State University of New York College at Cortland

Graduate Studies

School of Arts and Sciences

CAREER AND TECHNICAL EDUCATION INSTRUCTORS' VIEWS OF INTEGRATED CONTEXTUAL MATHEMATICS

Graduate Project: A Thesis on

Adolescence Mathematics Education

by

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Introduction

The Board of Cooperative Educational Services (BOCES) is a regional educational agency providing services in partnership with local school districts. There are currently 37 BOCES across New York State working in collaboration with local school districts to offer programs to students, teachers, administrators, and the community. One component of BOCES is Career and Technical Education (CTE). CTE is about helping students, workers, and lifelong learners of all ages fulfill their potential. Career and Technical Education programs provide students with:

- Academics that are relevant to the real world and meet the requirements of the New York State Learning Standards and the No Child Left Behind Act (2001)
- Employability skills that are aligned with business and industry standards
- Work-based learning experiences that help students explore interests and careers
- Opportunities to earn credit or advanced placement at post-secondary institutions

CTE programs also provide high school students with the opportunity to earn additional core academic credits that may be used toward their graduation requirements. Contextual mathematics is one of the core subjects integrated into most CTE programs, providing students with related real-world, technologically-based problem solving skills. An example of an integrated lesson (Appendix A) was created by me after attending a field trip with the building trades class to a local business that manufactures concrete blocks and cement forms. During the field trip, students observed how concrete blocks were made from raw materials and the business of how a cement company functions. The following day the building trades students were given the integrated math lesson based on what was discovered during the field trip. During the 40-minute lesson, students were

guided through a four question worksheet, one question at a time. Each question was thoroughly discussed and tied directly to what was learned the day before. The building trades instructor also shared the importance of knowing how math is used in the industry. Students were engrossed in what they were learning, asked questions, and commented that they should have more math lessons like this. Dewey's principles of continuity and interaction were quite evident during the lesson, establishing a positive attitude for both students and teachers alike.

The purpose of this study is to investigate career and technical education instructors' views of contextual mathematics integrated into their program at a BOCES in New York State.

Background

The constructivist theory of learning proposes that students have a natural sense of the world around them, and move from reactive observers to active learners by modifying their existing knowledge. This is in stark contrast to the traditional approach, which assumes students will believe what they have read in a textbook or are told in class (Carlson, 2003). John Dewey (1938) believed that educators are responsible for providing students with learning experiences that become immediately valuable to our society. He criticized traditional education of being focused only on a "pattern of organization," that is, core educational information and skills that were previously learned are transmitted to the new generation of students in virtually the same manner, leaving little room for change in application. Dewey felt that there must be an interface between previously learned subject matter and the application of it in the present situation, and that experience arises from the interaction of two principles – continuity and interaction.

Thus, hands-on, technological literacy was defined by John Dewey at the turn of the twentieth century, giving birth to the concept of career and technical education institutions.

Current trends in career and technical education with regards to mathematics education have focused on improving the continuity and interaction between the mathematics teachers and technical instructors. In a study to test the value of enhanced math learning in career and technical education (CTE), led by the University of Minnesota during the 2004-2005 school year, researchers created the Math-In-CTE model (Stone, Alfeld, Pearson, Lewis, & Jensen, 2006). The model is based on the principle that students need to go through an interactive process beginning with an introduction to solving a real, relevant problem, practicing on numerous related examples, and then applying the concept to a more tangible problem. The researchers considered it essential to develop a model that both math and CTE teachers could use in the instruction of math curricula embedded in the CTE curricula so that students could apply their understanding to the context as well as to other situations. These researchers also found that high school students who took career and technical education classes with enhanced mathematics instruction performed significantly better on standardized math tests than students in a control group – without any negative impact on occupational or technical knowledge (Stone et al., 2006). The experimental study, which involved more than 3,000 students in nine states, revealed that schools could have a significant effect on students' grasp of mathematics without investing enormous amounts of time. The CTE and math teachers that participated in the application of the Math-In-CTE model described their involvement as a positive learning experience for themselves and their

students. They commended the model as one that works – a model of "true integration." Since the Math-in-CTE model has been so successful at other technical education institutions throughout many states, it is currently being implemented at a BOCES in New York State.

