An Innovative and Collaborative Community College and High School Algebra Project: Contextualizing Career Technical Education (CTE) in Math

Serena Ota St. Clair, Ph.D., Doug Gardner, M.A.T.

St. Clair: Rogue Community College/Oregon State University
Gardner: Rogue Community College
sstclair@roguecc.edu, dgardner@roguecc.edu

Abstract

Rogue Community College (RCC) received a National Science Foundation (NSF) grant (2010-12) to transform Algebra I (MTH60) into a revised MTH 63 curriculum that it is entirely contextual-based, using examples from at least five CTE (Career Technical Education) disciplines. The course can be taught in one term at community college or over a full academic year in high school. Math and Pathways faculty wrote a textbook and facilitated a Summer Math Institute (2011 & 2012) where 24 high school and community college math teachers learned how to use the curriculum through actual math applications in CC's CTE labs. The course was piloted spring 2011 and has run for five terms. The student outcomes are very positive in both critical thinking advancement and achievement of credit. In fall 2012, the pass rate for CTE students in this course was 72% as compared to CTE students in our traditional MTH60 at 36%. Qualitatively, our CTE faculty can readily identify students coming from MTH63 over MTH60 due to their comprehensive and applications skills. The overall goal of this project is to improve pedagogical approaches, course design, and course articulation to improve students' math skills so that they are better prepared for their post-secondary education and, ultimately, for work as CTE technicians in the workforce. The Co-Principal Investigators propose to present the project status and findings from two years (pilot course and Summer Math Institute evaluation and subsequent curriculum adoption.) .

Intellectual Merit: This project is grounded in NSF funded work by Harold L. Schoen and Christian R. Hirsch, and Sol Garfunkel; and by the National Research Center for Career and Technical Education (NRCCTE). According to Dr. Stone, NRCCTE Director, the project distinguishes itself by wholly adopting a contextual math-in-CTE curriculum mode, and advances the President's *American Graduation Initiative*—"transitioning youth to a successful community college experience." [1] CC's Instructional Division will use the new course as a prerequisite for CTE programs, and as a dual credit course for high school students. The project hypothesis, tested by a comprehensive outcome assessment plan, is that if requisite mathematical skills in industry dictate the curriculum that students will more quickly and successfully complete courses, and improve their readiness to apply math in CTE areas. The project will aid in transforming how the traditional math sequence leading to college algebra math is taught in high school and at the community college as an integral part of career preparation.

Broader Impacts: This grant uses an interdisciplinary approach to develop math curriculum necessary for competence in five (5) community college CTE programs of study (Diesel, Welding, Manufacturing, Electronics, and Construction Technologies). At CC, over 90% of students, including first-generation, female and minority students, place into developmental math on the college's placement test. Since this lack of math success is a universal problem in the U.S., creating math curriculum that is industry-driven and focused on CTE programs is a promising practice model. Project evaluation will determine if contextualizing lessons in math curriculum increases content relevance, and boosts course retention and academic progress.

The broader impacts of the project go beyond the region. As Oregon begins to require a third year of math to graduate, project investigators will promote course effectiveness as an eligible high school

diploma requirement. CC is also part of a State of Oregon initiative to collect and adopt math outcomes that will serve as the basis for math alignment between high school and community college.

Keywords \: Contextualize Math Curriculum, Innovation in Math Education, Career Technical Education (CTE) and Math, Secondary to Post-Secondary Alignment, Vocational Math

SECTION 1: PROJECT OVERVIEW

Rogue Community College's (RCC located in Medford and Grants Pass, OR) **goal** is to improve pedagogical approaches, course design, and course articulation to increase students' math skills so that they are better prepared for post-secondary education and, ultimately, for work as CTE (Career Technical Education) technicians in the workforce. The p**roject objectives were to:**

1. Develop a one-term community college and a year-long high school Math 63 course with Algebra I and geometry concepts driven by contextualized applications from five career technical areas (CTE). This delivery includes writing a textbook to hold this curriculum.
2. Offer an in-depth Summer Math Institute (SMI) based on the curriculum to 25 regional high school, community college, and industry teaching professionals and to continue professional support when teachers were utilizing the new MTH63 text.
3. Integrate Math 63 into all CTE college programs as the requisite math and add as a dual credit offering for secondary schools that also satisfies State of Oregon diploma requirements as an eligible third-year high school math course.

