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Scientific Basis vs. Contextualized Teaching and Learning: The Effect on the Achievement of Postsecondary Students

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The purpose of the study was to compare two teaching methodologies for an integrated agricultural biotechnology course at the postsecondary level. The two teaching methods tested were the explanation of the scientific basis for content (comparison treatment) versus the application of content to a real–world agricultural context (experimental treatment). The study was implemented with two different classes over two semesters. The comparison treatment was administered to 22 students during the spring semester of 2009, and the experimental treatment was administered to 16 students during the fall semester of 2009. The research design used was a quasi–experimental non–equivalent control–group design with an identical pre/posttest given to each group as a means of assessing content achievement. The experimental treatment, based on the principles of contextual teaching and learning, was not statistically significant (p >.05), so the study's null hypothesis was not rejected. Based on these results, compared with traditional methods, a curriculum of contextualized teaching and learning can be implemented while maintaining a comparable level of student mastery of scientific concepts related to agricultural biotechnology.

Keywords: contextual teaching; contextual learning; agricultural education; agriscience

Introduction/ Conceptual Framework

One could argue that contextual teaching and learning has been present in vocational classrooms long before the title became a buzz word in educational research. The very essence of contextual teaching and learning relates to the notion of learning by doing, which has long been a pillar of secondary agricultural education. However, at the postsecondary level agricultural students are often taught the core sciences separately from their applied agricultural courses. The National Academy of Science (2009) examined postsecondary agricultural curriculum and recommended that students would be better prepared for the workforce if the core tenets of STEM curriculum were implemented.

> The focus should not be so much the learning of a certain body of information. It should rather be the learning of information in relationship to its use for the solution of major scientific problems. The students should be encouraged to seek information from multiple sources including texts, primary papers, laboratory manuals, the Internet, dialogue with specialists. The information should be reviewed critically and be interdisciplinary in nature. And the student should understand that the information will continue to grow and change and that he/she will continue to learn throughout his/her working life. (National Academy of Science, 2009, pp. 171–172.)

To carry this recommendation out, many universities are making campus wide efforts to teach interdisciplinary courses that often adopt contextual learning as a way to integrate course content.

In addition to better preparing students for the workforce, practitioners in agricultural education attribute increased motivation and retention of students to a sustained focus on contextual teaching and learning (Predmore, 2005). In a three year study of a Georgia teacher education program, Lynch and Padilla (2000) outlined some of the benefits present in a curriculum of contextual teaching and learning. The researchers reported that 16 students had *unusually high* ratings for the contextual teaching and learning based course and were aware and appreciative of how valuable the application of curriculum impacted their learning. In 1995, the Contextual Learning Institute and Consortium started a project to train teachers from a variety of content backgrounds on how to implement contextual teaching and learning. Results from thirty three teachers in five public high schools indicated that teachers noticed significant increases in student motivation with adoption of a contextual teaching and learning curriculum, and that students found the curriculum more fun and relevant (Reed, 1996).

Aside from the apparent benefits to student motivation and attitudes, some researchers suggest that contextual teaching and learning is beneficial to learning because it exercises the brain in a *natural* way. Johnson (2002) argued that contextual teaching and learning is successful because it asks students to behave in ways that are natural to human beings, and that are basic to human psychology. This concept is rooted in the idea that all humans possess an innate drive to find meaning in their lives. Johnson also asserted that contextual teaching and learning is a *brain compatible* system that generates meaning by linking academic content with the context of a student’s daily life. When viewed alongside research that finds contextual teaching and learning increases student attitudes and motivation, the idea that contextual teaching and learning is somehow easier or more natural for students than “traditional” methods does not seem too farfetched.

Even though the trend exists to integrate curriculum at the postsecondary level, few studies have focused on teaching science in the context of agriculture courses at the postsecondary level. The need for research in this area is addressed by the agricultural education profession in the *National research agenda: Agricultural education and communication* (Osborne, 2007) under the section named Agricultural Education in University and Postsecondary Settings Research. In this section, Osborne stated priority two is to “Improve the success of students enrolled in agricultural and life sciences academic and technical programs” (p. 7).

