teacher License or Certification

Type	Frequency	Percent
Temporary	7	12.0%
Permanent	46	78.0%
Other	6	10.0%
Total	59	100.0%

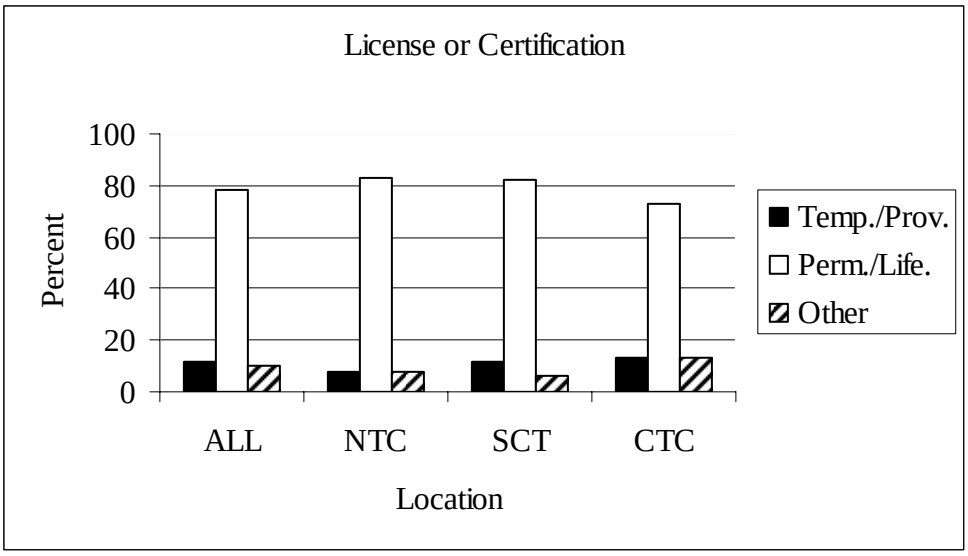

Figure 5. Frequency Distribution: Teacher License or Certification

Overall, only 48 percent or 29 of the 60 participants earned a subject area- or industry-based professional teaching credential. Wherein, 62 percent of NCT's teachers; 65 percent of SCT's teachers; and only 33 percent of CTC's teachers obtained an industry-based professional credential. Interestingly, 36 percent of SCT's teachers and only 10 percent of NCT and CTC's teachers passed some version of the Praxis exam (See Table 6 and *Figure 6*).

Table 6
Frequency Distribution: Teacher Professional Credential

Type	Frequency	Percent
Praxis	6	21.0%
Other	23	79.0%
Total	29	100.0%

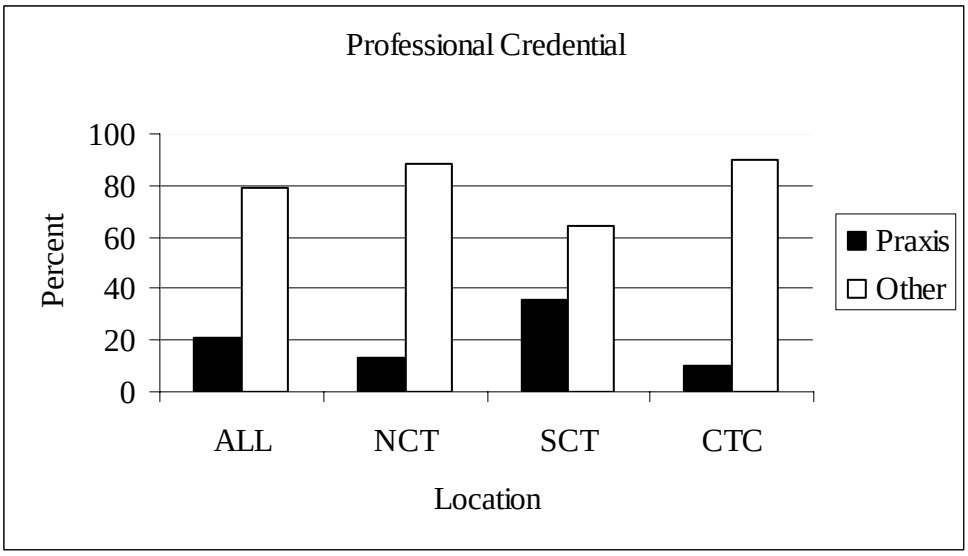

Figure 6. Frequency Distribution: Teacher Professional Credential

While nearly all NCT, SCT, and CTC's teachers hold some form of teaching license, less than half of them have earned a professional credential, and only 70 percent of them have earned bachelor degrees. Observation of the disaggregated data do not suggest that a major difference exists between the educational backgrounds of respondents from the two traditional programs (NCT and SCT) and one non-traditional program (CTC) represented herein.