1.1 Motivating rationale:

There is universal agreement that high schools and community colleges are experiencing an epidemic of failure to produce the numbers of competent CTE graduates needed to fuel our modern economy. The abysmal quality of math and science instruction in the United States is summed up by the following organizations:

- The National Commission on Mathematics and Science Teaching for the 21st Century notes "*In an age now driven by the relentless necessity of scientific and technological advance,* the current preparation that students in the United States receive in mathematics and science is, in a word, unacceptable." [2]

- The National Association of Manufacturers reports that "there is a growing skills gap. More than 80% of manufacturers say they are having trouble finding qualified employees. Sixty percent of manufacturers typically reject half of all applicants as unqualified because of the lack of basic skills. Moreover, entry-level skills in manufacturing have become more sophisticated, requiring more education and training." [3]

- Semiconductor Industry Association, "Choose To Compete: 21st Century Workforce" position paper notes that the lack of graduates in STEM disciplines is a troubling national workforce trend and recommends that we "upgrade K-12 mathematics and science teaching and improve the proficiency of all students in math and science" to help meet the demands of the U.S. economy in the 21st Century. [4]

- The American Society of Civil Engineers, in recognition of the expanding technology revolution and the nation's need to compete in a global economy, actively participates in a coalition of engineering and science groups as well as industry and educational partners to boost federal funding support for math and science educational reform. [5]

1.2 Key direction was found in the following:

a. **Goldin** (2002), a scholar in Mathematics Education states that "there is a pressing need for shared, scientific, nonideological framework for empirical and theoretical research in mathematical learning and problem solving". He describes the theories and methods that have been tried in mathematics education as a pendulum of methods over the hundreds of years. Relatively recently (1970's) we were more traditional by teaching rote [simplicity] of computational arithmetic and consumer mathematics which works when well drilled. However, he guesses that a subset of these students-20% or fewer- are able to "attain real understanding of algebra and geometry at the high school level. He ascribes to what he terms the "reform camp" in the 1990's which advocated for "curriculum that addresses higher level reasoning works best when students are instructed and assisted in finding patterns, making connections, communicating mathematically, and engaging in real-life contextualized, and open-ended problems." In short he states "Contextualized mathematics is valued for its meaningfulness and relevance". However, post 2001 we have swung around to the back to basics movement which he thinks is an ironic twist with academic mathematicians leading the charge. He challenges this traditional approach by stating "Mathematical power consists not only in being able to detect, construct, invent, understand, or manipulate patterns, but in being able to *[communicate*] these patterns to others." He makes a strong case for contextualized understanding because he states that using familiar contexts that are encoded internally such as: common words, images, strategies and operations, expectations, beliefs, competencies. Everyday experiences that can be easily referred to, widely shared and understood, culturally reinforced serve as the construction of "in context" mathematical representations which can help encode contextual understanding.[6]

b. Reporting on the **Third International Mathematics and Science Study (TIMMS-1995) Conley** noted that when the U.S. is compared to other countries for teaching math, American students do not excel because "students in U.S. classes do not engage actively in problem solving or develop a deep understanding of mathematical concepts" (Conley, 2005). He writes that the current secondary structure emphasizes completing required courses instead of mastering important skills and intellectual development. He also noted that high school teachers receive little guidance regarding the knowledge and skills that students should be developing to be ready for entry-level college courses.[7]

c. In a study by **Hoyt and Sorenson (2001**) they found that college faculty repeatedly responded that recent high school graduates may have completed required math courses for graduation without gaining any significant grasp on the subject matter. They cited a typical situation of high school students completing "college level algebra/trigonometry" at their local high school and with entrance exams scores that would not admit them into college algebra on campus. Their study on the connection between remediation education in college and high school preparation suggests that "there is a substantial difference in the rigor of high school math courses compared with the college curriculum". [8]

d. **Conley (2005)** offered one strategy to help bridge the gap of understanding and alignment in math between secondary and post-secondary teachers is for high schools to "develop culminating activities that require student mastery of challenging content and higher order thinking skills [by developing] a joint working group with local community college and university faculty members". [9]

e. **Research by Orr and Bragg (2001)** indicates student academic and vocational preparation, particularly to meet the demands of growth industries and changing labor markets for the global economy, is increased when there is **increased cooperation between secondary schools and community colleges** and other higher-education institutions. [10]