In addition, agricultural education should model effective curriculum in the field that is integrated across disciplines and includes collaboration among other teachers. Agricultural education students will learn how to facilitate integrated curriculum by being exposed to it in their agriculture and agricultural education courses (Kluth & Straut, 2003).

Literature Review/ Theoretical Framework

An abundant amount of research has been collected on agricultural education in secondary schools with regard to the integration of science some of which dealt with teaching science in the context of agriculture. Empirical studies have shown that integration of science and agriculture can positively affect student achievement (Warrick & Straquadine, 1998). Furthermore, principals, guidance counselors and teachers are favorably disposed toward integrating science and agriculture (Dyer & Osborne, 1999; Thompson & Balschweid, 2000; Thompson, 2001; Warnick, Thompson, & Gummer, 2004; Wilson, Kirby, & Flowers, 2001). However, some significant barriers are present that limit large scale, and *ideal* implementation (Myers & Thompson, 2008; Warnick & Thompson, 2007).

Roberts and Ball (2009) examined the issue of whether agricultural education at the secondary level is *content* that is taught to train agricultural workers, or the *context* with which other disciplines make sense to the learner. The notion that agricultural education is the *content* that is taught is consistent with the model of tech–prep pathways in high school designed to graduate students ready for the workforce. If agricultural education is the *context*, with which other disciplines make sense to the learner, then agricultural education is merely a small piece in a broader integrated picture of an educational system. Their theoretical discussion concluded that modern agricultural education at the secondary level finds basis in both philosophies.

Kozoll and Osborne's study (2004) on the role of science in postsecondary education examined the issue of how science affects, or is incorporated into a student's worldview on society. The researchers demonstrated that science can play a critical role in an integrated curriculum by helping students create a worldview regardless of whether they are going into a science related profession.

Contextual teaching and learning is defined as teaching that enables learning in which pupils employ their academic understandings and abilities in a variety of in– and out–of–school contexts to solve simulated or real–world problems (ERIC Clearinghouse on Adult, Career, and Vocational Education & ERIC Clearinghouse on Teaching and Teacher Education, 1998). More specifically, the authors defined contextual learning with certain fundamental characteristics. They asserted that contextual teaching and learning: is problem based; occurs in multiple contexts (schools, homes, worksites, communities); fosters self-regulated learning; anchors teaching and learning in students' diverse life contexts; employs authentic assessment; and uses interdependent learning groups.

These characteristics of contextual teaching and learning provided the theoretical framework for this study. They were used specifically to develop the curriculum and assessment materials for the application to a real–world context treatment that was administered during the fall semester of 2009. Each fundamental characteristic of contextual teaching and learning is unique and explained in the following sections.

Problem Based Curriculum

Problem–based learning (PBL) has become a significant component in secondary and postsecondary science curriculums including agricultural related courses. PBL is an approach to structuring the curriculum that involves confronting students with problems from practice which provides a stimulus for learning (Boud & Feletti, 1997). PBL has a particularly prominent footprint in medical schools and other areas where the professionals who are to be graduated are avid problem solvers within their field. The PBL approach is also regarded as the most effective way to teach secondary agriculture (Crunkilton & Krebs, 1992; Newcomb, McCracken, Warmbrod, & Whittington, 2004), thus it is heavily promoted in methods courses for agriculture teacher education programs (Ball & Knobloch, 2005). When the curriculum contains scenarios in which the students are required to solve real–world problems within the framework of learning for the course, postsecondary studies have shown that students have increased levels of achievement (Amador & Gorres, 2004; Finch, 1999).