Research Question Two: Do the teaching methods of secondary math and CTE teachers from traditional CTE institutions differ from those in a non-traditional setting?

Presented in Table 7 are measures of central tendency related to NCT, SCT, and CTC's participants' responses to 20 related survey questions. These questions were dedicated to specific teaching methods as ascertained from the contemporary literature and measured on a Likert Scale of 1: Never to 5: Always.

Table 7
Weighted Mean Scores: Teaching Methods

Survey	NCT		SCT		CTC	
Question	*M*	*SD*	*M*	*SD*	*M*	*SD*
22	3.923	1.320	3.529	1.125	3.665	1.125*
23	3.538	1.266	3.471	0.943	3.241	1.123
24	3.462	1.391*	2.882	1.166	2.759	1.091
25	4.462	0.660	4.176	0.890	4.000	1.069
26	4.539	0.776	4.000	0.809	3.759	1.069
27	3.846	0.899	3.529	1.111	3.379	1.066
28	4.308	0.630	3.882	1.111	3.724	1.066
29	3.923	0.954	3.765	1.091	3.379	1.115
30	3.231	0.927	3.176	1.015	2.724	0.996
31	4.000	0.816	3.706	1.047	2.517	1.122
32	3.462	0.967	3.412	1.121	2.862	0.915
33	2.917	0.515	3.000	1.173*	2.379	0.820
34	3.333	0.778	3.200	0.676	2.920	0.909
35	2.833	0.389	2.529	0.800	2.483	0.911
36	3.083	0.900	3.000	0.845	3.000	0.834
37	2.583	0.669	2.529	0.874	2.552	0.827
38	2.833	0.718	2.625	0.806	2.692	0.549
39	2.667	0.778	2.412	0.712	2.586	0.907
40	2.750	0.866	2.625	0.719	2.769	0.815
41	3.583	0.900	3.647	0.931	2.793	1.082

Note. * Response with greatest deviation from the mean within a group.

A one-way ANOVA was conducted to determine whether the differences in means of the NCT, SCT, and CTC's teachers' methods were statistically significant, the results of which are outlined in Table 8. For survey questions 22 through 41, a comparison of the F-ratio, 2.827, presented in Table 8 to the critical value of 3.159, based on a .05 level of significance, indicated no differences in teaching methods were found to be significant. Thus, the null hypothesis that no difference in NCT, SCT, and CTC's teaching methods exists was retained for matters relevant to questions 22 through 41.

However, when responses from the 20 questions mentioned above are studied in a disaggregated format, the results revealed something different for survey question 41. Herein, a comparison of the F-ratio, 4.930, presented in Table 8 to the critical value of 3.165, based on a .05 level of significance, indicated differences in teaching methods were found to be significant. Thus, the null hypothesis that no difference in NCT, SCT, and CTC's teaching methods exists was rejected for matters relevant to question 41. In other words, a significant difference exists between the teaching methods employed by NCT, SCT, and or CTC's teachers when it comes to issues of implementing curriculum changes based on pre- and post-testing students.

Table 8
Analysis of Variance for Teaching Methods

Question(s)		*SS*	*df*	*MS*	*F*	*P*
22-41	Between Groups	1.650	2	0.825	2.827	0.068
	Within Groups	16.637	57	0.292		
	Total	18.287	59[a]			
41	Between Groups	9.960	2	4.980	4.930	0.011
	Within Groups	55.558	55	1.010		
	Total	65.517	57[b]			

Notes. [a]*N*=61, *n*=60, *p*=0.05, *df*=2, 57, *F-crit*=3.159; and
[b]*N*=61, *n*=58, *p*=0.05, *df*=2, 55, *F-crit*=3.165

Research Question Three: Do the changes in students' WorkKeys Applied Math scores from traditional CTE institutions differ from those in a non-traditional setting?

