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Assessing the Effect of Using a Science–Enhanced Curriculum to Improve Agriculture Students' Science Scores: A Causal Comparative Study

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The academic skills of today's teenagers are diminishing, and are a cause for concern. One of the academic areas in need of improvement is science. The purpose of this causal comparative study was to determine the effect that a science–enhanced, curriculum would have on students' achievement in science. The population for this study consisted of students in secondary agricultural education programs whose instructors held a science credential in Oklahoma during the 2009–2010 school year and were selected by state staff in the Agricultural Education Division of the Oklahoma Career and Technology Education Department to teach the science–enhanced, curriculum. In addition, 10 equally credentialed instructors formed a purposeful comparison group and were selected according to specific variables (e.g., similarity of students' SES status) for equivalency purposes. The findings of this study revealed that a statistically significant difference in students' science achievement did not exist as a result of the treatment. However, small practical differences were detected between the groups, as student performance in the treatment group was more than two and one–half points higher than the means of students' performance scores in the comparison group. Recommendations point to the need for replication of the study over an entire school year.

Keywords: student science achievement; science–enhanced curriculum; agricultural education

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Introduction and Conceptual Framework

The academic skills of today's teenagers are diminishing, and a cause for concern exists among both state and national officials (Cavanagh, 2004). One of the academic areas in need of improvement is science (Dickinson & Jackson, 2008; National Center for Education Statistics, 2005; Provasnik, Gonzales, & Miller, 2009). The National Commission on Excellence in Education (NCEE) identified that a ". . . widespread public perception that something is seriously remiss in our educational system" (NCEE, 1983, p. 1) exists. In addition, the report, *A Nation at Risk: The Imperative for Educational Reform,* stated that, "The educational foundations of our society are being eroded by a rising tide of mediocrity" (NCEE, 1983, p. 5). Lloyd (1992) posited that as a result of these educational reports, evidence exists to support the need for educational change.

Reports on the success of students from across the globe in comparison to the achievements of those in the United States indicate that American students are falling behind in science achievement when compared to other countries (National Center for Education Statistics, 2005; Provasnik et al., 2009). Further, it appears as though progress in science achievement of American students has stagnated. As of 2007, the United States was ranked tenth out of 47 countries that participated in the Trends in International Mathematics and Science Study (TIMSS). Countries out–ranking American students in science achievement scores were Singapore, Chinese Taipei, Japan, Korea, England, Hungary, the Czech Republic, Slovenia, and the Russian Federation (National Center for Education Statistics, 2005).

Cavanagh (2004) noted that, according to the American College Testing (ACT) program, 78% of students who took a college entrance examination were deficient in the areas of mathematics, science, and English. Thus, it was determined that these students were ill–prepared for college–level coursework, justifying the need for improvements at the secondary level. Further, it was noted in the latest Program for International Student Assessment (PISA) that, "U.S. 15–year–olds are not able to apply scientific knowledge and skills to real world tasks as well as their peers . . ." (Provasnik et al., 2009, p. 45).

Provasnik et al. (2009) compared the average science scale scores of students in the United States to international students in the areas of reading, mathematics, and science. It was determined that Oklahoma ranked 28th in the nation out of the 45 states that reported science achievement scores. This figure is discouraging and serves as an indicator of the lack of preparedness of Oklahoma students for higher education and the real world.

Secondary agricultural education exists to prepare people for college and careers (Roberts & Ball, 2009). Because it has long been lauded as the world's oldest science (Ricketts, Duncan, & Peake, 2006), agricultural education strives to help students understand scientific principles and concepts better in the context of agriculture (Thompson & Balschweid, 2000). As such, agricultural education could serve as an effective medium to convey scientific terminology, principles, and those concepts that are inherent to botany and zoology (Parr & Edwards, 2004).

Because agricultural education holds the potential to aid students effectively in understanding science better through the context of agriculture, curricula developed toward this end should be made available in the secondary classroom. One such curriculum is available through the Center for Agricultural and Environmental Research and Training (CAERT). CAERT provides agriculturally–based, science–enhanced materials for use in agricultural and environmental instructional areas at the secondary level (CAERT, 2010a). Specializing in activities that are collaborative by nature, students of agricultural education are provided a curriculum that is intended to allow them to be more involved and engaged in the learning process (CAERT, 2010a).

