Enhancing Collaboration among Math and Career and Technical Education Teachers: Is Technology the Answer?

A. Christian Morgan
University of Georgia
Brian Parr
Auburn University
Nick Fuhrman
University of Georgia

ABSTRACT

Teacher collaboration has been recognized as a vital component to student success. This project represents an evaluation of the researchers' initial efforts toward providing in-service education for teachers focused on collaboration between math and CTE teachers. The purpose of this study was to (1) describe selected characteristics of secondary teachers of math and CTE, (2) describe their perceptions concerning the "value of" and their "willingness to implement" the instructional practices and activities presented during a professional development seminar, and (3) assess their views about the use of emerging technology for teacher collaboration. Survey responses indicated that using the Math-in-CTE Model was valued. Overall, respondents valued technology but seemed a bit reserved about the likelihood of implementing and using technology. Results imply that teachers with positive attitudes and self-efficacy for adopting the model may struggle to implement collaboration due to a lack of time and access to technology.

Introduction / Theoretical Framework

Contextualized learning experiences benefit secondary students in many ways (Bottoms & Sharp, n.d.; Buriak, McNurlen, & Harper, 1996; Enderlin & Osborne,1992; Glasgow, 1997; Parnell, 1996). While these experiences may be provided to students through various approaches, formal integration of subject matter between disciplines can equally benefit secondary teachers (Chiasson & Burnett, 2001; Enderlin & Osborne, 1992; Myers & Dyer, 2006; Parr, Edwards, & Leising, 2006; Parr, Edwards, & Leising, 2008; Parr, Edwards, & Leising, 2009).

Recently, a method of achieving subject matter integration was developed by researchers from the National Research Center for Career and Technical Education (Stone, Alfeld, Pearson, Lewis, & Jensen, 2006). This model was designed to allow career and technical education (CTE) teachers from various disciplines to integrate a deeper level of mathematical instruction by "uncovering" the embedded mathematics that were already in the curriculum and providing a more meaningful focus on those concepts.

The need for increased student achievement in secondary mathematics in the United States is well established (Stone, Alfeld, & Pearson, 2008). The National Assessment of Educational Progress (NAEP) reported that in 2009, 36% of 12th grade students performed at a "Below Basic" level on the math portion of their assessment. Additionally, 74% of students performed at a level lower than "Proficient" (National Center for Education Statistics, 2011). This plan for effective curriculum integration was termed the "Math-in-CTE" model (Stone, Alfeld, Pearson, Lewis, & Jensen, 2006, p. 10, Figure 1). This approach was developed through rigorous research methods and resulted in a plan that has proven to be an effective means of delivering mathematically-enhanced CTE lessons (Parr, Edwards, & Leising, 2006).

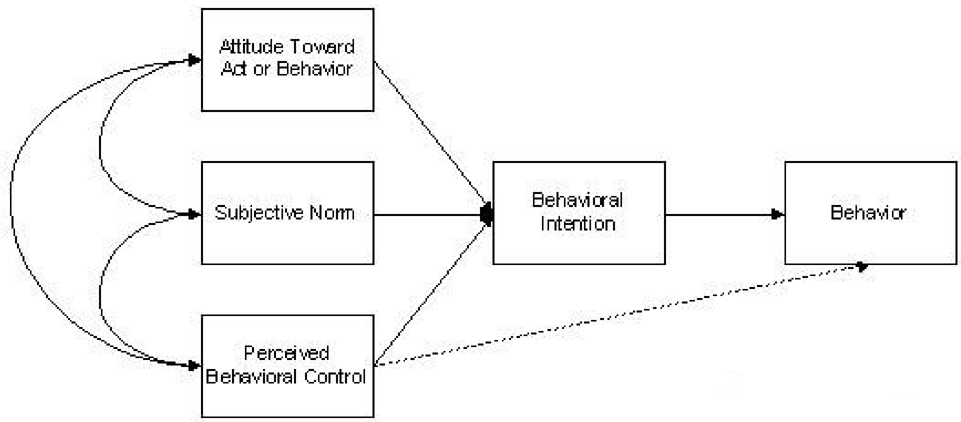

Figure 1. Theory of planned behavior. Adapted from "The theory of planned behavior," by I. Ajzen, 1991, *Organizational Behavior and Human Decision Processes, 50*, p. 182.