Presented in Table 9 is the frequency distribution for the NCT, SCT, and CTC's students' WorkKeys Applied Math pre- and post-tests scores. In addition, a one-way ANOVA was conducted to determine whether the differences in means of the NCT, SCT, and CTC's students' pre- and post tests score gains were statistically significant, the results of which are outlined in Table 10. A comparison of the F-ratio, 0.883, presented in Table 10 to the critical value of 3.017, based on a .05 level of significance, indicated no differences in students' changes in pre- and post-tests scores were found to be significant. Thus, the null hypothesis that no difference in NCT, SCT, and CTC's changes in students' WorkKeys Applied Math pre- and post-test scores exists was retained.

Table 9

Frequency Distribution: Students' Pre- and Post-Tests Scores and Gains

Level	**NCT**		**SCT**		**CTC**	
Scale Score	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Improvement						
<3	16	13	36	52	5	4
65-70						
Gain		3		-16		1
3	28	28	83	61	8	14
71-74						
Gain		0		-22		6
4	29	27	77	73	25	17
75-77						
Gain		-2		-4		-8
5	12	14	57	58	22	19
78-81						
Gain		2		1		-3
6	7	7	15	25	5	10
82-86						
Gain		0		10		5
7	0	3	1	0	3	4
87-90						
Gain		3		-1		1

Table 10

Analysis of variance for Change in Students' Test Scores

NCT SCT CTC		***SS***	***df***	***MS***	***F***	***P***
Change in Students' Pre / Post Tests	Between Groups	21.560	2	10.780	0.883	0.414
	Within Groups	5197.844	426	12.202		
	Total	5219.403	428			

Note. N=429, *n*=429, *p*=0.05, *df*=2, 426, *F-crit*=3.017

Other Findings: In addition to the data presented in response to the first research question, a number of other survey questions assist in further understanding both math and CTE teachers' backgrounds and methods involved within this study. To this end, whether or not teachers were mentored early in their careers and aspects of how teachers improve upon their current skill sets, among other factors, are points of interest as explained in contemporary literature. Accordingly, overall, nearly 50 percent of respondents participated in more than one year of school-sanctioned mentoring. However, when the data are disaggregated, only about 40 percent of NCT's participants received this level of mentoring while in excess of 80 and 90 percent of SCT and CTC's

participants were exposed to more than one year of mentoring, respectively (See Table 11 and *Figure 7*).

Table 11
Frequency Distribution: Teacher Mentoring Relationship

Months	Frequency	Percent
<12	12	41.0%
12-24	14	48.0%
>24	3	10.0%
Total	29	100.0%

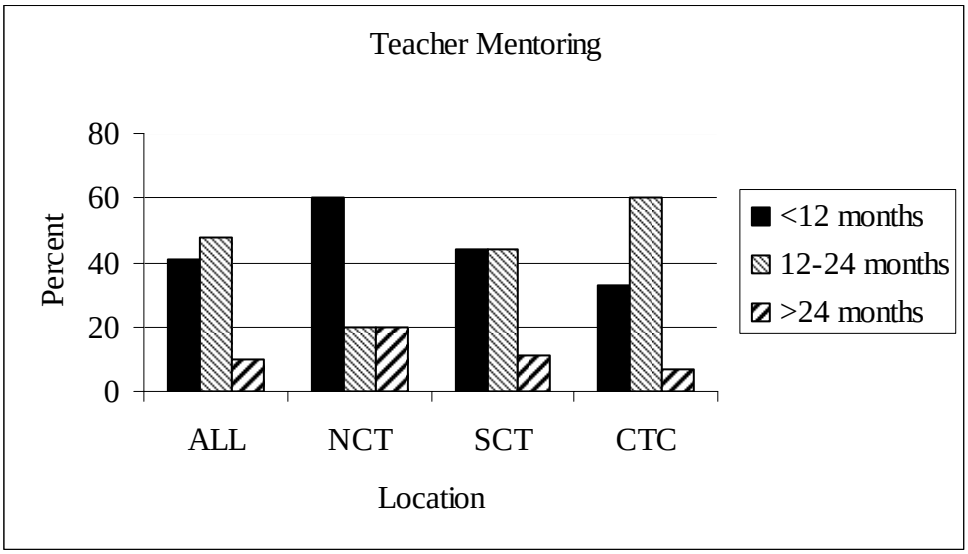

Figure 7. Frequency Distribution: Teacher Mentoring Relationship

With respect to professional development, nearly 100 percent of the respondents suggested that their schools offered focused and or organized professional development. Nevertheless, when the data are disaggregated, 30 percent of NCT's respondents and 24 percent of SCT's respondents indicated that they participated in professional development on a quarterly basis or less while approximately 66 percent of CTC's respondents fell into this category (See Table 12 and *Figure 8*).