Self–regulated Learning

Self–regulated learning is a component of contextual teaching and learning that pertains to the student taking responsibility in the learning process by analyzing their own cognition and setting goals for what they need to learn. Lindner and Harris (1992) defined self–regulated learning as "the integration and utilization of cognitive, metacognitive, motivational, perceptual, and environmental components in the successful resolution of academic tasks" (p. 1). In a study of over 150 postsecondary students, they found a strong positive correlation between the self–regulated learner and GPA. McCombs and Marzano (1990) discussed that when the learner is aware of the fact that he/she is an agent in their own learning, the processes of metacognition produces self–efficacy and allows the learner to begin to internalize goals.

Authentic Assessment

Key to the notion of contextual teaching and learning is the importance of not just how the curriculum is taught, but how the curriculum is assessed. Authentic assessment differs from traditional measures because it requires the application of knowledge to a real–world problem or scenario (Wiggins, 1993).

Darling–Hammond and Snyder (2000) cited the benefits of authentic assessment for teacher education programs charged with demonstrating proper strategies to future teachers. They concluded that authentic assessment has the ability to reveal what students understand well enough to apply, and the potential that by influencing the learning of teachers, the learning of their students is influenced as well.

Interdependent Learning Groups

Another fundamental part of contextual teaching and learning is the use of interdependent learning groups as a strategy to tap into the benefits of social interaction in order to encourage learning in a different way. The traditional postsecondary classroom has long been characterized by *professor–to–student* lecture; a system that embodies independent learning and a responsibility on behalf of the individual to process and learn information. Skinner, Williams, and Neddenriep (2004) argued that when implemented properly, interdependent groups can actually enhance learning due to the effects of reward and reinforcement present in group interaction. This increase in achievement can be associated to the obligation students feel to perform well for others, not just themselves.

Purpose

Traditionally, college students are taught scientific facts and principles with the expectation that they will be able to apply that information to other situations. During contextual learning, students are taught scientific facts and concepts in real–world situations, allowing students to clearly see the application of those concepts in practice. The purpose of this study was to compare two teaching methodologies for an integrated agricultural biotechnology course at the postsecondary level. The two teaching methods tested were the explanation of the scientific basis for content (comparison treatment) versus the application of content to a real–world agricultural context (experimental treatment).

Research Question and Null Hypothesis

This study was guided by one research question, Is there a difference in the student mastery of scientific concepts related to agricultural biotechnology between students who have been taught using a scientific basis approach versus an agricultural context approach?

Stated in the null form for the purposes of statistical analysis, the following hypothesis was tested at the .05 level of significance:

HO_1: There is no significant difference in mean gains between the treatment groups as measured by a pre/posttest analysis.

Methods and Procedures

The research design was a variation of the quasi–experimental, non–equivalent control–group design. In this study, no formal control group was utilized, instead two treatment groups utilizing different methodologies were compared (Gall, Gall, & Borg, 2003). A quasi–experimental design was necessary due to the inability to randomly assign research participants to a treatment.

The pretests were administered during the first week of the semester when students were learning the logistics of the course. The posttests were administered immediately at the end of the treatment units of instruction. The two treatment groups received instruction on the same seven units of instruction that dealt with environmental biotechnology, and were designed such that they would teach the same fundamental concepts that were assessed in the pre/posttest. These seven units were: environmental impact of agricultural biotechnologies, environmental pollutants, phytoremediation, bioremediation, plant byproducts, animal byproducts, and sustainability. Both treatment groups were taught the same *fundamental concepts* within each unit. For example, in the bioremediation lecture, a fundamental concept that was taught to both groups was the different types of bioremediation. The treatment groups differed in the way the *fundamental* concepts were presented to the learner, and the ways in which they were assessed.

The comparison treatment, delivered in the spring semester of 2009, employed a somewhat *traditional* approach to teaching scientific, biotechnology–centered material via distance education. Slideshow presentations were the main vehicle to deliver the instructional content that contained a strong focus on the explanation of biology, chemistry, and basic scientific principles behind the topics covered in each lesson. In the example of the bioremediation unit, this treatment group received an extensive discussion into the types of microorganisms responsible for bioremediation, as well as an in–depth look at the nitrogen cycle, all centered on explaining how the different types of bioremediation work. Instructional slideshow presentations included several links to web pages that engaged students in a *web quest* type approach to covering the material. To ensure students reviewed and understood instructional material and web–based content, students completed study guides and quizzes for each lesson.