f. **The National Research Center for Career and Technical Education's** recent report titled "Rigor and Relevance", (2008) Stone, Alfeld and Pearson explicitly noted that in an effort to improve post secondary preparation many states have increased the number of math courses required to graduate, but this move in and of itself is not effective. They suggest enhancing CTE courses with rigorous and relevant mathematics which mean learning through a concrete problem will support the understanding of the abstract math concept. "Applied learning is the delivery of content area curricula within a relevant, authentic, and presumably more motivating context". [11]

g. The **Southern Regional Education Board's** major report on school reform postulates that a key solution in educational reform is in harnessing "the applied teaching strategies of career/technical education (CTE)" and infusing "them into college-preparatory academics" to re-engage and challenge students. Among the report's recommendations are the following: "Align new and existing career/technical curricula with essential college and career-readiness standards"; and 2) "prepare and enable career/technical teachers to teach essential academic skills through application in authentic activities, projects, and problems." Importantly, the Carl D. Perkins Career and Technical Education Improvement Act of 2006, often referred to as Perkins IV, provides states unprecedented latitude to align CTE with broader high school redesign programs. [12]

SECTION 2: SUPPORTING DATA

Research indicates that low student achievement in math is often a function of lack of interest, boredom, difficulty with the content and lack of support, and/or a sense that the math is not relevant to their lives (Stone, et al 2008). [13] A good example of the decline in math skills is the 2008 report from School Data Direct for the State of Oregon (Table #1) shows a steady decrease in math proficiency on state math tests as students progressed through school. [14]

Table #1: Oregon Student Math Student Proficiency Results				
Grade 3	**Grade 5**	**Grade 6**	**Grade 8**	**Grade 10**
77.1%	76.7%	70.3%	68.7%	52.2%

And yet, there is an urgency of addressing this nationwide problem as illustrated in a study published by the National Research Center for Career and Technical Education (NRCCTE): "Mathematics is no longer a requirement only for prospective scientists and engineers. Instead some degree of mathematical literacy is required for anyone entering a workplace or seeking advancement in a career." [15] From a societal viewpoint, improving the mathematics transition of high school graduates attending college is an important step in preparing a generation for work in the age of globalization (Hammer 2009).[16]

Researchers have identified various strategies to begin addressing the problem including:

- **Dual credit** programs have long supported the concept that if students begin college-level technical training in high school, they are more likely go directly to community college to finish their education (2+2 concept) (Bailey, 2002).[17]
- **Applied math:** Among the high school math reform efforts in the 1990s funded by the National Science Foundation was research and curriculum development by Schoen and Hirsch indicating that "students perform particularly well on measures of conceptual understanding, interpretation

of mathematical representations and calculations, and problem-solving in applied contexts" (Schoen & Hirsch, 2003). [18] Students, however, did not score any higher than students in the traditional math sequence on a placement test at a major university. One problem with contextual learning is the student's inability to apply learned knowledge in one context to another because the learning is so embedded in the original context. One key to improving student success is a need for students "to practice math skills in a variety of ways so that they become proficient in knowing when and how to apply them" (Stone, et al, 2008).[19]

- **Math in the senior year:** Many students who do not take high school math in their senior year, need remediation in college, and fail to complete degrees even when aspiring to do so (T.R. Bailey & Morest, 2006; Kane & Rouse, 1999; National Commission on the High School Senior Year, 2001). [20-22] Research on student placement into college math indicates that placing into college-level math following high school can be increased simply by taking a math course in the senior year (National Commission on the High School Senior Year (ACT, 2005; Berry, 2003; Hoyt and Sorenson, 2001; Roth, et. al 2001).[23-26]

Like the rest of the nation, many Oregon high school students are graduating with math skills that leave them unable to enter college-level math (see Table 1). The impact on career technical education (CTE) graduation is clear—students who test into developmental (remedial) math, even with recent high school diplomas, experience slowed progress in their CTE programming and have a strong potential of not completing. The developmental math courses at Rogue Community College (RCC) include: Math 20 (Pre-Algebra), Math 60 (Fundamentals of Algebra I), Math 65 (Fundamentals of Algebra II), and Math 95 (Intermediate Algebra). Table #2 below shows the course content for each.

