

DOES A CURRICULUM INTEGRATION INTERVENTION TO IMPROVE THE MATHEMATICS ACHIEVEMENT OF STUDENTS DIMINISH THEIR ACQUISITION OF TECHNICAL COMPETENCE? AN EXPERIMENTAL STUDY IN AGRICULTURAL MECHANICS

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Abstract

The purpose of this study was to empirically test the hypothesis that students who participated in a contextualized, mathematics-enhanced high school agricultural power and technology curriculum and aligned instructional approach would not experience significant diminishment in acquisition of technical skills related to agricultural power and technology compared with those students who participated in the traditional curriculum. This study included teachers and students from 38 high schools in the state of Oklahoma (18 experimental classrooms; 20 control classrooms). Students were enrolled in an agricultural power and technology course in the spring semester of 2004. The total number of students who participated was 447 (206 experimental; 241 control). The experimental design employed was a posttest only control group design. One-way analysis of variance (ANOVA) was used to test the study's null hypothesis. The math-enhanced agricultural power and technology curriculum and aligned instructional approach did not significantly diminish ($p > .05$) students' acquisition of technical skills as measured by the National Occupational Competency Testing Institute (NOCTI) Agriculture Mechanics examination. A one-year replication of the study described is recommended.

Introduction

The lack of connection between subject matter in secondary schools has been widely recognized for a number of years (Glasgow, 1997; National Association of Secondary School Principals [NAASSP], 1996). Glasgow illustrated this separation when he said, "the only thing that connects classes in secondary schools are the corridors" (1997, p. ix). A clear picture of this lack of connection is evident when one examines the relationship between vocational and academic education. Many vocational courses are taught simply by showing a student how to perform an operation without properly training the student in the theory supporting it (Parnell, 1996). The opposite is true about many academic programs (Grubb, 1995). Frequently, in academic courses the student

is lectured to about theories and principles, but is never shown how these theories and principles can be applied to real situations (Bottoms & Sharpe, n.d.).

Parnell (1996) described the two categories: "Academic education: learning to know is most important; application can come later. Vocational education: learning to do is most important, and knowledge will somehow seep into the process" (p. 19). This dichotomy of instruction seems to be based on the distinction between "procedural knowledge" or knowing how to implement strategies toward the successful completion of a task and "conceptual knowledge" or knowing why the strategy was successful in completion of the task (Crowley, 2003). What is more, Crowley maintained that academic gains could be achieved through a proper mix of the two

approaches. This gap between practice and theory must be bridged. According to a guide for implementing curriculum integration published by The Ohio State University (Center on Education and Training for Employment, 1998), this bridge could come in the form of contextualized learning.

The need for educational reform was also expressed strongly in the report, *A Nation at Risk* (National Commission on Excellence in Education, 1983). The seriousness of this need was conveyed as follows:

If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. As it stands, we have allowed this to happen to ourselves. We have even squandered the gains in student achievement made in the wake of the Sputnik challenge. Moreover, we have dismantled essential support systems which helped make those gains possible. We have, in effect, been committing an act of unthinking, unilateral educational disarmament. (section 1, ¶ 2)

Among the recommendations put forth by the commission was a call for changes to be made in graduation requirements that increased the number of required academic courses. According to Barrick (1992),

The back to basics approach advocated by the 1983 book *A Nation at Risk* and subsequent publications included stringent graduation requirements with an increase in the number of credits required in the 'core academic' courses (language arts, mathematics, science, social studies, [and] history). (p. 6)

Although these changes appear to be reasonable on the surface, they often occur at the expense of the vocational education program. Cetron and Gayle (1991) deem this to be a mistake considering that two-thirds of vocational education program graduates matriculate to two or four-year colleges. Other evidence that this "indirect"

reduction of vocational education may be ill-conceived includes empirical evidence indicating students who were provided proper applications for their instruction (i.e., a contextualized approach to learning) actually achieved higher scores on standardized, general education tests (Chiasson & Burnett, 2001; Enderlin & Osborne, 1992; Parr, 2004; Parr, Edwards, & Leising, 2006; Wu & Greenan, 2003). However, is there a "cost," (i.e., diminished student technical competence), associated with using a career and technical education course as an instructional forum for improving student learning in a core curricula area such as mathematics?