The experimental treatment, delivered in the fall semester of 2009 was also administered through distance education, but employed an approach that was based on the critical components of contextual teaching and learning based out of the theoretical framework previously described. Slideshow presentations were also used as a vehicle to deliver content, but the topics presented were applied to real–world situations that highlighted the ways in which the technologies operated in industry. In the example of the bioremediation unit, this treatment group examined the differences between agricultural and industrial type bioremediation, and discussed the ethical concerns associated with genetically modified microorganisms for bioremediation, all centered on showing the practical implications of this technology in the real world. Lessons contained extensive use of video presentations such as *virtual field trips* and *how–to* type documentaries of environmental biotechnologies in a variety of contexts. Instructional activities and assignments included case studies, problem solving scenarios, and team based exercises with several requiring the students to produce things an agriculture teacher would have to create in a job–related scenario. All teaching and assessment materials utilized during the experimental treatment were designed with the components of contextual teaching and learning in mind.

Students enrolled in the *Agricultural Biotechnology in Today's Society* course during the spring and fall semesters of 2009 at North Carolina State University were asked to participate in this study. The course was taught both semesters via distance education through the learning management system Moodle. Students were asked for their participation at the beginning of each semester, and only those students who granted permission were included in this study. Although participants and nonparticipants in the study still received the same treatment because it was a part of the course, data were only collected for students who voluntarily participated in the study in accordance with IRB regulations. Total class size for the comparison group was 24 students, while the total class size for the experimental group was 18 students. Two students from each group declined to participate in the study. As such, treatment group samples consisted of 22 and 16 students for the spring (comparison) and fall (experimental) semesters respectively.

Of the 38 students included in the study, 35 were identified as agricultural education majors and three were identified as plant biology majors. The course was designed to be implemented with sophomores, but any North Carolina State University student was eligible to enroll. Academic information collected on participants in the study included college GPA, high school GPA, high school class rank, and SAT scores. The data were collected during the semester in which the treatment was being administered from the department of registration and records at North Carolina State University. The purpose of collecting the indicators of success data was to assess for any pre–existing differences in the treatment groups.

The instrument used to determine achievement pertaining to the content taught to both treatment groups was a 25 question multiple choice exam given as both a pretest and posttest. The items included in the instrument aligned with the learning objectives of the environmental biotechnology section of the course and covered principles that were common to both treatment groups. The instrument was evaluated by a panel of experts in the field of biotechnology to ensure content validity. Their feedback, along with feedback from a panel of teacher educators who evaluated the phrasing and delivery of questions was used to improve the instrument. The instrument was not pilot tested due to time constraints and the inability to find a group that would perform similarly given the specificity of the questions. Instead, internal consistency, as a measure of instrument reliability, was assessed on the instruments completed by the two treatment groups.

The two groups of students that participated in this study were considered a sample of students in the College. Therefore, inferential statistics were used to analyze the data. T–tests were performed on college GPA, high school

GPA, high school class rank, and SAT scores to determine if there were any preexisting differences between the treatment groups. The alpha level was set at .05 for all significance tests. There were no differences in scores on any of the covariate variables between the treatment groups, so the groups were considered equal at the beginning of the study as seen in Table 1.

Table 1
Indicators of Student Success Data

		n	M	SE	*t*	df	*p*
College GPA	Experimental	16	3.10	0.14	0.51	34	.61
	Comparison	20	3.00	0.11			
High School GPA	Experimental	10	4.21	0.11	1.87	24	.07
	Comparison	16	3.88	0.16			
High School Class Rank	Experimental	7	0.14	0.02	2.71	16	.08
	Comparison	11	0.23	0.03			
SAT Score	Experimental	12	1064	37.20	0.70	26	.49
	Comparison	16	1099	32.00			