Conceptually, this study was based on the premise of contextual teaching and learning (CTL). CTL "is a system of instruction based on the philosophy that students learn when they see meaning in academic material, and they see meaning in schoolwork when they can connect new information with prior knowledge and their own experience" (Johnson, 2002, p. vii). CTL involves the learning situation, the content being learned, and the opportunity to apply the content in other contexts (Clough & Lehr, 1996). Because the brain is a parallel processor and can perform functions and activities between contexts simultaneously (Caine & Caine, 1995), CTL is an effective method for helping students understand the meaning and relevance of how specific content applies to their daily lives (Berns & Erickson, 2001). Through the CTL method, students are able to transfer better their knowledge from one environment to another (Clough & Lehr, 1996; Edling, 1993). Because students use their prior knowledge to make meaning and solve problems when instructed through CTL (Berns & Erickson, 2001), the central question of this study was, "Does teaching science concepts in an agricultural context help students learn science principles better?"

Statement of the Problem

High stakes tests have placed increased requirements on schools to raise students' test scores in science. Moreover, the ever–increasing demand for workers who are scientifically literate and capable of applying their understanding of science in the workplace continues to be an escalating imperative. Agricultural education at the secondary level, including animal science and horticulture curriculums, is based inherently on fundamental science principles and concepts. However, little empirical evidence exists that demonstrates whether teaching a science–enhanced curriculum in the context of animal or plant science courses would affect student achievement in science positively.

Purpose of the Study

The purpose of this study was to determine if a science–enhanced curriculum (i.e., CAERT) taught in a secondary level animal science or horticulture course would improve students' understanding of selected scientific principles significantly, when compared to students who were instructed using a traditional curriculum. The following objectives and hypothesis guided this study.

1. Determine the personal characteristics (i.e., gender, age, grade classification, Biology I End of Instruction score, race/ethnicity, and number of agricultural education courses taken) of students enrolled in selected animal science or horticulture courses in Oklahoma during spring semester 2010.
2. Determine the effect of a science–enhanced (i.e., CAERT) curriculum on students' science achievement, as determined by a science proficiency examination.

H_o1: The science achievement of students who received the science–enhanced CAERT curriculum in animal science or horticulture will not differ significantly (i.e., $p \geq .05$) from those students who were taught the traditional animal science or horticulture curriculum, as measured by the TerraNova[3] science achievement examination (H_o1: $\mu_{1\text{treatment group}} = \mu_{2\text{comparison group}}$).

Methodology

The population for this study consisted of students whose secondary agricultural education instructors held a science credential in Oklahoma during the 2009–2010 school year. The purposeful sample consisted of 10 treatment groups, including students whose teachers were selected by Agricultural Education Division staff of the ODCTE to use the science–enhanced CAERT curriculum developed for the instruction of animal science and horticulture courses during the 2009–2010 school year. In addition, students of 10 different instructors formed a purposeful comparison group. These teachers also held a science credential and were selected according to specific school and student data obtained from the 2008–2009 Computerized Enrollment System for Instructors (CESI) report. The CESI report is used by the ODCTE's, Information Management Division to collect selected information of Oklahoma secondary agricultural education programs and their students. Therefore, schools that "matched" the treatment group, based on review of established criteria, were selected to provide an appropriate counterfactual group (Creswell, 2008) for the comparison of students' test scores.

The criteria used in this study were established and recommended by the National Research Center for Career and Technical Education (NRCCTE) (J. Stone, personal communication, December 3, 2009), who also provided funding for the use and scoring of the TerraNova[3] science achievement examinations. The criteria considered for selection of the counterfactual group included agricultural education instructors who held a teaching certification in science at the time of the study, as well as academic performance index (API) scores of their schools, and socioeconomic status (SES) of the student participants. Random sampling was used to select students to take the science examination. The instructors' classrooms served as the study's *units of analysis* for purposes of comparison.