Conceptual/Theoretical Framework

The idea of contextualized learning suggests that neither vocational nor general education is completely capable of standing alone but must be integrated to maximize benefits for the students (Prescott, Rinard, Cockerill, & Baker, 1996). To that end, Parnell (1996) stated,

No longer can the debate over the importance of vocational or academic programs be allowed to degenerate into an either/or argument. The basis for good teaching is combining an information rich subject matter content with an experience rich context of application. (p. 1)

Cetron and Gayle (1991) stated in their book, *Educational Renaissance*, that, "This integrated approach may give students a finer grounding in the 'three R's' [reading, writing, and arithmetic] than do book and blackboard classes" (p. 72). The authors predicted that in the future students will value vocational education more, but this may only hold true if reform occurs as it relates to curricular and instructional integration.

In 1996, the NASSP released a report titled, *Breaking Ranks: Changing an American Institution*. This report included many recommendations for reform in secondary education including a call for the integration of curriculum. According to the report, "Teaching subjects in isolation of

each other, as high schools are wont to do, distorts knowledge” (p. 13). The authors also recommended that teachers form interdisciplinary teams to better familiarize themselves with related curriculum and to provide a more comprehensive, well-rounded education for students. Further, the report’s authors asserted that, “The content of the curriculum, where practical, [should] connect itself to real-life applications of knowledge and skills to help students link their education to the future” (p. 15). Officials of the NASSP recognized the need for knowledge to be made practical and useful for the student. Further, they supported the following position:

This requires that high schools do more to present the curriculum in the context of experiences that call upon students to apply knowledge in situations approximating those in which they will use knowledge in real life—‘authentic learning,’ if you will. (p. 15)

In addition, the report’s authors recognized that not only would this practical application approach to learning help students to understand the subject matter more readily but would also provide a source of interest thus improving their attitudes about *what* they were learning.

Agricultural education has been based on practical application of knowledge since its inception (Phipps & Osborne, 1988). Theories that describe effective teaching and learning in agricultural education (Lancelot, 1944; Newcomb, 1995; Phipps & Osborne; Shinn et al., 2003) have long reflected values expressed in much of the recent mathematics education literature. Inherent to these values is the emphasis placed on methods used to deliver instruction. The problem-solving method of instruction, as employed by agricultural educators for many years, relies on a contextually bound “problem” through which instruction toward a more general or abstract principle may be delivered (Crunkilton & Krebs, 1982; Dyer & Osborne, 1996; Krebs, 1967; Newcomb, McCracken, & Warmbrod 1993; Parr & Edwards, 2004; Phipps & Osborne). This approach to teaching can be traced back through secondary agricultural education to

as early as 1918 when Nolan recorded his stance on its value. Later, Shepardson (1929) expressed his support for this notion when he stated, “Agriculture is a meeting-ground of the sciences. Physics and chemistry lie at its base. To these elements biology adds its conception of organism. Mathematics is their common instrument” (p. 69).

Researchers (Johnson, 1993; Johnson, Wardlow, & Franklin, 1997) have recognized the value of other subject matter knowledge to achievement in specific areas of agricultural education. Johnson determined that years of mathematics studied in high school had a moderate positive relationship with achievement in the Mississippi state agricultural mechanics career development event (CDE). Franklin and Miller (2005) concluded that “the best predictor of total student achievement in [the] agricultural mechanics CDE was a linear combination of average grade in agriculture classes and the number of years of mathematics courses taken” (Conclusions section, p. 8). What is more, recent research concerning the impact of curriculum integration on the mathematics achievement of agriculture students has provided empirical evidence that such activities could reduce the amount of mathematics remediation required for students entering post-secondary institutions (Parr, 2004; Parr et al., 2006).

Even though the preceding literature provides evidence that curriculum integration has been touted as a superior method of presenting subject matter in a meaningful manner to the student, some have expressed concerns about the potential *cost* to career and technical education associated with such integration. The fear of curriculum integration efforts resulting in inferior career and technical training was stated clearly by Stasz and Bodilly (2004):

State academic standards and assessments reportedly had widespread influence over vocational courses and programs at the local level. In particular, teachers reported reduced vocational enrollments stemming from pressure to meet higher academic standards and increased course

requirements; reduced time on vocational tasks arising from increased time on academic requirements and test preparation; and possible reduced quality of instruction, given the emphasis of some tests on simplistic understanding and answers. (p. 20)

So, would an intensive curriculum and instructional intervention, (i.e., one aimed at improving students' mathematics performance using agricultural power and technology as the learning context), significantly diminish their acquisition of technical competence?