Teacher collaboration has shown to be a very important component of effective implementation of the Math-in-CTE model. While this holistic approach appears to be a valuable teaching and learning tool, implementing it may prove difficult. Earlier studies have shown that curriculum integration and the necessary teacher collaboration that is associated with it has many barriers. Enderlin and Osborne (1992) identified several of these barriers when considering the integration of agricultural education and science education. These barriers included insufficient planning time, incomplete teacher training, and a lack of administrative support. Through research, these authors determined that while contextualized learning proved to be very beneficial, the collaborative activities that were required were time consuming and sometimes difficult. Further, science teachers must feel that contextualized learning is important and work cooperatively with agricultural teachers to achieve effective results (Enderlin & Osborne, 1992). This reflects the vital importance of educating the general education teacher on the many benefits associated with contextual learning and the benefits of increased collaboration. Enderlin and Osborne focused on the integration of agricultural science and biology but it is reasonable to believe that the barriers are common to the integration of other areas and disciplines.

Later studies echo the findings of Enderlin and Osborne (1992). Thompson (1998) identified barriers to contextualized learning such as lack of preparation time, lack of knowledge concerning how to integrate subject matter, and a lack of administrative support. Warnick and Thompson (2002) described barriers to integration from the perspective of the general education teacher and discovered that a major barrier to collaboration was the general education teacher's lack of agricultural knowledge. While nearly 80% of the science teachers questioned agreed that collaboration between the agriculture and science teachers could be beneficial to science students, the teachers were obviously unaware of how they could achieve integration with agricultural educators. The obvious solution to overcoming the barriers that prevent effective contextualized learning is sustained teacher collaboration, yet it is also evident that this needed collaboration is happening on a limited basis (Stephenson, Warnick, & Tarpley, 2008).

Teacher collaboration has long been recognized as a vital component to student success. Garet, Porter, Desimone, Birman, and Yoon (2001) stated, “First, teachers who work together are more likely to have the opportunity to discuss concepts, skills and problems that arise during their professional development experiences” (p. 918). The authors also posited that, “. . . teachers who share the same students can discuss students’ needs across classes and grade levels” (p. 918). Balschweid, Thompson, and Cole (2000) studied the integration of science and agricultural education and, consequently, the collaboration between teachers in the two disciplines. The researchers acknowledged, “Agricultural education teacher preparation graduates should be encouraged to participate in activities at their building sites which would foster relationships with members of the science department and general faculty to increase the opportunities for collaborative endeavors” (p. 43). This same philosophy could also be applied to other career and technical education teacher preparation programs.

Teacher collaboration can also strengthen faculty camaraderie and teamwork. Myers and Thompson (2009) documented the value of teacher collaboration as evident in the following statement, “Collaboration with other academic teachers through cross-curricular projects will help students better understand the academic as well as technical concepts and principles” (p. 84). The researchers went on to say, “These collaborative efforts will help agriculture teachers understand the importance and become stronger team members within the total educational community in developing the whole student” (p.84).

While collaboration provides many benefits for students and teachers alike, it also requires extra effort. One of the hurdles impeding secondary teachers from collaborating is a lack of time (Delnero & Montgomery, 2001). Given this dilemma, it would seem unreasonable to expect teachers to add another meeting to their frantic schedule. However, current internet technology has provided a means for individuals to collaborate with a fraction of the time requirements associated with face to face encounters. Tools such as wikis, blogs, and communities of practice, as well as social networking sites (e.g. Facebook, Twitter, MySpace etc.), have made interaction between individuals much more time efficient and less prohibitive in terms of scheduling (Friedel, Rhoades, & Morgan, 2009; Morgan & Parr, 2009). Yet the question remains, how well prepared and willing are current teachers to implement the use of technology as a viable means for collaboration toward contextualized learning?