Although research has shown that mathematics integrated into career and technical classrooms has had significant effect on students' understanding of math (Boaler, 1993; Brown, 1989; Johnson, Charner, &White, 2003; Stone et al., 2006), little is known about the continuity and interaction that may take place between the mathematics teacher and the technical education instructors as well as the technical education teachers' views about an integrated math program. A positive experience with an integrated math teacher in a technical classroom may encourage the technical instructor to be more receptive to sharing curriculum and class time with the math teacher.

Describing technical instructors' views of integrated mathematics in their career and technical education program is important for improving the exchange of information between the mathematics teacher and the technical instructor. Stone et al., 2006 found that CTE instructors widely favored and supported the Math-in-CTE model, created enthusiasm among the teachers, and had overcome tensions and anxiety in working collaboratively. Brendefur and Hernandez (2003) reported that conflicting notions of what establishes high quality integrated, authentic curriculum and instruction were subsided when math and CTE teachers shared understandings about important collaborative work concepts and opportunities for quality interactions in school.

Method

At the BOCES where the data for this study was collected, mathematics is identified and integrated into most curricula. It is enhanced by core academic teachers during instruction, thereby giving students a clearer understanding of how math can be used as a powerful tool for solving real-life problems.

Participants in this study were seven career and technical education instructors from a variety of technical programs at a BOCES center in New York State. These seven CTE instructors are highly qualified educators with technical degrees in their respective career fields as well as years of personal field experience. The instructors surveyed in this study include one Agriculture Production & Science, two Building Trades, one Cosmetology, one Criminal Justice, and two Culinary Arts.

The instrument used for this study was a six question survey (see Appendix B). Survey questions included the following:

1. What do you think are the strengths of using integrated math in your program? Please provide specific examples.
2. What do you think are the weaknesses of using integrated math in your program?
3. Prior to the math integration into your program, what expectations (positive and negative) about the integration did you have in regards to student learning?
4. In what ways has math integration not met, met, or exceeded your expectations?
5. What specific math topics would you like the math teacher to teach your students?
6. How do you think math integration into your program may be improved? Please be specific.

The survey was given to the CTE instructors in January 2008. Instructors had approximately two weeks to complete them. After the data was collected and read, instructors were asked follow-up questions. Follow-up interviews were conducted on an as needed basis for survey response clarification. Then, themes for the data were created by looking for similarities and differences.

Results

Each of the survey question responses are described in the following section. Instructor responses were sorted into themes by looking for similarities and differences in the responses. Responses for Questions 1 and 2 were sorted into three themes, *Learning Mathematics*, *Learning Career,* and *CTE Programs*. All other questions indicated unique themes.

Question 1: What do you think are the strengths of using integrated math in your program? In the first theme, *Learning Mathematics,* teachers commented on the usefulness of the co-teaching process, where complicated math problems are simplified.

> The students understand the math concepts better. (Culinary Arts, A)
>
> The curriculum cannot address the assumed prerequisites, such as fundamental math skills. There is no room in a two year vocational program for a CTE instructor to teach students years of math skills. This makes the core math instructor an absolute necessity. (Building Trades, A)
>
> Complicated problems are broke down into simple components. (Agriculture Production & Science)

In the second theme, *Learning Career,* the teacher responses refer to how the process benefits student learning in their career rather than simply understanding mathematics.

> The strengths of using integrated math in my programs allows my students to see how math has a direct link to the field of work they are exploring. An example would be how to use math while evaluating blood spatter to determine direction of force, degree of force, and point of origin. (Criminal Justice)
>
> Information from other teachers who specialize in material. (Cosmetology)

During the follow-up interview, the Cosmetology instructor said that a majority of the math taught in the cosmetology program revolves around preparing students for developing a cosmetology business plan, and that the integrated math instructor can teach students content such as banking, budgets, fractions, and percentages.

One response fit neither of the other two previous themes, since it pertained to strengthening the program in general. Thus, the response was placed a third emerging theme, *CTE Programs*.

> Gives teachers a helping hand and sometimes a needed direction in the classroom. (Culinary Arts, A)

The Culinary Arts instructor (A) shared during a follow-up interview that having an integrated math teacher in the classroom during a math lesson gave him the assistance needed in guiding students to mathematical understanding.

Question 2: What do you think are the weaknesses of using integrated math in your program? In the *Learning Mathematics* theme, teachers shared their concerns about student difficulties in learning math in CTE programs.

