ABSTRACT

CURRY JR., KEVIN WYLIE. Scientific Basis vs. Contextualized Application of Knowledge: The Effect of Teaching Methodology on the Achievement of Post-secondary Students in an Integrated Agricultural Biotechnology Course. (Under the direction of Elizabeth Wilson.)

The purpose of the study was to compare two teaching methodologies for an integrated agricultural biotechnology course at the post-secondary 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 out of the principles of contextual teaching and learning, had a greater numerical mean gain on the pre/posttest however it 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 achievement.

Scientific Basis vs. Contextualized Application of Knowledge: The Effect of Teaching Methodology on the Achievement of Post-secondary Students in an Integrated Agricultural Biotechnology Course

by
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BIOGRAPHY

Kevin Wylie Curry Jr. was born in Denver, Colorado, but raised in the rural town of Oakboro, North Carolina. After graduating high school in 2004, Kevin enrolled at North Carolina State University where he declared a double major in agricultural education and animal science. After four memorable years of academic work and extracurricular efforts in the department of Agricultural & Extension Education, he decided to stay with the department accepting a graduate assistantship. Keeping with his passion for both education and agriculture, Kevin spent his graduate elective credits in animal science courses to receive a minor in animal science. In his graduate program, Kevin worked extensively in developing curriculum materials for a post-secondary biotechnology course, and researching integrative techniques and teaching methods. He hopes to continue his agricultural education research in a PhD program after four years of teaching secondary agriculture in the state of North Carolina.

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CHAPTER I: INTRODUCTION

Chapter one will provide the conceptual framework or "need" for the study. The purpose, research objectives, and research hypothesis will be stated, and the limitations to this study will be addressed. Additionally, several basic assumptions and operational definitions will be presented.

CONCEPTUAL FRAMEWORK

What is the function of post-secondary degree programs in the realm of agriculture and agricultural education? Should collegiate degree programs be more concerned with providing scientific content so that students exit with the most amount of information possible, or should they be focused on preparing students with real world problems they will face in the workforce? These are questions that may or may not be specifically answered by post-secondary institutions, but the answers are ultimately evident in the types of students they graduate.

After decades of educational reform, our current educational system at the secondary level is making great attempts to integrate curriculum across disciplines. With different ways to integrate content among and across disciplines, the ideal implementation of an integrated curriculum is unclear. Should agricultural education be treated such that it integrates the scientific concepts of chemistry and biology, or should agriculture be the vehicle that is used to apply the scientific concepts to a real world setting?

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

At the post-secondary level, there are fewer studies focused on the integration of science and agricultural education. For teacher education programs, this can be a case of "do as we say, not as we do." We cannot expect teachers to employ effective curriculum in the field that is integrated across disciplines and includes collaboration among other teachers, if we do not emulate or model how to do it in teacher education programs (Kluth & Straut, 2003). If agricultural teacher education programs wish to instill good tactics for integrating content in their future educators, then the courses they provide should model effective ways of doing just that.

The reason the "integration focus" has not been as strong at the post-secondary level as it has at the high school level may be explained by the relationship that exists between universities and industry. The university-industry relationship is drastically different from that of the relationship between high school agriculture programs and industry. Research is a prominent component of post-secondary agricultural biotechnology programs which demands time and attention to the overall goals of the program. In a study conducted at five prominent land-grant universities with agricultural biotechnology research programs, including North Carolina State University, researchers found that administrators of these agricultural biotechnology programs indeed encourage university-industry relationships and the commercialization of research discoveries (Glenna, Lacy, Welsh, & Biscotti, 2007). Said one researcher on the subject of university-industry relationships:

> "So, I think that in some instances you run the risk of faculty becoming too jaded by the money that industry might throw at them, by the prestige they might get by working in the industry. From my perspective, I tend to think only in terms of how much more good comes from the relationships than the negative" (Glenna et al., 2007) (p.153)

Agricultural and teacher education programs at the collegiate level are funded in part, and have significant obligations to, research endeavors. This relationship translates into a different perspective to teaching and training students than what is seen at the secondary level. One could argue that this apparent focus on content research, not pedagogy research at the post-secondary level leads to fewer quantitative studies on teaching strategies for undergraduate education.