The design of the study was *ex post facto*, causal comparative because no random assignment of the treatment group occurred (Ary, Jacobs, & Razavieh, 2002). The treatment group was *pre–determined* through selection of instructors by ODCTE staff, i.e., agricultural education teachers who received access to the CAERT curriculum. The curriculum was designed to explicate and reinforce scientific principles through the instruction of select agricultural education courses, including modules supported by downloadable lesson plans, aligned learning standards, summary reports, PowerPoint® files, and E–Units (K. Murray, personal communication, October 1, 2009). E–Units are online student text resources that are designed to reinforce the lesson plans that were a part of the CAERT science–

enhanced, curriculum (D. Pentony, personal communication, December 6, 2010).

The CAERT curriculum was selected for use because it was developed according to standards for agricultural education in Oklahoma, was acceptable as science credit for college entrance purposes, and consisted of an online delivery method. As a result of the state alignment, the animal science curriculum included 28 units with 160 instructional lessons, and the horticulture curriculum included 29 units with 148 lessons (CAERT, 2010b). The unique purpose of CAERT is that it is a science–enhanced curriculum not otherwise offered by curriculum providers for use in Oklahoma (K. Murray, personal communication, October 1, 2009).

The treatment group teachers were provided access to the CAERT curriculum via passwords and user names in summer 2009. These teachers were instructed by ODCTE state staff members to become familiar with the modules pertaining to animal science and horticulture prior to the beginning of the up–coming fall semester. In addition, this group of teachers was brought onto the ODCTE campus for a one–half day training seminar during September 2009 to receive an overview of the curriculum (i.e., the functions of the curriculum and how to use its teaching resources). For the purpose of testing this study's intervention (i.e., the CAERT curriculum), a purposeful comparison group was selected from the same list of agricultural education teachers who had achieved science certification in Oklahoma (N = 40). This group was instructed to teach their courses (i.e., animal science or horticulture) using the same curriculum as they always had in the past. In most cases, this was the curriculum produced by the Curriculum for Instructional Materials Center (CIMC), which is created specifically for agriculture teachers in Oklahoma.

To determine equivalency of the treatment and comparison groups, student performance was compared on the Oklahoma Department of Education's End of Instruction (EOI) examination in science. In addition, school district's academic performance index and accountability data (API), and the schools' percentage of low income clientele served by the free and reduced lunch program (SES) were compared.

The Oklahoma Department of Education's EOI examination in science is a part of a larger, statewide testing program known as the Oklahoma School Testing Program (OSTP) (Oklahoma State Department of Education, 2010a). Students completing an area of instruction are expected to pass the corresponding standardized assessment. EOI examinations are designed to assess a student's level of competency relative to the Priority Academic Student Skills (PASS), which are Oklahoma–based content standards (Oklahoma State Department of Education, 2010b).

Evaluation of student competency in Biology involved the use of core curriculum test scores for Biology in Oklahoma. These core curriculum tests in Oklahoma are administered in accordance with students' ability level as established by local school administration and admission, review, and dismissal (ARD) meetings. The two types of core curriculum tests used to measure students' science achievement include the Biology I End of Instruction test, which is administered to the general school population, and the Oklahoma Modified Alternate Assessment Program (OMAAP) test, which is administered to those students qualifying for modified testing as a result of local ARD meetings.

Four performance levels exist to classify student achievement. For the regular test administration (i.e., EOI), performance levels are divided into *advanced* (755 – 999), *satisfactory* (691 – 774), *limited knowledge* (627 – 690), and *unsatisfactory* (440 – 626). The alternate test administration (OMAAP) is divided into four performance levels. They consist of *advanced* (265 – 350), *satisfactory* (250 – 264), *limited knowledge* (233 – 249), and *unsatisfactory* (100 – 232) (Oklahoma State Department of Education, 2010c). EOI categorical scores were coded as 1 = *unsatisfactory*, 2 = *limited knowledge*, 3 = *satisfactory*, and 4 = *advanced* for comparison purposes between the regular and alternate test administrations (Oklahoma State Department of Education, 2010a).

The Academic Performance Index (API) for Oklahoma was developed based on the need to compare school performance to meet requirements established by Oklahoma law, as well as legislation pursuant to Public Law 107–110, commonly referred to as No Child Left

Behind (Oklahoma State Department of Education, 2010c). API scores range from 0 to 1500, with the most recent reported state average being 1279 (Oklahoma State Department of Education, 2010c). Components of a school's API include EOI scores, Academic Excellence as measured by students' participation in the ACT college entrance examination, remediation rates for college students in reading and mathematics, and school completion, as determined by student attendance coupled with graduation and dropout rates (Oklahoma State Department of Education, 2010c). To ensure equivalency of the treatment and comparison groups, schools were compared on the basis of EOI scores, API, and socioeconomic status (SES).