Table 12
Frequency Distribution: Professional Development Type

Type	Frequency	Percent
Focused	52	87.0%
Organized	7	12.0%
Haphazard	1	2.0%
Non-existent	0	0.0%
Total	60	100.0%

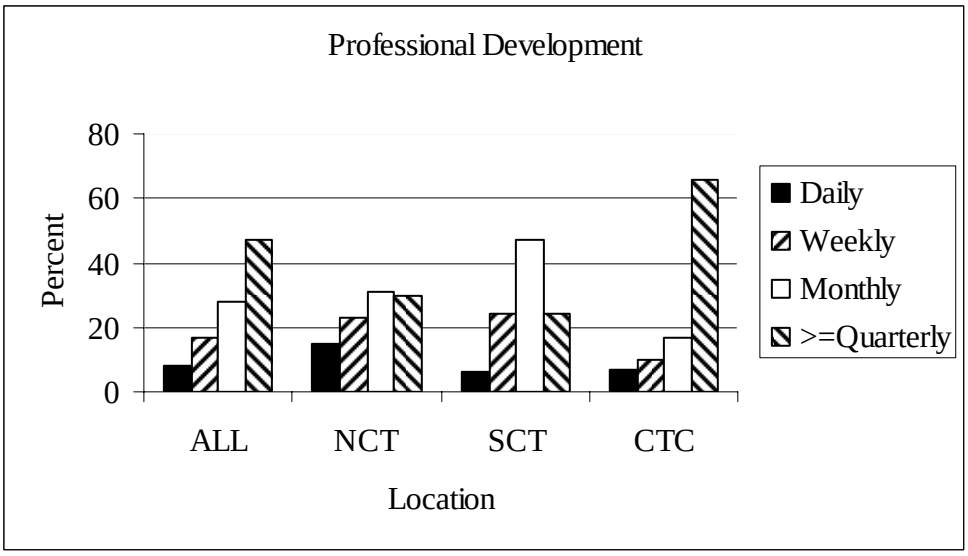

Figure 8. Frequency Distribution: Professional Development Contact

Although approximately 40 percent of the overall respondents participated in some form of video study within their classrooms, only one of the 58 respondents published a peer-reviewed article pertaining to math subject matter or pedagogy and less than 10 of the 58 respondents presented math-related topics in professional workshops (See Table 13 and *Figure 9*).

Table 13

Frequency Distribution: Teacher Participation in Video Study

Participation	Frequency	Percent
Yes	24	41.0%
No	34	59.0%
Total	58	100.0%

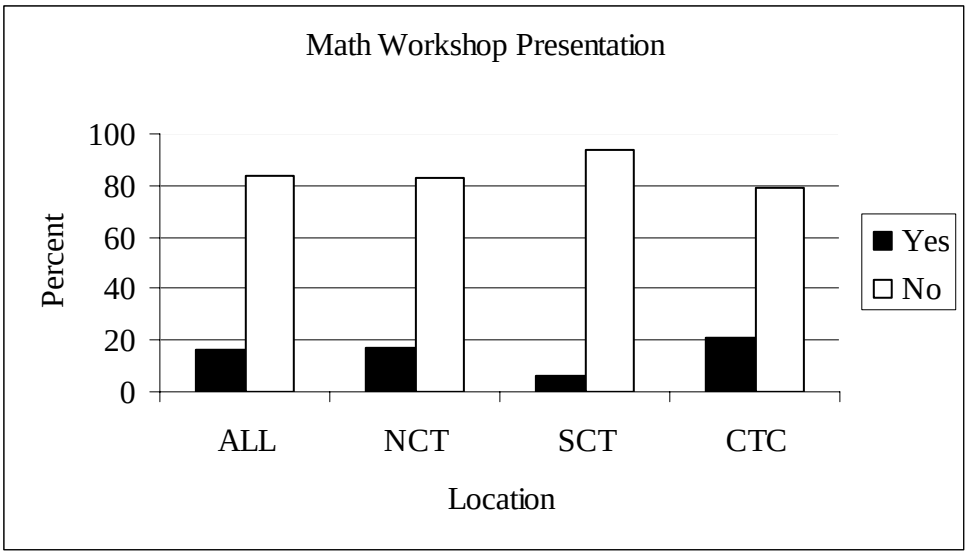

Figure 9. Frequency Distribution: Teacher Presentations on Math Topics

Finally, in the five years prior to 2006, less than 20 percent of the 58 respondents participated in workshops, of 40 hours or more, dedicated to math or the use of math in industry (See Table 14 and *Figure 10*).