Despite the focus, integrated curriculum at the post-secondary level is nonetheless present. The benefits provided to students when teaching an integrated curriculum are universal regardless of age, but the fact that post-secondary education in the realm of agriculture and biotechnology produces industry professionals, makes the specific way in which integration is carried out all the more crucial. Should the integration of agricultural and science content for post-secondary courses be contextually based that allows students to understand real world application, or should it be more focused on scientific principles so students can better understand how the technologies work?

The quasi-experimental approach of this study was aimed at determining the best way to implement an integrated biotechnology course at the post-secondary level. The study employed two different methods in an attempt to identify a method that yielded greater gains in student achievement.

PURPOSE OF THE STUDY

The purpose of the study was to comparatively evaluate two teaching methodologies for an integrated agricultural biotechnology course at the post-secondary level. The two teaching methods tested were the explanation of the scientific basis for content versus the application of content to a real world agricultural context. Following, is the research question used to direct the study.

1. Is there a difference in the content achievement of students who have been taught using a scientific basis approach versus an agricultural context approach?

RESEARCH HYPOTHESIS

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 scientific basis treatment and the agricultural context treatment groups as measured by a pre/post test analysis.

DEFINITION OF TERMS

Contextual teaching and learning (CTL)- 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).

Integration- Curriculum organization which cuts across subject-matter lines that brings together the various segments of the curriculum into meaningful association (Good, 1945).

Post-secondary agricultural education- Delivery of agricultural content at the college level.

Agricultural teacher education program- Collegiate degree program that prepares high school agriculture teachers.

Secondary agricultural education- Delivery of agricultural content at the high school level. Referred to as vocational agriculture, agriscience education, and other terms.

Achievement- The mastery of factual information core to the environmental biotechnologies presented in the course to both treatment groups.

ASSUMPTIONS

1. Participants' scores on pre/posttest assessments were reflective of knowledge gained in the class, and not due to any cross contamination from previous course implementations.
2. Performance on pre/posttest assessments were not influenced by a history effect from the time period between the two semesters.
3. There was no difference between the treatment groups as to what they remembered from the pretest.

LIMITATIONS

1. This study has limited external validity due to the small treatment group sizes and limited scope.
2. Although students from both treatment groups were not given correct answers to any pre/posttest items, the possibility of contamination between treatment groups from students sharing information was plausible.

3. Due to the small sample size of both treatments, the ability to detect differences was more difficult.
4. Reliability estimates of the pre/posttest were not ideal. Therefore the predictability of repeating these results is somewhat limited.

SUMMARY

This chapter highlighted the need for the study by posing questions and looking at opinions as to how an integrated curriculum should be carried out at the post-secondary level. The void in the post-secondary pedagogy literature for an experimental study in the area of agricultural education concerning ideal teaching methodology for integrated curricula prompted the need for this study. The general direction of the study was outlined, and statistical hypotheses as well as operational terminology were clearly defined. Finally, a few basic assumptions and limitations to the study were indentified.

CHAPTER II: REVIEW OF LITERATURE

Chapter two will describe the theoretical framework that the study operated under. In addition, a review of literature will be presented pertaining to teaching methodologies performed in post-secondary courses. The review of literature generated the following topics that will be the organizational structure of the discussion of literature.

1. Educational reform
2. Educational philosophy
3. Integrated curriculum in post-secondary education
4. Contextual teaching and learning in post-secondary education

The review of literature included *The Journal of Agricultural Education*, *The Journal of Teacher Education*, *The NACTA Journal*, proceedings of the *National Agricultural Education Research Meetings*, and proceedings of the *American Association of Agricultural Education Meetings*. After a thorough review of the preceding publications, an *EBSCO Host* search was conducted covering a variety of databases including, but not limited to, *ERIC*, *Agricola*, and *CAB Abstracts*.

THEORETICAL FRAMEWORK

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 of this information series define contextual learning with certain fundamental characteristics. They assert 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
- Uses interdependent learning groups

These characteristics of contextual teaching and learning, when aligned with the program components of an effective teacher education program provided the framework for this study. This theoretical framework is depicted in Figure 1.

Although it can also be used to assess whether a teacher education program is aligned with the basic principles of contextual teaching and learning, it was used in this study 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. A checklist, based out of the theoretical model, was developed that displays which characteristics of CTL were used in each lesson (Figure 2).