When comparing these variables for equivalency, the treatment group had an EOI group mean score of 2.67 (2 = limited knowledge) (*SD* = 1.12). The mean score for the comparison group was 2.88 (2 = limited knowledge) (*SD* = .93). The treatment group had an API group mean score of 1387.00 (*SD* = 57.42); the mean score for the comparison group was 1295.86 (*SD* = 74.40). The treatment group had a SES group mean score of 44.85 (*SD* = 13.94). The comparison group had a mean score of 43.53 (*SD* = 9.40) for SES. An independent samples *t*–test comparison of the treatment and comparison groups did not reveal a statistically significant difference in student science knowledge (p = .580) prior to the treatment at an alpha level of .05 (see Table 1).

Independent samples *t*–tests were used to compare the treatment and comparison group participants on the EOI, API, and SES variables. It was revealed that a statistically significant difference (see Table 1) in API scores existed between the two groups (p = .045) at an alpha level of .05. No significant differences were found for the other measure. However, the reader is cautioned on making generalizations beyond the sample examined in the study (see Table 1).

Table 1
Treatment and Comparison Group Equivalency According to A Comparison of EOI, API, and Socio–Economic Status Scores

Groups	Minimum & Maximum	*M*	*SD*	*t*–value	*p*–value
EOI[a]	1 – 4	2.67	1.12	-.561	.579
EOI[b]		2.88	.93		
API[a]	0 – 1500	1387.00	57.42	2.290	.045[*]
API[b]		1295.86	74.40		
SES[a]	0 – 100%	44.85	13.94	.197	.848
SES[b]		43.53	9.40		

[a] = Treatment; [b] = Comparison; [*]p < .05

To determine the effect that the CAERT curriculum had on students' science achievement, a science proficiency examination was used. The TerraNova[3] Form G assessment series examination, designed and developed by CTB/McGraw–Hill (a subsidiary of The McGraw–Hill Companies, Inc.), was the examination used in this study. The examination consisted of normed sections that are designed to test student competencies in reading, language, mathematics, social studies, and science (CTB/McGraw–Hill LLC, 2008). "A normed section is a subset of *TerraNova Third Edition* for which scores from a nationally representative norm group are available" (CTB/McGraw–Hill LLC, 2008, p. 1). The normed section for science consisted of 40 multiple choice questions designed to assess student competence in science. The students were provided four answers for each multiple choice question from which to determine the correct answer. School district testing liaisons arranged for and proctored the science examination.

The NRCCTE agreed to provide science examinations and their scoring for 80 students in the study (i.e., four to five students per classroom, treatment and counterfactual). An online calculator was used to estimate the appropriate sample size needed for this study (Soper, 2010). It was determined that if three covariates were used for prediction, 76 participants were needed to accommodate an alpha level of .05, with an anticipated effect size of .15, and a desired power level of .80. For practical testing purposes, 80 treatment and comparison students were chosen randomly from the 20 classrooms in the study to participate in taking the science examination. This allowed the researcher to select four to five students randomly per classroom to achieve the appropriate sample size for the study. In all, 80 students were randomly selected to ensure a strong power analysis and effect size for the study. Power is determined typically by sample size (Keppel, 1991) and is defined as, "the probability of correctly rejecting a false null hypothesis" (Shavelson, 1996, p. 314). Therefore, one means to increase power is to increase sample size. As power increases, so does the magnitude of the effect, or effect size (Shavelson, 1996). "Effect size is the discrepancy between the null hypothesis and the alternative hypothesis of interest" (Shavelson, 1996, p. 317).

Statistical analysis for the study was completed with the Predictive Analytics Software (PASW) 18.0 and Microsoft Excel 2007. To assess research question one, students were asked to identify characteristics pertaining to their gender, age, grade classification, and race/ethnicity. To summarize trends and tendencies relating to the personal characteristics data, descriptive statistics (i.e., mean, median, mode, frequency, and percentages) were computed. To assess research question two, an independent samples *t*–test was used. Ary, Jacobs, and Razavieh (2002) identified that a *t*–test for independent samples serves as an ideal statistical procedure for determining statistically significant differences between groups.