The current project represents the researchers’ initial efforts toward providing in-service education promoting collaboration between math and CTE teachers. To that end, data were collected to determine the perceived needs of the teachers concerning their perceptions about their self-efficacy (Bandura, 1995; DeMoulin, 1993) for collaboration and the use of innovative technology as a collaboration tool. The educators’ views about the “importance of” and “desire to implement” using methods they learned during the in-service were conceptualized as “proxies” or indicators of their self-efficacy and related “planned behaviors” (Ajzen, 1991, see Figure 1). Davis, Ajzen, Saunders, & Williams (2002) described three major factors that hold high relationships with human action. These three factors were defined as: evaluation of the behavior ("attitude toward the behavior"), social pressure associated with the behavior ("subjective norm"), and self-efficacy in relation to performing the behavior ("perceived behavioral control", p. 811). Of the three aspects that Davis et al. described, self-efficacy holds the strongest association with behavioral intention and the resulting behavioral engagement.

Many researchers have called attention to the need to systematically determine the best strategies for collaboration between teachers (Goddard, Goddard, & Tschannen-Moran, 2007; Myers & Thompson, 2009; Osborne & Dyer, 1998; Schmoker, 2001). This study sought to address one facet of this question by investigating likelihood for teachers to use technology for collaboration. The training approach used was designed to enhance math and CTE teacher self-efficacy toward collaborating and increase the likelihood that they would collaborate with the help of technology.

Purpose of the Study

The multi-fold purpose of this study was to (a) describe selected characteristics of secondary level teachers of math and CTE, (b) describe their perceptions concerning the "value of" and their "willingness to implement" the instructional practices and activities that were presented during a professional development seminar, and (c) to assess their views about the use of emerging technology as tools for teacher collaboration. In addition, findings will be used to better inform providers of professional development regarding the relevance, appropriateness, and anticipated value of trainings on enhancing teacher collaboration using technology. Specifically, this study was guided by four objectives:

1. Determine the value that CTE and mathematics teachers place on collaboration facilitated by the Math-in-CTE Model;
2. Describe the likelihood that such educators would implement the model in their teaching;
3. Determine the value that CTE and mathematics teachers place on collaboration facilitated by technology (wiki's, blogs, Google docs, and Facebook);
4. Describe the likelihood that these educators would use technology to enhance teacher-to-teacher collaboration.

Methods and Data Sources

Both qualitative and quantitative methods were used to collect data from 44 teachers of mathematics and CTE for this descriptive study. The participants attended a professional development seminar in which topics were presented by two faculty members from four-year universities, one who focused on teacher education and the other on web-based technology. The researchers developed a questionnaire that elicited three categories (constructs) of information: (a) personal/professional data; (b) assessments about the "importance of" and teachers' self-perceived "ability to" perform the seminar's topics (i.e., competencies); and (c) perceptions about trends in technology that could be used as tools for collaboration.

For this research a convenience sample was used to obtain data. This is an appropriate method when it is difficult to select a random or systematic non-random sample and has been used in previous studies (Fraenkel & Wallen, 2006; Jennings, Brashears, Burris, Davis, & Brashears, 2007; Smith, Park, & Sutton, 2007).

A researcher-developed instrument was implemented with a group of secondary educators at a national CTE conference following participation in a workshop highlighting the Math-in-CTE Model and collaborating using technology. The instrument contained two constructs and a series of demographic questions used to describe respondent gender, school size, and level of teaching experience. The first construct, Math-in-CTE Model and Mathematics, fulfilled study objectives one and two and measured the value that educators place on using the Math-in-CTE Model during collaboration and the likelihood that they would implement the model (see Table 1). This construct contained five items with response options ranging from 1 (*no value* and *not likely)* to 10 (*highly value* and *highly likely*). The second construct, Technology, fulfilled study objectives three and four and measured the value that educators place on collaboration facilitated by technology and the likelihood that they would use technology to enhance collaboration (see Table 2). This construct contained two items with response options ranging from 1 (*no value* and *not likely*) to 10 (*highly value* and *highly likely*). Descriptive statistics, including frequencies, means, and standard deviations, were used to summarize the data at the item level and to describe the respondents. Internal consistency was determined using Cronbach's alpha. If an acceptable (≥ 0.70) internal consistency was found within a construct, mean summated scale scores were calculated within the construct.