Table # 2: RCC Traditional Developmental Math Course Sequence

MATH 20	MATH 60	MATH 65	MATH 95
Review whole numbers, fractions & decimals, percent ratio/proportion, exponents, order of operations, integers, use of variables, and simple equation solving.	Application of real numbers, operation with real numbers, exponents, order of operations, mathematical modeling, linear equations/functions, problem solving, modeling with data and basic geometry.	Review linear functions and expressions, systems of linear equations, linear inequalities, exponents, polynomials/introduction to quadratic function and factoring.	Quadratic, radical, rational, exponential and logarithmic functions, and their applications.

Depending on the placement score, a student may place into any one of the four developmental math courses. The math sequence is representative of a contemporary algebra approach which includes technology usage (i.e. the scientific graphing calculator). The reason for offering this course sequence is to prepare students for the rigors of transfer-level college math as part of the Associate of Arts/Oregon Transfer (AAOT) degree.

Students at RCC like those nationwide reflect this under-preparedness (see Table #3 below). Located about five hours south of Portland, Oregon, RCC serves students from Jackson and Josephine counties in southern Oregon. The region is experiencing robust population growth and its economy is expected to produce more jobs than the state as a whole, according to the Oregon Employment Department. [27] However, according to the local economic development agency, the region must prioritize efforts to produce a diversified, trained workforce to effectively compete in the global marketplace. [28]

How are we doing in preparing technicians for the workforce? According to the Alliance for Excellence in Education, the United States is not only not preparing students for the demands of college and the modern workforce but that the country would save $3.7 billion a year in reduced college expenses if in

part "more students who graduate from high school were prepared for college, and thus did not require remediation." [29] At RCC, all incoming students take a placement test. In the past 5 years, o**ver 90 percent**, including incoming high school students, **tested into developmental math** (Math 60, 65, and 95), see Table #3.

Table 3: RCC College Math Results at Placement, Completion Rate, Poor Grade Rate

Academic Year	Total Math placement tests	Placed at or below Math 60 (#)	%	Placed at or below Math 95 (%)	Enrolled at or below Math 60	Non-Successful Completion Of Math 60 or below(#)	%	Received Poor grade in Math 60 or below (F, NP, W & Z) %
05-06	3067	2410	72.66	87.13	986	431	43.71	32.97
06-07	3235	2278	68.66	90.26	878	427	48.63	37.01
07-08	3188	2362	74.09	93.85	1308	636	48.24	29.97
08-09	4489	3340	74.40	93.72	1639	745	45.45	27.21
09-10	4532	3422	75.51	93.95	1875	910	48.53	44.85
10-11	4666	3430	73.51	92.63	1679	810	48.24	34.54

Although students may enter CTE classes with the pre-requisite math, three typical scenarios unfold as described by RCC career technical education (CTE) department heads: 1) student math skills are so low that substantial in class remediation is required to cover the most basic skills; 2) students succeed in their math classes but cannot apply the concepts to CTE coursework; and/or 3) the traditional math sequence delays the introduction of math topics critical to specific CTE areas which adds considerable time to a student's training

As noted above, research on student placement into college math indicates that placing into college-level math following high school can be increased simply by taking a math course in the senior year (National Commission on the High School Senior Year (ACT, 2005; Berry, 2003; Hoyt and Sorenson, 2001; Roth, et. al 2001). [30-33] In Oregon, the current high school diploma will require three years of math beginning with the Class of 2010. By 2014, this additional math requirement must be two years beyond Algebra I. This presents a daunting challenge to many high school principals and curriculum coordinators who already question whether all of their students will successfully complete Algebra II (traditional sequence is Algebra I, Geometry, and Algebra II). The Oregon State Department of Education (ODE) has indicated that an applied or integrated course will fit this new math requirement because it will be considered as "value-added" math. This could be good news in support of CTE programs since some area high schools have opted to end CTE programs in favor of hiring more math teachers.