It should be noted that the characteristic “occurs in multiple contexts” as defined by the authors of the model refers to instruction that is done in multiple settings. For example, teaching not only in the classroom, but out in the field and in the community. Because the treatment groups were based within a distance education course, physically teaching in different settings was not possible, however all units contained videos from a variety of real life settings appropriate to the content being taught.

Likewise, the authors’ definition that CTL “anchors teaching and learning in students’ diverse life contexts” primarily refers to appealing to multiple cultural/ethnic backgrounds. In this study the definition was extended to include career and academic interests. Since the students in the course had aspirations to become teachers, each of the lectures had curriculum/assessment components geared toward future educators.

	Components of Teacher Education										
Characteristics of Contextual Teaching and Learning	Goals	Curriculum	Instructional strategies	Contexts: workplaces, classrooms, clinics, schools, community	Learners	Staff	Themes	Ethos	Partnerships	Regulations	Location
Is problem based											
Occurs in multiple contexts											
Fosters self-regulated learning											
Anchors teaching and learning in students diverse life contexts											
Employs authentic assessment											
Uses interdependent learning groups											

Figure 1 A framework for contextual teaching and learning in preservice education

	Environmental Biotechnology Lessons							
Characteristics of Contextual Teaching and Learning	Intro to Environmental Biotechnology	Detecting and Tracking Pollutants	Phytoremediation 1	Phytoremediation 2	Bioremediation	Plant and Cropland Waste management	Animal Waste management	Sustainability
Is problem based				X	X	X	X	
Occurs in multiple contexts	X	X	X	X	X	X	X	X
Fosters self-regulated learning				X				X
Anchors teaching and learning in students diverse life contexts	X	X	X	X	X	X	X	X
Employs authentic assessment	X	X	X		X	X	X	
Uses interdependent learning groups			X					

Figure 2 Components of CTL reflected in curriculum/assessment materials

PROBLEM BASED CURRICULUM

Problem-based learning (PBL) has become a significant component of secondary and post-secondary 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, post-secondary 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) define 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 post-secondary students, they found a strong positive correlation between the self-regulated learner and GPA. McCombs and Marzano (1990) discuss 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 defines authentic assessment as:

> Engaging and worthy problems or questions of importance, in which students must use knowledge to fashion performances effectively and creatively. The tasks are either replicas of or analogous to the kinds of problems faced by adult citizens and consumers or professionals in the field (Wiggins, 1993, p. 229).

Darling-Hammond and Snyder (2000) cite the benefits of authentic assessment for teacher education programs charged with demonstrating proper strategies to future teachers. They highlighted that authentic assessment has the ability to reveal what students understand well enough to apply, and assert that if you influence the learning of teachers, the learning of their students is influenced as well.

INTERDEPENDENT LEARNING GROUPS

The traditional post-secondary 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. The use of interdependent learning groups is a strategy used by educators to tap into the benefits of social interaction in order to encourage learning in a different way. Skinner, Williams & Neddenriep (2004) argue 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.

BENEFITS OF CONTEXTUAL TEACHING AND LEARNING

One could argue that CTL has been present in vocational classrooms long before the title became a buzz word in educational research. The very essence of CTL relates to the notion of learning by doing, which has long been a pillar of secondary agricultural education. Practitioners in agricultural education attribute increased student motivation and retention to a sustained focus on CTL (Predmore, 2005). Still, these anecdotal accounts are not enough to warrant large scale implementation.

In a three year study of a Georgia teacher education program, Lynch and Pydilla (2000) outline some of the benefits present in a curriculum of CTL. The researchers reported that students had "unusually high" ratings for the CTL 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 the how to implement CTL. Results from thirty three teachers in five public high schools indicated that teachers noticed significant increases in student motivation with adoption of a CTL 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 CTL is beneficial to learning because it exercises the brain in a "natural" way. Johnson (2002) argues that CTL 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 asserts that CTL 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 CTL increases student attitudes and motivation, the idea that CTL is somehow easier or more natural for students than "traditional" methods does not seem to farfetched.