> Weaknesses would include getting the students to “buy into” having a math lesson. (Criminal Justice)
>
> Students are at many different learning levels and the math has to adjust to their needs and IEP needs. One-on-one math teaching would be an asset due to the limited time the CTE teacher has to dedicate to math. (Culinary Arts, A)

> The biggest problem right now is that all students are not at a 9th grade level or higher in math. If all students were at that level, math would be a lot easier for them. (Building Trades, B)

During a follow-up interview the Criminal Justice instructor expressed that it is the CTE instructor's responsibility to convince students that having a math lesson is important, and that students should agree to the lesson by "buying" into it. The Culinary Arts instructor (A) later elaborated on his response by remarking that math instruction needs to be adjusted for IEP students by "toning down" complicated problems. When interviewed, the Building Trades instructor related that students entering the Building Trades program have completed most, if not all of the required commencement (ninth grade or higher) level math needed for graduation. The instructor was concerned that most students do not retain their commencement level math skills, forcing the instructor to take time from the CTE program to refresh their mathematical skills before moving on.

In the second theme, *Learning Career,* one teacher commented on the inconsistency of math lessons as a weakness of integrated math.

> There is not a consistency with planning (days). Students are told we are having math then plans change. This is not the teachers fault, plans change within the programs. (Cosmetology)

During a follow-up interview, the Cosmetology instructor clarified by stating that sometimes lessons have to be rescheduled due to changing plans or priorities, which cause possible disruptions in the flow of the planned lesson.

In the third theme, *CTE Programs,* teachers remarked that a weakness of integrated math in their program is the lack of time in which the math teacher spends in their programs due to difficulties in scheduling.

> Our biggest current problem is scheduling, there isn't enough Mr. Math to go around. (Criminal Justice)

> The amount of time needed by the students to understand the math concept. (Culinary Arts, B)

Both instructors expressed that it was sometimes difficult and frustrating when trying to schedule math lessons that fit into available time slots.

Question 3: Prior to math integration into your program, what expectations (positive and negative) about the integration did you have in regards to student learning? The responses indicated that the positive aspects mainly related directly to the improving students' mathematical knowledge, with the exception of one response that related to the instructor's expectation on his own growth in mathematics. The negative aspects focused mostly on time management and curricular issues.

In the *Positive Expectations* theme, instructors shared what expectations they had that may benefit students by using integrated math in their CTE program.

> Would be having a math teacher who could expand on the topic so students could understand the entire math concept being used in the topic of study. (Criminal Justice)

> The additional instructional resource is needed and welcomed. There is no time for a CTE instructor to teach years of missed learning. All students would suffer if the majority is unable to perform in the program due to lack of basic knowledge. (Building Trades, A)

> I looked forward to "seeing" another way to approach the subject. (Culinary Arts, A)

> So the students are given the correct concepts to use when they go on after the program. (Culinary Arts, B)

In the *Negative Expectations* theme, instructors voiced their negative expectations and concerns of using integrated math in their CTE programs. Interestingly, all of these concerns were not related to how students learn concepts, but focused on planning time and curricular issues.

> Would be “sharing my time” with a core teacher and how to schedule lessons. (Criminal Justice)
>
> TIME , we always need more of it, and concern about taking more time out of regular teaching. (Culinary Arts, A)
>
> Planning and the amount of time needed when there is so much curriculum to cover. (Culinary Arts, B)
>
> Thought that the math teacher would not be able to teach the students anything that the instructor could do himself. (Agriculture Production & Science)

Question 4: In what ways has math integration *met, not met,* or *exceeded* your expectations? None of the instructors responded to the *exceeded* expectations portion of the survey. In the *Met Expectations* theme, the responses were as follows:

> Math integration has been great in helping students understand how math is used in the real world of work. I have seen “the light turn on” for some. (Criminal Justice)
>
> My teaching skills are different, which is good for all students, and also good for the instructor. (Agriculture Production & Science)
>
> Math integration has helped strengthen the program because we dedicate time just for math. (Culinary Arts, A)
>
> When math class is in session, my expectations are met. (Cosmetology)

In the follow-up interview, the Agriculture Production & Science instructor said it would be good for students and instructors to witness different teaching styles.