Effect sizes were also calculated to determine what practical effect the treatment had on the post–treatment measures of the study (i.e., animal science and horticulture agricultural competency examinations). The effect size was calculated per Cohen's (1988) procedure. According to Cohen (1988), effect size is calculated and compared to three benchmark standards: *small* effect size (d = .20), *medium* effect size (d = .50), and *large* effect size (d = .80). However, research by Thompson (2002) indicated that adherence to this standard may be too stringent and that the effect itself is determined by what has been studied. For example, large effect sizes can be considered trivial when applied to outcomes that are trivial (Trusty, Thompson, & Petrocelli, 2004). So, the benchmark standards to interpret effect size for selected results of this study (as calculated by Cohen's [1988] formula) were expanded and compared to the following standard proffered by Thalheimer and Cook (2002) (see Table 2).

Using Thalheimer and Cook (2002), the relative size of a *negligible* effect must be greater than or equal to – 0.15 and less than .15. To be classified as having had a *small* effect, the relative size must be greater than or equal to .15 but below .40. A *medium* effect classification must be greater than or equal to .40 but less than .75 in relative size. Those effect sizes that are considered to be *large* must have a relative size of greater than or equal to .75 but less than 1.10. To have an effect size classified as *very large*, the relative size must be greater than or equal to 1.10 but less than 1.45. Finally, to have an effect size considered *huge*, the relative size must be greater than 1.45.

Table 2
Relative Size of Cohen's d According to Thalheimer and Cook (2002)

Effect Size Classification	Relative Size
Negligible Effect	> = - 0.15 and < .15
Small Effect	> = .15 and < .40
Medium Effect	> = .40 and < .75
Large Effect	> = .75 and < 1.10
Very Large Effect	> = 1.10 and < 1.45
Huge Effect	> 1.45

Agricultural teachers and their students from 20 secondary agricultural education programs in the state of Oklahoma served as the subjects for this study and provided the data described in the findings section. However, mortality occurred during the study and affected the final sample size. Mortality is "a potential threat to internal validity in an experiment when individuals drop out during the experiment for any number of reasons" (Creswell, 2008, p. 642).

Findings/Results

Research question one sought to determine the personal characteristics (i.e., gender, age, grade classification, end of instruction score (EOI), number of agricultural science courses taken, and race/ethnicity) of students enrolled in the targeted courses involved in the study and who were selected randomly for testing (N = 80). The students were asked for their personal characteristics information in conjunction with their post–test administrations. A total of 69 students completed the questionnaire (treatment n = 29; comparison n = 40) administered during the post treatment testing process. The treatment group students included 13 males (45%) and 16 females (55%) (see Table 3).

Table 3
Selected Personal Characteristics of Treatment (n= 29) and Comparison (n= 40) Group Students

	Treatment		Comparison	
Variable	*f*	%	*f*	%
Gender				
Male	13	44.8	18	45.0
Female	16	55.2	22	55.0
Age				
14	0	0.0	1	2.5
15	1	3.4	5	12.5
16	9	31.0	15	37.5
17	6	20.7	11	27.5
18 years or older	13	44.8	8	20.0
Race/Ethnicity				
White/Caucasian	24	82.8	34	85.0
American Indian/Alaskan Native/Pacific Islander	4	13.8	5	12.5
Other	1	3.4	1	2.5
Grade Classification				
9th	0	0.0	6	15.0
10th	11	37.9	17	42.5
11th	4	13.8	7	17.5
12th	14	48.2	10	25.0

None of the students in the treatment group were 14 years of age. One respondent was 15 (3%), nine respondents were 16 (31%), six (21%) respondents were 17, and 13 (45%) respondents were 18 years of age or older.

Regarding race/ethnicity of those who responded, 24 respondents (83%) self–selected their classification as White/Caucasian. None of the students reported they were African–American or Asian. Four (14%) students reported they were American Indian/Alaskan Native/Pacific Islander, and one (3%) student selected his/her ethnicity as *other* (see Table 3).

No respondents from the treatment group represented the ninth grade. Eleven of the respondents (38%) were tenth graders, four of the respondents (14%) were eleventh graders, and the other 14 students (48%) were twelfth graders (see Table 3).