Table 14
Frequency Distribution: Teacher Participation in Math Workshop

Participation	Frequency	Percent
Yes	10	17.0%
No	48	83.0%
Total	58	100.0%

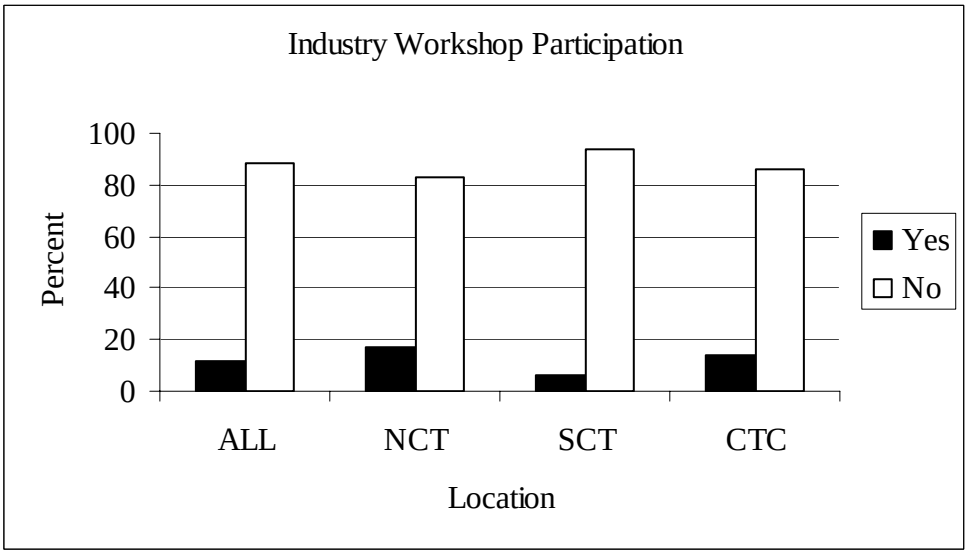

Figure 10. Frequency Distribution: Teacher Participation in Industry-related Workshop

Conclusions & Implications

The first research question examines the backgrounds of math and CTE teachers as outlined by NCLB's HQTC below:

> a) Has obtained full state certification or passed the state licensing exam and does not have either of these requirements waived on an emergency, temporary, or provisional basis; b) Holds a minimum of a bachelor's degree; and c) Has demonstrated competency in the subject area(s) taught. (OESE, 2005, p. 2)

The survey results indicate that 98 percent of the respondents have obtained a teaching license. Interestingly, between eight and 13 percent of the teachers at NCT, SCT, and CTC hold temporary or provisional certificates. The survey also revealed that 70 percent of the respondents hold bachelor's degrees. Wherein, NCT and SCT have an approximate 17 percent advantage over CTC. Finally, the survey found that 48 percent of the respondents earned a professional industry credential signifying demonstrated competency in a subject area. Accordingly, Ma (1999) declares that in order to enhance U.S. students' understanding of math, U.S. elementary mathematics teachers must acquire a profound understanding of fundamental mathematics. In conclusion, if all respondents were subjected to NCLB's guidelines for new teachers, these findings would indicate that less than one-half of this survey's respondents would be considered highly-qualified teachers. This may be one of many telltale signs of why no statistically significant differences were found in the following two research questions.

More importantly, research found that the teachers' backgrounds between the control groups and or the experimental group were mainly focused on subject areas other than primary, middle school, or secondary education with a math emphasis. In other words, the research literature posits that effective teachers are those who display a balance of content and pedagogy. Consequently, educational leaders should identify teachers with appropriate skill sets or develop deficient skill sets of incumbent teachers prior to implementing the embedded math credit teaching strategy. Ill-prepared teachers are incapable of producing better results based solely on an improved math curriculum (Ball et al., 2005).

