Capitalizing on Context: Curriculum Integration in Career and Technical Education

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NRCCTE Curriculum Integration Workgroup

NRCCTE
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A Joint Report of the NRCCTE Curriculum Integration Workgroup

University of Louisville

Donna Pearson
Jennifer Sawyer

Cornell University

Travis Park
Laura Santamaria
Elizabeth van der Mandele
Barrett Keene
Marissa Taylor

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National Research Center for Career and Technical Education
University of Louisville
Louisville KY 40292

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Executive Summary

The NRCCTE has undertaken three scientifically based research studies in an effort to determine whether the integration of career and technical education (CTE) courses with academic content can increase student achievement. These include the Math-in-CTE study, completed in 2005 (also known as *Building Academic Skills in Context*; Stone, Alfeld, Pearson, Lewis, & Jensen, 2006); the Authentic Literacy Applications in CTE pilot study, completed in 2009, with a full-year study launched in 2010; and the Science-in-CTE pilot study, launched in 2010. Each of these three studies was designed as a group-randomized trial in which teachers and their classes were randomly assigned to control and experimental groups. Each also employed a mixed-methods approach intended to capture qualitative data in order to ensure fidelity of the treatment.

This report contains a summary of findings from the Math-in-CTE study, with emphasis on the five core principles that emerged from the study. Evaluation data collected from Math-in-CTE technical assistance sites further illustrate these principles. This report also contains findings from the Authentic Literacy in CTE pilot study and evidence from that study supporting the five core principles.

The Math-in-CTE study began as a pilot in the spring semester of 2004; the full-year study spanned the 2004-2005 academic year. Volunteer teachers assigned to the experimental groups worked with math teacher partners to examine the CTE curricula and develop math-enhanced CTE lessons. The experimental CTE teachers implemented the math-enhanced lessons in their classrooms, while the control group teachers taught their courses without changing their curricula. After one year of learning math-enhanced lessons, students in the experimental classrooms performed significantly better on two of the three standardized measures of math achievement. This result was accomplished without reducing students' occupational knowledge and skills.

The improved math achievement of students was attributed to (a) the pedagogic framework that ensured the transfer of learning and (b) an extended process of professional development that provided an environment that encouraged the emergence of communities of practice. The study revealed five core principles essential to successful integration:

1. Develop and sustain a community of practice among the teachers.
2. Begin with the CTE curriculum and not the academic curriculum.
3. Understand that academics are essential workplace knowledge and skills.
4. Maximize the academics in the CTE curriculum.
5. Recognize that CTE teachers are teachers of academics-in-CTE, and not academic teachers.

The creation of the NRCCTE's Math-in-CTE technical assistance project provided a means through which to broadly implement this tested approach. Math-in-CTE technical assistance strives to maintain consistency and accuracy in the implementation of the tested model in new and different settings; measures are taken to ensure that implementations will result in students' improved math abilities. Evaluation data collected from the technical assistance sites support the core principles revealed in the study.

The purpose of the Authentic Literacy in CTE pilot study was to determine the impact of disciplinary literacy strategies on the reading comprehension, vocabulary development, and motivation to read for students enrolled in CTE courses. Using an experimental design, the researchers randomly assigned teachers to one of three groups: a control condition and two models of content-area reading interventions. Researchers compared the effects of literacy strategy instruction on the aforementioned measures of student achievement. During the half-year pilot study, researchers refined and tested existing reading models and instructional strategies to improve reading comprehension of all CTE students, even those who struggle with reading for content knowledge and solving problems. Researchers conducted student focus group sessions and teacher interviews in addition to the experimental pilot study.

Reading strategy instruction produced a statistically significant impact on reading comprehension and vocabulary learning but did not impact students' motivation to read. Analysis of teacher interviews yielded six main themes related to creating opportunities for successful strategy use in CTE courses: developing teacher confidence, building communities of practice related to literacy, utilizing authentic text in CTE courses, providing professional development in literacy strategies, making strategy adjustments to meet the needs of CTE fields, achieving framework adoption, and experiencing student receptiveness. Through student focus groups, researchers found four main themes that defined the findings: students desired a utility value in their strategy use; students understood the importance of reading to their career; students engaged in reading if they could apply the information; and students desired a social aspect to reading to foster motivation.

Findings from the Authentic Literacy pilot project supported the core principles from the Math-in-CTE project. In schools in which a critical mass of teachers within the same group were participating in the pilot study, communities of practice grew organically. Other teachers indicated that they sought interactions with their peers regarding literacy and wanted feedback on their ideas for implementing the literacy frameworks; these teachers sought communities of practice. From the outset, all professional development began with the CTE curriculum. All teachers involved in the pilot study realized and affirmed that reading and writing skills and knowledge are essential to developing competent leaders in all CTE fields. Through the professional development, teachers determined where they could maximize the authentic literacy applications in their CTE curriculum. Finally, during the professional development, facilitators disabused teachers of the notion that they were expected to be English teachers. Realizing this, CTE teachers implemented the literacy frameworks into their curriculum in an authentic, purposeful, and explicit manner.

A full-year test of the Authentic Literacy in CTE model will conclude in the summer of 2010. The Science-in-CTE pilot study will conclude in the summer of 2010; a full-year test of the model is proposed for 2010-2011.

Capitalizing on Context: Curriculum Integration in Career and Technical Education

The integration of career and technical education (CTE) with academics is a topic not only of considerable interest but also of considerable investment in terms of money and human resources. A simple internet search yields hundreds of links to information about curriculum integration theories, models, and programs. Nationwide, whole conferences are sustained by the belief that integration works. Educators and students alike have declared the value of integrated courses. Yet for all the acclaim and support curriculum integration has received, the scientific evidence of its effectiveness has been scant and systematic implementation elusive.

Furthermore, although legal definitions are embedded in legislation (particularly in Perkins IV), a proliferation of terms and concepts is used to describe curriculum integration in the literature—sometimes used interchangeably and sometimes not. Exacerbating the situation is an obvious disjuncture between the aims of education in the CTE and academic worlds—both in meaning and theoretical underpinnings. The outcome is a lack of understanding among researchers, policymakers, administrators, and educators as to what curriculum integration is or ought to be.

This report is a work in progress that contains a synthesis of the research findings from scientifically based curriculum integration studies conducted by the National Research Center for Career and Technical Education (NRCCTE). We first present a summary of the Math-in-CTE study (also known as *Building Academic Skills in Context*; Stone, Alfeld, Pearson, Lewis, & Jensen, 2006) and of ongoing Math-in-CTE technical assistance activities that followed the study. We follow with preliminary findings from the Authentic Literacy Applications in CTE study, which is moving from the pilot stage to a full-year study this year (2009-2010). Finally, we introduce the Science-in-CTE study, which is beginning as a semester-length pilot in the spring of 2010. These research presentations are focused on the five core principles that emerged from the original Math-in-CTE study. In this way, we believe our research contributes to a clarification of what curriculum integration is and what makes it work.

The Math-in-CTE technical assistance facilitation teams who have been implementing the curriculum integration model across the country, along with the state leaders with whom they work, often describe the model as a "new paradigm"—a new way to think about preparing our teachers, as well as a new way of teaching. Some have rather humorously described it as an effort equivalent to "turning around a battleship." The images and expressions people have used to describe this change in approach vary widely; however, they reveal a common thread. This endeavor to integrate CTE and academics, though desired, challenges the status quo and stands in contrast with systems and traditions that have long been in place. This revelation is not new; rather, it strongly resonates with themes uncovered in earlier work by Grubb, Davis, Lum, Plihal, and Morgaine (1991). We draw on their work and that of others in order to provide context and background for the NRCCTE's curriculum integration studies and a sense of why it is important to keep history in mind as we move forward with these efforts.

The integration of academics into the CTE curriculum is a major policy objective of the most recent iteration of the Carl D. Perkins Vocational and Technical Education Act (referred to as Perkins IV) and those that preceded it in 1985, 1990, and 1998 (Hoachlander, 1999). The Perkins IV legislation explicitly links the concept of professional development to improved teaching practices, as measured by student outcomes. It requires “the integration of coherent and rigorous academic content standards and career and technical education curricula, including through opportunities for the appropriate academic and career and technical education teachers to jointly develop and implement curricula and pedagogical standards,” and professional development that “is high quality, sustained, intensive and increases academic knowledge” (Carl D. Perkins Career and Technical Education Act of 2006, S. 250, Sec. 122 (c)(A), p. 36).

A Brief Historical Background

This current mandate stands in stark contrast to the Smith-Hughes Act of 1917, which gave legislative birth to vocational education in the United States. Although the movement toward vocationalism in American education was clearly underway prior to the passage of the Smith-Hughes Act, this landmark legislation formalized and funded vocational education as a separate track of education for the working class in the United States (Lazerson & Grubb, 2004; Wirth, 1980). As Kliebard (2004) summarized:

> By 1917, the main direction of vocational education was sealed—job skill training in the public school supported generously by federal government…. With money, powerful lobbying groups, energetic leadership in high places, and a sympathetic public, vocational education was well on its way to becoming the most successful curricular movement of the twentieth century. (p. 123)

At that time, Charles A. Prosser (who authored the Act) and David Snedden were champions of “real vocational education.” They advocated for a separate system of schools in which training programs prepared graduates for specific occupations. Wirth (1980) noted this important distinction made by Snedden: “Vocational education was designed to make an efficient producer and liberal education was intended to train the efficient consumer” (p. 158).

In contrast to Prosser and Snedden, John Dewey (1944) argued for designing curricula so that students could be educated *through* the occupations rather than *for* the occupations. Rather than conceptualizing narrow, specific job skills as the goal of occupational courses, Dewey believed that occupational contexts could provide a rich venue through which students could effectively learn important fundamental concepts in traditional subject matter. Kliebard (2004) suggested that Dewey’s position, although not effective at stemming the “tide of direct trade training” (p. 129), may have in some way helped prevent the pursuit of completely separate systems of education and what amounted to educational predestination for certain populations of children.

Kliebard (2004) described the shift of curricular focus that occurred at the turn of the twentieth century, prior to the passage of the Smith-Hughes Act:

> With the change in the social role of the school came a change in the educational center of gravity; it shifted from the tangible presence of the teacher to the remote knowledge and values incarnate in the curriculum. By the 1890s, the forces that were to struggle for control for the American curriculum were in place, and the early part of the twentieth century became the battleground for that struggle. (p. 1)

He identified the forces driving this change as: (a) humanists who promoted the traditional academic curriculum, (b) developmentalists who promoted a scientific curriculum, (c) social efficiency educators who promoted vocational education, and (d) social progressives who promoted an issues-based curriculum. With regard to vocational education, Kliebard stated, "vocational education was the most successful curricular innovation in the twentieth century in the sense that none other approached it in the range of support it received and the extent to which it became implemented into the curriculum of American schools" (p. 127).

Some may question why this conversation is noteworthy; however, the historic dissonance underlying these conflicting curricular perspectives is still with us, often unacknowledged and clearly unresolved, as Kliebard further described:

> No single interest group ever gained absolute supremacy, although general social and economic trends, periodic and fragile alliances between groups, the national mood, and local conditions and personalities affected the ability of these groups to influence school practice as the twentieth century progressed. In the end, what became the American curriculum was not the result of any decisive victory by any of the contending parties, but a loose, largely unarticulated, and not very tidy compromise. (Kliebard, 2004, p. 25)

The ideals and goals represented by these varied perspectives are fundamentally different and serve competing interests. Yet the vast majority of students served by the educational system enter the workplace, raise families, and contribute as citizens to their communities and country. Some educators argue that the persistence of the academic-vocational debate diminishes the potential for infusing relevance and innovation into students' educational experiences.

It is difficult to disentangle the current movement toward curriculum integration from the barriers created by past legislation and, more significantly, from established educational systems and subsequent traditions of curriculum and instruction that separated vocational education from academic education for more than a century. The historically grounded dual system of education frustrates current efforts to integrate curriculum and instruction in CTE programs. As Grubb et al. (1991) stated:

> Vocational and academic education have been growing apart at least since 1890; the split between the two is a deep one—one which affects content and purpose, teaching methods, teacher training and philosophy, the kinds of students in vocational and academic programs, and status. Healing this division is a difficult and time-consuming process. (p. 2)

In essence, the field of CTE is attempting not just to integrate curriculum, but also to re-connect educational traditions that have been historically legislated and funded to operate separately. The images of vocational education as an inferior educational option for the "rank and file worker," set apart from the rigor of the academics or the relevance of progressive education, remain fixed in the minds of many. In the course of the NRCCTE's work with research and technical assistance, we have found that these images not only persist, but frequently confound efforts to educate young people through CTE courses and programs. We continue to serve teachers in schools in which CTE programs are located in a separate wing or building. One teacher described his classroom location as “where the carpet meets the concrete.” We continue to hear stories of parents who wish for the best possible future for their children and resist what they perceive to be a “second-best education” or a “blue-collar” future. Secondary CTE teachers have noted that the increased emphasis on academic credits for college preparation has resulted in fewer opportunities for students to select CTE courses.

Given the untidy history of the vocational-academic debate, it should come as no surprise that resistance or indifference to CTE and academic integration persists. One of the teachers currently participating in Math-in-CTE technical assistance asked why the teaching of academics had fallen to CTE teachers. Why, he asked, weren’t academic teachers equally responsible for making changes to contextualized teaching as CTE teachers were for teaching academics?

Why Integration?

The answer to this teacher’s question is, in part, found in what the workplace demands, which has become increasingly similar to the objectives and aims of postsecondary education. The two are no longer mutually exclusive, as many high-skilled trades require some form of postsecondary training. Meeting the increasing needs of the field and supporting high academic standards requires procedural and academic rigor in the career and technical curriculum. A survey conducted by the National Association of Manufacturers (NAM, 2005) suggested that many public schools are not producing employees who are qualified for entry-level positions. Citing the prevalence of technology in manufacturing, NAM claimed that the low-skilled division of the workforce is rapidly disappearing. The increasing number of retiring baby boomers has also contributed to a majority of companies reporting a shortage of skilled workers. Of those companies noting this shortage, nearly half reported that they had left positions unfilled because of unqualified applicants.

Another, more compelling answer is found in national achievement data, which show flat or declining scores in student academic achievement. The need to sustain and increase academic achievement of students in the United States is well-documented in the literature. As the National Governors Association (NGA, 2007) reported:

> On a variety of STEM indicators, it is clear that too many of our high school graduates are not prepared for postsecondary education and work. A recent study by ACT, Inc., has demonstrated that regardless of a student’s postsecondary pathway, high school graduates need to be educated to a comparable level of readiness in reading and math proficiencies. Nearly three out of 10 first-year college students are placed immediately into remedial courses. In the workforce, employers report common applicant deficiencies in math, computer, and problem solving skills. A wide variety of studies and indicators have demonstrated that our education system continues to fail to prepare many students for the knowledge based economy. (p. 1)

Today’s demands on students’ academic skills, particularly literacy, are more intense than at any other time in history (Alvermann, 2001; Kamil, 2003; Moore, Bean, Birdyshaw, & Rycik, 1999; NGA, 2005; Snow & Biancarosa, 2004). The consequences of illiterate graduates entering the workforce and society are severe, detrimental, and limiting. Individuals lacking literacy skills fail to fully participate in careers and society (Cappella & Weinstein, 2001; National Association of Secondary School Principals, 2005; National Association of State Boards of Education [NASBE], 2006; Wright, 1998). High school graduates need proficient literacy and reading skills in order to succeed in school, develop lifelong careers, participate in democracy, and navigate the information age (Forget & Bottoms, 2000; Guthrie, Schafer, Wang, & Afflerbach, 1995; Kamil, 2003; Meltzer, 2001; Snow, 2002; Vacca, 2002).

Although the most recent TIMSS report (Gonzales et al., 2008) showed that U.S. students score higher than the TIMSS scale average of 500, science scores of eighth-grade students have not measurably increased since 1995: “The U.S. eighth-grade average science score in 2007 was 520 and in 1995 was 513” (p. 34). Only 10% of U.S. eighth graders performed at or above the advanced benchmark. The introduction to the new National Science Education Standards (National Committee on Science Education Standards and Assessment and the National Research Council, 2007) opens with this statement:

> Science understanding and ability will enhance the capability of all students to hold meaningful and productive jobs in the future. The business community needs entry-level workers with the ability to learn, reason, think creatively, make decisions, and solve problems. In addition, concerns regarding economic competitiveness stress the central importance of science and mathematics education that will allow us to keep pace with our global competitors (p. 12).

As with math achievement, data also indicate that an increase in required science credits does not result in increased science achievement. National Assessment of Educational Progress (NAEP, 2005) data show that despite an increase of required credits from 1.4 in the mid-1980s to 3.2 in 2004 (Silverberg, Warner, Fong, & Goodwin, 2004), student scores on tests of science achievement have not increased. In fact, NAEP data show that at the Grade 12 level, the average score for science achievement has declined since 1996. In 2005, only 54% of students scored at or above the Basic level on the science exam. These data give credence to ongoing efforts to integrate CTE curricula as a means of increasing the academic skills of young people.