The pretest was administered to both treatment groups prior to exposure of any content covered in the course. Students were not graded for their performance on the pretest, but were given credit for completing it. Students were unable to access the pretest questions after attempting, and were not given the correct answers at any time. The posttest was given to both treatment groups at the end of the appropriate treatment. The instrument had a .49 and a .30 (KR–20) reliability estimate for the pretest and posttest deliveries respectively. Low external consistency for the instruments were a limitation to the study but could not be addressed without affecting content validity of the instruments. A further analysis of the reliability estimates showed that the low reliability of the instrument as a whole can be greatly attributed to a number of non–discriminatory questions that were answered correctly by most students.

Results

To test the null hypothesis directing the study, mean achievement scores for the pre and posttest for each treatment group were calculated. The experimental group began their respective curriculum with a mean score of 56.25 on the pretest, slightly lower than the comparison group performance of 59.64. The experimental group finished with a mean score of 86.25 on the posttest, posting a gain of 30 points; while the comparison group finished with a mean score of 86.36, posting a gain of 26.72 points as seen in Table 2. A t–test showed that even though the experimental treatment had a greater raw gain score, it was not a statistically significant difference (p=.48). Thus, the null hypothesis was not rejected.

Table 2
Statistics for Student Achievement by Treatment Group on the Pre/Posttest

Treatment Group	*n*	Pretest M	Posttest M	Gain M	SE	*t*	df	*p*
Agricultural Context (Experimental)	16	56.25	86.25	30.00	3.77	0.71	36	.48
Scientific Basis (Comparison)	22	59.64	86.36	26.72	2.79			

Conclusions/Discussion

Conclusions were drawn after analyzing the data in the context of the research question guiding the study. Is there a difference in the student mastery of scientific concepts related to agricultural biotechnology of students who have been taught using a scientific basis approach versus an agricultural context approach? A curriculum grounded in the principles of contextual teaching and learning did not have a significantly greater gain in pre/posttest scores when compared to the traditional method of delivering an environmental biotechnology course at the postsecondary level. Therefore, it was concluded that the contextualized curriculum performs comparable to the scientific basis alternative in terms of student mastery of scientific concepts related to agricultural biotechnology. The findings of this study were similar to those found in a high school mathematics study designed to test a contextualized agriculture curriculum (Parr, Edwards, & Leising, 2009). In the study, the researchers wanted to determine how students from an agricultural power and technology course would perform on basic mathematics concepts when they received a contextualized curriculum and an aligned instructional approach. The authors found no significant differences in the performance of students in the experimental and *traditional* treatments.

If the goal of postsecondary instruction is to teach students to apply scientific information in a contextual setting, the contextual approach provides a model for student learning and thinking. One of the principles of education is that students learn what they practice. Therefore, the contextual approach may show promise in two areas– teaching students to think contextually and, at the same time, to learn scientific concepts. If students are capable of learning the basic scientific content in a contextualized curriculum just as they would have learned it in a traditional manner, then those who are wanting to reap the benefits that contextualized teaching and learning has to provide can implement contextual teaching and learning with more peace of mind that students will still learn the basics.

Recommendations

Further replication of this study with larger class sizes, classes operating during the same semester, and classes at other universities would yield results more generalizable to the typical postsecondary course. Applying this research design in other science and non–science disciplines would help in determining the consistency of contextual teaching and learning as a broad educational approach. The dependent variable in this study was the achievement of scientific content knowledge of students taught by these two approaches. Since application of knowledge, not the memorization of facts, is critical in agricultural contexts, studies that measure the ability of students taught in a contextual framework to apply knowledge and think critically should be conducted.

If contextualized teaching and learning has no significant advantage in improving the achievement of students over the traditional method, then empirical evidence needs to be derived that supports the claim that contextualized curriculum actually improves life skills. Do students who learn content in a contextualized manner outperform those students who learn in a traditional fashion on a performance or problem based assessment? In other words, can students make the connection between the content that is traditionally taught and its' real– world context, or do they perform better when we as educators make the connection for them?

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