Domain analysis (Spradley, 1980) was used to summarize responses to the open-ended items on the questionnaire. Color coding was used to categorize responses into themes and themes were then collapsed into broader domains. Domains were then ranked by how often they surfaced in the raw data.

Results

Respondent demographics

Six demographic questions were included in the questionnaire and were answered by most participants ($n = 44$). Respondents were composed of 25 females (57%) and 17 males (39%), who had been teaching professionally 1 to 36 years ($M = 14.29$ years, $SD = 10.44$) and teaching at their current school 1 to 29 years ($M = 6.74$ years, $SD = 6.62$). Many teachers were early in their career, with 12 respondents teaching 0-5 years and seven teaching 6-10 years. Mid and late career teachers made up the remainder with six teaching 11-15 years, four teaching 16-20 years, and 13 teaching more than 20 years. Similarly, most teachers had been teaching at their current school for five years or less ($n = 25$). Twenty-six respondents identified themselves as mathematics teachers and stated they taught the following subjects (some respondents taught more than one subject): algebra ($n = 14$), math ($n = 12$), geometry ($n = 4$), pre-calculus ($n = 4$), calculus ($n = 3$), and statistics ($n = 2$). In addition, 15 stated they were CTE teachers whose subjects included the following skill areas: business ($n = 5$), engineering or technical ($n = 4$), computer ($n = 3$), and automotive related ($n = 3$).

Respondents were also asked to provide information about their schools. Student enrollment ranged from 34 to 5,200, with a mean of 1,078 students. Further analysis revealed that nearly half ($n = 20$) of the respondents were from schools with 501-1000 students, while nine schools had an enrollment of 1-500, six schools had an enrollment of 1,001-1,500, and four schools had an enrollment larger than 1,501. When asked to describe their school as rural, suburban, or urban, 18 respondents chose rural (41%), 14 suburban (32%), 8 urban (18%), and one used all three descriptors.

Objectives 1 and 2

Objective one was to determine the value that CTE and mathematics teachers place on collaboration facilitated by the Math-in-CTE Model, while objective two was to describe the likelihood that such educators would implement the model in their teaching. Table 1 depicts the descriptive statistics at the item level and the internal consistencies for the Math-in-CTE Model and Mathematics construct.

Table 1.
Descriptive statistics for Math-in-CTE Model and Mathematics by teaching discipline (Value α = 0.81, Likelihood α = 0.88, n = 39).

	Mean Value Score (SD)[a]		Mean Likelihood Score (SD)[b]	
Item	CTE	Math	CTE	Math
Discuss the Math-in-CTE Model with a teaching partner.	8.25 (1.53)	8.32 (1.89)	8.31 (1.40)	7.42 (1.89)
Use the Math-in-CTE Model in my own classroom at least once.	8.44 (1.75)	7.86 (1.86)	8.33 (1.59)	7.29 (2.60)
Embed the Math-in-CTE Model in my own classroom by using it more than once.	8.25 (1.84)	7.45 (1.85)	8.27* (1.58)	6.79* (2.36)
Partner with a teacher in my school to illustrate contextual applications, like those found in CTE courses, into core subject courses.	8.75 (1.53)	8.95 (1.33)	7.80 (2.48)	7.75 (1.92)
Partner with a teacher in my school to infuse core subject concepts into CTE coursework.	8.75 (1.44)	8.77 (1.51)	7.73 (2.49)	7.79 (1.98)

[a] 1 (*no value*) to 10 (*highly value*)
[b] 1 (*not likely*) to 10 (*highly likely*)
* $p < 0.05$

Items within the Math-in-CTE Model and Mathematics construct had moderate to strong internal consistency (Table 1), warranting the creation of summated scale scores within the construct. This construct had a mean summated scale score of 41.85 ($SD = 6.13$) for the value teachers placed on incorporating the Math-in-CTE Model with mathematics. With minimum and maximum possible value scores of five and 50 for the construct, this implies that teachers place high value on integrating the Math-in-CTE Model with mathematics they teach. The mean summated scale score for the likelihood that teachers would incorporate the model was 38.79 ($SD = 8.55$). With minimum and maximum possible likelihood scores of five and 50 for this construct as well, this implies that teachers are likely, but not highly likely, to incorporate the model into their teaching.