The comparison group students consisted of 18 (45%) males and 22 (55%) females (see Table 3). One of the respondents (3%) was 14 years of age, and five (13%) were 15 years of age. Fifteen (38%) respondents were 16 years of age, 11(28%) were 17 years of age, and eight (20%) were 18 years of age or older (see Table 3).

As for race/ethnicity, 34 (85%) students classified themselves as White/Caucasian, five (13%) identified their race/ethnicity as being American Indian/Alaskan Native/Pacific Islander, and one respondent (3%) selected the *other* classification. None of the students identified African–American or Asian as their race/ethnicity (see Table 3).

None of the comparison group students were eighth graders. Rather, the students were distributed evenly across the remaining grade classification levels: six respondents (15%) were ninth graders, 17 (43%) were tenth graders, seven (18%) were eleventh graders, and 10 (25%) were twelfth graders (see Table 3).

Research question number two sought to determine the effect that a science–enhanced CAERT curriculum had on students' science achievement, as determined by the TerraNova[3] science proficiency examination. The science portion of the examination was administered after the treatment (i.e., teaching of the CAERT science–enhanced curriculum) to assess and compare the science achievement of the treatment and comparison group students. Data were analyzed and converted to percentages (0 – 100) from raw data (0 – 40) for purposes of analysis using the following formula: *Science–Enhanced Examination Raw Score/Total Raw Score X 100 = % Score*

The treatment group students (n = 29) who took the science–enhanced examination had a group mean score of 55.86 with a standard deviation of 16.55 (see Table 4). The comparison group students (n = 40) had a group mean score of 53.31 with a standard deviation of 16.01. An independent samples t–test comparison of the treatment and comparison groups did not reveal a statistically significant difference in science achievement as a result of the treatment (t = .64; p = .522) at an alpha level of .05. Further, the effect size, calculated according to Thalheimer and Cook (2002), was *small* (d = .16) (see Table 4).

As such, the null hypothesis (H_o1) was accepted, indicating that the CAERT curriculum did not have a statistically significant effect (p < .05) on students' science achievement.

Table 4
Science–Achievement Examination Scores of Treatment and Comparison Groups

TerraNova[3] Examination	Min. & Max.	*f*	*M*	*SD*	*t*–value	*p*–value
Treatment	0–100	29	55.86	16.55	.644	.522[a]
Comparison		40	53.31	16.01		

p < .05; [a]Effect size = Small (.16 per Cohen's d; Thalheimer & Cook, 2002)

Limitations

Certain conditions and variables important to this study were outside of the control of the researcher. For example, treatment teachers were selected purposefully by ODCTE state staff, which affected generalizability of the study due to non–randomization of the treatment teachers. Further, multiple attempts were made at collecting EOI data for those students who participated in the study. In Oklahoma, each school district "houses" its own student database (i.e., EOI results). As such, some schools were reluctant to release those data for the purpose of the study. Additionally, comparison of the schools by API scores found that the treatment group schools were statistically significantly different (i.e., at p < .05) than the comparison group schools, indicating a higher degree of aptitude overall. Finally, no incentives were provided for the teachers. Unfortunately, some teachers chose not to use the curriculum in its entirety or test their students accordingly.

Conclusions

This study found that a majority of those students who participated were female; fifty–five percent of the students in both groups were female. Further, in terms of race/ethnicity, the category representing the majority of both groups (treatment and comparison) was White/Caucasian. Finally, most students were 16 years of age or older and belonged to the sophomore and senior classes primarily.

This study found that the use of the science–enhanced, CAERT curriculum did not result in a statistically significant increase ($p < .05$) in student performance as determined by the TerraNova[3] science proficiency examination. Therefore, the null hypothesis was not rejected. However, small practical differences were detected between the groups, as the student performance score mean of the treatment group was more than two and one–half points higher than the mean of students' performance scores of the comparison group. Although not statistically significant, these results are similar to findings reported by Roegge and Russell (1990). The findings also suggest that students can learn academic content better when it is embedded in a familiar context (Caine & Caine, 1995; Parr et al., 2009; Roberts & Ball, 2009; Young, Edwards, & Leising, 2009).