In the *Not Met Expectations* theme, the responses were as follows:

> The expectation that has not been met is the unavailability to schedule math lessons due to the teacher being ½ time, plus conducting program reviews; therefore reducing actual in program, teaching time. (Criminal Justice)
>
> The resource of core academic teachers is undervalued. The lack of basic academic skills in students entering CTE programs is alarming. The response to this situation must meet the need however it is currently

> falling far short of even minimal response. Core academic teachers are not spending nearly enough time in classrooms teaching students. Sharing teachers between schools and utilizing them for activities other than CTE classroom instruction is a misuse and ignores the real need of CTE programs and CTE students. (Building Trades, A)
>
> Does not meet the needs of the IEP student. (Culinary Arts, A)
>
> The number of lessons that have to be planned for the students to understand the concepts. (Culinary Arts, B)
>
> I wish we could have more consistency in days and times. (Cosmetology)

The Culinary Arts instructor (B) explained during a follow-up interview that expectations were not met due to the fact that more lessons needed to be planned for students. The instructor also mentioned that the number of lessons was insufficient due to math teacher availability.

Question 5: What specific topics would you like the math teacher to teach your students? There was a variety of responses from the CTE instructors. Table 1 reflects the instructor responses by program, math topic, and its connection to the *New York State Learning Standards for Mathematics* (NYSED, 2005). The math topics were connected with the *New York State Learning Standards* and CTE. Interestingly, all of the topics were at the commencement level for the *New York State Learning Standards*. The data also indicates that instructors were only concerned about meeting Algebra process and content performance indicators.

Table 1: Math Topics and NYS Learning Standards

CTE Program	Math Topic	NYS Learning Standards
Agriculture Production & Science	Logic	A.PS.8, A.RP.5, A.CM.5, A.CN.7, A.R.5
	Same-system conversions	A.PS.5, A.RP.2, A.CM.4, A.CN.5, A.R.5, A.N.1, A.A.26, A.M.2
	Fraction/decimal conversions	A.PS.6, A.RP.6, A.CM.5, A.CN.4, A.R.5, A.N.5, A.M.2
	Fraction operations	A.PS.6, A.RP.6, A.CM.5, A.CN.1, A.R.5, A.N.5
	Ratios	A.PS.6, A.RP.6, A.CM.11, A.CN.4, A.R.5, A.N.5, A.A.26
Building Trades	Reading rulers	A.PS.4, A.RP.1, A.CM.2, A.CN.3, A.R.1, A.N.1
	Fraction/decimal conversions	A.PS.6, A.RP.6, A.CM.5, A.CN.4, A.R.5, A.N.5, A.M.2
	Basic math fundamentals (operations)	A.PS.8, A.RP.6, A.CM.5, A.CN.4, A.R.5, A.N.5, A.A.22, A.A.26
Cosmetology	Checking accounts	A.PS.5, A.RP.2, A.CM.5, A.CN.6, A.R.4, A.N.5
	Time/interest	A.PS.6, A.RP.6, A.CM.4, A.CN.4, A.R.5, A.N.5
	Fraction operations	A.PS.6, A.RP.6, A.CM.5, A.CN.1, A.R.5, A.N.5
Criminal Justice	English & metric conversions	A.PS.5, A.RP.2, A.CM.4, A.CN.5, A.R.5, A.N.1, A.A.26, A.M.2
	Plotting and graphing	A.PS.5, A.RP.6, A.CM.3, A.CN.5, A.R.1, A.G.4
	Distance/time/rate problems	A.PS.5, A.RP.5, A.CM.4, A.CN.5, A.R.5, A.N.5
	Budgeting	A.PS.4, A.RP.2, A.CM.5, A.CN.6, A.R.4, A.N.5
	Percentages	A.PS.4, A.RP.2, A.CM.5, A.CN.3, A.R.2, A.N.5
Culinary Arts	Yield percentages	A.PS.4, A.RP.2, A.CM.5, A.CN.3, A.R.4, A.N.5
	Menu pricing	A.PS.4, A.RP.2, A.CM.5, A.CN.3, A.R.4, A.N.5
	Portion costing	A.PS.4, A.RP.2, A.CM.5, A.CN.3, A.R.4, A.N.5
	Recipe ratios	A.PS.6, A.RP.6, A.CM.11, A.CN.4, A.R.5, A.N.5, A.A.26
	Weights and measures	A.PS.2, A.RP.4, A.CM.4, A.CN.4, A.R.5, A.N.5, A.A.26, A.M.2
	Volume	A.PS.2, A.RP.4, A.CM.4, A.CN.4, A.R.5, A.N.5, A.G.2

Question 6: How do you think math integration into your program may be improved? After reviewing the instructor responses to Question 6, two central themes emerged: *Planning/Accessibility* and *Student Learning.*

In the *Planning/Accessibility* theme, instructors voiced their ideas of how integrated math may be improved through math teacher availability.