Comparing the scores of math teachers to CTE teachers showed much similarity. Both CTE and math teachers value the Math-in-CTE model; however, when comparing the likelihood scores, CTE teachers had higher scores for all but one question. With this in mind, an independent samples t-test ($\alpha = 0.05$) was used to determine if differences existed between these two groups and revealed a significant difference for only one question, "Embed the Math-in-CTE Model in my own classroom by using it more than once." This implies that CTE teachers were more likely to use the Model multiple times than were the math teachers.

Objectives 3 and 4

Objective three was to determine the value that CTE teachers place on collaboration facilitated by technology, and objective four was to describe the likelihood that these educators would use technology to enhance teacher-to-teacher collaboration. Table 2 depicts the descriptive statistics at the item level and the internal consistencies for the Technology construct.

Table 2.
Descriptive statistics for Technology by teaching discipline (Value α = 0.96, Likelihood α = 0.90, n = 39).

	Mean Value Score (SD)[a]		Mean Likelihood Score (SD)[b]	
Item	CTE	Math	CTE	Math
Use technology (such as wiki's, blogs, Google docs, and Facebook) to communicate with other teachers at least once.	8.00 (2.24)	8.45 (1.47)	7.07 (2.84)	7.61 (1.53)
Implement technology to increase collaboration between career tech and mathematics teachers over time.	8.00 (2.00)	8.41 (1.40)	7.33 (2.58)	7.54 (1.53)

[a] 1 (*no value*) to 10 (*highly value*)
[b] 1 (*not likely*) to 10 (*highly likely*)

Items within the Technology construct had strong internal consistencies (Table 2), warranting the creation of summated scale scores within this construct as well. The construct had a mean summated scale score of 16.58 ($SD = 3.29$) for the value teachers placed on using technology. With minimum and maximum possible value scores of two and 20 for the construct, this implies that teachers value, but do not highly value, the use of technology to enhance their teaching. The mean summated scale score for the likelihood that teachers would implement technology to increase collaboration was 15.07 ($SD = 3.88$). With minimum and maximum possible likelihood scores of two and 20 for the construct, this implies that teachers are less likely to use technology to enhance collaboration with other teachers. Analyzing the data further revealed that although not statistically significant, math teachers appear to value technology more and are more likely to use technology, than are CTE teachers.

The qualitative findings presented below on the barriers to using technology to collaborate with colleagues provide further evidence concerning the possible reason for this lower likelihood.

Qualitative findings

Participants were asked to respond to two open-ended items on the questionnaire. The first item explored the barriers which would keep participants from using technology for collaborating with colleagues. The second item asked participants to complete the statement, "When I think about the [Math-in-CTE Model], the take home message for me would be…" using a creative slogan or phrase similar to one which might appear on a bumper sticker.

Domain analysis revealed six major barriers which would keep participants from using technology to collaborate with colleagues. Because of space limitations, raw data are not reported. Listed in order of prevalence, these barriers (domains) included: (1) "lack of a common planning period between math and CTE teachers," (2) "terminology/language used within discipline," (3) "familiarity with technology," (4) "willingness to change," (5) "access to technology," and (6) "stereotyping math and CTE." Although respondents indicated a willingness to collaborate with math or CTE teachers, not having adequate time in the day to do so effectively was the strongest barrier.

Following examination of the take home messages/creative slogans generated by participants, three major domains surfaced. Listed in order of prevalence, these included: (1) "math as a teaching tool," (2) "math and CTE together make it real," and (3) "breaking boundaries to build bridges." Participants noted the link between math and CTE curricula, and the ability of each to enhance the real-world relevance of course content to students.