The need for remedial math is of importance to students interested in career technical education (CTE). Electronics, Construction, Automotive, Diesel, and Manufacturing are among the CTE one-year certificate and two-year degree programs at RCC. Some of these programs also have short-term State approved Career Pathway Certifications. Despite the slowing of the economy overall, all are critical to the local region and state. Construction, for example, has been one of the fastest growing sectors locally for

the past several years. According to the State Regional Economist, the 2006-2016 employment forecast for construction shows overall job growth of 16 percent, and 7.3 percent for manufacturing which includes occupations in electronics in Region 8 (Jackson and Josephine counties) between 2006 and 2016. Within automotive technology, mechanics and technicians are projected to grow by 16.1 percent in the region; and in diesel technology, such major occupations as bus and truck mechanics, and diesel engine specialists are projected to grow by 14.1 percent in the region. It is noteworthy that more than 90% of RCC's CTE graduates are hired, despite the economic downturn in the state and the nation. [34]

RCC students enrolled in career technical education (CTE) courses have varying levels of math pre-requisites and math requirements. Pre-requisites for most include Math 60 through 65, with the exception of the Computer Numerical Control (CNC) Technician students who need MTH 112, an AAOT course. The successful CTE graduate has a mathematics proficiency at the Basic Algebra I level along with some elements of Algebra II, and in some cases must be familiar with applications of right triangle trigonometry and basic statistical analysis. Despite this modest level of proficiency, many CTE students struggle with mathematics and are not well-served by the traditional algebra to calculus course sequence.

Approximately 38.5% of non-dual enrolled students in Math 60 received sub-standard grades from 05/06 to 08/09. Among these students, some spent one or more terms bringing their math skills to a level required for a program of study, but more frequently students receiving a poor grade did not re-enroll in math at all (52.8%). Thirty-six percent (36.0%) of those who received a poor grade in Math 60 and did not re-enroll in any math have also not subsequently enrolled in any other credit courses at RCC.

SECTION 3: RESEARCH QUESTIONS

Clearly, many students get discouraged which can adversely impact student retention, completion, and financial aid standing. Likewise, CTE instructors spend precious time and resources reviewing pre-requisite math concepts that support their content areas, despite the fact that students have already met the math pre-requisites by transcript or by the placement test. Increasing evidence suggests that CTE programs nationally are appealing to more students because of applied teaching strategies and contextual applications. Math is inherent in CTE coursework and it is inextricably interwoven into individual course and program outcomes. **These observations led us to ask "how can the institution better serve its CTE students so that they comprehend and retain the essentials of mathematics needed for future study and career development?"**

Research confirms that context-specific instruction is essential if students are to interact with material at more than an algorithmic level, and that selecting applications that will shortly be in practice is an effective and efficient approach to instruction. Consequently, investigators seek to develop curriculum that directly and unequivocally prepare students mathematically for CTE coursework by using curricula that uses the math from CTE programs. **These observations led us to ask whether teaching algebra with this approach will adequately prepare Math 63 students to successfully re-enter the traditional sequence at Math 65.**

Investigators concluded that they wanted to study and find solutions to: 1) the math remediation needs of community college and high school students; 2) the third year high school math diploma requirement for students interested in CTE; 3) inadequate and financially burdensome curricular math options for CTE college students; and 4) the lack of knowledge about college math requirements of high school teachers and administrators. In the process, they will also seek to determine the following:

- Can curriculum be written that is entirely composed of CTE applications and still meet the prerequisites for the next math class in the traditional sequence;

- Can a curricular format matched to the college's CTE programs and shared with other technical community colleges and high schools in an electronic format allow others to adapt the new curriculum to their CTE applications;
- Can a larger dialogue begin between interested colleges to create a living curriculum be accessed by any high school or college teacher to enliven traditional mathematics courses that gets beyond the expense and irrelevance of a published text?

SECTION 4: FINDINGS

Quantitative and Qualitative Metrics of Algebra I course on Student Success: Student achievement results are disaggregated by the one section pilot in spring 2010-11 (Table 1) and the three sections in 2011-12 (Table 2). In the pilot, 70% of students passed Math 63 as compared to 56% of Math 60 students. Though the sample size was small, results were preliminary but positive in both critical thinking advancement and achievement of credit. In year 2, the larger Math 63 cohort of 34 students as compared to Math 60 students (112) from the same CTE areas also achieved a greater pass rate than their Math 60 peers by 27.47%, affirming a positive trend among CTE students in Math 63. Given low numbers of women and minorities in Math 63, however, the *Math 67* project team will allocate greater resources to recruiting under-represented students plus veterans (per new NSF priority) from CTE/STEM target areas.