The broader theoretical framework for this study was developed by Dunkin and Biddle (1974). The researchers posited that variables which contribute to teaching and learning may be organized and analyzed within four domains (Parr et al., 2006). This study employed the framework to determine if professional development of agricultural education teachers concerning the teaching of mathematical concepts (presage variable) through the context of agricultural mechanics (context variable) and subsequent implementation of such lessons (process variable) would be detrimental to students' acquisition of technical competence (product variable).

Purpose

The purpose of this study was to empirically test the hypothesis that technical competence of students who participated in a contextualized, mathematics-enhanced high school agricultural power and technology curriculum and aligned instructional approach would not differ significantly ($p > .05$) from that of students who participated in the traditional curriculum.

Research Questions and Null Hypothesis

The following research questions guided the study: 1) What were selected characteristics of students enrolled in and instructors teaching agricultural power and technology in the state of Oklahoma during the spring 2004 semester? 2) Does a math-enhanced agricultural power and technology

curriculum and aligned instructional approach diminish students' acquisition of technical skills? The following null hypothesis guided the study's statistical analysis: H_0 There is no difference between the two study groups on technical competence in agricultural power and technology as measured by an examination used to assess students' agricultural power and technology competence (i.e., the National Occupational Competency Testing Institute [NOCTI] Agriculture Mechanics examination).

Methods and Procedures

This study employed a posttest only control group experimental design (Campbell & Stanley, 1963). Thirty-eight agriculture teachers were recruited to participate in the study. Before teachers agreed to take part, researchers explained that each teacher would be randomly assigned to either the experimental or control group to increase the probability of equality among the two groups of students who would provide data for analysis. Subsequently, classrooms were randomly assigned to either the experimental or control group. The assignment involved intact groups of students; thus, the "unit of analysis" was by classroom. In addition to the random assignment to groups, the two groups (experimental and control) were assessed to determine level of equivalence concerning basic mathematics aptitude (Campbell & Stanley; Tuckman, 1999) prior to the treatment. The two groups were not significantly different ($p > .05$) based on their performance on the Terra Nova CAT Basic Battery Examination (Parr, 2004; Parr et al., 2006).

Following the treatment, comparisons were made between group means on a posttest measure designed to assess students' technical competence in agricultural power and technology. This design was chosen primarily on the basis of its robust nature concerning validity. According to Tuckman (1999), this type of experimental design "provide[s] completely accurate controls for all sources of internal validity" (p. 161).

The NOCTI Agriculture Mechanics examination (42 items) was the posttest used to assess students' agricultural power and technology competence. The examination had an internal reliability estimate of .91 (Cronbach's alpha) (A. Thomas, personal communication, November 16, 2004). This examination included multiple choice test questions from the following areas of agricultural mechanics: safety, power and machinery, agricultural electrical power and processes, structures, and soil and water management.

The experimental intervention (or treatment) embedded in this design required the preparation of agriculture teachers to develop and implement a math-enhanced curriculum in the context of an agricultural power and technology course. The experimental group agriculture teachers had math teacher "partners" to assist them in developing math-enhanced lesson plans in the context of agricultural power and technology and in how to enhance student understanding of the embedded mathematics in those lessons.

Eighteen agriculture teachers and their math teacher partners were randomly assigned to the experimental group, and 20 agriculture teachers to the control group. Initially, two additional teachers were randomly assigned to the experimental group, but both teachers chose to not participate in the study prior to the first professional development meeting. The experimental group teachers implemented a math-enhanced agricultural power and technology curriculum and instructional approach. The control group teachers taught the traditional agricultural power and technology curriculum (Oklahoma Department of Vocational and Technical Education, 2000) and were instructed to use the same instructional approach they had followed in the past. This design yielded an overall N of 447 agricultural power and technology students (experimental $n = 206$; control $n = 241$) who provided data for analysis by classroom.

The partnering of high school math teachers with agricultural power and technology teachers encouraged the instructors to function as a team (Hernandez & Brendefur, 2003). The pairs of teachers

(agriculture and math) spent five days together in professional development during the fall of 2003. The purpose of this activity was to create math-enhanced lessons in the context of agricultural power and technology. Math teachers worked with their agriculture teacher partners to identify and develop content as well as to design lesson activities to more fully contextualize the embedded mathematics terminology, principles, and concepts found in the agricultural power and technology curriculum.