Discussion, Conclusions, and Recommendations

The information found in this study provides valuable information for CTE teacher educators and university faculty planning in-service opportunities for CTE teachers. The first and second objectives of the study were to determine the value that CTE and mathematics teachers place on collaboration facilitated by the Math-in-CTE Model and the likelihood that educators would implement the model. Survey responses and construct summated scale scores indicated that using the Math-in-CTE Model was valued (41.85/50). When viewing individual item means, it appears that math teachers were more comfortable discussing the Model with a colleague (M = 8.25 CTE, M = 8.32 math) than they were with using the model within their own lessons more than once (M = 8.25 CTE, M = 7.45 math). Perhaps this is an indicator of a cautious skepticism these educators have to altering existing curriculum. Yet, overall the educators appeared to value collaborating with colleagues to enrich their curriculum, which was underscored by the value they placed on, "Partnering with a teacher in my school to illustrate contextual applications into core subject courses," (M = 8.75 CTE, M = 8.95 math). According to the theory of planned behavior, this indicates a positive evaluation of the behavior and increases the intention of the individual to carry out the behavior which, in this case, is to collaborate with their cross-disciplinary peers.

The likelihood construct also showed a positive trend (38.79/50), indicating that respondents were somewhat likely to implement the behaviors measured. Once again, the item scores indicated a possible cautious skepticism to curriculum change, and perhaps a desire for educators to learn more about using the Model and collaboration to develop a greater comfort level before implementing changes to their current coursework. According to the theory of planned behavior model, this would be associated with subjective norms; that is, because this is a new idea and they are not aware of other people in their school carrying out such collaboration, they are hesitant to be the pioneers in this area. This may indicate the need for social and administrative support for the implementation of new ideas such as cross disciplinary collaboration.

Objectives three and four focused on using technology to facilitate collaboration. First, determining the value that CTE teachers place on collaboration facilitated by technology and second to describe the likelihood that educators would use technology to enhance collaboration. Overall, respondents valued technology (16.58/20) but seemed a bit reserved about the likelihood of implementing and using technology (15.07/20). Once again, when presented with a new or unfamiliar behavior, there appears to be some hesitance to embracing the behavior, especially among CTE teachers. When the qualitative statements are taken into consideration, barriers emerge which may help explain the reservations observed in the likelihood construct. Statements such as "familiarity with technology" and "access to technology" indicate that not only does new technology create a barrier to carrying out a behavior, but easy access to technology may also be a challenge. In this day when the expectation is that every classroom has Internet access, the responses seem to indicate that other impediments, such as school Internet filtering programs (firewalls) or a lack of access to computers, make it difficult for teachers to utilize existing technology. In addition, respondent age may be a factor, as over half of the respondents had been teaching for 11 years or longer (n = 23). Older teachers may not be as quick to explore new technologies as younger teachers (Broady, Chan, & Caputi, 2008).

Based on quantitative findings, the likelihood that respondents would collaborate to embed the Math-in-CTE Model into their curriculum is moderately high. Respondents saw value in the ideas presented and tended towards being likely to implement the ideas as well. Yet, the qualitative portion of the instrument revealed other barriers with which teacher educators and in-service program developers should be aware. Time was the most prevalent barrier acknowledged, especially not having coinciding planning periods with potential collaborators. This is an important finding, as this issue is one that would have to be addressed by school administrators, hence the need for strong administrative support of collaborative activities. Another barrier was "terminology/language used within the discipline," indicating that the nomenclature of the respective disciplines is likely a barrier to collaboration. CTE teachers need to be reminded of the mathematical terms used and math teachers need to be introduced to the nomenclature of technical disciplines. Teacher educators can assist in the area by emphasizing common mathematical terms during teacher preparation and explaining to pre-service teachers the importance of sharing with math teachers the terminology commonly used in technical programs. Others have also found a lack of sufficient preparation time to be a barrier to teacher collaboration (Enderlin & Osborne, 1992; Thompson, 1998).