There also is mixed evidence as to whether completing CTE coursework contributes to students’ overall academic achievement. The National Assessment of Vocational Education (NAVE) (Silverberg, Warner, Goodwin, & Fong, 2002) stated that, “on average, vocational courses as currently structured do not appear to contribute to an increase in students’ academic achievement” (p. 97), especially in reading. Any gains students have made in reading achievement were most likely made despite, not because of, additional reading strategy instruction in CTE courses. An exception to the NAVE data was found in the Math-in-CTE study, conducted by the NRCCTE (Stone et al., 2006). This study provided compelling evidence that enhancing the math that naturally occurs in CTE curricula can improve the math skills of students. The replications of the Math-in-CTE pilot study and full-year experiment within agricultural classes were also analyzed and found to have a statistically significant impact on student math achievement (Parr, Edwards, & Leising, 2004; Young, Edwards, & Leising, 2008).

What we do know from the data is that more of the same is not working for our young people—that is, increasing academic requirements does equate to increased academic achievement.

Likewise, resistance to change on the part of CTE does not help students. Many believe a viable answer lies in curriculum integration efforts, through which it is possible for CTE teachers to identify and enhance the instruction of significant amounts of academic knowledge and skills embedded in the technical content. Curriculum integration also may help CTE teachers spend less time dealing with remediation in academic areas (Zirkle, 2004). Because the content of technical education is driven by the needs of the workplace, instructors maintain a close connection with "real work." Thus, opportunities abound for CTE teachers to provide their academic counterparts with authentic, problem-based activities through which students can apply academics in relevant ways. Learning the academics within a rich context helps students learn in an environment that reflects the way knowledge will be used in real life (Johnson, 1996).

What Is Curriculum Integration?

Recent versions of the Perkins legislation represent a major development in CTE—notably, an increased emphasis on academic achievement as well as occupational skills (Hayward & Benson, 1993; Rose, 2008). The Perkins IV legislation requires the integration of rigorous and challenging academic and career and technical education. Beyond that mandate, the legislation provides little detail about what the integration process should look like. Most obviously, the term *curriculum integration* is not used in Perkins IV. The lack of definition has enabled states, schools, and districts to customize integration plans to fit the needs and circumstances of their own students. However, that relative freedom and the ensuing variations in approach to curriculum integration have contributed to difficulties in reaching common understandings of essential terminology and concepts.

As a matter of history on the general subject of integration, Harold Alberty, an early advocate of curriculum integration, claimed during the 1940s that the demands of democratic citizenship required "marshalling, combining, and focusing the strengths of the disciplines for common problem solutions" (Bullough, 1999, "General and Specialized Education," para. 1). Alberty proposed five ranked models of integration, ranging from a simple blurring of subject lines to a totally constructivist, problem-based, student-oriented system. Along this continuum lie most of the curriculum integration models in use today.

By the broadest definition, any attempt to remove an academic subject area from its respective silo can be considered curriculum integration. Kysilka (1998) found that in its early stages, curriculum integration could mean "whatever someone decides it means, as long as there is a connection between previously separated content areas and/or skill areas" (p. 198). The ASCD (formerly known as the Association for Supervision and Curriculum Development) offers this definition: "Integration is a philosophy of teaching in which content is drawn from several subject areas to focus on a particular topic or theme" (ASCD, 2003).

Integration between content areas with closely related subject matter is often termed *interdisciplinary* (Harris & Alexander, 1998). This is generally the first effort to make connections between subjects. For example, language arts instruction has been enriched by the integrated teaching of reading and writing. Integration across established curricular boundaries has been more difficult to define and achieve.

Another way to frame curriculum integration is by its occurrence in relationship to the student experience. *Horizontal* curriculum integration occurs across subjects at the same point in time; this form of curriculum integration is frequently discussed in the literature. However, many educators have given attention to integration that is *vertical*—that is, deliberately sequential from one level of instruction to another (Grubb et al., 1991). Kerr (2000) proposed that vertical integration enhances critical concepts and abilities that increase as students progress through the curriculum. Beane (1993, 1997) found that effective integrated learning is more than simply connecting two or more disciplines, but also includes students' use of previous knowledge and experiences as foundation. Both perspectives are pertinent to our discussion to integration of academics with CTE.

Any effort to bridge academic subjects requires the valuable step of illustrating the relevance of each subject to the other, which in turn can lead to a more complete understanding of both. Furthermore, research indicates that integration that includes relevance to real-world applications might yield a bigger cognitive bang for the buck. Brown, Collins, and Duguid (1989) claimed that what is learned cannot be effectively separated from how it is learned. They compared an artificial method of learning language strictly from a dictionary with the natural process of learning words within the context of ordinary communication.

Experiential learning is based on the premise of a connection between learning and experience (Merriam, Caffarella, & Baumgartner, 2007, p. 169). Although numerous perspectives and theories exist as to how experiential learning works and for whom, educators generally agree on the value of relevance and application. The importance of relevance is prominent in the experiential learning theory of situated cognition, which promotes the context in which learning occurs as being central to understanding cognition (Brown et al., 1989; Paige & Daley, 2009). Brown and colleagues (1989) suggested that situated cognition requires us to consider knowledge as a set of tools that can (a) be useful only when understood and (b) vary in purpose based on the situation at hand. Situated cognition emphasizes learning experiences in "authentic versus decontextualized contexts" (Choi & Hannafin, 1995, as cited in Merriam et al., 2007, p. 180).

Although *context* is a term that can refer to a number of environmental, social, or cultural factors, "clearly, it is no longer possible to think about learning without context" (Niewolny & Wilson, 2009, p. 26). Because CTE courses and programs are context-rich, they are particularly well-suited to implementation of theories of applied and experiential learning. In fact, they may serve as laboratories for experiential learning because they inherently provide relevance and opportunity for immediate application.

Curriculum Integration in Career and Technical Education

We have found that curriculum integration in CTE is more easily described than defined. As we earlier noted, curriculum integration in CTE is an attempt to reconnect systems and approaches to education that have historically been at odds (Rose, 2008). Thus, the integration of academic content and the CTE curriculum involves much more than simply finding common instructional ground (Hoachlander, 1999).

The complexities are many. Johnson, Charner, and White (2003) found that curriculum integration in CTE requires flexibility on the part of administrators, students, teachers, and the entire school community. Reshuffling already crowded academic schedules and reallocating resources can create ripples of discontent among those who are resistant to change. Turf wars (McLeod, 2000) may arise over concerns about maintaining the integrity of course content (Zirkle, 2004) or perceptions that years of personal investment in a field of study are being disregarded. Beginning a program of curriculum integration involves not only a change in pedagogy and teaching methods, but also a willingness to bridge both sides of the perceived divide.

Kysilka (1998) proposed that in reality, the *how* of curriculum integration can take precedence over the *what*, potentially leading to superficial content. Based on our work with Math-in-CTE technical assistance, we contend that the how and the what of curriculum integration are not mutually exclusive. We suggest that it is helpful to think about the literature on curriculum integration and disparate terminologies contained therein along two dimensions: first, by identifying the structure of the model and/or its system of delivery, and second, by considering the teaching/learning approach of the model, which relates more to the substance of the integrated content. Both dimensions are essential to the successful implementation and sustainability of curriculum integration; they also provide a lens through which to consider the genesis or focus of integration efforts.

Grubb et al. (1991) offered a foundational, comprehensive look at curriculum integration. They found that both industry representatives and educators criticized a perceived narrowness of focus in CTE classes. In response, Grubb et al. proposed that the logical, authentic integration of academic content into CTE curricula provided both the academic and broader occupational needs of students. After observing integration efforts at schools across the country, Grubb et al. synthesized their findings into eight models that represented a continuum of curriculum integration efforts:

1. Incorporating more academic content in vocational courses: The CTE teacher incorporates more academic content into their instructional lessons;
2. Combining vocational and academic teachers to enhance academic competencies in vocational programs: The academic and CTE teachers collectively combine academic and CTE content into both subject areas;
3. Making academic courses more vocationally relevant: The academic teachers incorporate CTE subject matter into their lessons;
4. Curricular "alignment:" The modification of both CTE and academic courses;

5. Senior projects: The collective efforts of the academic and CTE teachers in organizing curriculum around student projects;
6. Academy model: School-within-a-school concept in which a team of teachers collaborate using a team teaching method to the same group of students;
7. Occupational high schools and magnet schools: A collaboration process between academic and CTE teachers in aligning courses in specific occupational areas; and
8. Occupational clusters, career paths, and occupational majors. Programs utilized in comprehensive high schools or specialized vocational schools in which the academic and CTE teachers usually belong to occupational clusters rather than traditional departments, thus encouraging collaboration. (pp. 14-15)

Reminiscent of Alberty's continuum (see Bullough, 1999), Grubb et al.'s (1991) models vary in point and method of delivery, curricular structure and schedule, and required resources. Hoachlander (1999) later condensed these models into four types of integration: course-level, cross-curriculum, programmatic, and school-wide. He recognized the variety of circumstances, resources, and structures across schools and proposed that even a modest effort at integration could produce a "deep and lasting understanding" (p. 9).

Context-based approaches to integration. A major issue in the current discussion on curriculum integration is the proliferation of terminologies and concepts used by the field to describe curriculum integration. For instance, terms such as *integrated*, *applied*, and *contextual* have been frequently used interchangeably, yet may hold different meanings in actual practice. Few attempts have been made to clarify these related but not synonymous terms (Czerniak, Weber, Sandmann, & Ahern, 1999; Dare, 2000).

This paper does not seek to identify or sort out all of the terms currently in use. Instead, we propose that two overarching classifications of curriculum integration emerge from the literature: *context-based* approaches and *contextualized* approaches. We believe that it is within these two predominant approaches that the various terms and concepts related to curriculum integration may be best situated and discussed.

A context-based approach provides a structure for academic instruction taught within a context that is relevant to the student. The distinction between this and a contextualized approach is found in the focus of the approach: the academic content. A context-based approach begins with the identification of academic content and situates it, sometimes literally, into a workplace setting. Ideally, students learn the academic content by doing, such as ongoing participation in a workshop classroom or by completion of a project.

We suggest that the term *applied academics,* as it is widely used in the literature, represents a context-based approach. Applied academics is a broad concept encompassing a variety of curricula, pedagogies, and methods. At one end of the spectrum, it has been criticized as a form of remedial instruction (Bragg, Layton, & Hammons, 1994; Dornsife, 1992; Rose, 2008); on the other, it has been utilized as a successful method for structuring learning in career academies. Applied academics typically focuses on academics, and the relevance it offers students may increase their engagement and achievement (Shields, 1997).

Applied learning may also be a component of applied academics. Hershey, Silverberg, Owens, and Hulsey (1998) found an emerging shift within applied academics away from identifying certain courses as applied, and toward applied content and contextual teaching methods within academic classes. This shift recognizes a differentiation of meaning between applied academics (programmatic) and applied learning (process-oriented).

Applied academics as a pedagogy usually, but not always, includes experiential learning; it reinforces the academic material and provides the "hook" of relevance (Knowles, Horton, & Swanson, 2005). Hull and Parnell (1991) described applied academics as the blending of "head skill" and "hand skill" (p. 70). The practice is often associated with curricula and learning materials such as those developed by The Center for Occupational Research and Development (CORD; see Dare, 2000; Dornsife, 1992). The CORD model organizes instruction around specific mathematics courses, such Algebra 1 or Geometry, and provides students with authentic workplace applications through which to learn mathematics concepts. However, applied academics can be also conceptualized as an almost entirely academic curriculum. In some states, carefully designed applied CTE courses provide students with academic credits (Meeder, 2008).

Contextualized approaches to integration. In contrast to the context-based approach, the genesis and focus of a contextualized approach to integration is the CTE content. In other words, the process of integration begins with the CTE curriculum and the identification and enhancement of the academic content naturally occurring within it. Contextualized teaching and learning does not require the sacrifice of CTE content or the addition of artificially imposed academic content. Rather, the academic concepts resident in authentic applications of CTE support the understanding of both; rigor resides in combining CTE and academic skills as applied to real-world problems.

The NRCCTE integration studies described in this report embody the contextualized approach to integration and are further illustrated by the core principles that emerged from in the Math-in-CTE study. Whereas other contextualized approaches may take the form of curricula, the NRCCTE integration models are not curriculum-bound. They provide a process and pedagogy through which CTE teachers enhance the academics in any CTE curriculum. Refuting the notion of integration as a static effort or an event, we hypothesize that these tested models will generate enduring and sustainable changes in teaching practice. In the sections that follow, we describe the NRCCTE's studies and focus on the core principles of curriculum integration identified by scientifically based research as we answer the question of what makes curriculum integration work.

What Makes Curriculum Integration Work?

The goal of the No Child Left Behind (NCLB) Act of 2001, which is to improve the academic performance of all students, required programs and practices implemented in schools to be based on rigorous scientific research. The Education Sciences Reform Act of 2002 also reflected the federal government's concern with a lack of rigor in education research. Because many schools are engaged in systemic reform involving the simultaneous implementation of multiple innovations, isolating the effects of a single program or activity is difficult at best (Guskey, 2002a).

Practitioners often grow weary and skeptical of the latest fads in educational reform. Many experienced teachers invest their time and energy in new initiatives, only to see them fade away. Teachers want instructional models that are tested and enduring, and policymakers want proof that a given program is a worthwhile use of their shrinking budgets. Only scientifically based research—that is, rigorously constructed experimental tests—can provide such proof (Coalition for Evidence-Based Policy, 2003; Cook, 2001; Cook & Payne, 2002; Guskey, 2002b; Mosteller & Boruch, 2002; National Research Council, 1998, 1999, 2000, 2002; Shadish, Cook, & Campbell, 2002). However, the term *research-based* is sometimes applied to practices that vary considerably in the scientific rigor of their investigation (National Staff Development Council [NSDC], 2009). The mandate for research-based programs raises questions regarding definition, enforcement and the quality of existing education research (Margolin & Buchler, 2004).

In response to the federal government's requirements regarding scientifically based research, many vendors tout their products and services as evidence-based and rely on anecdotal evidence or charismatic spokespeople to support what may be an unproven innovation (Margolin & Buchler, 2004). Section A of the NCLB legislation is frequently quoted when establishing a definition of scientifically based research; such research should:

(i) apply rigorous, systematic, and objective methodology to obtain reliable and valid knowledge relevant to education activities and programs; and
(ii) present findings and make claims that are appropriate to and supported by the methods that have been employed.

A more specific description of those research methods considered scientifically based occurs in Section B. These include:

(i) employing systematic, empirical methods that draw on observation or experiment;
(ii) involving data analyses that are adequate to support the general findings;
(iii) relying on measurements or observational methods that provide reliable data;
(iv) making claims of causal relationships only in random assignment experiments or other designs (to the extent such designs substantially eliminate plausible competing explanations for the obtained results);
(v) ensuring that studies and methods are presented in sufficient detail and clarity to allow for replication or, at a minimum, to offer the opportunity to build systematically on the findings of the research;

(vi) obtaining acceptance by a peer-reviewed journal or approval by a panel of independent experts through a comparably rigorous, objective, and scientific review; and

(vii) using research designs and methods appropriate to the research question posed. (Margolin & Buchler, 2004, "Six Criteria for SBR," para. 1)

Although research using other methodologies has value, educational practices grounded in scientifically based research increase the possibility that tested approaches will actually help students. Moreover, the impact on student academic achievement can be attributed to the interventions or practices. Such studies are generally difficult and costly to accomplish, particularly in complex educational settings. The NRCCTE has undertaken three such scientifically based studies in an effort to establish how the integration of CTE courses with academic skills can increase student achievement and knowledge. These include the Math-in-CTE study, completed in 2005 (Stone et al., 2006); the Authentic Literacy Applications in CTE pilot study completed in 2009, with a full-year study launched in 2010; and the Science-in-CTE pilot study launched in 2010. Each study has been designed as a group-randomized trial in which teachers and their classes are randomly assigned to control and experimental groups. Additionally, each has employed a mixed-methods approach intended to capture qualitative data in order to ensure fidelity of the treatment.

The Math-in-CTE Study[1]

Math-in-CTE was the subject of the first scientifically based curriculum integration study (Stone et al., 2006). Conducted from 2003-2005, the purpose of this national-level project was to help CTE teachers more explicitly teach mathematics concepts embedded in the occupational curriculum as necessary tools for solving workplace problems. This approach was designed to provide the dual benefit of improving students' mathematics skills and reinforce their general mathematics understanding.

Much of the mathematical knowledge required for both workplace success and entry into higher education is generally taught late in middle school or early in high school, with little follow-up or reinforcement for students who do not advance to courses in higher math. The study addressed how students' math knowledge and skills could be refreshed and enhanced during their final years in high school without detracting from the CTE skill-building required to meet the demands of the workplace. Based on considerable evidence regarding contextual learning, the Math-in-CTE researchers hypothesized that high school students learning in a math-enhanced CTE curriculum would develop a better understanding of mathematical concepts than students learning in a traditional CTE curriculum. The following research questions were thus posed:

1. Does a math-enhanced CTE curriculum improve math performance as measured by traditional and applied tests of math knowledge and skills?
2. Does enhancing a CTE curriculum reduce the acquisition of technical skills or knowledge?