Prior to developing the math-enhanced lessons, a panel of experts was convened to identify specific mathematics constructs that were present in the Oklahoma agricultural power and technology curriculum. It was determined that there were nine constructs in the existing curriculum that aligned with state and national mathematics standards (Parr, 2004). The teacher teams were charged with developing a lesson to address one of the identified constructs, which would result in 18 lessons. The development of two lessons per construct gave teachers a choice of which lesson they would teach to address each of the nine constructs. Following review of the lessons' rough drafts, it was determined that two of the lessons were very similar and should be combined into one. So, ultimately, 17 lessons were developed that emphasized selected mathematical concepts embedded in the agricultural power and technology curriculum. During the spring 2004 semester, mathematics teachers continued to collaborate with agriculture teachers concerning specific questions related to the math-enhanced lessons and to facilitate teachers' reflections about lessons taught.

The treatment was defined as a series of math-enhanced learning experiences (i.e., lessons) designed to raise the embedded, contextualized mathematics found in the agricultural power and technology curriculum to a level of explicit instruction intended to facilitate students' learning of selected mathematics competencies and to improve their ability to transfer that competence to new and novel settings (Stone III, Alfeld, Pearson, Lewis, & Jensen, 2005). The treatment was delivered as a series of nine lessons with each addressing a

specific math construct over the spring 2004 semester. For example, a lesson that explained the proper method of area calculation when constructing a greenhouse or agricultural mechanics facility addressed a construct that aligned with state and national mathematics education standards, (i.e., National Council of Teachers of Mathematics [NCTM], Geometry Standard for Grades 9 – 12 [2004]). The lessons were to be taught using a prescribed instructional model. This math-enhanced pedagogical approach included seven steps (Bickmore-Brand, 1993; Stone III et al.):

- 1) Teacher recognizes math with the class;
- 2) Teacher assesses students' math awareness;
- 3) Teacher walks through a "pulled out" example;
- 4) Teacher explains math concepts, integrating math terminology with Agricultural Power and Technology terminology;
- 5) Teacher reinforces student understanding by having students try similar agricultural and math examples;
- 6) Teacher checks for understanding;
- 7) Students either create or are presented with new agricultural as well as broader math examples to be solved. (Parr, 2004.)

This teaching approach was supported by mathematics education literature (Bickmore-Brand, 1993; Diaz, 1998; Gawned, 1993). Agriculture teachers were expected to deliver their lessons without any outside assistance from their math teacher partners or other math education professionals during the act of teaching. Elements of the treatment described were delivered only to experimental group teachers and students. Control group teachers were instructed to make no change relative to the teaching of mathematics in their classes.

Findings

Frequencies and percentages were calculated for selected personal characteristics of student and teacher participants in the study. One-way analysis of variance (ANOVA) was used to compare experimental and control groups' classroom means to test the research hypothesis.

Selected Characteristics of Students and Teachers

Student participants were asked to respond to questions that described selected personal characteristics. The questionnaire revealed that the majority of students were male (84.4%) and of European/ Anglo descent (58.5%). One-fourth of the students reported their ethnicity as Native American. About one-third (31.8 %) of the student participants were seniors in high school, a similar number (34.5%) were juniors, and about one-fourth (26.4%) were sophomores; the remaining students were either freshmen (6.1%) or did not respond to the question of grade level. Most of the students (82.7%) were between the ages of 16 and 18 years at the time of the experiment, and the majority held self-reported grade point averages ranging from 2.6 to 4.0 (72%). The data collected about agriculture teacher participants ($N = 38$) revealed that 86.8% of the teachers were male, and 2.6% were female; 10.8% elected not to report their gender. The data also indicated that 73.7% of teachers identified themselves as being of European/Anglo descent and 15.8% were Native American; 10.8% did not report their ethnicity.

Posttest Analysis of Students' Technical Competence

Means were calculated by group for the purpose of comparative statistical analysis following the treatment. One-way analysis of variance (ANOVA) was used to compare the experimental and control groups' classroom means to test the study's null hypothesis.

An analysis was conducted of students' technical performance by group (control and

experimental) using an examination to measure achievement in agricultural power and technology (i.e., the NOCTI Agriculture Mechanics examination). The test was taken by students after the study's treatment was completed. The control group students achieved a mean score of 16.18 with a standard deviation of 2.88 on this measure.

The experimental group had a mean score of 16.31 with a standard deviation of 2.42 (Table 1). The analysis detected no significant difference in technical competence between groups following the treatment ($p = .883$) at an *a priori* determined alpha level of .05 (Table 2). So, the null hypothesis was not rejected.