> The best way to improve math in my program is to be available on a regular basis. (Criminal Justice)
>
> Core teachers must be allowed to teach their respective subjects in the classroom on a regular basis. CTE teachers can not rely on this resource in the current environment. Core teachers must be able to commit to regularly scheduled classroom sessions. Core teachers must be dedicated to one school if they are to be able to function as the situation demands. (Building Trades, A)
>
> The math teacher should already know what math concepts need to go over based on the curriculum map. The how and when needs to be planned. (Culinary Arts, B)
>
> I wish we could have more consistency in days and times. (Cosmetology)

In the *Student Learning* theme, instructors voiced their ideas of how integrated math may be improved by sharing ways that the math teacher can help students better understand mathematical concepts in their programs.

> Retention time is my problem. A test given at the end of a lesson will most likely result in an "A," a week later, "C" or "D." Some sort of built in refresher would be good. (Agriculture Production & Science)
>
> The students need more visual clues. Meet IEP needs: use of other tools or modifiers or small groups. (Culinary Arts, A)

During the follow-up interview with the Agriculture Production & Science instructor, the instructor said it might be a good idea for the math teacher to give a follow-up, refresher type lesson shortly after the initial lesson's completion. The instructor also said that

another possibility may be for the math teacher to give the CTE instructor materials to use as a lesson follow-up.

Discussion

CTE instructor responses to the survey questions are minimally varied. Generally the instructors conveyed that integrated math is by and large a positive attribute for the strengthening of their program. All of the instructors that participated in the survey convey that contextual mathematics integrated into their program through co-planning and co-teaching is a useful tool for creating student success. There were three major findings in this study.

1. CTE instructors believed students lacked commencement level mathematics skills.
2. An overwhelming majority of CTE instructors noted simple algebraic skills as the most commonly needed mathematical skills for their programs.
3. CTE instructors believed that when time constraints are minimized, greater student continuity and interaction may be achieved as well as overall program enhancement, perpetuating Dewey's (1938) idea of how learning experiences arise.

Many of the instructors believed that students lacked commencement level mathematics skills when entering CTE programs. On the contrary, nearly all students attending CTE programs in their junior and senior years have previously completed their math sequence requirement for graduation. A small percentage of students will earn a third credit in math. One possible reason for students' lack of commencement level mathematics skills is retention of skills from their mathematics classes in high school. Another reason for their lack of commencement level skills is that students may not have ever been shown how to apply basic math skills into real-world, technologically-based problems. Increased communication with traditional middle and high school mathematics

teachers about this problem may help establish a stronger mathematical foundation for future CTE students to build upon. Eighth and ninth grade mathematics teachers could easily elaborate on the importance of mathematics in real-life technical applications by giving examples of its use during math lessons. Maybe further study should be conducted to examine the quality of real-world, technology-based problems in eighth and ninth-grade textbooks. And, further study might be needed to see how willing middle and high school teachers are to encourage these types of problems.

Setting the mathematical foundation during students' earlier school years will help for a smooth transition into CTE mathematics. The core math instructor can then cognitively connect previously learned math skills to a particular vocational program. This allows for students to obtain a better grasp on understanding mathematical concepts, especially in problem solving, where math skills are tied directly to a particular CTE program. This specialized math can benefit all CTE programs by strengthening students' known math concepts of a career field into a more concrete understanding of those concepts. Mathematics becomes a means of directly linking real-world, technologically-based problem solving skills in any CTE program.