[1] Unless otherwise noted, references to the Math-in-CTE study are from Stone et al. (2006), *Building Academic Skills in Context: Testing the Value of Enhanced Math Learning in CTE*. The full report is available at http://136.165.122.102/UserFiles/File/Math-in-CTE/MathLearningFinalStudy.pdf.

Volunteer teachers from five occupational areas participated in the study. These areas included agricultural power and technology, automotive technology, business and marketing, information technology, and health occupations. CTE teachers assigned to the experimental groups participated in professional development workshops in which they worked with math teacher partners to examine the CTE curricula and develop math-enhanced CTE lessons. The experimental CTE teachers implemented the math-enhanced lessons in their classrooms; the control group teachers taught their courses without change to their curricula.

After one year of learning math-enhanced lessons, students in the experimental classrooms performed significantly better on TerraNova (CTB/McGraw-Hill, 1997) and Accuplacer (College Board, 1998), two of the three math posttests administered. Scores from occupational tests demonstrated that students did not lose technical skill or content knowledge as the result of the integrated instruction. The final sample included 136 classrooms (57 experimental, 79 control), and a total of 1,591 students. The results were achieved without the need for exemplary school-based leadership or cultural change within the school, contrary to what is commonly concluded in the school reform literature (Blankenship & Ruona, 2007). Instead, the improved math performance of the experimental group students was achieved by assembling teams of teachers in a single occupational area across multiple schools and by providing them with a process and a pedagogy through which they could effectively enhance the math in their own curricula.

During the school year following the original Math-in-CTE experimental intervention, Lewis and Pearson (2007) conducted a follow-up survey to determine the level at which math and CTE teachers continued to use the methods and materials from the model. Although no continuing professional development was offered in that year, almost three-fourths (73%) of the experimental CTE teachers and two-thirds (66%) of the math teachers indicated that they continued to use the process and the pedagogy they learned during the previous year's professional development. One teacher reported that the model had become an "internalized way of thinking about teaching."[2]

Math-in-CTE Technical Assistance

The Math-in-CTE model of curriculum integration emerged as a unique and extended process of change. Positive findings from the original study were shared through various conference venues, and national interest in the model grew. As a result, the NRCCTE's ongoing Math-in-CTE technical assistance project was created to provide a means to broadly implement this tested approach.

Math-in-CTE technical assistance strives to maintain consistency and accuracy in the implementation of the tested model in new and different settings; measures are taken to ensure that implementations will result in improved student math abilities. The NRCCTE approach to technical assistance is congruent with Section (102) of the Education Sciences Reform Act of 2002, in which the term "technical assistance" is defined as:

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[2] See *Sustaining the Impact: A Follow-up of the Teachers who Participated in the Math-in-CTE Study* (Lewis & Pearson, 2007), available at http://136.165.122.102/UserFiles/File/pubs/Sustaining_the_Impact.pdf.

> Assistance in identifying, selecting, or designing solutions based on research, including professional development and high-quality training to implement solutions leading to improved educational and other practices and classroom instruction based on scientifically valid research and improved planning, design, and administration of programs; assistance in interpreting, analyzing, and utilizing statistics and evaluations; and other assistance necessary to encourage the improvement of teaching and learning through the applications of techniques supported by scientifically valid research. (HR 3801, Sec. 102, (23) p. 5)

In delivering technical assistance, the NRCCTE also seeks to sustain scientifically based research practices related to curriculum integration. This involves identifying researchers and expert facilitators who are available to engage with state, regional, and district leaders and teachers in the ongoing implementation of tested models and innovations. This level of engagement not only expands the impact of current research, but also generates future research that is responsive to the needs of the field. As Louis and Jones (2001) argued, "creating sustained interactivity [of researchers and practitioners] is not the only solution to the dissemination and utilization problem, but if it becomes a norm, it may well increase the scholarly impact because it enlarges the field of CTE communications systems" (p. 30).

Notably, the research-based Math-in-CTE model embodies many of the features of effective professional development identified in the Perkins IV legislation, which mandates that professional development in career and technical fields (a) promote the integration of coherent and rigorous academic content standards and CTE curricula and (b) provide opportunities for the appropriate academic and CTE teachers to jointly develop and implement curricula. Perkins IV also requires professional development that is high quality, sustained, intensive, and increases academic knowledge.

Participation in Math-in-CTE technical assistance has increased steadily since the model's inception. Hundreds of teachers and administrators have received Math-in-CTE professional development. Out of 13 states or districts that initiated a full implementation of the model during the 2006-2009 period, 11 have actively sustained and/or expanded their use of model after the first year of technical assistance.

Evaluations are continuously conducted at the Math-in-CTE technical assistance sites to ensure a satisfactory level of service, ascertain that the activities offered are the most effective in meeting states' needs, and inform the NRCCTE's future technical assistance and professional development work. Using methods and instruments developed for the original study (Stone et al., 2006), such systematic data collection results in the accumulation of reliable evidence of the ongoing impact of the Math-in-CTE model.

The Core Principles of Curriculum Integration[3]

The processes of conducting rigorous scientific research (e.g., pre- and posttesting students in search of statistically significant results) and identifying "what works" in real educational settings using sound methods are two very different enterprises. Throughout the original Math-in-CTE study (Stone et al., 2006), researchers sought to capture the classroom experience and determine the fidelity of the intervention through the collection of data from multiple sources, including observations, teaching reports, teaching tapes, instructional artifacts, lesson plans, individual teacher interviews, and teacher focus groups. Direct input from the teachers who participated in the study was particularly valuable in helping researchers identify what made the integration work and what did not. Researchers triangulated and analyzed these data in order to learn more about the model. These analyses generated five core principles supporting curriculum integration. For the purpose of this paper, we have adopted the principles to use as a lens through which to examine curriculum integration and what makes it work:

1. Develop and sustain a community of practice among the teachers.
2. Begin with the CTE curriculum and not the academic curriculum.
3. Understand that academics are essential workplace knowledge and skills.
4. Maximize the academics in the CTE curriculum.
5. Recognize that CTE teachers are teachers of academics-in-CTE, and not academic teachers.

We also draw on Yali, Koppal, Linn, and Roseman's (2008) concept of *design principles,* "rules of thumb or guidelines supported by research results that draw attention to similar successful features in distinct instructional approaches" (p. xiv). Based on this concept, we define a *core principle* of curriculum integration as a fundamental assumption supported by research findings that draw attention to features that lead to effective integration of academics into CTE.

Develop and Sustain a Community of Practice Among the Teachers

The importance of communities of practice emerged as a key finding of the Math-in-CTE study and continues to be validated by evaluation data collected over three years of technical assistance activities. Processes central to establishing communities of practice include extended professional development opportunities that bring academic and CTE teachers together several times during the academic year, external facilitators to keep teachers focused on math interventions (e.g, someone who can monitor their progress), and ongoing support in the development and implementation of math-enhanced lessons.

Communities of practice are based on foundational principles that include shared leadership, shared mission, collaborative culture, data-driven instructional practices, supportive practices, and peer critique (Dufour & Eaker, 1998; Hord, 2004; Murphy & Lick, 2004). Akkerman, Petter, and de Laat (2008) defined the key elements of communities of practice as *domain*, *community*,

[3] Unless otherwise noted, references to the Core Principles are from Stone et al. (2006), *Building Academic Skills in Context: Testing the Value of Enhanced Math Learning in CTE*. The full report is available at http://136.165.122.102/UserFiles/File/Math-in-CTE/MathLearningFinalStudy.pdf.

and *practice*; balanced development of all three requires collegial professional development. Servage (2008) reported that a successful professional learning community is characterized by beliefs that staff professional development is critical to student learning; that professional development is most effective when it is collaborative and collegial; and that this collaborative work should involve inquiry and problem-solving in authentic contexts of daily teaching practices. Other research (Borman et al., 2005; Borman & Rachuba, 1999; Giles & Hargreaves, 2006) also points to the importance of teachers having personal investment and participation in the design of professional development.

Communities of practice in Math-in-CTE. The Math-in-CTE study brought together groups of CTE teachers to work with math teacher partners to enhance the math embedded in CTE curricula with the common goal of improving students' math skills. Creating communities of practice was never a declared goal of the study. In fact, the concept was neither addressed in the proposal nor fully recognized until site facilitators began to observe growing interactions among teacher teams, and teachers began to describe the experience in their interviews and surveys. Communities of practice in the study thus emerged somewhat differently from those that are planned and intentionally introduced (Wenger, McDermott, & Snyder, 2002). CTE teachers and their math partners convened around a common core of CTE content in specific occupational areas. Teachers represented schools and districts from across their states and, in some cases, from several states in a region.

Focus groups revealed that CTE teachers and math teachers alike benefitted from the experience of working together over an extended period of time. CTE teachers came away with not only the math-enhanced lessons, but also a deeper understanding of what and how they taught. Mathematics teachers gained contextualized examples to use in their classrooms. Both groups commented on the importance of working together on a regular basis, away from the distractions of their classrooms, to work together toward a common goal of improving their students' math skills. One teacher described the experience this way: "At some point, the whole had become greater than its parts." In their follow-up study, Lewis and Pearson (2007) extended this thought:

> The teachers connected their participation in the study to the goal of improving the mathematics skills of their students. They developed learning resources that made mathematics tangible and useful to their students. As they worked together to develop and improve these lessons, a community of practice emerged within each of the five occupational areas that motivated and supported their efforts and encouraged mutual accountability. (p. 6)

Findings from the Math-in-CTE study confirmed what Wenger (1998) described—that communities of practice are not a matter of method, but instead emerge as teachers are brought together around organizational arrangements or commonly held interests. Similarly, Wenger et al. (2002) reported that communities of practice are more successfully cultivated than created. In fact, Wenger (1998) specifically rejected thinking of communities of practice as a methodology, which the findings of the Math-in-CTE study (Stone et al., 2006) also affirmed:

> In particular, they are not a design fad, a new kind of organizational unit or a pedagogic device to be implemented. Communities of practice are about content—about learning as

> a living experience of negotiating meaning—not about form. In this sense, they cannot be legislated into existence or defined by decree. They can be recognized, supported, encouraged, and nurtured, but they are not reified, designable units. (pp. 228-229)

Benefits of communities of practice for curriculum integration. Communities of practice provide many benefits for those engaged in curriculum integration. CTE teachers who interact with colleagues who teach core academics find renewed interest and insights into teaching and learning. CTE teachers also benefit from the opportunity to collaborate with their CTE peers. Communities of practice also foster efforts to sustain curriculum integration efforts.

The Math-in-CTE model's extended professional development gave CTE and math teachers the opportunity and time to share their content knowledge and teaching strategies not only among teams, but also between individual teachers. Teachers spoke of how their respect grew for each others' fields of study and for one another as teaching professionals as a consequence of their collaboration. Prior to the study, a majority of the math and CTE teacher partners had little, if any, interaction with one another. A classic example was found in one team who were located in the same building and worked the same lunchroom duty, but never met before coming together for Math-in-CTE professional development.

Upon experiencing the study's collaborative atmosphere and productive conversations, math teachers were surprised at the amount and depth of math embedded in CTE courses and found answers to the perennial student question, "Why do I need to learn this?" At the same time, CTE teachers gained confidence and a new appreciation for the math teachers who helped them learn to bridge the languages of math and the workplace. Stone, Alfeld, Pearson, Lewis, and Jensen (2007) summarized that "the condition for successful replication of the … model is a group of CTE teachers from a single occupational focus and their math-teacher partners working together in a community of practice to identify the math inherent in unique occupational curricula" (p. 69).

Evaluation data from the Math-in-CTE technical assistance sites validate the importance of fostering communities of practice, giving further credence to what was found in the original study:

> A single CTE teacher working with a math colleague will be more effective than either of them working alone; but if they can interact with several others who are focused on the same objective, the effect will be exponential. This is why communities of practice are critical to replication success. (Stone et al., 2007, p. 69)

We continue to observe CTE teachers whose classrooms, laboratories, and workshops are often physically isolated from the rest of the school. As in the original study, these teachers have acknowledged the benefit they receive from their association with other CTE teachers, especially in their own content area. As one CTE teacher reflected, "I have learned the ways that other teachers teach the units and have benefited from their creativity."

Recognizing the importance of sustainability, a primary goal of Math-in-CTE technical assistance is to build the capacity of state, regional, and district leaders to work with their teachers and continue the process of implementation. Akkerman et al. (2008) suggested that a system of overlapping communities of practice may emerge as groups are created among different domains of the educational system. When implementing Math-in-CTE, teachers and administrators operate as a community of practice during and sometimes between professional development sessions as they contribute to the integration process. CTE teachers from a specified content area, along with their math teacher partners, focus as a group on the curriculum and mathematical concepts related to their areas of expertise. And finally, the community of practice that emerges as NRCCTE facilitators work with state leadership teams has proven to be an important factor in successful implementation and sustainability of the model.

Criteria critical for replication of the communities of practice. We have found several aspects within this principle to be particularly essential to replication of the model, primarily the importance of convening a critical mass of teachers. Because Math-in-CTE began as a research study, the number of teachers involved was controlled throughout its implementation. Although there was no empirical evidence to show just how many teams were required, interviews with teachers pointed to the need to create a minimum of 10 CTE-math teacher teams to accomplish a successful implementation.

The importance of convening and maintaining a critical mass of teachers in a community of practice has been magnified through our technical assistance work. Enough teachers need to be involved in order to produce a sufficient number of enhancements that will have a measureable impact on student achievement. A number of states and districts requesting implementation have experienced difficulty in convening groups of 10 or more CTE teachers from the same content area, due mostly to the declining number of CTE courses/programs in the schools and the prevalence of one-teacher departments. Others have grappled with the logistics and cost of bringing together teachers who are scattered across large geographic regions. Our technical assistance experience shows that as numbers of participants drop, the challenges to implementation increase. Teachers in small groups must work harder and longer to generate the quantity and quality of treatment (math enhancements) to ensure measurable impacts.

Attempts to increase the numbers of teachers participating in communities of practice by bringing together those whose curricula is loosely connected have produced mixed results. Teachers who are anxious to integrate content may be especially creative in identifying a common core of content across their varied courses and programs as a means to begin the process. For example, Family and Consumer Science (FACS) teachers may find that they can join with Business teachers to create enhancements to address the concept of financial management. However, too much variation in content creates difficulty for teachers in mapping the intersections of academic and CTE concepts, and sometimes results in enhancements that do not fit well with their individual curricula or teaching plans. The negotiation of concepts that leads to the development of integrated lessons can be strained, and lessons that are forced to fit into a curriculum may feel contrived. Teachers and students easily identify such lessons as being taught only for the sake of the math. Both NRCCTE facilitators and site facilitators have recognized the negative impact of low participant numbers on the development of communities of practice and subsequently the strength of the implementation.

Another vital component of communities of practice was found in the opportunities for CTE and math teachers to work together to deeply examine the curriculum and identify the concepts that could be developed into the math-enhanced lessons. Feedback from focus groups indicated that the process of lesson development contributed to a sense of shared commitment and enabled the sharing of ideas, which are defining characteristics of communities of practice. Teachers in the study were able to establish the dialogue needed to reach consensus and foster group support and critique. This produced a sense of ownership of the final set of lessons that emerged as Stone et al. (2006) reported:

> Our teachers worked together to develop lessons to enhance instruction in the math. Much of the time spent in professional development with the experimental teachers in this study involved writing, critiquing, and revising the math-enhanced lessons, but the lessons themselves were not the key outcome. (p. 69)

Findings from the Math-in-CTE technical assistance evaluation data echo this theme. Although the CTE teachers are convene around a common core of content (e.g., automotive technology or business and marketing), they each teach differently, adapting curricula to local needs and/or context. Flexibility and compromise are frequently required to find common mathematical concepts with which to begin. In learning more about each other, CTE teachers and math teachers find a deeper level of collegiality. As one math teacher commented: “We will definitely begin a working relationship that we didn’t have before.” As teachers of similar CTE content areas work together to map their prescribed or created curricula, and as math teachers subsequently join the process as “math detectives,” interaction between and within the groups increases.

We found that the CTE teachers in the technical assistance workshops continue to learn from each other, and not just in the development of the math enhancements. As they critique one another’s lessons, they learn more about teaching their own content. One CTE teacher cited “opening [a] dialogue with CTE colleagues” as one of the most valuable aspects of the Math-in-CTE workshops. A veteran teacher stated that the experience had changed his outlook on teaching as a whole. CTE teachers also appreciated and gained confidence from working from their math teacher partners; one commented, “Working with a math teacher added valuable content to the lesson plans.”

One CTE teacher seemed almost surprised to have discovered that “our math teacher appreciates our shop classes.” Math teachers have benefitted from the “ammunition” they receive in the form of relevant applications for their math assignments. Numerous math teachers have expressed that they gained “great real-life examples to use in class”:

> I enjoyed listening to all the ways math is being used in the CTE world. I need/want to bring those ideas into my math class. Too many times math students ask “Why am I learning this?” – Sometimes our textbooks don't always do a great job of showing our students the “need” of the math we teach. This class has given me some ideas to help motivate my students.

Although the value of teachers working together in communities of practice is widely acknowledged, they are provided with little structure and surprisingly few opportunities to actually put this into practice. The Math-in-CTE model provides an environment that fosters the emergence of communities of practice. This has been one of the most profound benefits of the NRCCTE's curriculum integration work.