Table 1: Comparison of Pilot Math 63 with Traditional Math 60, Spring Term 2011										
	Students		**Male**		**Female**		**White**		**Minority**	
	#	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
Math 63	10		5	50	5	50	7	70	3	30
Passed Course	**7**	**70.0**	**3**	**60**	**4**	**80**	**5**	**71.4**	**2**	**66.7**
Math 60	529		245	46.3	284	53.7	403	80	101	20
Passed Course	**298**	**56.3**	**127**	**51.8**	**171**	**60.2**	**236**	**58.6**	**53**	**52.5**
Table 2: Comparison of Target CTE Students in Math 63 with Traditional Math 60, 2011/12										
	#	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
Math 63	34		32	94.12	2	5.88	30	88.24	2	5.88
Passed Course	23	67.65	23	71.88	0	0	20	66.67	1	50.0
Math 60	112		102	91.0	10	8.93	80	71.34	24	21.43
Passed Course	45	40.18	43	42.16	2	20.0	30	37.5	11	45.83

Most recent data: Fall 2012		
Course #	# CTE students	Pass Rate
Math 60	22	36.4
Math 63	18	72.2

External Evaluation: Corroborating Math 63 quantitative data is the qualitative data collected and analyzed by SOURCE (Southern Oregon University Research Center for Evaluation), the second year external evaluator. Overall, interview results point to the value and effectiveness of this course from four perspectives: High school teachers, high school students, community college faculty, and community college students. Below are excerpts from the SOURCE final report. **High school: Interviews with the five high school teachers who implemented Math 63.** All appreciated Math 63 because it fulfilled a state requirement for a third year of math beyond Algebra 1, and they were pleased to have a new course

for their struggling math students. There was unanimity in their positive assessment of the applied curriculum and its relevance for their students. One explained, "I think the problems are mathematically rich. And I think that the applications lend themselves to that building of curiosity that is really important for learners." Another noted the curriculum's flexibility saying it accommodated learners at various levels, "it can be taught at a differentiated rate -- some of the kids can really extend this and do the challenge problems, and some kids just want to get to a certain level, and that's good." **Approximately six students from each high school's Math 63 class were interviewed.** There were two consistent themes from the 30 students about (1) Applied Problems: Most appreciated the Math 63 problem- solving that was, as one young person put it, "based in real life; and (2) Supplemental Math 63 Activities: These activities helped with comprehension. **Community College**: Like the high school teachers, the two community college instructors who taught Math 63 pointed to the applied curriculum as the key strength. One explained, "it makes sense…they seem to enjoy it because they're not just working a math problem. They're solving a problem!" The other said, "Students see how the problems apply to their career major." In interviews held with 13 RCC Math 63 students, the applicability of the coursework was discussed as a major strength of the curriculum. Students chimed in with comments like, "It's more applicable to your trade" and others explained that they use the formulas in their career technical classes. **Summer Math Institute (SMI) and Professional Learning Community (PLC):** Participants from 2011 and 2012 gave high scores, and 100% would recommend SMI to others (see letters of support). Table 3 aggregates scores regarding the application, proficiency and relevance of the labs held in five RCC CTE areas on how the curriculum applied to their math knowledge and teaching responsibility.

Table 3: SMI 2011				
Totals	**Response**	**Applications**	**Proficiency**	**Relevance**
18 Participants: High School - 12 Comm. College - 6	Agree	92%	48%	92%
	Neutral	5%	26%	7%
	Disagree	3%	6%	1%

In Table 3, neutral and disagree responses were concerns over proficiency and technical background required for context in the CTE areas. This is supported by the lower percentages under "Proficiency." For SMI 2012, 23 participants addressed the quality of the experience, textbook, and potential to sustain SMI on fees and graduate credit awarded (14 high school teachers, 2 middle school teachers, and 7 community college math faculty. (*Graduate credit for licensure required only for high school teachers.)

Table 4: SMI 2012 (Scale: 1/low to 5/high)			
Overall Quality	**Textbook**	**Attend SMI if fee?**	**Attend if Grad Credit?***
4.56%	4.48%	65.2%/Yes; 17.4%/Maybe;17.4%/No	61%/Yes; 39%/No

Representative teacher attitudes about SMI's impact on CTE:

- "The technical math is heavy in fractions and order of operations, 2 areas where my students are weak. This curriculum fills that gap. ..It's not just the paper/pencil/calculator math that's needed.
- "Getting a chance to manually work with objects that we take for granted and having to calculate, design, and plan using the math behind these objects really made the math hit reality for me. It made me excited to be teaching the math that can actually do this kind of stuff."