The second research question focuses on math and CTE teachers' methods. A review of contemporary literature suggests that engaging students as active learners requires teachers to have an in-depth knowledge of the subject matter as well as a grasp of multiple teaching strategies in order to address a variety of student learning styles. The findings in Table 8 indicate that no significant difference exists between NCT, SCT, and or CTC's teaching methods when observed in an aggregate manner. However, when the teaching methods are studied in a disaggregated manner, only one of the 20 qualities measured reveals a statistically significant difference: Pre- and post-testing students prior to implementing curriculum changes. To this end, the former White House indicated that grant monies would be made available to target interventions that assist teachers in delivering research-based math instructional strategies that improve student accountability (Davis, 2006). Despite the lack of science-based evidence, to date, one State's Department of Elementary and Secondary Education continues to promote embedded math credit as a means for CTE students to complete rigorous core academic and technical courses (MCCE, 2006). In conclusion, CTC's intervention strategy of embedded math credit requires the use of non-traditional teaching methods that apparently do not differ from the traditional teaching methods at NCT and or SCT. This

too may be one of many telltale signs of why no statistically significant difference was found in the following research question.

Additionally, the research found that the teachers' methods between the control groups and or the experimental group were not significantly different. The research literature suggests that effective math teachers are those who are capable of engaging students in active learning versus passive techniques. Once again, educational leaders should identify teachers with appropriate skill sets or develop deficient skill sets of incumbent teachers prior to implementing the embedded math credit teaching strategy (Darling-Hammond, 2004). Teachers who rely heavily on rote memorization teaching strategies that focus on individualized drills may be an indicator that these teachers do not possess a profound understanding of fundamental math.

The third research question was designed to identify the differences between NCT, SCT, and or CTC's students' pre- and post-test math scores. Although Gregory and Clarke (2003) recommend that decision-makers consider a broader contextual analysis when defining educational achievement, one indicator of determining whether or not an intervention strategy has been effective is to pre- and post-test students with a standardized test. To this end, NCT, SCT, and CTC, pre-test their juniors in the first three months of 11^{th} grade and post-test their seniors in the last three months of 12^{th} grade with ACT's WorkKeys Applied Math assessment. As revealed in Table 10, no statistically significant difference was found between NCT, SCT, and or CTC's students' gains in pre- and post-test math scores. In conclusion, it would appear that intervention strategies must involve efforts beyond implementing different curriculum to include the hiring of highly-qualified teachers and improving the skills sets of incumbent teachers in order for students to reap the rewards (Brewer, 2003).

Finally, the research revealed that no significant difference existed between the gains in the control groups and or experimental group's students' pre-and post-test math scores. Other than a few instances of individual test fatigue within each group, when aggregated, all three sites displayed positive gains between their pre- and post-test math scores. Although critics may argue that testing should not be the only means of measuring success, the research literature indicates that, when compared to Singapore and Japan, U.S. students of various ages have not faired well on recent international math tests (Bybee & Stage, 2005). Accordingly, States' DESE should consider utilizing a validated math test (i.e., WorkKeys) so that students' results can be generalized across the state and or nation for purposes of showing progress in a standardized manner.

With regards to Other Findings, Reese (2006) insists that effective mentoring programs are those that include an element of measuring outcomes. In addition, Stigler and Hiebert (1999) claim that if U.S. teachers continue to teach in isolation, student outcomes will not improve. Findings in this study suggest that although most teachers were mentored and have attended focused professional development, for the most part, these experiences have not added value to students' gains in math test scores. Accordingly, Ma (1999) contends that U.S. teachers can learn lessons from the Chinese teachers' adherence to participation in peer-based research groups and ongoing study of the topic. In conclusion, upon review of the descriptive statistics pertaining to Other Findings within this section, it should be no surprise that less than two percent of the survey's respondents have published peer-reviewed articles pertaining to math content or

pedagogy or that less than 20 percent of the respondents have presented at professional workshops on similar matters.