Begin With the CTE Curriculum

In the earliest stages of the Math-in-CTE study, researchers sought to test existing integrated curricula but could not find models that represented contextualized teaching and learning. Most integration models were "context-based," meaning that the math, and not the CTE content, was the primary focus of and starting point for the integration. Context-based approaches typically provide examples of math abstracted from the CTE or occupational context. Such examples do not flow from the kinds of authentic and frequently complex problems that students encounter in workplace settings. Attempts to integrate in this manner can result in lessons that seem artificial and CTE courses that feel more like math courses.

The principle of "begin with the CTE curriculum" illustrates the conceptual dissonance between contextualized and applied academic approaches to curriculum integration. Math-in-CTE is not a curriculum; rather, it is a process through which teachers learn to enhance the math that already exists in their own CTE content area. Prior to lesson development, CTE teachers and their math partners must examine the CTE curriculum and map the intersection of CTE and math concepts. In the original study (Stone et al., 2006), we thought of this deep examination as "interrogating" the CTE curriculum. CTE teachers begin by walking through the CTE curriculum. Math teacher partners listen and act as resources to bridge CTE concepts or applications with appropriate mathematics concepts and processes. In this process, math is never forced into the CTE curricula; the integrity of the CTE content is maintained as the math is enhanced.

Curriculum mapping is the genesis of the math-enhancement process, and its value cannot be underestimated in a successful implementation. The difference between enhancing math versus superimposing it on the CTE curriculum may seem subtle, but from the perspective of CTE teachers and students, this difference is both profound and empowering. CTE teachers frequently express their surprise at how many math opportunities are present in their curriculum in such statements as "[I] did not recognize how much math we already used," and "I know more math than I thought."

Sometimes math teachers stumble over this principle when they make assumptions about the role of math in the integration process. After an "Aha!" moment during a recent professional development session, several math teachers revealed that they finally understood the model, affirming that "CTE drives the math." Others noted, "The level of math used is already there—[it] just needs to be highlighted within the program." A CTE teacher summed it up this way: "Do not add math to the [CTE] lesson—pull it out."

Contextual learning happens when students realize how much they already know and want to know more about the concepts behind the application. Brophy and Alleman (1991) said that curriculum integration is not an end in itself, but rather a means for accomplishing basic educational goals: “Activities should foster, rather than disrupt or nullify, accomplishment of major goals in each subject area.” Integration for the sake of integration can seem contrived and artificial and lose its contextual value. Within the framework of relevance and authenticity, the principle of beginning integration with the CTE curriculum promotes academic skills and interests while maintaining the integrity of the CTE content.

Understand the Academics as Essential Workplace Knowledge and Skills

At the heart of this principle is the notion that integration should involve strategies and lessons through which students may apply their academic skills to solve authentic workplace problems. It furthermore speaks to the importance of addressing the historical purpose of CTE to prepare young people for a role in the workplace and society by strengthening both CTE and academic skills. Stone et al. (2006) noted:

> Since its inception as a part of the high school curriculum, CTE has been linked to labor market needs. These links to the workplace are what attract CTE students and provide the engagement that they often find lacking in academic courses. For these reasons, we required that the math to be taught as part of the CTE courses should emerge from the curriculum—not be superimposed into it. (p. 70)

Following this principle, CTE teachers introduce and reinforce academic skills that students add to their technical skills—the “tools” needed in the workplace. Importantly, CTE teachers purposefully bridge the languages of the CTE and academic worlds as they teach. In the Math-in-CTE study, Stone et al. (2006) emphasized the importance of developing lessons that called for application of math concepts authentic to the workplace:

> Like any other tool, [math] has its place in the toolbox required to solve genuine workplace problems. The mechanic may reach for a wrench or a formula to determine how to improve the performance of an automobile. The marketing CTE teacher will teach advertising, marketing research, statistics, economics, and the like. For all CTE teachers, math is part of their curriculum and it is part of the workplace, and they should share that reality with their students. (p. 72)

CTE courses are rich with opportunities for learning mathematics; however, CTE teachers, who are not mathematics educators, often teach without making explicit the math inherent to the CTE task or concept. For example, a carpentry teacher may use and demonstrate the “3-4-5” rule to measure a square corner but never specifically refer to the Pythagorean theorem on which this rule is based. One challenge often cited by teachers of both CTE and math is students’ attitudes about math. Most teachers are concerned about “scaring students off” and “changing the students’ mindsets.” However, they also recognize the value of math in the workplace as a means of engaging students who are wary of attempting anything that resembles math. One math teacher observed: “[The] math embedded/disguised in CTE is potentially effective in engaging uninterested students.”

Connecting occupational vocabulary to the language of math can open students’ and teachers’ eyes to the math they already know. In the Math-in-CTE model, this process is referred to as *bridging the vocabulary*. One CTE teacher's comment represents the experience of many: "I realized that I am already doing lots of math—I'm just not using the correct vocabulary!" Another said, "'Oh, so that's what you call it in Math! The [vocabulary] connection was so prevalent it almost became a cliché." A math teacher said, "CTE teachers don't have to change what they're teaching, just the 'vocab' used while teaching."

Educators instinctively know that CTE helps students more readily see the value of school in preparing them for careers. Plank, DeLuca, and Estacion (2008) reported a positive correlation between students' taking CTE and academic courses at the same time and their school persistence. The engagement provided by CTE may also enable students to clarify the application and value of academic subjects. In a previous study, Plank (2001) found that the combination of CTE and academic courses, even if not intentionally integrated, had significant potential in reducing the likelihood of dropping out, especially for students who were otherwise at risk.

Providing students with appropriate technical and academic skills should be the goal of any CTE program. Accomplishing (or failing to accomplish) that goal has consequences that reach beyond the scope of the individual student:

> The most consistent message of the past two decades of educational reform is that high school students have not acquired the literacy and mathematical skills required for the United States to remain competitive in the world economy, or at a personal level, to qualify for jobs that pay enough to support a family. In an age of instantaneous communication, a nation's most valuable resource is the ability of its workers to access and use information. (Stone et al., 2007, p. 71)

Maximize the Academics in CTE

The thrust of this principle is the need for CTE teachers to become increasingly aware of and take full advantage of the opportunities to improve their students' academic skills. This does not negate the prior principle of beginning with the CTE content, but rather illuminates what is necessary for sustaining integration. In some ways, this principle represents what more confident and experienced CTE teachers may accomplish once they become skilled at integration.

During the study, "maximizing the math" was first actualized in the curriculum mapping process, through which the CTE teachers were encouraged to locate as much math as possible in their CTE curricula. As newcomers to the process, they were surprised at the amount of math they found in the CTE curriculum. Later, as they became more practiced at integration, they began to "see math everywhere." The math teacher partners also expressed surprise at the amount of math used in applications of CTE content, commenting that it was an "eye-opening" experience. With increasing recognition of the opportunities, many CTE teachers in the study began to capitalize on teachable moments that followed the math-enhanced lessons. Some noted that they watched for opportunities to re-teach aspects of the lessons. This finding was further verified in a later sustainability study (Lewis & Pearson, 2007), in which teachers reported that they had "internalized" the Math-in-CTE process and drew upon the model in their daily teaching practice.

This principle also is evident in the seven-element pedagogic framework that served as both the foundation for creating and a rubric for assessing lesson plans in the Math-in-CTE model. The elements began with the CTE content and guided teachers to extend the math concepts to other contextual examples and traditional examples. The seven elements are:

1. Introduce the CTE lesson.
2. Assess students' math awareness as it relates to the CTE lesson.
3. Work through the math example *embedded* in the CTE lesson.
4. Work through *related, contextual* math-in-CTE examples.
5. Work through *traditional math* examples.
6. Students demonstrate their understanding.
7. Formal assessment.

By following the framework, particularly through Element 2, CTE teachers in the study became more skilled at assessing their students' prior math knowledge and skills before proceeding through the CTE lesson. The transfer of learning built into Elements 3, 4, and 5 of the framework provided opportunities to expand the use of applications and examples while strengthening students' understanding of math vocabulary. As Stone et al. (2006) noted:

> Another aspect of maximizing the math included constant and consistent bridging of the math and CTE vocabularies. The CTE teachers themselves identified the importance of moving back and forth from CTE to the math terminology in helping students make the link (modeling transfer). The teacher-teams were also encouraged to develop more instructional materials that met more levels of student math abilities. We did not establish methods to monitor the extent to which they did this, but discussions in professional development sessions and comments in focus groups suggest that some teachers practiced ongoing reinforcement. (p. 72.)

In the Math-in-CTE technical assistance, we continue to see the centrality and importance of this principle to the sustainability of the model. NRCCTE facilitators have increased their understanding of the value of curriculum mapping as a systematic means of sustaining integration. Facilitators now encourage state and district leaders and teachers to revisit and revise curriculum maps as a first step toward expanding their integration efforts. Sometimes, in a push for academic rigor, administrators and math teacher partners misinterpret this principle to mean an increase in the amount and levels of math. However, the central idea is an acknowledgment that CTE courses and programs hold a vast array of opportunities for students to learn math in context.

Teachers of Academics in CTE, not Academic Teachers

CTE teachers did not choose to be academic teachers; nor, in most cases, are they formally prepared to teach academics. This is not to be misinterpreted as CTE teachers' resistance to integration or inability to learn and teach the embedded academics. Rather, it speaks to the importance of maintaining realistic expectations of teachers as they engage in the Math-in-CTE professional development and learn to teach their content differently. Most CTE teachers understand Perkins IV mandates and the importance of their role in contributing to student academic achievement. However, limitations of their own academic experiences as well as restricted instructional timeframes can make the process of integration a daunting task.

Many CTE teachers find their way to the classroom by a path that diverges significantly from the conventional educational pipeline. Many may have spent decades in industry and find themselves more comfortable in workplace settings than in the classroom. However, differences in teacher preparation among CTE and academic teachers do not necessarily represent a disadvantage for CTE teachers. As we found in the Math-in-CTE study (Stone et al., 2006), a CTE teacher paired with a math teacher can help students learn in a unique and effective way—their combined perspectives give students a more complete view than either can provide in isolation.

Facilitators and NRCCTE researchers observed the disposition of CTE teachers in the initial days of the study. In some cases, their fear was palpable. Many reported that they were initially intimidated by the presence of their math partners and doubted their own ability to understand math, let alone teach it to their students. One teacher candidly described himself as a "deer in the headlights." Some teachers had difficulties beginning to teach the lessons because they lacked confidence in their ability to accurately address the math. However, these fears steadily diminished as teachers began working together in their communities of practice and developed a sense of mutual collegiality and respect. Stone et al. (2006) noted:

> Throughout the professional development provided the experimental teachers, we stressed the partnership between the CTE and math instructors. We made an explicit decision not to refer to the math teacher as a coach or mentor, because these terms imply differing status. We wanted the CTE teachers to be full partners, to stay firmly grounded in their specialty, and to teach math where it contributed to the learning of occupational skills. Discussions in the focus groups at each SLMP indicated that the process produced the intended result. Several math teachers said that their participation in this study increased their understanding and respect for CTE. Some began using the examples developed for the CTE courses in their own classes. (p. 72)

Researchers believed that the structured environment within the extended professional development led to the development of fruitful, collegial relationships and increased CTE teacher confidence. Teachers were given adequate time away from their schools to engage in fully learning the model. The 10 days of professional development provided to teachers over the period of an academic year became a hallmark of the model.

An important finding validated by the technical assistance evaluation data is the mutual benefit that CTE and math teachers experience from working together over time. As a math teacher recently commented, "Math isn't worth much unless it is applied. Together we are stronger and better." On a regular basis, math teachers comment on how they come away with examples to use in their classrooms. Another math teacher made this comment at the conclusion of the launch at her site:

> As a math teacher, it is a great experience (almost a dream come true!) to be able to sit with another professional and actually be able to discuss the differences in "our language" of math. I think we both benefited from those discussions and will actually become habitual about relying on each other to check on the "math in business" progress and how we can help each other.

Many CTE teachers embrace the idea of integrating academic content into CTE curricula; however, achieving balanced and authentic integration is a complicated process. Careful attention to the aforementioned core principles not only enhances integration, but also produces multiple additional benefits. Collaborative relationships, such as those fostered among teachers in communities of practice, help reinforce shared language and a multidimensional understanding of both CTE and academic concepts. Reinforcing the CTE curriculum as the driver of the integration encourages teachers and students to see associated academic proficiencies as valid and relevant workplace skills. Our research and experience continue to strengthen relevance and authenticity as hallmark characteristics of successful curriculum integration.

In the next section of this report, we share preliminary findings from the pilot year of the Authentic Literacy in CTE study, reflect on these core principles, and provide added insight into what makes curriculum integration work.

Authentic Literacy in Career and Technical Education: The Pilot Study

Reading is the gateway skill for learning in other disciplines. Students who read well are able to use oral and written language skills more effectively, solve problems, analyze solutions, and develop a lifelong interest in learning and achieving. Improving comprehension skills is vital to building cognitive skills. Reading and literacy skills enable youth to gather information and create knowledge from various sources, then cognitively and creatively consider solutions to problems in and about their lives. By implementing disciplinary reading strategies in CTE curricula, teachers enable all youth with the requisite skills to succeed in school, careers, and daily life. As Richard Ferguson, CEO of ACT, stated, “If students can’t read well, we can’t expect that they’re going to do well in math and science courses” (Marklein, 2006, para. 2), an idea that extrapolates to CTE courses.

Little research has been conducted in CTE with regard to literacy and the uses of language and texts with authentic applications. Researchers do know that content area teachers, although becoming more aware of reading and literacy strategies, still do not readily adopt these strategies into their instructional routines (Barry, 2002; Bean, 1997; Jackson & Cunningham, 1994-1995; O’Brien, Stewart, & Moje, 1995). Yet the applications of literacy in CTE areas may be more meaningful for students than applications in other academic areas. Whereas failures in literacy negatively impact students’ grades in other courses, the consequences in CTE may be more dire and dramatic. For example, failures in literacy within CTE may result in immediate danger from misreading a chemical label or financial loss from misinterpreting construction plans. .

Demands for Literacy Increase as Students Move into Disciplines

As students move through school, literacy demands increase, especially in highly technical CTE courses. Students must become more adept at meeting the challenges of more sophisticated disciplinary reading and information (Meltzer, 2001; National Association of State Boards of Education, 2006; Snow, 2002; Snow & Biancarosa, 2003; Tomlinson, 1995). This is vitally important when the topic is unfamiliar and the reading is demanding (Alexander & Kulikowich, 1991; Allington, 2002). The task is especially difficult when students attempt to make decisions about CTE issues and problems, because in such situations they must rely upon diverse texts for information and formulation of arguments. Making informed decisions about complex issues also often involves gathering information from and evaluating the arguments contained in widely varying texts.

Literacy is vital for the development of transferable skills needed for all vocations (Kakela, 1993). However, the diversity of knowledge domains and teacher knowledge of reading challenges the incorporation of reading instruction in a vocational context. To exacerbate the problems of comprehension and problem-solving with text, CTE courses do not rely solely on textbooks, but also integrate other sources of complex technical information (Gartin, Varner-Friddle, Lawrence, Odell, & Rinehart, 1994), which, again, are written at advanced levels. The primary problem being addressed in the ongoing Authentic Literacy study is the lack of instructional support for reading comprehension among CTE students.

Literacy has been defined in many ways, and the concept continues to undergo revisions to that definition. Currently, the National Assessment of Adult Literacy (NAAL; U.S. Department of Education [USDE], 2007) identifies three literacy scales: prose, document, and quantitative literacies. Prose literacy is the "knowledge and skills needed to perform prose tasks (i.e., to search, comprehend, and use information from continuous texts)" (p. 2). Examples of prose literacy include reading and understanding editorials, online news stories, technical magazine articles, and instructional materials. Prose texts also include expository, narrative, procedural, and persuasive genres of text. Document literacy is the "knowledge and skills needed to perform document tasks (i.e., to search, comprehend, and use information from noncontinuous texts in various formats)" (p. 2). Examples of document literacy include completing job applications, developing feeding schedules, and reading tables for engine specifications. Quantitative literacy involves the "knowledge and skills required to perform quantitative tasks (i.e., to indentify and perform computations, either alone or sequentially, using numbers embedded in print materials)" (p. 2). Examples of quantitative literacy include balancing a checkbook, computing a balance sheet, and filling out an order in a supervised experience.

The Authentic Literacy research project developed and measured interventions related to document and prose literacy. Within CTE contexts, students frequently read documents that are specialized to a career field. For example, students may complete job applications within their supervised work experience or read a table of engine specifications to repair a small engine. When reading these documents, students are engaged to learn and use key pieces of information. Less frequently, students are asked to read entire continuous documents, thus developing prose literacy. CTE students learn about key issues in CTE related to various career fields; for example, students in family and consumer sciences may read and write about early childhood obesity, or students in business courses may read and write about business ethics—both applications of prose literacy. Within this project, specific models of reading programs and strategies were implemented that augment student learning with prose and document literacy in CTE.