Investigators established a professional learning community among the high school instructors and are successfully carrying on email conversations as to the use and application of the activities. Their feedback is being considered and assimilated by the investigators in the improvement of the course and its activities.

Investigators designed and piloted the Summer Math Institute (SMI) to acquaint 25 community college and high school instructors with the text, its applications and this philosophy of teaching mathematics. It consisted of four days where the attendees were immersed in one CTE area per day and its attendant mathematical applications. They calculated and cut rafters, designed and built electrical circuits with resistors and volt meters, and put their hands on Cummins diesel engines to see what makes them work. Participants were universally enthusiastic, engrossed in the activities, and made numerous comments about the value of the institute. One participant said that, "it was the best professional development that he had ever attended". Another made a point of finding the investigators at the end expressing that he arrived skeptical but left inspired and has since made efforts to include the material in his community college courses.

The investigators conclude that their efforts to enliven the understanding of mathematics, by taking their curricular cues from real world applications, universally increased enthusiasm and engagement in students and teachers. Math teachers, by necessity, train at university mathematics and seldom have opportunity to be exposed to the myriad of uses that people are making every day of that mathematics. Simple exposure to some of these applications and a curriculum of interesting problems made a measureable and obvious qualitative and quantitative difference in the students and teachers in the pilot course and summer math institute.

A grant from the National Science Foundation (NSF) has made this study and curriculum possible. For access to a free copy of the curriculum and its resources, contact us by email for our website address, username and password.

REFERENCES

1. James R. Stone, III, Corinne Alfred, Donna Pearson, Morgan V. Lewis, and Susan Jensen, *Building Academic Skills in Context: Testing the Value of Enhanced Math Learning in CTE*, National Research Center for Career and Technical Education, Grant Number V051A990004 and VO51A990006, p. 1, July 2006, Website: http://cehd.umn.edu/nrccte/publications/ PDFResearch/ MathLearningFinalStudy.pdf.

2. John Glenn, Commission Chairman, *Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century, pp.* 24-37, Published 2000, Website: www.ed.gov/americacounts/glenn.

3. National Association of Manufacturers, *To The Point, Talking Points for Manufacturers*, March 2007, Website:www.nam.org/PolicyIssueInformation/SiteContent/TothePointTalkingPoints forManufacturers.aspx.

4. Semiconductor Industry Association, *Choose to Compete*, Website: http://www.choosetocompete.org/21st_century_workforce.html.

5. American Society of Civil Engineers (ASCE), *This Week In Washington*, Website: http://www.asce.org/ pressroom/news/grwk/event_release.cfm?uid=1717.

6. Gerald A. Goldin, *Representation in Mathematical Learning and Problem Solving,* pp.197-218), Handbook of International Research in Mathematics Education, London: Erlbaum Associates (2002)

7. David T. Conley, *College Knowledge: Getting In Is Only Half The Battle.* Principal Leadership, 6(1), (2005).

8. Jeff E. Hoyt, Colleen T. Sorenson, *High School Preparation, Placement Testing, and College Remediation.* Journal of Developmental Education, 25(2), 26-34 (2001).

9. David T. Conley, *College Knowledge: Getting In Is Only Half The Battle.* Principal Leadership, 6(1), (2005).

10. Margaret T. Orr, Debra D. Bragg, *Policy directions for K-14 education: looking to the future.* In B. K. Townsend & S. B. Twombly (Eds.), Community colleges: Policy in the future context (pp. 101-127). Wesport, CT: Ablex. (2001)

11. James R. Stone, III, Corinne Alfred, Donna Pearson, *Rigor And Relevance: Enhancing High School Students' Math Skills Through Career and Technical Education,* American Educational Research Journal, (2008).

12. Gene Bottoms and Marna Young, "How States Can Join Academic and Technical Studies to Promote More Powerful Learning," Southern Regional Educational Board, 2008, p.i, Website: http://www.sreb.org/publications/2008/08V07CraftingNewVision.asp.