This study may also serve as a reminder of the value in combining quantitative and qualitative data collection techniques when making program improvement decisions. It is interesting to note that if only the quantitative portion of the study were analyzed, the theory of planned behavior model would seem to indicate a high probability that teachers would implement the behaviors shared in the workshop. However, when examining the qualitative responses, barriers emerge that were difficult to capture in the quantitative responses. Although respondents valued the information that was presented and even indicated their desire (i.e., likelihood) to apply the information, the barriers revealed may indicate that, regardless of a teacher's desire to embrace a behavior or technology, there may be barriers which prohibit doing so. These may be barriers that do not readily fit into the current theory of planned behavior model. A teacher can have a positive attitude towards a behavior, and self-efficacy for the behavior, but without time or technology to implement the behavior there is a high probability the behavior will not be performed.

Additional research should be conducted to replicate this study with other groups of CTE, and specifically agricultural education, teachers to determine if the findings are similar to other populations. Also, future workshops should be developed to address barriers to collaboration and embedding the Math-in-CTE Model in current secondary curricula. Perhaps identifying local or regional facilitators who can assist teachers to establish collaborative relationships and work with administrators will help overcome perceived barriers. Finally, research should be conducted to determine if an additional variable should be added to the theory of planned behavior model which addresses comfort and confidence with technology barriers.

REFERENCES

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211.

Balschweid, M. A., Thompson, G. W., & Cole, R. L. (2000). Agriculture and science integration: A pre-service prescription for contextual learning. *Journal of Agricultural Education*, 41(2), 36-45.

Bandura, A. (Ed.) (1995). *Self-efficacy in changing societies*. Cambridge: Cambridge University

Bottoms, G., & Sharpe, D. (n.d.). *Teaching for understanding through integration of academic and technical education* . Southern Regional Education Board.

Broady, T., Chan, A., & Caputi, P. (2008). Comparison of older and younger adults' attitudes towards and abilities with computers: Implications for training and learning. *British Journal of Educational Technology, 41*(3), 473-485.

Buriak, P., McNurlen, B., & Harper, J. G. (1996). Toward a scientific basis for the craft of teaching. *Journal of Agricultural Education, 37*(4), 23-35.

Chiasson, T. C., & Burnett, M. F. (2001). The influence on enrollment in agriscience courses on the science achievement of high school students. *Journal of Agricultural Education, 42*(1), 60-70.

Davis, L. E., Ajzen, I., Saunders, J., & Williams, T. (2002). The decision of African American students to complete high school: An application of the theory of planned behavior. *Journal of Educational Psychology, 94,* 810–819.

Delnero, J., & Montgomery, D. (2001). Perceptions of work among California agriculture teachers. *Journal of Agricultural Education, 42* (2), 56-67

DeMoulin, D. F. (1993). Efficacy and educational effectiveness. In J. R. Hoyle & D. M. Estes (Eds.), *NCPEA: In a new voice* (pp. 155-167). Lancaster, PA: Technomic Publishing Company, Inc.

Enderlin, K. J., & Osborne, E. W. (1992). Student achievement, attitudes, and thinking skill attainment in an integrated science/agriculture course. *Proceedings of the 19th Annual National Agricultural Education Research Meeting* (pp. 37-44). St. Louis, MO.

Fraenkel J. R. & Wallen, N. E. (2006). *How to design and evaluate research in education* (6th ed.) Boston: McGraw-Hill.

Friedel, C. R., Rhoades, E. B., Morgan, A. C. (2009). Can Web 2.0 improve our collaboration? *Techniques (84)*1, 24-27. http://www.acteonline.org/uploadedFiles/Publications_and_E-Media/files/files-techniques-2009/Theme_3.pdf

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001,Winter). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915- 945.

Glasgow, N.A. (1997). *New curriculum for new times*. Thousand Oaks, CA. Corwin Press.