Explicit, Multiple Strategy Instruction

A teacher's job is "less about teaching books than it is about teaching processes with which to approach and make meaning with the world's texts" (Wilhelm, 2001, p. 29). CTE teachers must be provided with knowledge and processes for implementing disciplinary reading strategies in their classrooms. The goal of reading strategy instruction is to enable students to select appropriate strategies, adapt them to particular texts, employ them to solve reading problems (Pressley, Symons, McGoldrick, & Snyder, 1995; Wilhelm, 2001), and have them independently initiated by the student (National Reading Panel [NRP], 2000; Snow, 2002). Teaching reading strategies helps students understand the importance and application of these strategies to learning about concepts and issues in CTE (Pressley et al., 1995; Rhoder, 2002). Application of reading strategies helps students solve reading problems as well as make decisions about authentic problems in CTE.

Explicit instruction of individual reading strategies has a positive effect on reading comprehension and motivation to read (Autrey, 1999; Carriedo & Alonso-Tapia, 1995; Little, 1999; Lynch, 2002; Mastropieri, Scruggs, & Graetz, 2003; Meyer & Poon, 2001). Additionally, reading strategy instruction leads to positive improvements in achievement tests (Cooper, 1998; Yu, 1997). Reading strategies should "be tailored according to how they best fit within specific, local learning contexts" (Bean, 2001, para. 25). Tailoring explicit strategy instruction to CTE involves reading for comprehension and proposing solutions to key issues and problems in each discipline of CTE.

Importantly, effective reading does not rely upon a single strategy but incorporates the coordination of several strategies (Bos & Anders, 1992; Bulgren & Scanlon, 1997-1998; Meltzer, 2001; Morgan & Hosay, 1991; Palinscar & Brown, 1984, 1986; Snow, 2002; Taraban, Rynearson, & Kerr, 2000; Vaughn, Klinger, & Bryant, 2001; Weedman, 2003). Therefore, use of academic literacy strategies involves the "constant, ongoing adaptation of many cognitive processes" (Williams, 2002, p. 244). Teaching a package of reading strategies improves comprehension, leads students to read more, bolsters critical reading, increases the variety of texts read, improves standardized test scores, and enhances general comprehension (Morgan & Hosay; NRP, 2000; Weedman, 2002). The package of comprehension strategies used in the Authentic Literacy project was a collection of strategies that build on one another to improve the comprehension and problem-solving ability of secondary CTE students.

Practical Importance: CTE Context

An emerging issue in comprehension instruction is the need to fine-tune existing strategies and reading models for program areas in order to promote higher-order comprehension processes (Pressley, 2001). Several researchers (Pressley & Allington, 1999; Snow & Biancarosa, 2003; Taraban et al., 2000) have proposed that reading strategy instruction should be investigated in specific contexts, such as CTE. Comprehension instruction should prepare students to tackle real-world tasks, such as the application of comprehension strategies to real problems like those often found in CTE. This research tested and refined reading models and instructional strategies with the potential to improve reading comprehension of all CTE students, even those who struggle with reading for content knowledge and solving problems.

Within CTE, various program areas read for different purposes depending upon the task, problem, or focus of the lesson. For example, students may read an entire novel to provide context for a situation. Alternatively, students may need a particular type or piece of information in order to solve a problem and thus would scan quickly one or more sources to find the appropriate piece of information. Further, the design of many CTE courses, especially those offered through technical centers, involves more reading and writing early in the academic year to prepare students for internships and work experiences that are primarily offered in the second semester of the course.

Currently, within CTE, no CTE-specific tested reading or literacy programs exist. Teachers and administrators in schools have attempted to adapt existing reading and literacy programs on a local basis. Although some schools provide literacy and reading coaches, CTE teachers in comprehensive high schools have experienced limited success in garnering the attention of these professionals. The literacy coach's time is focused on core academic areas such as mathematics, science, and social studies (van der Mandele, Park, & Welch, 2008). Thus, in all practical senses, CTE teachers are left to their own devices to implement literacy strategies and programs to help their students comprehend and learn from text (Park & Osborne, 2007). These teachers lack knowledge of or formal preparation with content area reading strategies (Park & Osborne, 2007).

Research Questions

This project sought answers to the following research questions:

1. Do students in the intervention groups score differently (higher) than students in the control condition on reading comprehension, vocabulary, and motivation to read?
2. What are students' perceptions of reading and reading strategy use in CTE?
3. How do CTE teachers adapt their teaching practice to include explicit, embedded scaffolding of reading and use of literacy strategies?

Objective, Purposes, and Hypotheses

The purpose of the experimental portion of this research was to determine the impact of disciplinary literacy strategies on reading comprehension and motivation to read for students enrolled in CTE courses. The objective was to compare the effects of literacy strategy instruction under a control condition and two models of content area reading interventions: a CTE framework and the MAX Teaching Framework, described below. The research sought to determine if students in the intervention groups scored differently (higher) than students in the control condition on reading comprehension, vocabulary, and motivation to read.[4]

In the qualitative component of the study, focus groups were conducted with students and interviews were conducted with teachers at the conclusion of the study's trial period. The purpose of the focus group interviews with students was to ascertain students' perceptions of (1) reading in CTE and (2) reading strategy use in CTE. The primary research question for the teacher interviews was "How did CTE teachers adapt their teaching practice to include explicit, embedded scaffolding of reading and use of literacy strategies?" By answering this question, researchers may be (1) better able to prepare pre-service CTE teachers for literacy instruction and (2) more effectively re-equip current CTE teachers with instructional approaches that support literacy and create a classroom culture that scaffolds text as a learning tool.

Methods

Interventions

Researchers compared the effects of literacy strategy instruction under a control condition and two models of content area reading interventions: a CTE framework and the MAX Teaching Framework. During the one-year pilot study, researchers refined and tested existing reading models and instructional strategies to improve reading comprehension of all CTE students, even

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[4] For additional information on the structure and methodology of this study, please see Authentic Literacy in Career and Technical Education: Technical Appendices to the Spring 2009 Pilot Study, available on the NRCCTE website: http://136.165.122.102/UserFiles/File/Tech_Reports/Authentic_Literacy_Pilot_Study_Technical_Appendices.pdf.

those who struggle with reading for content knowledge and solving problems. The approaches defined below are those the research team identified as having potential for implementation and effectiveness within the contexts of CTE disciplines.

MAX Teaching Approach. The MAX Teaching (MAX) approach was developed by Forget (2004) and is a framework of classroom learning activities that uses systematic reading and writing in all classes. The MAX Teaching framework is advocated through the High Schools That Work network of schools and professional development model. It is also being incorporated into the newer Tech Centers That Work program from the Southern Regional Education Board. MAX is an acronym for **M**otivation, **A**cquisition, and e**X**tension, a tripartite teaching framework. The framework is based in the Vaughn and Estes (1986) framework involving anticipation, realization, and contemplation. The framework, as with most frameworks in reading comprehension, involves the application of strategies before, during, and after reading. Further, MAX extends the framework to incorporate two additional components: cooperative learning and a skills acquisition model (Forget & Morgan, 1997; Greenleaf, Schoenbach, Cziko, & Mueller, 2001).The skills acquisition model (SAM) involves several phases (Forget, 2004). Students first become engaged in learning through the use of setting purposes for reading and activating background knowledge. They acquire knowledge through guided practice, silent reading, and teacher probing for understanding. Then students extend knowledge through debates, discussions, and other organized activities.

In its approach, MAX is similar to many other before-during-after reading frameworks. What separates MAX from the others is its heavy emphasis on cooperative learning and skills acquisition (see Table 1). These two factors should be "explicit and central" to each lesson (Forget, 2004, p. 14). The central tenet of MAX is the acquisition of comprehension and reading skills, which is fundamentally different than learning according to Forget and others (Krashen, 1996; Smith, 1983, 1988). Acquisition occurs without learner realization or effort involved with learning (Forget, 2004), and, according to the model, is likened to learning a first language; it occurs with little conscious effort and naturally over time.

The pedagogic framework of MAX addresses the before-, during- and after-reading microperiods in its three-part framework. In the first part of MAX Teaching, *motivation* is the focus of the pre-reading stage. It is important that students who may otherwise feel unfamiliar or intimidated by the reading are given some time to activate background knowledge, set a purpose for reading, and build an interest in the reading. During this stage, the selected reading strategy is introduced. In the second part of MAX Teaching, *acquisition*, the student is guided through the reading by the strategy and the teacher. This not only helps to keep the student engaged, but it also helps the student organize the information he or she is reading and understand the reading more effectively. In the final part of the framework, *extension* is used. After the reading, students are able to reflect on what they have read, discuss with others, and elaborate on their ideas. This helps students utilize social learning through the discussion of ideas (Forget, 2004). Within MAX, the implementation of strategies to develop students' literacy skills consists of the following important elements:

- The teacher will introduce and model the skill to be developed.
- Background knowledge is activated.

- Each student creates purpose for the reading through writing. The writing is determined by the strategy utilized.
- Students participate in guided practice as they read the prescribed text individually.
- In groups, students attempt to reach consensus on predetermined aspects of the reading.
- Teacher mediates a large group discussion on the reading extending the information to "real life" situations.
- Students reflect on the use of the skill.

Table 1

Combining the Three Phases of MAX with Cooperative Learning and the Skill Acquisition Model

Microperiod of Reading	MAX	SAM	Cooperative Learning
Before Reading	**M**otivation Reducing anxiety and improving the probability of success in reading	Introduction and modeling of the skill	Written commitment and small-group discussion
During Reading	**A**cquisition Individual silent reading for personal interpretation	Guided practice in learning skill	Individual gathering of data for discussion
After Reading	e**X**tension Cooperative construction of meaning through discussion, writing, etc.	Reflection on how the skill worked	Attempt to achieve group consensus

Source. Forget (2004), p. 24.

The reading strategies advocated in MAX include individual reading strategies that accomplish the goals of the framework, namely motivation to read, acquisition of skills and knowledge, and extension of skills and knowledge. Because of the nature of the content in CTE, some of the strategies are not applicable, and thus were deleted from the pedagogic framework in this research. Those strategies that are included in this research are anticipation guides, previewing nonfiction text, Cornell note-taking, cubing, Generating Interactions between Schemata and Text (GIST; Richardson & Morgan, 2005), guided reading procedure, Interactive Notation System to Effective Reading and Thinking (INSERT; Vaughn & Estes, 1986), paired reading, Preview-Question-Read-Remember-Scan-Touch-up-GoBackAndStudyYourNotes (PQR$_2$ST+; Morgan, Forget, & Antinarella, 1996), Pre-Reading Plan (PReP; Langer, 1980), student-generated graphic representation, think-pair-share, three-level study guides, and pre- and post-learning concept checks.

CTE Reading. The CTE Reading framework was developed from a literature review of content area reading strategies in the before- and during-reading microperiods (Snow, 2002). This particular intervention focused on the before-reading and during-reading microperiods. Before students read, the strategies embedded in the framework assisted students in setting purposes for reading, activating relevant background knowledge, generating questions, identifying problems to be solved, and selecting strategies to use while reading. The specific before-reading strategies included in the framework were the *K-W-L*, *Making Predictions A-Z*, and anticipation guides. The *K-W-L* (Ogle, 1986) prepares readers by examining background knowledge with what they already **K**now, developing motivation for reading by analyzing what they **W**ant to know, and then later connected what they **L**earned from the reading. *Making Predictions A-Z* (Block, Rodgers, & Johnson, 2004) encourages students to skim the text ahead of time, pulling out perceived keywords and then envisioning what they thought the text would be about. Anticipation guides (Vacca & Vacca, 2008) help students examine students' preconceived notions on the topic of the text before reading. These three strategies were easy to use and to implement, and therefore were good strategies with which to begin.

During-reading strategies assisted students in continuing to ask questions, rereading, checking context, monitoring comprehension, organizing information, and checking and modifying predictions. The specific strategies used during reading included the *3-Level Question Guides* (comprehension, interpretation, and application; Vacca & Vacca, 2008), *Concept of Definition Map* (Nagy, 1988), *Alpha Boxes* (Hoyt, 1999; L'Allier & Elish-Piper, 2007), *Text Connections Matrix* (Harvey & Goudvis, 2000; Keene & Zimmerman, 1997), and *Cornell Notes* (Pauk, 2001). The *3-Level Question Guides* helps students look beyond the surface text to meanings and connotations behind what was being read. The *Concept of Definition Map* enables students to organize the ideas within a text in a graphical format, thereby assisting in understanding complex ideas. *Alpha Boxes* encourages students to read carefully for keywords and identify those for which definitions would be helpful. The *Text Connections Matrix* supports students as they examine the relationships the text has to itself, to the student's self, and to the world as a whole, therefore putting the text in perspective. Finally, *Cornell Notes* scaffolds students' reading by providing a structured framework for note-taking. These strategies were helpful tools that the research team thought would work well in a CTE environment.

Control. Teachers in the control group used a business-as-usual approach to teaching. They did not implement reading strategies but continued to teach with their normal teaching approaches. When assigning texts to read, they used a default routine of assigning the reading, asking students to answer questions related to the reading, and discussing the reading in class. This limited their use of reading and literacy practices while still exposing students to a minimal level of instruction related to reading comprehension and strategy use. The control condition asked that students read the text, answer questions at the end of the chapter or section, and participate in classroom discussion of the text. In essence, teachers in the control condition followed their normal routine of teaching. Both the treatment and control groups monitored how they taught, but the control group did not use any literacy strategies and was specifically informed not to use additional reading strategies. The control group participated in all data-gathering activities just like the treatment groups.

Experimental Design

Within this pilot study, an experimental design was used with intact groups of students and teachers, randomization of class treatments, and pre- and posttests (Ary, Jacobs, & Razavieh, 2002; Campbell & Stanley, 1963; Gall, Gall, & Borg, 2003). Teachers were randomly assigned to the treatment and control groups. Experimental designs are appropriate for this research because researchers presume the cause to be our intervention—the independent variable—and the effect to be changes in reading comprehension and motivation to read in CTE courses, the dependent variables (Gall et al., 2003). The purpose was to determine the causal relationships between the variables of interest: two reading framework treatments (X_1 and X_2) and control (X_3) groups:

Treatment[1]	O_1	$X_{\text{1.MAX Teaching}}$	O_2
Treatment[2]	O_1	$X_{\text{2.CTE Reading}}$	O_2
Control	O_1	$X_{\text{3.control}}$	O_2

The first observation (O_1) consisted of the Motivations for Reading Questionnaire (MRQ; Wigfield & Guthrie, 1997, 2004) and the Gates-MacGinitie Reading Test (GMRT; MacGinitie, MacGinitie, Maria, Dreyer, & Hughes, 2006). These assessments were conducted during the week prior to the initiation of the treatment, prior to March 1. The second observation (O_2), concluded by May 15, consisted of a demographic questionnaire, the MRQ and the GMRT. Pre- and posttest scores for the treatment and control groups on each of the above measures were compared and analyzed. The intervention began on March 1, 2009 and concluded on May 15, 2009. The research included 51 teachers in New York State and 1,313 students by the conclusion of the study.[5] All groups monitored how they taught; the control group teachers were informed not to use any literacy strategies during the treatment period.

Student's reading comprehension was assessed using the GMRT for Grades 7-9. The GMRT is a norm-referenced test that measures comprehension and vocabulary with 48 vocabulary questions and 45 multiple-choice comprehension questions about several short passages. Reliability ranges from .88 to .92. Motivation to read was assessed with the MRQ. The MRQ consists of 29 items to which students respond on a seven-point, summated rating scale, ranging from (1) *very different from me* to (7) *a lot like me*. The motivation to read score was treated as interval data and developed by summing the individual item responses for the 29 items. Validity was established with a panel of experts at the National Reading Research Center. Reliability of the instrument ranges from .56 to .74.

Teacher Interviews

Interviews were conducted with teachers at the conclusion of the trial period. Researchers hoped to learn more about (a) preparing pre-service CTE teachers for literacy instruction and (b) more effectively re-equipping current CTE teachers with instructional approaches to support literacy and create a classroom culture that scaffolds text as a learning tool.

Teachers participating in the study were asked a series of questions in one-on-one interviews regarding their experiences in the study. The questions were designed to encourage reflection without interviewer interruption, which allowed teachers to discuss anything they found striking about their experiences using reading strategies.

[5] The study initially started with 20 teachers each in the treatment groups and 13 teachers in the control group, but two teachers, a MAX and a control, dropped out of the study.

Audio recordings from teacher interviews were analyzed by transcribing the audiotapes of the conversations and using content analysis to determine themes and general conceptions about reading strategy instruction and use in CTE courses (Glaser & Strauss, 1967; Hatch, 2002; Miles & Huberman, 1994; Spradley, 1979). To examine the data, researchers worked together to identify general comments and concepts, detect emergent themes, and locate quotations that represented those themes (Creswell, 2009).

Emergent themes were checked among the researchers for validation. The audit trail consisted of audio recordings, interview transcripts, interview guides, list of interviewees, themes generated from the transcripts, and working conclusions about teachers' perceptions of disciplinary literacy and cognitive strategy instruction in CTE.