13. James R. Stone, III, Corinne Alfred, Donna Pearson, Morgan V. Lewis, and Susan Jensen, *Building Academic Skills in Context: Testing the Value of Enhanced Math Learning in CTE*, National Research Center for Career and Technical Education, Grant Number V051A990004 and VO51A990006, p. 1, July 2006, Website: http://cehd.umn.edu/nrccte/publications/ PDFResearch/ MathLearningFinalStudy.pdf.

14. Guy Tauer, *Regional Profile: Industry Employment in Region 8*, Oregon Labor Market Information System, pp. 1-2.

15. James R. Stone, III, Corinne Alfred, Donna Pearson, Morgan V. Lewis, and Susan Jensen, *Building Academic Skills in Context: Testing the Value of Enhanced Math Learning in CTE*, National Research Center for Career and Technical Education, Grant Number V051A990004 and VO51A990006, p. 1, July 2006, Website: http://cehd.umn.edu/nrccte/publications/ PDFResearch/ MathLearningFinalStudy.pdf.

16. Joyce Hammer, *High School to Community College Transitions: The Effect of Taking the Applications of Mathematical Reasoning Course*, Unpublished Dissertation, Oregon State University, 2009.

17. Thomas R. Bailey, Katherine L.Hughes, Melinda M. Karp, *What Role Can Dual Enrollment Programs Play in Easing The Transition Between High School and Postsecondary Education?* Community College Research Center and Institute on Education and the Economy (2002).

18. Harold L. Schoen and Christian R. Hirsch, *Responding to Calls for Change in High School Mathematics: Implications for Collegiate Mathematics,* The Mathematical Association of America, p. 114, February 2003.

19. James R. Stone, III, Corinne Alfred, Donna Pearson, *Rigor And Relevance: Enhancing High School Students' Math Skills Through Career and Technical Education,* American Educational Research Journal, (2008).

20. Thomas R. Bailey, Vanessa S. Morest, (Eds.) *Defending The Community College Equity Agenda*. Baltimore: Johns Hopkins University Press, (2006).

21. Thomas J. Kane, Cecilia E. Rouse, *The Community College: Educating Students At The Margin between College And Work.* Journal of Economic Perspectives. 13(1), 63-84. (1999).

22. National Commission on the High School Senior Year, *Raising our sights: No high school senior left behind*. Princeton, NJ: Woodrow Wilson National Fellowship Foundation (2001).

23. ACT, Inc. *Courses Count: Preparing Students for Postsecondary Success,* Iowa City, IA: (2005).

24. Laura Berry, *Bridging the Gap: A Community College and Area High Schools Collaborate To Improve Student Success In College.* Community College Journal of Research and Practice: 27: 393-407 (2003).

25. Jeff E. Hoyt, Colleen T. Sorenson, *High School Preparation, Placement Testing, and College Remediation.* Journal of Developmental Education, 25(2), 26-34 (2001).

26. Jeffry Roth, Gerald G. Crans, Randy L. Carter, Mario Ariet, & Michael B. Resnick, *Effect of high school course-taking and grades on passing a college placement test.* High School Journal, *84*(2), 72-84. (2001*).*

27. Guy Tauer, *Regional Profile: Industry Employment in Region 8,* Oregon Labor Market Information System, pp. 1-2.

28. Southern Oregon Regional Economic Development, Inc., 2007 Comprehensive Economic Development Strategy Plan, p. 5. Website: http://www.soredi.org/Files/ 07%20 CEDS% 20Report.pdf.

29. Alliance for Excellence in Education, *Paying Double: Inadequate High School and Community College Remediation*, Issue Brief August 2006, p. 4.

30. ACT, Inc. *Courses Count: Preparing Students for Postsecondary Success,* Iowa City, IA: (2005).

31. Laura Berry, *Bridging the Gap: A Community College and Area High Schools Collaborate To Improve Student Success In College.* Community College Journal of Research and Practice: 27: 393-407 (2003).

32. Jeff E. Hoyt, Colleen T. Sorenson, *High School Preparation, Placement Testing, and College Remediation.* Journal of Developmental Education, 25(2), 26-34 (2001).

33. Jeffry Roth, Gerald G. Crans, Randy L. Carter, Mario Ariet, & Michael B. Resnick, *Effect of high school course-taking and grades on passing a college placement test.* High School Journal, *84*(2), 72-84. (2001*).*

34. Guy Tauer, *Regional Profile: Industry Employment in Region 8*, Oregon Labor Market Information System, pp. 1-2.