Goddard, Y. L., Goddard, R. D., & Tschannen-Moran, M. (2007). A theoretical and empirical investigation of teacher collaboration for school improvement and student achievement in public elementary schools. *Teachers College Record, 109*(4), p. 877-896. Retrieved from http://www.tcrecord.org/Content.asp?ContentId=12871.

Jennings, M., Brashears, T., Burris, S., Davis, C. S., & Brashears, M. (2007). *A National Assessment of Beef Cattle Producers' Educational Needs Regarding Pre-Harvest Food Safety.* Paper presented at the AAAE National Research Conference, Minneapolis, MN.

Morgan, C. & Parr, B. (2009). Using technology to increase collaboration between career tech and core subject teachers. *Techniques (84)*8, 48-52. http://www.acteonline.org/uploadedFiles/Publications_and_E-Media/files/files-techniques-2009/Research_Report%287%29.pdf

Myers, B. E., & Dyer, J. E. (2006). Effects of investigative instruction on content knowledge and science process skill achievement across learning styles. *Journal of Agricultural Education*, *47*(4), 52-63.

Myers, B. E., & Thompson, G. W. (2009). Integrating academics into agriculture programs: A Delphi study to determine perceptions of the National Agriscience Teacher Ambassador Academy participants. Manuscript accepted for publication in the *Journal of Agricultural Education, 50* (2), 75-86.

National Center for Education Statistics. (2011). *National assessment of educational progress.* Retrieved from, http://www.nces.ed.gov/nationsreportcard/naepdata

Osborne, E. W., & Dyer, J. E. (1998). Attitudes of Illinois high school science teachers toward educational programs in agriculture. *Journal of Agricultural Education, 39* (1), 8-16

Parnell, D. (1996). Cerebral context. *Vocational Education Journal, 71*(3), 18-21.

Parr, B. A., Edwards, M. C., & Leising, J. G. (2008). Does a curriculum integration intervention to improve the mathematics achievement of students diminish their acquisition of technical competence? An experimental study in agricultural mechanics. *Journal of Agricultural Education, 49*(1), 61-71

Parr, B. A., Edwards, M. C., & Leising, J. G. (2009). Selected effects of a curriculum integration intervention on the mathematics performance of secondary students enrolled in an agricultural power and technology course: An experimental study. *Journal of Agricultural Education, 50*(1), 57-69

Parr, B. A., Edwards, M. C., & Leising, J. G. (2006). Effects of a math-enhanced curriculum and instructional approach on the mathematics achievement of agricultural power and technology students: An experimental study. *Journal of Agricultural Education, 47*(3), 81-93.

Schmoker, M. (2001) *The results fieldbook: Practical strategies from dramatically improved schools*. Alexandria, VA: Association for Supervision and Curriculum Development.

Smith, E. A., Park, T. D., & Sutton, M. (2007). *Effect of Location and Education on Perceptions and Knowledge about Agriculture.* Paper presented at the AAAE National Research Conference, Minneapolis, MN.

Spradley, J. P. (1980). *Participant observation.* New York, NY: Holt, Rinehart, and Winston.

Stephenson, L. G., Warnick, B. K., & Tarpley, R. S. (2008). Collaboration between science and agriculture teachers. *Journal of Agricultural Education, 49*(4), 106-119.

Stone, J. R. III, Alfeld, C., & Pearson, D. (2008). Rigor "and" relevance: Enhancing high school students' math skills through career and technical education. *American Educational Research Journal, 45*(3), 767- 795.

Stone, J. R., III, Alfeld, C., Pearson, D., Lewis, M. V., & Jensen, S. (2006). *Building academic skills in context: Testing the value of enhanced math learning in CTE* (Final study). St. Paul, MN: National Research Center for Career and Technical Education.

Thompson, G. (1998). Implications of integrating science in secondary agricultural education programs. *Journal of Agricultural Education, 39*(4), 76-85.

Warnick, B., & Thompson, G. (2002). Perceptions of Oregon science teachers regarding the integration of science into the agricultural education curriculum. *Proceedings of the 29th Annual National Agricultural Education Research Conference*. (CD-ROM, December 11, 2002 release, Las Vegas, NV.)