Student Focus Group Sessions

Focus groups were conducted with students at the conclusion of the pilot period to ascertain students' perceptions of (a) reading in CTE and (b) reading strategy use in CTE. Participants in these focus groups included 129 students whose teachers used disciplinary literacy strategies in their Spring 2009 CTE instruction. Students volunteered to participate in the 23 focus group interviews (a total of 8.29 hours of audio recordings) in June 2009. All students and their parents signed letters of informed consent. Audio recordings from student focus groups were analyzed in a manner similar to the teacher interviews.

Findings from the Pilot Study

Demographic Analyses of Participants

As noted, more than 1,300 students and 51 teachers participated in the pilot test of this study in the Spring 2009 academic semester. Nearly all students were high school juniors (46.1%) or seniors (43.8%) at the time of the study. Nearly 60% were female, and the vast majority were White (84.2%), followed by Hispanic/Latino (5.7%) and Black/African American (3.5%). Over 96% of the students spoke English as their native language. As a proxy for socioeconomic status, researchers measured students' enrollment in free or reduced-price lunch programs; more than 40% of students received some form of free or reduced-price lunch. Half (51.0%) of the students indicated that their mother's education level included more than a high school education, and 38.5% that their father's education level was more than a high school education.

Experimental Effects of Treatment Group on GMRT and MRQ

Analysis of the impact of the treatments (MAX Teaching Framework and the generic CTE Reading Framework) included analysis of the pretest group means and analysis of covariance (ANCOVA) of the gains in group means of GMRT total score, GMRT vocabulary, GMRT comprehension, and MRQ motivation measure among the three groups: control, CTE Reading Framework, and MAX Teaching Framework.

Analyses of the change in total GMRT scores from the pretest to the posttest, taking into account the pretest GMRT total score, showed that students in the CTE reading framework and students in the MAX teaching framework scored statistically higher than students in the control condition.[6] Analyses of the change in GMRT vocabulary scores, taking into account the pretest GMRT vocabulary scores, showed that students in the MAX teaching group had statistically higher scores than students in the control group.

Analyses of change in GMRT comprehension scores, taking into account the pretest GMRT comprehension scores, showed that both students in the CTE reading group and students in the MAX teaching group had statistically higher scores than students in the control condition. Analyses of change in MRQ scores, taking into account the pretest MRQ scores, showed that students in the MAX teaching framework group, as well as students in the control condition, had statistically higher scores than the CTE reading group.

In sum, students in the MAX treatment group had statistically higher scores than the control group on the GMRT vocabulary test, the GMRT comprehension test, and the overall GMRT comprehension score. There was no statistical difference between the MAX and control groups on the MRQ. Students in the CTE reading group had statistically higher scores than the control group on the GMRT vocabulary test, the GMRT comprehension test, and the overall GMRT comprehension score. There was a statistically significant difference between the CTE reading group and control groups on the MRQ, favoring the control group.

Findings from Teacher Interviews

The 51 teachers involved in the study represented CTE program areas including health occupations, general education, cosmetology, and auto body. The teachers were self-selected and had a range of experience with literacy strategies. The analysis of the qualitative teacher interviews yielded six main themes related to creating opportunities for successful strategy use in CTE courses: developing teacher confidence, building communities of practice, utilizing authentic text, providing initial professional development, making strategy adjustments, achieving framework adoption, and experiencing student receptiveness.

Teacher confidence. Teachers expressed confidence in strategy use due to three interconnected elements: understanding how a strategy enhances reading comprehension or vocabulary learning, receiving critique from an experienced observer, and utilizing sample lesson plans. When teachers lacked these three elements, they expressed hesitation or uncertainty and attributed that lack of confidence to a deficiency in these elements. Many teachers connected strategy success with their own confidence in implementing the strategies. Our research thus indicated that developing teacher confidence should be a keystone of successful implementation of any literacy framework in CTE.

Many participating teachers expressed unease at the thought of taking on an academic discipline. One cosmetology teacher in the MAX group stated, “I’m not an English teacher … and to have to take what I refer to as an academic [subject area] … reading is English, you know; it’s different.” This sentiment was echoed by others. Ensuring that CTE teachers are comfortable and confident with a set of literacy strategies they view as new and different should be an objective of professional development focused on implementing a literacy framework in CTE.

[6] See the pilot study technical report for additional details.

Some teachers were satisfied with their implementation of the strategies. As this same teacher noted, “I was able to deliver it successfully… a success for myself.” This was also true for a teacher in the general CTE reading group who planned to continue using the strategies. She explained, “I feel like I can take my knowledge of how to take these strategies and incorporate it into my [class] readings.” Because of students’ positive responses, another teacher in the MAX group commented, “I’m able to do all that literacy analysis and it just worked so well … [I] actually had students coming in saying, ‘Oh, what’s the strategy for today?’”

However, many teachers lacked confidence in their strategy use. A natural resources teacher in the general CTE reading group said, “When I looked at some of the strategies, I just [thought] how am I going to use this …It's just not going to work. So I didn't try it….I don't jump right in unless I have everything figured out.” Another teacher in the MAX group stated, “I really wasn't sure in some of the ones that I'd done. … I thought ‘Am I really… doing this the right way?’” A cosmetology teacher in the MAX group summed up the uncertainty this way: “Maybe I just didn’t plan it right or … maybe I really wasn’t 100% sure what the outcome should’ve been.” All of these responses indicated that more direction and assistance would have helped these teachers to feel more confident during implementation. Interviews with teachers revealed a direct relationship between a teacher’s level of confidence in implementing literacy strategies and the amount of implementation in that teacher’s classroom.

Communities of practice. Teachers desired the ability to discuss strategy use with other teachers both within and outside of their CTE area. To be sure that teachers did not discuss ideas across treatment groups—a threat to the internal validity of the research—collaboration among teachers outside of their treatment or control group was prohibited; thus all collaborations and statements regarding such are in reference to that which occurred among teachers in the same groups. They seemed to perceive the ability to communicate with other teachers, as well as with experienced teachers, as forming a web of support to develop mentors and increase their confidence levels. The more teachers believed they had other teachers to collaborate with them on literacy interventions—both to explore new ideas and to critique their work constructively—the more confident they felt in their ability to integrate literacy strategies effectively.

Communication between teachers—the establishment of a community practice—was a key issue for those interviewed. Those who had access to others discussed the helpful benefits of communication; those who did not experience such a community of practice asked for it consistently. Teachers asked each other about utilizing reading strategies and how to implement them for the project. A business communication teacher in the MAX group stated, “I might get together with [a fellow teacher] and say, ‘Okay, how did this work for you,’ so that I feel more comfortable with some of the other [reading strategies], too.” In one especially poignant example, a collision repair teacher shared an experience he had with a teacher he was mentoring:

> She came in and observed the [strategy] and then she came back after class was over so we could talk about it…. because the idea was to get her to do one of the strategies. And after … we were done talking and the enthusiasm I had over this got through to her.… she ended up saying ‘God, I wish we had started this much earlier in the year.’ And so it

> started as pretty positive—we're talking about a pretty hard-headed … type of teacher that was converted and that has ordered the book.

Unfortunately, not all teachers experienced communities of practice, yet many expressed an interest in “[connecting] with people related to what we teach [so] we could share some ideas.” As another noted, “I think it would have been helpful to come back together.... [to share] what worked, what didn’t, what could we do better, maybe …. some materials.”

Teachers not only wanted to discuss strategies with other teachers, but also requested the presence of an experienced observer, one of the researchers, throughout the year: “If we had had a site visit… an opportunity to reflect and process how things were going …. [that] would have helped.” Those who had an experienced observer attending their class and offering constructive criticism and ideas highlighted those instances as important to their implementation of the literacy framework and its associated strategies.

Teachers consistently expressed their desire for a community of teachers: partners with whom they could share ideas, ask questions, and receive support and encouragement. In multiple cases, an unintended development of the pilot study was that groups of teachers informally created a community of practice of their own.

Use of authentic text. Use of authentic text was defined as teachers utilizing text that CTE students do or will encounter in their professional careers beyond high school, all in an effort to enhance the authenticity of CTE learning and to improve students’ willingness to read. In essence, the use of authentic text in CTE provided a great starting point for implementing the literacy frameworks, without the students or teachers feeling like something new or additional was being added to the classroom instruction. Teachers who were interviewed discussed the use of authentic text as important to the CTE classroom. They felt that the students were motivated by the connections between the text with which they interacted and their current lives and future careers.

One of the collision repair teachers in the MAX group told researchers, “We use a lot of technical reference manuals, and they have to be able to go find exactly what they need out of that 10 pages.” A natural resources teacher in the general CTE reading group added, “So there’s tons of articles in here that relate. And I started to go through these and rip them out and put them according to my modules and used them in these lessons, and it was just perfect.” Finally, an animal science teacher in MAX stated, “We had podcasts, scripts to read, articles and newscasts, so [the strategies] actually worked out really well.”

Teachers felt that authentic text was integral to their classroom. As an automotive teacher in the MAX group said, “I think [my] students probably come away seeing how reading and writing can help them improve their profile in a welding- or machining-class work environment.” Another added, “We don’t have a textbook ….Not that I would really like a textbook…. So but that’s why these resources are real valuable to me. You know that kind of stuff I could supplement what we’re teaching.”

The ability of teachers to integrate text into the curriculum and make it of real value to students was key. As an outdoor power equipment teacher in the MAX group reflected, “everything had to be related to what they were doing, not reading *Of Mice and Men* and hoping they enjoy the book.” Again and again, teachers spoke of the importance and effectiveness of using content-specific or authentic text as a way to heighten students’ engagement and comprehension of the course content.

Initial professional development. Initial professional development was highly valued by teachers. Both specifically as CTE teachers and as teachers in general, they made constructive comments regarding what would work for them in regard to professional development. They asked for specific elements, such as hands-on time with the reading strategies, applied use of the reading frameworks within lesson plans, and clarity in directions for implementing both the general framework and specific reading strategies.

Many teachers felt demonstrating the strategies made them “easier to use because I’d seen [the strategies and framework] in action.” Others added that if they had left with something to get them started, as in lesson plans, then they would have been “really ready to go.” A general education teacher in the MAX group told researchers:

> I think just [having] one of [my lesson plans done] so you have something that first week to be like ‘w-o-w like let’s do it,’ …something to get you started in the right mind set I think might have helped me out just a little bit.

Most of the teachers suggested that they would have preferred a format that included “breakouts, work on the strategy, and [having] groups demonstrate [the framework]” during professional development.

Teachers needed clarity regarding implementation directions and practice with the reading strategies during the professional development. An automotive teacher in the MAX group explained, “We just sat there and listened for, I don’t know how ever many, hours, but maybe even practicing some of these or having a model would help.” A collision repair teacher in the MAX group agreed, saying, “Some of the things weren’t clear to me.” Time after time, teachers mentioned their desire to have more than an explanation of the strategies. They wanted both to observe the strategies in action and to attempt to integrate and carry out the strategies during the training sessions.

Strategy adjustment. Teachers frequently discussed strategy adjustment, meaning any changes made to the implementation of the literacy framework and its associated strategies. Many teachers thought that literacy strategies as typically used would not work in their classroom, so they modified individual strategies in minor ways to make them more contextualized, interactive, and tailored to the texts they were reading. In some instances, teachers divided the strategies into shorter, simpler chunks so that neither the strategies themselves, nor the reading were as daunting to the struggling reader. Some teachers felt that they had to adhere to the written instructions for the strategy.

One of the main adjustments included competitions among students. As a metal trades and outdoor motor sports teacher in the MAX group said, “The kinds of kids we have, they get into a war zone” during the competitions. Some teachers gave extra points when using the strategy *Stump the Teacher*. A cosmetology teacher from the MAX group combined strategies by taking *KWL charts* and having “incorporated all of that into [*Cube It!*].” A collision repair teacher in the MAX group modified the time period for an activity: “You have one minute to read and one minute to discuss,” adding, “the timer is the key element there.” Teachers adjusted strategies in order to make them “[relate] really well with the writing process I use” or because “it was hard to get them to ask questions” in the way the three-level questions strategy initially expected. Another teacher “took [*Making Predictions*] a step further and actually defined what those words were, and how they’re related to what they read, then I thought that worked fairly well.”

Multiple teachers noted that mixing or combining strategies best fit their classroom, such as an outdoor power equipment teacher in the MAX group who “incorporated [a strategy] into *Cornell Note Taking* because I think it grouped them together, and they had to compare notes with each other and it worked pretty well.” In brief, several teachers adjusted the literacy strategies to meet the needs of their content area or particular group of students.

Framework adoption. Framework adoption was defined as the acceptance and understanding of the framework. Indications of the lack of acceptance or understanding of the framework included (a) rote use of strategies, (b) no mention of the framework elements when discussing why strategies worked or did not work, or (c) wanting to cut the theory out of the professional development.

For example, a cosmetology teacher from the MAX group expressed her desire to ignore the discussions of reading and literacy theory in professional development, saying:

> If you had said, “You are going to implement these strategies,” we could’ve wiped out everything else we talked about and gone right to that book, and we could’ve brainstormed right there in the initial meeting. I mean it was good stuff that we heard and it was supportive, but…

However, a general education teacher in the MAX group seemed to use the cooperative learning from the framework, saying, “We would do something together because we don’t usually [collaborate with one another].” An outdoor power equipment teacher from MAX noted, “From a reading aspect, cooperative learning works pretty good.” As cooperative learning is an integral aspect of the MAX approach, the acceptance of that part of the framework into both classrooms was especially effective. Most of the teachers, however, did not seem to understand or accept the framework as an integral part of strategy use.

Teachers seemed to perceive the literacy framework as separate from the reading strategies and therefore superfluous in their already busy curricula. Many seemed unaware of the literacy framework at all. As stated above, it is possible that the frameworks were not as well adopted as expected due to apparent notions of what the framework meant rather than what it was, or the perceived rigidity of the strategies themselves. Although many teachers incorporated features (e.g., cooperative learning) of the literacy framework, the majority of teachers seemed unprepared or unwilling to fully incorporate the literacy framework, opting instead to utilize the strategies on their own.

Student receptiveness to reading and strategy use. Teachers also discussed students' willingness to use strategies, their competent use of strategies through teaching other students, or transfer of strategies into other academic courses. Student reactions had a positive impact on teacher confidence and strategy effectiveness. They likely also played an indirect role in framework adoption. If students resisted the strategies, then teachers were less likely to adopt the framework. Students' acceptance of strategy use within the classroom seems to be essential for any literacy framework, and comfort with the strategies seems to affect that acceptance.

According to teachers, when students "were interested, they were excited, they were willing to try something different." Multiple teachers related examples of "kids [getting] excited about looking in a textbook." "[Students] sit down and they ask the kid next to them and they start talking about the day-before's lesson," and these strategies were the "most effective way because then they would talk to each other and the class would start class discussion."

Teachers told stories of improvement in students' reading comprehension and motivation to read, such as one student who "started reading more novels. He had been reading just newspaper stories and he read two books." Regarding students, teachers felt as though "once [students have] seen it done, [they] are like, 'Okay, I want to try this again next time, now that I know really what to expect.'" Teachers noted that students "were really interested in reading to see what else they could learn from it." Another teacher even said her students "actually said, 'Wow, this made reading really easy!'" On the whole, students were receptive to the integration of literacy strategies. Students' receptivity surprised teachers and was a source of teacher confidence and reassurance.

Findings from Student Focus Group Sessions

Through the focus groups, researchers found four main themes that defined the findings: students desired a utility value in their strategy use, students understood the importance of reading to their careers, students engaged in reading if they could apply the information, and students desired a social aspect to reading to foster motivation.

Utility value. *Utility value* means that CTE students read with specific purposes in mind, specifically to utilize the information from text in some meaningful application within the CTE context. Subthemes emerged and included three different elements: general interest in the reading purposes and text, relating the reading activity to immediate career interests, and reading authentic texts related to the CTE area.

General interest. When researchers asked students what they read and why, many commented that they liked to read texts inside and outside of class, including those they found interesting and related to their own lives. An advanced cosmetology student said, "If I do read, it would have to be something that is interesting to me…something connected to my life." An outdoor power conservation student added, "If there is a book we're reading in school, [and] it's not interesting, I just don't read it." Another echoed the same: "If [a text's] not interesting it doesn't stick."

Another student preferred “books I can relate to…my life.” Overall, students related that they wanted “stuff I find interesting,” “something that you really can do,” or something “I can relate to” to read about.

Immediate career interest. Many of the students expressed they were most interested in reading texts related to their intended career or area of study, and enjoyed reading in their CTE courses more than other courses because of CTE’s direct application to their career goals. “I’ll read anything about culinary, even if I don’t like part of it,” commented one culinary arts student. This sentiment was also expressed by an animal science student, who said, “Reading in this class is a lot better because you can actually…get involved into what you’re reading.” Students in another conversation agreed: “What I read in here, I’m going to use a lot more than what I read about in English class,” because “whatever you learn in here, you are looking toward a career with it.”

Authentic texts. Many students commented that textbooks are boring, intimidating, and dull. A criminal justice student said in reference to textbook reading, “I hate that!” Students preferred using various sources for learning such as magazines, articles, and trade books. A student in cosmetology said, “I don’t really like to read from the textbook because adults have a different perspective on what’s…good reading than teenagers do…. I would much rather go pick out an article that I know I can understand … [and] be interested in.” Many students, especially those in graphic art classes, expressed their preference for readings accompanied by pictures and visuals because “pictures always make more things fun.”