Recommendations for Research

Although the findings of this study did not indicate a statistically significant difference in science achievement for the treatment group students, the intervention (i.e., the science–enhanced, CAERT curriculum) may have potential in this area. However, additional research is needed. Because the treatment sample was pre–determined by ODCTE staff, the generalizability of this study suffered. So, this study should be replicated using a true experimental design in which teachers are selected randomly in an effort to generalize any future findings more broadly. A future investigation should occur with a different sample of teachers to determine if the science–enhanced CAERT curriculum was the determining factor in the outcome of the research that was conducted, or if it was a result of teacher effect. To answer this question, a hierarchical linear modeling (HLM) analysis could be conducted.

This study lacked prolonged, sustained professional development regarding pedagogy needed to teach science content effectively (e.g., an inquiry–based teaching approach). However, the treatment group teachers were instructed to become familiar with the curriculum (i.e., the modules pertaining to animal science and horticulture) and were brought to the ODCTE campus for a one–half day training seminar during September 2009 for an overview of the functions of the curriculum and how to use its teaching resources. Therefore, from a pedagogical perspective (Brazen & Clark, 2005), future research should determine if a student–centered approach (e.g., inquiry–based teaching and learning) has an effect on students' ability to learn science in the context of agriculture when compared to a teacher–centered approach.

Recommendations for Practice

The science achievement of students who received the study's treatment yielded promising results. As a result of the findings of this study and others, (e.g.,Parr, Edwards, & Leising, 2006; Parr, Edwards, & Leising, 2009; Roegge & Russell, 1990; Young et al., 2009), improvements in student achievement can be realized as a result of teachers integrating curriculum. Put simply, students are capable of learning better when information is presented to them in a way that it relates to their personal experiences. Therefore, it is recommended that agriculture teachers collaborate with their science teacher colleagues in the development and reinforcement of learning resources that support and supplement the science aspects of the agriculture curriculum.

Moreover, a *community of practice* should be established between agriculture teachers and their respective science teacher counterpart. Chalmers and Keown (2006) identified this as a cost–effective practice for providing professional development to teachers, which could also reinforce the self–efficacy of instructors in teaching the science content inherent to their curricula. Further, professional development should focus on helping instructors understand the use and format of the CAERT curriculum better. Specifically, workshops should focus on helping teachers learn ways to emphasize science concepts effectively as well as assist teachers in acquiring the pedagogical practices supporting inquiry–based teaching and learning.

Discussion and Implications

As a result of the curricular intervention, this study showed potential for improving student achievement in science when curriculum is taught in the context of agriculture. This implication is consistent with other studies that emphasized science (e.g., Balschweid, 2002; Chiasson & Burnett, 2001; Ricketts et al., 2006; Roegge & Russell, 1990), as well as different academic areas such as math (e.g., Parr et al., 2006; 2009; Young et al., 2009). Many of the instructors in this study had 21 or more years of teaching experience (Haynes, 2010) and all held a science endorsement or certification. Is it possible that having an additional teacher certification in science, some of the teachers may have actually taught science in Oklahoma before they became an agriculture teacher? If so, this could have been a confounding variable that affected the study's results.

Dewey (1938) argued for the integration of academics and vocational training as a way to reinforce the principles of learning thereby allowing for the development of life skills readily transferable across contextual areas. That position speaks to the potential for a science–enhanced curriculum being effective, regardless of students' prior instructional experiences.

Perhaps an increased amount of time exposing students to the science–enhanced, CAERT curriculum would have had a stronger effect on their science achievement. Parr et al. (2009), in their study on the selected effects of a curriculum integration intervention on the mathematics performance of secondary students enrolled in an agricultural power and technology course, stated that, "perhaps the short time period over which this study was conducted (i.e., one semester) did not allow sufficient opportunity for significant differences in student math achievement to emerge. . . " (p. 66). The same statement could be applied to this study, perhaps.

Likewise, maybe the short duration (i.e., the spring 2010 semester) during which this intervention occurred did not provide enough time for significant differences in students' science achievement to appear. It is also possible that the comparison group teachers were doing a good job of emphasizing the science inherent to agriculture in their curriculum already. It is possible that instructors in Oklahoma were teaching a high level of science in their classes already. If so, this could account for the lack of a statistically significant difference in science achievement favoring the treatment group. Additional research should address these and related questions.

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