Another interesting finding in this study is the CTE instructors' overwhelming desire for their students to have no more than simple algebra skills. This belief may be due to the fact that CTE instructors generally felt that students are entering CTE programs below commencement level and may lack the capability to perform higher problem solving mathematics. When challenged with higher level mathematics most students respond eagerly, especially when the math is tied directly within their particular CTE program. For example, in the building trades lesson that was previously shared (see

Appendix A), students were challenged with volume and dimensional analysis type problems that are linked to the building trades career field. All students actively participated in the lesson and most found the questions quite challenging. But, when broke down into simpler, easy to follow steps, all students completed the higher-level algebra and geometric problems, and were eager to learn more. Students are willing to accept thought-provoking mathematical challenges, especially those that are solved collaboratively with the guidance of a math teacher. Therefore, students should be challenged regularly.

In a third finding, nearly all of the CTE instructors indicated how time constraints minimize students' understanding of CTE mathematics. Most all of the negative responses can be tied directly to the fact that more time in the CTE classrooms is needed by the math teacher. The CTE instructors believed that integrated mathematics is a great concept and works well when the math teacher spent additional time co-planning and co-teaching. Since the majority of instructors mentioned the lack of availability of the mathematics teacher as a weakness, the programs would benefit from additional mathematics teachers.

One limitation of this study is that the results are not generalizable to other CTE programs since only instructors at one BOCES site were interviewed. Instructor interviews conducted at other vocational schools where integrated mathematics has been incorporated may be beneficial as additional data to this study. Nevertheless, this study provides some insight into the CTE instructors' views of the Math-In-CTE at this particular BOCES site. This study brings to the forefront the need for further study of the

traditional high school curriculum with regards to the use of simple algebra in real-world, technologically-based problems, and the importance of planning time for teachers.

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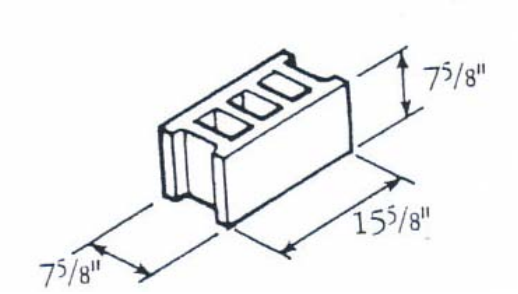
Appendix A

Building Trades Math
Area & Volume Worksheet

1. We usually refer to this block as a 8 x 8 x 16 inch block. Why?



2. Determine the total number of 8 x 8 x 16 inch blocks that are needed to construct a 4 ft. by 32 ft. retaining wall.

3. A cubic yard is how many cubic feet?

4. Assume a 15 ft by 20 ft by 3 in patio is to be poured. Determine the volume (in cubic yards) of concrete needed to build the patio.

Lesson Plan: **Integrated/Applied Mathematics for Building Trades**
Topic: **Using Area and Volume to Solve Construction Problems**

Objective:

Students will be able to use geometric formulas and conversions to calculate area and volume for determining needed materials to construct a block wall and pour a patio foundation.

Materials:

- Pen/pencil
- Calculator
- Scenario worksheet

NYS Learning Standards:

A.PS.8
A.RP.4
A.CM.12
A.CN.4
A.R.1
A.G.1
A.G.2
A.M.2

Procedure:

1. Review the rectangular solid area and volume formulas with students.
2. Read worksheet to students and have them solve the associated word problems.
3. Working collaboratively with students, describe possible ways to solve the given word problems.
4. Review answers with students as they make appropriate corrections.

Assessment:

Scenario worksheet, class participation and short write-up for turn-in.

Closure:

Have students share what they have learned from the lesson for turn-in.

Appendix B

"CTE Teacher's Views of Integrated Mathematics in Their Program"

Teacher Survey Questionnaire

Instructions:

a. Please complete each survey question as thoroughly as possible, as your responses will enable me to improve my/our instructional practices at ONC BOCES.
b. If additional space is needed to respond, feel free to write your comments on a separate sheet of paper.
c. Follow-up interviews will be conducted for response clarification as needed.

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1. What do you think are the strengths of using integrated math in your program? Please provide specific examples.

2. What do you think are the weaknesses of using integrated math in your program?

3. Prior to math integration into your program, what expectations (positive and negative) about the integration did you have in regards to student learning?

4. In what ways has math integration *not met, met,* or *exceeded* your expectations?

5. What specific math topics would you like the math teacher to teach your students?

6. How do you think math integration into your program may be improved? Please be specific.

Date completed: _____

CTE Program: _____

Survey ID #0801