Importance to career. Many students understood the importance and necessity of reading in their future careers as a life skill, despite their frustrations regarding reading. A business student explained, “If you can’t read, you can’t run a business.” Even in a shop class, it is necessary to be able to read in order to complete the task at hand. Students in outdoor power equipment, mechanics, and metal-working agreed: “If you don’t know how to read it’s [going to] be more challenging for you to do that task.” These students specifically mentioned the importance of the ability to “read a repair manual,” “understand diagrams,” and “understand the vocab.”

From collision repair to culinary arts, students indicated that reading was important simply to follow directions, or else “you… ruin things when you don’t read.” As one graphic arts student mentioned, “We are going to have to read in order to know what you’re supposed to be doing…I think it’s the backbone to any and every job out there.” Some of the students also said reading was a life skill. A student in cosmetology expressed, “Reading is a life thing…you’re always going to need to know how to read and you’re always going to keep reading.”

Reading to apply. Many of the students enjoyed the reading in class and found it necessary in order to apply the lessons learned from reading to the hands-on lesson within their CTE area. A mechanics student responded, “Reading’s all right, but just for information for working on something,” and a collision repair student shared similar views, saying, “You do a little reading and then you go out into the shop and actually do it hands-on.”

Social aspect. Students expressed a preference for using the strategies in a social setting. Two elements related to the social aspect of reading emerged from the focus group sessions—social engagement with other students and competitions with other students. Social engagement and competitions with other students centered on learning from the text. Students enjoyed discussions related to information in the text and the applications of that information on practical CTE problems.

Engagement. Students were more engaged with reading when it was paired with an activity, especially a competition or game. An early childhood education student said, "[The strategy] helps me instead of just reading it." Also, a culinary arts student said, "It was … a competition…that's what made it so fun." A student from advanced cosmetology replied, "We'll have…a race to see…who can write down what pertains to the topic …we're getting more out of it because you remember the fun times you had."

Discussion. Students believed that discussion helped them to understand material better and generate more ideas because "if you discuss [the reading]…they might bring up a point you never thought about." Also, students noted that discussion was helpful "because if you don't understand something or…if you interpret it … one way and somebody else interpreted [it] a different way, you could talk about it and figure out which one … got the right idea," or "because … if … you missed [something] maybe they caught [it]." As a culinary arts student explained, "When you just read it and try to comprehend it yourself, I don't understand…. It's easier if we all discuss it and do it together;" especially, as another student mentioned, "because sometimes when you ask teachers questions they can't always explain it in ways that you'll understand so you have students around that might understand it and they can explain it to you in a way that you'll understand."

Conclusions from the Pilot Study

Experimental Portion of the Research

Findings from the Authentic Literacy pilot study suggest that the use of disciplinary literacy strategies within the context of CTE had a more positive effect on students' reading comprehension and vocabulary development than a control condition in which teachers did not implement reading strategies.

In sum, the gain scores of the MAX Teaching Framework significantly exceeded those of the control group, with the exception of scores for the MRQ. The CTE Reading Framework gain scores of total GMRT and GMRT comprehension significantly exceeded the scores of the control group. This helps establish the notion that CTE teachers can, through implementation of the MAX Teaching Framework, improve students' reading comprehension and vocabulary development, even over the course of a relatively short-term treatment. Further testing of the MAX Teaching Framework in the context of CTE over a longer duration, preferably one academic year, is needed to validate these findings.

Contrary to our initial suppositions, researchers detected no significant differences in MRQ motivation scores between the MAX Teaching Framework and control groups. One possible explanation is that the treatment did not affect this measure. An alternative explanation is that the MRQ motivation was measured via a self-report questionnaire in the second week of May, which occurred after the end of course assessments for many courses and near the end of the academic year, when juniors and seniors typically check out of coursework and motivation lags. In future research, the posttests for the GMRT and MRQ should occur earlier in the semester when a more accurate measure of motivation would likely occur.

Several questions for further research remain, including the determination of the impact of such reading frameworks as the MAX Teaching Framework on total GMRT scores, GMRT comprehension, GMRT vocabulary development, and MRQ (motivation to read) over the course of an entire academic year. Does the integration of reading strategies in a pedagogic framework with longer duration enhance or detract from students' comprehension, vocabulary development, and motivation to read? Are these changes in students' comprehension, vocabulary development, and motivation to read durable over longer durations and in multiple states with multiple CTE formats?

Throughout this pilot study, researchers refined the administration of the project and collected detailed treatment validity measures. The pilot test validity measures tended to be open-ended in nature, whereas the weekly reporting format for the current intervention includes options for open-ended responses as well as systematic responses of pages read, amount of time assigned for reading, use of the pedagogic frameworks, and implementation of individual reading and writing strategies with the frameworks. Because of teacher and student responses to the interviews and focus groups conducted after the posttesting period, professional development was altered for Year 3. Professional development was lengthened to include more intensive lesson planning and emphasis on the pedagogic frameworks in greater detail.

This research lends influence to the CTE profession by helping establish the efficacy of reading frameworks and the implementation of content area reading strategies in CTE courses to improve students' comprehension, vocabulary development, and motivation to read. Although further testing is necessary to establish this effectiveness, administrators, teacher educators, and those who deliver professional development may find the MAX Teaching Framework effective in enhancing students' engagement and achievement in CTE.

Conclusions Arising from the Teacher Interviews

Regarding the teacher interviews, it is important to note that the themes we uncovered are interrelated. These six themes provide the basis for a discussion of strategy use in CTE. Teacher confidence in strategy use and framework implementation increased with (a) clear professional development, (b) continuous communication between an expert coach and the teacher, (c) experienced real-time observations, and (c) provision of samples that cut preparation time for teachers who might be less likely to use these strategies without examples. When professional development gave teachers experience with strategies from the student's point of view, an opportunity to ask questions in a "safe" environment, and the chance to work on integrating the framework into their curriculum while an expert was at hand, teachers felt more confident facing their class with something that they had never tried before. The more confidence teachers build, the more likely teachers may continue to use the strategies and the more willing they may be to take the time to integrate the framework and strategies into their classrooms.

Communities of practice provide opportunities for feedback from experienced practitioners. For example, in a community of practice, teachers may assist one another with framework and strategy implementation, which could boost teacher confidence and efficacy. Teachers also might find communities of practice beneficial when the community is formed with teachers from other CTE fields who experience similar challenges with literacy integration. If such communities of practice had been in place, teachers could have become more confident about what they were doing and made more use of the strategies. It is likely that, given that many teachers had mentors at the beginning of their teaching careers, most would feel more comfortable implementing the framework and strategies if such a familiar environment were available to them.

Use of authentic text can be encouraged through both collaboration with other teachers and perhaps a database of resources to create engagement and motivation among students, which would improve literacy. Furthermore, if the text has familiar components such as blueprints for a carpentry student or engine schematics for an automotive student, students may be more comfortable using the strategies on it, rather than on something as intimidating to a reluctant reader as *Pride and Prejudice* or *Moby Dick.*

Teachers who adjusted their strategies found them easier to use in the hands-on environment of CTE, which lead to better learning and student familiarity. When strategies were adjusted to acknowledge fears of students, their difficulties with reading, and differing lengths of time they had with their CTE teachers, the students became more comfortable with and willing to use the strategies. This again led to teacher confidence. According to the teachers, an effective framework needs to be clear, have direction, and offer proof that it works in order to build teacher confidence. An effective framework for CTE needs to be open to strategy adjustment so that the needs of CTE can be addressed.

The lack of a framework adoption in this study may be attributed to a lack of student receptiveness, unclear objectives regarding the framework itself, and even a lack of teacher confidence in how to use the strategies alone, not to mention within the framework. The final and perhaps the most important component was the influence of student receptiveness. Based on teacher interviews, when students felt both comfortable and safe, they had more motivation to read and more ease using the strategies. Without student cooperation, no program will be effective, no matter how well-researched and thought-out it may be.

Many of the above themes can be seen in a single factor: cooperative learning. The cooperative learning component of the MAX teaching framework seemed to be very popular within the classrooms studied and also seemed to fit extremely well into the hands-on atmosphere of the CTE classroom. Teachers reported more student involvement, improvement with reading skills, and motivation to read when those students were able to work with each other and think through the readings. Students were more receptive when they could work together to understand a text. Teachers were more confident when they saw students able to do what they needed to do. Given how many of these themes cooperative learning affects, it likely is a key component to an effective literacy framework.

Conclusions Arising from the Student Focus Group Sessions

Knowing that many CTE students appreciate engagement with their learning, usually through hands-on methodologies, the social aspect of reading is important for increasing engagement and boosting students' understanding of texts. Many CTE teachers are not professionally educated to be teachers, and therefore lack the familiarity and understanding of those reading strategies that best integrate these social aspects into the classroom. In order to reduce student resistance, teachers need to make reading more fun and enjoyable, thus increasing motivation and engagement to read.

Researchers know that the use of authentic text is more interesting and engaging for students and leads to less resistance. CTE students read many different forms of texts such as diagrams, charts, blueprints, and recipes. Teaching with a textbook, which often presents ideas in large chunks of information without many of these extra features, does not prepare students for the types of reading that they will encounter in their future careers. Teachers may encounter less resistance if text is presented in shorter snippets of information, such as articles. CTE students do not feel they are reading for a grade, as they might in an academic classroom, and recognize the difference between reading classic literature and an instructional manual. It is important, then, for teachers to provide varying sources of text that students will recognize as valuable and applicable to their lives. Students willingly read, especially when they know that they will apply the information in a problem-solving, concrete manner. CTE teachers can leverage these findings to engage students in reading in their courses.

Reflections on the Core Principles in the Authentic Literacy in CTE Study

As the Authentic Literacy research project has progressed, the core principles of curriculum integration uncovered by the Math-in-CTE study (Stone et al., 2006) have developed resonance with the literacy project. The Authentic Literacy pilot study tells us something about the value of teachers coming together in communities of practice around literacy. The Literacy study was developed using a similar research design and data collection methods to those used by the original Math-in-CTE study, although there are some notable differences in the two studies' approaches. The Authentic Literacy model utilizes an interdisciplinary approach to integration in which teachers from all occupational or CTE content areas were brought together to learn and develop literacy strategies. Teachers in the Authentic Literacy study also received a shorter duration of professional development than those participating in the Math-in-CTE study. This section reflects upon the five core principles of the Math-in-CTE model as principles for integration of academic content and processes into CTE. The five principles are:

- Develop and sustain a community of practice among the teachers.
- Begin with the CTE curriculum and not the academic curriculum.
- Understand that academics are essential workplace to knowledge and skills.
- Maximize the academics in the CTE curriculum.
- Recognize that CTE teachers are teachers of academics-in-CTE, and not academic teachers.

Develop and Sustain a Community of Practice

As with the Math-in-CTE study, there was no particular intent to create communities of practice at the onset of the Authentic Literacy study. Notably, we did find evidence of communities of practice as we observed the teachers stating their desire to be able to discuss strategy use with other teachers (both within and outside their CTE area) or with an experienced observer—or to create this type of opportunity on their own. Based on teacher feedback in this study, an effective program would include developing communities of practice, both school- and system-wide, to provide support for teachers. As mentioned, the responses of the teachers were highlighted with regard to developing and sustaining a community of practice. The community of practice was built among CTE teachers from various disciplines because of the procedural knowledge orientation and breadth of reading required in CTE courses. In many cases, the diverse community of practice fostered innovation about how and where to implement reading frameworks and strategies.

Having other teachers in the school provided a type of support system for the teachers and helped the implementation process run much more smoothly. Administrative support of faculty was another factor in the success of the literacy implementation. When the administration was supportive of what the teachers were doing, it was much easier for the teachers to stay focused on the implementation process.

Teachers were especially interested in getting feedback after a classroom observation by a more experienced teacher or a researcher who knew the framework and reading strategies well. Many teachers thought that having that kind of feedback drastically cut down on the frustration or resistance they felt in implementing strategies within their classrooms. As many teachers seemed to find that implementation became easier after the third time, helping them get past the initial frustration at not seeing the strategies work as expected would greatly improve the acceptance of the strategies and framework as a whole. The cosmetology teacher in the MAX group asked us for “[a] mentor teacher,” and further commented: “We’re sending you our lessons and [you are] looking over those, coming into the class, seeing what we’re doing, and how we’re doing it. I think [it] would help to get more feedback [from a mentor] because we kind of [were] on our own.”

Teachers requested collaboration areas or opportunities to see specific lessons that others had made, which may trigger a better way to utilize the strategies within their classrooms. As one teacher explained, “That would help us to bounce ideas off of each other and say ‘Wow, I don’t know what to do. This is what I have coming up.’ So being able to talk to somebody to help fumble our way through… lesson plans maybe they’ve already done one… I threw out the beach ball idea to a couple other [teachers]… So you know we bounced a few things but you just kind of feel like a fish [out of] water there for a little bit.”

Begin with the CTE Curriculum, not the Academic Curriculum

In the Authentic Literacy study, the principle of beginning with the literacy that already occurs within the CTE curriculum was approached somewhat differently by teachers. Because literacy and reading are interwoven into the curriculum as means of learning about CTE, teachers certainly had to begin with opportunities for reading in their curricula. However, CTE teachers readily acknowledged that their focus was on the CTE curriculum and not on increasing the intensity or duration of reading for its own sake. Teachers specifically mentioned that they were not English teachers, and that they were uncomfortable with the idea of teaching what they perceived to be English strategies. Therefore, in order to bring teachers on board, an effective framework would allay those fears and discomfort by starting with what they know—the CTE content.

CTE teachers acknowledged that students enroll in their courses for the experiential learning components, and not necessarily because they believe the course will be text-driven. The goal of the implementation of reading frameworks and strategies was not to create another English class or to implement reading arbitrarily. Teachers were encouraged to continue to use authentic texts, similar to those that students will encounter in their careers beyond the classroom. Many teachers found that by having the students read relevant articles and content-specific materials, such as blueprints, manuals, and recipes, the students were more engaged and interested in the reading because it was relevant to their interests and future careers. Teachers specifically mentioned the importance of reading in their classrooms. Beginning with the CTE curriculum really means beginning with reading that is authentic, not contrived.

The teachers' perception was validated as students made some of the same observations. Many of the students expressed that they were most interested in reading texts related to their intended careers or areas of study and enjoyed reading in their CTE course more than other courses because of CTE's direct application to their career goals.

Literacy Skills are Essential Workplace and Lifelong Skills

Although the ability of students to apply mathematics skills is certainly essential to their success, a greater, more overarching need may be workplace literacy. The preliminary findings from the Authentic Literacy study provide further evidence of the significance of this core principle. Many students understood the importance and necessity of reading in their future careers as a life skill, despite their frustrations or disinclinations toward reading.

After speaking with many of the students in focus groups after the study, it became evident that many of them were aware of the importance of literacy to their future careers and success. They realized the impact that misreading instructions or a diagram can have on their work; they were also more willing to do the reading because they knew that it was important.

Teachers in general noted that when students saw a direct connection between the reading skills they were learning and the career skills they were acquiring, they were more willing to read and continue to use or try to use the new strategies. As one teacher told us, her students "don't see the point in reading unless it's for information like instructions." Therefore, if the teachers demonstrated the need to read and learn the strategies to their students in the context of learning CTE skills, the students "recognized the value" of the strategies.

Teachers also found that when readings related to the hands-on, experiential work the students were doing in a laboratory or shop, they were more apt to remember and utilize information.

They noted "success on the floor" when they were able to get students to connect with readings through literacy strategies, and one even said, "I think some of those kids that don't get the concepts … were able to understand because they were doing more hands-on" work involving the reading.

When teachers connected reading with life skills in the workplace, students were more likely to decide to read on their own. The internal motivation this realization triggered is the cornerstone of any successful teaching program, as students who are convinced of the worth of something are more likely to use it, more likely to learn it, and ultimately more likely to succeed.

Maximize the Literacy in CTE

The Authentic Literacy study is extending our understanding of this principle. Maximizing the reading in the CTE curriculum is better understood as fully utilizing the text that is already there, as well as making teachers more aware of the reading expected of their students in order to learn about the CTE content. When teachers understand how various texts within their classroom can contribute to student learning, they will be more likely to see the benefits of using reading strategies to break down the technical language barrier between some students and success. Students would be able to focus on reading that they want to do, which in turn would help them overcome their resistance to reading in general, which then would lead to success in other areas.

It appears that the maximizing principle may apply to a differing degree depending on the area of study. For example, in many of the automotive classes, there was very little reading assigned before the study began. For those particular classes, it was important that the appropriate texts were found and implemented into classroom instruction. It remained an important theme throughout the study that reading should be implemented into classrooms, but it should not become a main focus of those classes. Some of the classes already featured a large amount of reading, so the implementation of additional texts was not necessary.