Recommendations

This original study into the relationship between secondary math and CTE teachers' backgrounds and methods and their students' gains on pre- and post-test math scores has provided important insights for educational leaders in one Midwest State. It is now incumbent upon the researcher to utilize these findings and implications, as noted above, in a manner that allows stakeholders to adjust their embedded math credit teaching strategy for purposes of garnering a greater return on their investments. Furthermore, from a generalizability standpoint, this researcher recognizes the need to perform additional research on this topic in order to provide results that are more useful to a wider audience. In light of the fact that the one State's Department of Elementary and Secondary Education (DESE) has actively endorsed embedded math credit as a new teaching strategy for CTE programs to address students' needs pertaining to transportation issues and or increased graduation requirements, the findings of this study should be taken into consideration prior to further program implementation. The research found that teachers' demographics involved in this study were fairly common: mostly Caucasian; nearly evenly split on gender; and greater than 50 percent with six to 20 years of experience. Despite the fact that scant scientific-based research on this study's topic exists, the narrow focus of this study may raise questions as to whether or not these findings can be generalized over a more diverse population. In addition, some critics may insist on allowing the embedded credit math teaching strategy to operate a few more years, in order to gather more data, before passing judgment on its effectiveness.

Additional research opportunities can expand the scope of the research and or modify the methodology of the original study. Wherein, all secondary CTE programs throughout the Midwest or across the U.S. utilizing the embedded math credit teaching strategy can be included in future studies. Research involving a more diverse population would provide data to validate and or refute the findings in this original study. In addition, the expansion of scope could include the study of the embedded credit teaching strategy for another area targeted by one State's DESE: language arts coursework.

Research opportunities that modify the methodology of the original study could include observing data over longer periods, identifying narrower aspects, studying multiple variables, and or utilizing different significance levels. Accordingly, a longitudinal study would involve gathering and analyzing data sets from the original study's control groups and experimental group over a period of five or more years. Future research could also include studying the one teaching method to have revealed a significant difference between the control groups and or experimental group (See Table 8). In addition, future research should consider employing an inferential statistical tool which allows for the simultaneous study of multiple variables. Finally, future research on small groups, as in this original study, may select to employ a 0.01 level of significance in an attempt to determine differences between the control group and experimental groups. Any or all of these recommendations are made in an attempt to further ensure that the teaching strategies promoted by one State's DESE actually provide Midwest's students with the relevant math skills required to meet the demands of today's global marketplace.

References

Achieve, Inc. (Achieve). (2004). *The expectations gap: A 50-state review of high school graduation requirements.* Washington, DC: Author.

Ball, D., Hill, H., and Bass, H. (2005, Fall). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator, 29*, 14-17, 20-22, & 43-46.

Boe, E. & Shin, S. (2005, May). Is the United States really losing the international horse race in academic achievement? *Phi Delta Kappan, 86*, 688-695.

Borg, W. & Gall, M. (1983). *Educational Research: An introduction* (4th ed.). New York, NY: Longman.

Brewer, T. (2003, July-August). The grand paradox in teacher preparation and certification policy. *Arts Education Policy Review, 104*, 3-10.

Brown, C., Hadley, E., Handley, C., Kronley, R., Rocha, E., and Sharkey, A. (2005, August). *Getting smarter, becoming fairer: A progressive education agenda for a stronger nation*. Washington, DC: Center for American Progress and Institute for America's Future.

Bybee, R. & Stage, E. (2005, Winter). No country left behind. *Issues in science and Technology, 21*, 69-75.

Cavanagh, S. (2006, March 8). NSF educator-training effort seen as helpful. *Education Week.* Retrieved on March 8, 2006 from http://www.edweek.org.

Cavanagh, S. (2006, March 15). Career academics. *Education Week.* Retrieved on March 15, 2006 from http://www.edweek.org.

Cogan, L. & Schmidt, J. (2002). Culture shock: Eighth-grade mathematics from an international perspective. *Educational Research and Evaluation, 8*, 13-39.

Darling-Hammond, L. (2004, June). Standards, accountability, and school reform. *Teachers College Record, 106*, 1047-1085.

Davis, M. (2006, February 1). Bush proposes steps to boost math and science teaching. *Education Week.* Retrieved on February 7, 2006 from http://edweek .org.

Dillard, D. (2004, June 24). *AVCTC Embedded Credit*. Presentation at the Missouri High School Task Force Meeting in Jefferson City, Missouri.

Fink, A. (2003). *The survey handbook: The survey kit* (2nd ed.). Thousand Oaks, CA: Sage.

Friedman, T. (2005, April, 3). It's a flat world, after all. The *New York Times*. Retrieved on May 5, 2005 from http://web.lexis-nexis.com.