Table 1
Descriptive Statistics for Student Performance by Group on the NOCTI Agriculture Mechanics Examination

	<i>n</i>	<i>M</i>	<i>SD</i>	Min	Max
Control	20	16.18	2.88	11.62	20.77
Experimental	18	16.31	2.42	12.88	21.70
Total	38	16.24	2.64	11.62	21.70

Table 2
Comparative Analysis of Student Performance by Group Means as Measured by the NOCTI Agriculture Mechanics Examination

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Between Groups	.156	1	.156	.022	.883
Within Groups	256.878	36	7.136		
Total	257.034	37			

Conclusions

Because no significant difference between the two study groups on technical competence was detected by the NOCTI Agriculture Mechanics examination, which was the measure used to assess students' agricultural power and technology competence, the study's null hypothesis: H_0 was not rejected. Accordingly, the primary conclusion drawn from this study was that, in this particular population, the intervention of a math-enhanced agricultural power and technology curriculum and aligned instructional approach did not significantly diminish ($p > .05$) students' acquisition of technical competence in agricultural

mechanics. Moreover, when examining this phenomenon through the theoretical lens of Dunkin and Biddle's model (1974), prescribed changes in presage and process variables did not negatively affect the product variable (i.e., students' acquisition of technical competence) as manifested in the context examined.

Recommendations for Future Research and Practice

The results of this study indicated that the math-enhanced lessons delivered through the context of agricultural power and technology did not significantly diminish students' acquisition of technical

competence ($p = .883$). These findings suggest that the intervention described in this manuscript may be a viable way of increasing student math achievement (Parr, 2004; Parr et al., 2006) without decreasing the acquisition of technical knowledge and skills. However, because the treatment described was limited to one semester, this intervention should be extended over a longer time period, i.e., one academic year (Stone III et al., 2005). Accordingly, a similar study was conducted for an entire school year during 2004-2005 (Young, 2006).

Additional research is needed to describe teachers' perceptions concerning barriers or challenges faced when delivering an integrated, contextualized curriculum that provides students with opportunities to build academic competence while ensuring that the objective of rigorous technical skill acquisition is met. Future investigations should include experiments that involve other areas of agricultural education, e.g., animal production, horticulture, agriscience, and aquaculture. A similar study could be designed to provide a better understanding of the potential value of curriculum integration intervention efforts involving other academic areas such as science. Opportunities may exist to lift biological and physical concepts to the surface in a way that increases student academic performance as pupils learn that content in the context of agriculture (Chiasson & Burnett, 2001; Enderlin & Osborne, 1992; Johnson et al., 1997). Moreover, replications in other areas of career and technical education also might reveal the value of implementing a similar curriculum integration intervention in those occupational contexts. Findings from a larger study support this recommendation (Stone III et al., 2005).

Effort should be expended to identify other lesson topics in the agricultural power and technology curriculum that contain embedded mathematics. Then, additional lesson plans could be developed that focus on those inherent concepts and use an agricultural context to provide meaning and perspective. Moreover, special emphasis should be placed on those mathematics constructs that align with state and national mathematics education standards.

Discussion and Implications

This intervention was not designed to infuse additional mathematics into the agricultural power and technology curriculum. Rather, the core concept was to identify mathematics constructs that were inherent to the existing curriculum. This design provided meaningful, contextual applications for the mathematics constructs without appearing to be "forced" into the instruction. This aspect also increased teachers' "ownership" of the lessons by helping them to realize the significant amount of mathematics present in their existing curricula. It was essential that experimental group teachers perceived that they were still teaching their "own" subject matter and not contrived scenarios only superficially related to agricultural education.

Each student, teacher, and testing liaison who participated in this study received a monetary reward. Even though the monetary compensation paled in comparison to the actual hours spent in preparation and implementation of this project, it did serve as a catalyst in garnering participants and insuring that they persisted with the project until its completion. There is little doubt that the educators involved in this study were genuinely interested in seeing their students succeed, but it is questionable whether teachers would be willing to participate in such an intensive project without some monetary remuneration.

What is more, Thompson (1998) identified the lack of administrative support as a significant barrier to curriculum integration efforts. Before participating in this study, teachers were asked to secure the signature of their principals to indicate his or her support of the project. In addition, state staff officials encouraged teachers to participate. Consequently, the combined support of local and state administrators was essential to proper implementation of the study.

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