In interviews, CTE teachers often initially indicated that their courses offered little reading for students. However, after teachers were given the opportunity and impetus to reflect on reading expectations in their courses and share collaboratively, they often found abundant opportunities for reading. A culinary arts teacher first indicated that she expected little reading from her students, then continued to discuss recipes and how "they [students] have to research [for a project involving a dinner for a hundred people] what was going on that month,…to go actually do the orderings. So that involves a lot of reading of a different type, on a different level." An automotive teacher said he did not expect a lot of reading, but then cited of the many technical reference manuals used in his courses. As another example, a conservation teacher noted field guides for tree identification.

The principle of maximizing the academic opportunities in CTE raises a question that has yet to be answered. As researchers continue to engage in curriculum integration research and present tested models for implementation, at what point might the CTE community as a whole integrate so much academic content into CTE courses that such integration begins to diminish the value of the CTE content? The Math-in-CTE data (Stone et al., 2006) showed that CTE students did not lose occupational skills at the level of integration undertaken in the study. However, concerns about how much integration would be too much was not answered by the Math-in-CTE study, a concern identified by these researchers as the "tipping point." In Math-in-CTE technical assistance, teachers sometimes challenge the integration process and ask why CTE teachers are required to "do both" when the academics teachers are not asked the same. Recent efforts by states to offer CTE courses for academic credits raise this question to a new level. On the one hand, the assignment of academic credit rewards the efforts of teachers and students in the authentic application of academic skills. On the other hand, NCLB requirements, state-led standards, and high stakes tests present new pressures and expectations for both students and teachers—a force that could weaken the integrity of CTE programs.

CTE Teachers are Teachers of Literacy-in-CTE, not Teachers of Literacy

Although still in its pilot stage, the Authentic Literacy study is also helping us learn more about CTE teachers' experience with integration. As stated, many CTE teachers felt uncomfortable utilizing tools from what they viewed as the field of academic English, specifically saying that "I'm not a reading teacher. I'm not a writing teacher." They were unsure of themselves with such tools, and therefore had difficulties fitting them into their lesson plans; they also felt frustration when their results after the first try were not exactly what they had been expecting. Teachers would benefit highly from receiving assistance from someone who acknowledges that CTE teachers are not English teachers.

Teachers wanted to know that whatever they were doing to adjust the strategies would still produce positive results. Teachers mentioned not being "100% sure what the outcome should have been." One teacher expressed this concern by stating that she was "not always so sure that I was doing the right thing." Support from someone who understood that they were teaching in a CTE classroom rather than an academic English classroom would have allayed these fears, giving them the needed impetus to feel comfortable with what they were doing. Also, such support could assist them in adjusting the strategies to better fit the needs of their classrooms while also keeping the integrity of the framework intact.

By taking the focus away from reading strategies as reading skills, and instead recognizing those strategies as teaching tools for better CTE learning, teachers were more willing to implement the reading framework and strategies. Further, students realized greater results from the teachers' efforts with those reading frameworks and strategies. When teachers knew that they could adjust the strategies to fit the typical hands-on, experiential CTE classroom, they were more comfortable using them, and therefore were better able to transfer their knowledge of the strategies to their students.

Concluding Thoughts

The Authentic Literacy study's experimental findings, combined with teacher and student interviews, indicate that the use of disciplinary literacy strategies improves students' comprehension and vocabulary skills more than if there had been no strategy use at all. In order for strategy implementation to be the most beneficial, teachers need to be sufficiently trained so they feel confident to teach and use the strategies. This higher confidence level can be achieved through the initial professional development workshops as well as community support. Through the professional development workshops, teachers also get a chance to fully understand and accept the framework underpinning reading strategy use. Teachers need a community to converse and share ideas with in order to find the best modifications, adjustments, and practices with the strategies in their classrooms.

In addition to confidence levels and support, teachers need to use a variety of authentic texts that are similar to the texts that their students will encounter in their careers. Authentic texts are applicable and relevant to students' interests and vital to their success in their chosen professions. Using texts that are more relevant and interesting leads to the students being more receptive of the readings and strategies. The less resistant the students were to the readings and strategies, the more confident and accepting of the framework the teachers became. Student focus groups showed that students are receptive to reading if they can find the utility value of the strategies in their future careers and classroom practices. Students tend to be more open to readings if they are interesting and authentic to the CTE context, which for most of these students is why they chose their CTE subject. Many of these students also prefer the reading in their CTE classes because it relates to their career choices and is therefore more applicable to their lives. Students also enjoy the social aspect of using the strategies and found that class discussions helped them retain and understand the readings better. The social aspect and discussion combined resulted in greater engagement with texts.

With the pilot study completed, the research team analyzed the pretest and posttest data, student focus group transcripts, and teacher interview transcripts to modify the literacy frameworks to meet the needs of CTE. Based upon the experimental data from the pilot study, the team decided to substitute the generic CTE Reading framework with the Adolescent Literacy Support/Ash framework in the ensuing full-year study. The researchers also modified the professional development for teachers by including additional time for practicing literacy strategies, incorporating the frameworks into their curriculum, and developing lesson plans implementing the frameworks and strategies. Volunteer teachers in two states were randomly assigned to either the control group or one of two treatment groups (MAX Teaching, or Adolescent Literacy Support/Ash Framework). Beginning in September 2009, the treatment groups began a year-long intervention. Students completed pretests, including a demographic questionnaire, the MRQ, and the GMRT. Throughout the year, teachers have monitored and reported their use of the frameworks and strategies, assignment of student reading, and students' engagement with reading on a weekly basis. In April 2010, students will complete posttests that include the MRQ and GMRT. Researchers will conduct follow-up interviews with teachers about their experiences with the literacy frameworks and strategies. Researchers also will conduct focus group sessions with students and triangulate the findings with those from the teacher interviews.

New Directions for the Integration of CTE and Academics

The Math-in-CTE study, completed in 2006, provided sound evidence of the statistically significant impact of the integration of CTE and academics on student academic achievement. We have reflected on the five core principles identified by the Math-in-CTE study (Stone et al., 2006), using data collected from subsequent evaluations of the Math-in-CTE technical assistance and the Authentic Literacy pilot study. Findings and insights from previous studies and technical assistance services continue to inform our future research, including the pilot of the Science-in-CTE study.

Looking Ahead to the Science-in-CTE Pilot Study

A growing conversation has emerged among professionals in the science community about the need to adopt alternatives to traditional science teaching methods. Gilbert (2006) summarized the criticism of the traditional science education in this way:

> (a) Because of high content loads, the science curricula are too often aggregations of isolated facts detached from their scientific origin;
> (b) Students do not know *how* they should connect the aggregations of isolated facts that do not lend themselves to the formation of coherent mental schema and give no meaning to what they have learned;
> (c) Students fail to solve problems using the same concepts in other situations than those that closely mirror the ways in which they were taught.
> (d) Students do not feel a sense of *why* they learn the material required; it does not become relevant for them.
> (e) The traditional emphases of the science curriculum ("solid foundation," "correct explanation," and "scientific skill development") are increasingly seen as an inadequate basis for the more advanced study of science. (p. 958)

One of the more recent trends in science curriculum development has been the use of contexts and applications of science as a means of enhancing scientific understanding. This is often described as adopting a context-based approach. The following definition of a context-based approach to science education was developed by Bennett, Lubben, and Hogarth (2007):

> *Context-based approaches* are approaches adopted in science teaching where contexts and applications of science are used as the *starting point* for the development of scientific ideas. This contrasts with more traditional approaches that cover scientific ideas first, before looking at applications. (p. 348)

Bennett et al. proposed that context-based science courses can motivate students and make them feel more positive about science by helping them see the importance of what they are studying. If students are more interested and motivated by the experiences embedded in their lessons, their increased engagement may result in improved learning.

An emerging model supporting knowledge integration can be found among those in the science community (e.g., Kali, Linn, & Roseman, 2008) who argue for coherent science education. In doing so, they promote a movement beyond standards to a more systematic approach to science instruction that makes explicit the connections among scientific concepts and principles. More specifically, the Center for Curriculum Materials in Science (CCMS) approach emphasizes curricular coherence based on these characteristics: (a) interconnectedness of core knowledge, (b) connections between ideas of science and phenomena in the real world, (c) connections between new ideas and prior knowledge, and (d) connections between scientific ideas and the enterprise that produced them (Kali et al., 2008). The authors further promoted *contextualized* science learning through the use of real-world problems and inquiry-based projects. CCMS modeling, based on empirical research, closely parallels the approach of the evidence-based contextualized approach employed by the Math-in-CTE model.

Using a group-randomized approach, the Science-in-CTE pilot study replicates the Math-in-CTE study (Stone et al., 2006) in the fields of chemistry and biology as applied to agriculture. The primary research question is: *Will students who receive science-enhanced CTE instruction perform significantly higher on standardized tests of scientific knowledge than those in control classrooms?*

In the fall of 2009, volunteer teachers were recruited and randomly assigned to experimental and control groups. The experimental group of CTE teachers and their science partners received four days of initial professional development patterned after the Math-in-CTE model. The teams worked together to map curricula and develop science-enhanced lessons.

Students in the experimental and control classrooms were tested in January 2010, after which the experimental CTE teachers began teaching the enhanced lessons. The intervention is not a team-teaching model, therefore the CTE teachers will teach all of the enhanced lessons on their own. However, they will receive ongoing support from their science teacher partner and participate in two days of additional professional development at a midpoint in the pilot treatment period. CTE teachers randomly assigned to the control groups were instructed to conduct “business as usual” and to refrain from changing their instruction or curriculum during the treatment period. At the conclusion of the treatment period, students will take a posttest. Experimental teacher teams will reconvene for a one-day session that will include debriefing and focus groups; control teachers will be invited to a one-day workshop during which they will be debriefed and receive training in the model and all instructional materials developed by the experimental teachers.

Researchers will utilize a mixed-method approach that will involve the collection of both quantitative and qualitative data (Miller & Crabtree, 2000). The quantitative aspect of this study will involve the pre- and posttesting of students in classrooms of the teacher participants. Quantitative and qualitative data will analyzed to document the teaching experience. Fidelity of treatment will be ensured through the collection and analysis of pre- and post-study questionnaires, science teacher pre-teaching reports, CTE teacher post-teaching reports, instructional artifacts, and focus groups.

We anticipate considerable interest from the fields of CTE and science in learning the results of this study. If the intervention results in a significant difference between the scores of students in the experimental and control classrooms, there will be even more interest. This would confirm the strength of the Math-in-CTE model when replicated in a different academic area.

Beyond the Perkins IV Mandate: True Integration

Although not exactly a new discovery, the importance of relevance continues to be reinforced through these varied studies. The concept of curriculum integration, whether applied, context-based, or contextual, is founded on the premise that learners learn best what is important to them. For example, students enjoy (or at least show less resistance to) reading articles or manuals that relate to their career choice. As discussed previously, they understand the immediate benefit of reading instructions before attempting a task in the workshop. Similarly, students in a construction class are more willing to learn geometry because they see an immediate connection to a skill they want to master.

However, the benefit of relevance can also extend beyond the dimension of immediate application. We have seen evidence that after experiencing true contextual learning, students may begin to see beyond a particular lesson to the relevance of math in real-world applications. And whereas they may or may not read for the pure joy of reading, they understand that they can use a set of skills acquired in their CTE class to comprehend the varied documents they will encounter as productive adults. Helping students see the relevance of the process, not just of today's lesson, is a goal that is difficult to measure but worthy of our continued efforts.

A major finding of the Math-in-CTE study was the critical role of the extended professional development provided to teachers. The Math-in-CTE approach proved effective because its methods fostered the development of communities of practice focused on instructional improvement. This finding is consistent with a large body of research (e.g., Borman et al., 2005, Carpenter et al., 2004; Fullan, 2000; Hargreaves & Goodson, 2006; Joyce & Showers, 2002; Newmann & Associates, 1996) that documents the importance of professional learning communities to educational change. The communities of practice that continue to emerge through Math-in-CTE technical assistance create benefits for both teachers and students without involving an expansive school-wide reform effort. This model is even more promising due to its sound footing in scientifically based research.

The pilot of the Authentic Literacy study offered less professional development than the Math-in-CTE study; however, the participating CTE teachers indicated that they needed more structured time together, as much for moral support as for extended training in the reading strategies. Based on this feedback, study researchers have determined that more professional development is needed during the full-year test. Overall, more research is needed to determine the generalizability of communities of practice to other academic content areas and other group configurations. . As we have learned through our research thus far, effective professional development and communities of practice can rarely be mutually exclusive, so research on either topic should consider the inclusion of the other.

A concern about curriculum integration overall is the prospect of forcing academic concepts that do not fit or that take time away from teaching CTE content. Curriculum models that promote context-based instruction or applied academics still represent academic instruction for some teachers, and although these can provide valuable relevance and authentic applications of academic material, both teachers and students recognize forced integration when they experience it. CTE teachers do not always feel confident teaching academic content in such a manner. "A fish out of water" is a phrase that often appears in surveys issued to teachers at the beginning of a Math-in-CTE implementation. Whether it involves working with an academic partner or learning new strategies, reinforcing the centrality of the CTE curriculum in the process of integration is often a liberating and empowering experience for CTE teachers and one that helps them integrate enhance their instructional decision-making.

CTE teachers involved in integration efforts often come away with a new understanding and respect for their own content. After realizing how much academic content is available for enhancement, they are enthusiastic about taking one more step toward integration. This experience illustrates a concept in the literacy community, understood as "disciplinary literacy," meaning that a teacher "builds an understanding of how knowledge is produced in the disciplines, rather than just building knowledge in the disciplines" (Moje, 2008, p. 97). Moje suggested that "it may be most productive to build *disciplinary literacy* instructional programs, rather than to merely encourage content teachers to employ literacy teaching practices and strategies" (p. 96). This observation harks back to the previous discussion of the distinction between context-based and contextualized approaches.

Through evaluation from the Math-in-CTE technical assistance, NRCCTE researchers have also identified three levels at which one should think about and act on curriculum integration: systemic, curricular, and instructional. These levels somewhat echo those identified by Hoachlander (1999). All must be effectively addressed if integration is to have lasting impact.

The first level involves the understanding that whatever the context in which one works, the system of which one is a part must allow for and actively support integration. This means that people who administrate and lead agencies, regional consortia, districts, and school systems need to hold some philosophic agreement or in some way reach a consensus that integration of CTE and academics is the right thing to do. More importantly, they must be willing to put resources in place to support this work, including time, personnel, and monetary support. If this level of integration is not in place, implementations will be limited to the resources and ingenuity of departments or teachers. Although their efforts are often remarkable, this alone is not enough to enact change with lasting, sustainable impact. We have learned that teachers desire assurance from administrators that their work to integrate will be consistently supported and that their investment in the change will be lasting—as one teacher said, they are not interested in another "reform du jour."

At a second level, administrators and teachers need to examine both the depth and breadth of the CTE curricula to extract the potential it holds for academic integration. We must first take a systematic, intentional look at the opportunities within the content of individual courses, looking below unit titles and task lists to reach into the concepts and applications of CTE content. Only when we examine the curriculum at this depth do we recognize where the nexus of CTE and the academics resides—where authentic learning for students will occur. We must also examine opportunities for breadth of integration across whole programs to find the connectedness of those concepts and applications over time, and further, to understand the learning experience as students move through their CTE programs of study. By identifying gaps and redundancies, we will build coherence into the student learning experience.

This kind of multi-dimensional examination represents something different from a crosswalk of mandated standards to the CTE curricula. Crosswalks, in fact, may have the unintended effects of delimiting the CTE curricula to the current standards and/or superimposing academic content onto CTE curricula at the expense of authenticity. Without negating the significance of the crosswalks, we suggest they should be only the beginning. We are seeing the need for teachers and administrators to really know and understand the inherent value of CTE content within and across courses in order to maximize the opportunities for integration that lie within.

Through the NRCCTE's research and technical assistance activities, we have found the engagement and empowerment of teachers to be of utmost importance in the implementation and sustainability of curriculum integration. Integration must occur at the instructional level. We have worked with teachers across the country who are hungry to learn new and tested teaching methods that will help their students learn. Even teachers who were previously reluctant to depart from their long-established methods are willing to implement new teaching practices when they are convinced that the change will help their students. But integrating academic content with the CTE curriculum seems to work best and is most sustainable when it is practically invisible—it must be embodied not in occasional lesson plans, but as an overall approach to teaching.

Findings indicate that with time, practice, and understanding, most teachers seem to absorb the integration techniques they learn in professional development, making the profound step from implementation of the model to internalization, as Lewis and Pearson (2007) reported in their sustainability study of Math-in-CTE. We believe this also holds important implications for CTE teacher education programs. If the tested pedagogic models of curriculum integration could be effectively introduced during the pre-service experience, more teachers would have ongoing exposure to the proven benefit of authentic integration of academic content. More research is needed in this area.

As we await findings from the full-year Authentic Literacy study and as we complete the Science-in-CTE pilot study, we anticipate adding to what we have already learned about what makes integration work. We continue to test approaches with the potential to reinforce and improve the skills of thousands of students who otherwise would not have the opportunity to learn academics in context.

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CTE

National Research
Center for Career and
Technical Education

National Research Center for Career and Technical Education
University of Louisville, College of Education and Human Development, Louisville, KY 40292
Phone: 502-852-4727 • Toll-Free: 877-372-2283 • Fax: 502-852-3308
Email: nrccte@louisville.edu • www.nrccte.org