Gray, K. (2000). *Getting real: Helping teens find their future*. Thousand Oaks, CA: Corwin Press.

Gregory, K. & Clarke, M. (2003, Winter). High-stakes assessment in England and Singapore. *Theory into Practice, 42*, 66-74.

Isaac, S. & Michael, W. (1997). *Handbook in research and evaluation: A collection of principles, methods, and strategies useful in planning, design, and evaluation of studies in education and the behavioral sciences* (3rd ed.). San Diego, CA: EdITS.

Johnston, W. & Packer, A. (1987). *Workforce 2000: Work and workers for the 21st century.* Indianapolis, IN: Hudson Institute.

Judy, R. & D'Amico, C. (1997). *Workforce 2020: Work and workers in the 21st century*. Indianapolis, IN: Hudson Institute.

Kaplan, L. & Owings, W. (2003, May). The politics of teacher quality. *Phi Delta Kappan, 84*, 687-692.

Keller, B. (2006, March 22). Path to classroom not linked to teachers' success. *Education Week.* Retrieved on March 22, 2006 from http://edweek.org.

Kelly, D. (2002). The TIMSS 1995 international benchmarks of mathematics and science achievement: Profiles of world class performance at fourth and eighth grades. *Educational Research and Evaluation, 8,* 41-54.

Kingsbury, G. (2006, March). The medical research model: No magic formula. *Educational Leadership, 63*, 79-82.

Kronholz, J. (2004), December, 7). Economic time bomb: U.S. teens are among worst at math. *The Wall Street Journal*, pp. B1, B6.

Lemke, M. Sen, A., Pahike, E., Partelow, L., Miller, D., Williams, T., et al. (2005). International outcomes of learning in mathematics literacy and problem solving: PISA 2003 results from the U.S. perspective. *Education Statistics Quarterly, 6*. Retrieved on December 5, 2005 from http://nces.ed.gov/programs/quarterly/vol_6/6_4/2_2.asp.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Lawrence Erlbaum Associates.

Missouri Center for Career Education (MCCE). (2006, July). *Embedded credit toolkit*. Warrensburg, MO: Central Missouri State University.

MTEC-SOWR (2004, March 5). *Missouri's Workforce Investment System.* Presentation at the Workforce Investment Board Committee Meeting, Jefferson City, MO.

National Center for Education Statistics (NCES). (2005, January 4). Comparing NAEP, TIMSS, and PISA in mathematics and science. *NCES Brief*. Retrieved on December 4, 2005 from http://www.nces.ed.gov/timss/pdf/naep_timss_pisa_comp.pdf.

Perie, M., Grigg, W., & Dion, G. (2005). *The nation's report card: Mathematics 2005* (NCES 2006-453). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

Office of Elementary and Secondary Education (OESE)-U.S. Department of Education. (2005, August 3). *Highly qualified teachers: Improving teacher quality state grants: Non-regulatory guidance*. Washington, DC: Author.

Podgursky, M. (2005). Teacher licensing in U.S. public schools: The case for simplicity and flexibility. *Peabody Journal of Education, 80*, 15-43.

Porter-Magee, K. (2004, September-October). Teacher quality, controversy, and NCLB. *The Clearing House, 78*, 26-29.

Reese, S. (2006, September). Elements of an effective mentoring program. *Techniques, 81*, 20-21.

Schoeff, M. (2006, March 13). Amid calls to bolster US innovation, experts lament paucity of basic math skills. *Workforce Management, 85*, 46-49.

Silverberg, M., Warner, E., Fong, M., and Goodwin, D. (2004). *National assessment of vocational education: Final report to Congress*. Washington, DC: U.S. Department of Education.

Smith, T., Desimone, L. and Ueno, K. (2005, Spring). Highly qualified to do what?: The relationship between NCLB teacher quality mandates and the use of reform-oriented instruction in middle school mathematics. *Educational Evaluation and Policy Analysis, 27,* 75-109.

Stigler, J. & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York, NY: The Free Press.

Stone, J. (2005, December 7). *Math in CTE*. Presentation at the Association of Career and Technical Educators National Convention, Kansas City, MO.

Wang, J. & Lin, E. (2005, June-July). Comparative studies on U.S. and Chinese mathematics learning and the implications for standards-based mathematics teaching reform. *Educational Researcher, 34,* 3-13.