LITERATURE REVIEW

Upon a review of the literature, the need arose to organize topics into the following four prevailing themes:

1. Educational reform
2. Educational philosophy
3. Integrated curriculum in post-secondary education
4. Contextual teaching and learning in post-secondary education

EDUCATIONAL REFORM

In April of 1983, a "landmark" report was published by the U.S. Department of Education entitled *A Nation at Risk*. The report highlighted monumental deficiencies of the American educational system and called for a "back to the basics" type approach to increase the rigor of the high school system. The report published five recommendations dealing with everything from curriculum and accountability, to teacher requirements and fiscal support. Put rather bluntly by the commission:

> "More and more young people emerge from high school ready neither for college nor for work. This predicament becomes more acute as the knowledge base continues its rapid expansion, the number of traditional jobs shrink, and new jobs demand greater sophistication and preparation" (National Commission on Excellence in Education, 1983, p.12)

Since the publication of *A Nation at Risk*, the landscape of the high school system has changed drastically. A greater focus on core curricular areas has placed a greater emphasis on standardized testing, and paved the way for an increased focus on accountability pertaining to legislation such as No Child Left Behind (PL-107-110).

Understanding Agriculture: New Directions for Education, published just five years after *A Nation at Risk* was the call for reform that was more specific to the agricultural education community. Secondary agricultural education was challenged to be more reflective of the modern global landscape with which agriculture resides. Specifically, the report charged that a better job be done with preparing students for the next step in their educational journey, be it the workforce or higher education. One of the key recommendations from the report states that:

> "…agriculture programs must be upgraded to prepare students more effectively for the study of agriculture in postsecondary schools and colleges and for current and future career opportunities…" (National Academy Press, 1988, p. 4)

The secondary agricultural education classroom has changed in light of these reform recommendations. Following *A Nation at Risk*, and *Understanding Agriculture: New Directions for Education*, a plan was developed in 1989 called *A National Mobilization Plan for Revolutionary Change in Agricultural Education* that detailed the ways in which the agricultural education profession could move forward. Among others, the report called for an increase in collaboration with other teachers in the school in order to increase the relationship between agriculture and science (The strategic plan for agricultural education. A national mobilization plan for revolutionary change in agricultural education, 1990). In light of these reforms, there have been numerous attempts at integrating science and agricultural education in a variety of ways in order to meet the demands of making educational curriculum more rigorous and more relevant.

EDUCATIONAL PHILOSOPHY

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.

This theoretical discussion is in some ways a continuation of the debate between Charles Snedden and John Dewey. Snedden favored a more vocational type approach to agricultural education that focused on job skills and the training of individuals for the workforce. It was Snedden's belief that vocational and liberal education was not only fundamentally dissimilar, but that the "integration" between the two was counterproductive. Snedden wrote:

> It is further contended that vocational education and liberal education cannot be effectively carried on, so far as regards a given group of pupils, in a way which permits of a considerable blending of the unlike types of instruction. To attempt this is to defeat the aims both of liberal and of vocational training. (Snedden, 1977, p. 43).

Dewey however, viewed agricultural education as a piece of a broader integrated curriculum that students could use to make the connections for greater life skills. Said Dewey, "Perhaps the greatest of all pedagogical fallacies is the notion that a person learns only the particular thing he is studying at the time" (Dewey, 1938, p. 49). Dewey's philosophy is arguably the more prominent of the two in today's secondary agricultural education due to the trend of the agriscience movement, but there is no doubt that remnants of both still exist and influence modern educational theory.

In many ways the present study fits among a hybrid between the philosophies of both Snedden and Dewey. The contextualized application to real world agricultural concepts is a notion that Snedden would likely praise as a valuable way to prepare students for the workforce. However the fact that this treatment methodology is being performed in an integrated course where students are connecting those contextualized applications to scientific principles and issues of ethics makes it also fit within Dewey's philosophy of an integrated educational focus.

INTEGRATED CURRICULUM IN POST-SECONDARY AGRICULTURAL EDUCATION

To understand how integrated curriculum is being conducted at the post-secondary level, it is crucial to first be able to distinguish the different types of integration in practice. Tress, Tress, Fry, and Opdam (2006) characterize the different types of integration which are visually depicted in Figure 3. Many of the integrated post-secondary courses in operation, including the agricultural biotechnology course with which the present study is associated, employ a multidisciplinary approach. This approach aligns multiple disciplines under a common theme. An interdisciplinary approach is one that crosses disciplinary and scientific/academic boundaries that results in integrated knowledge and theory.

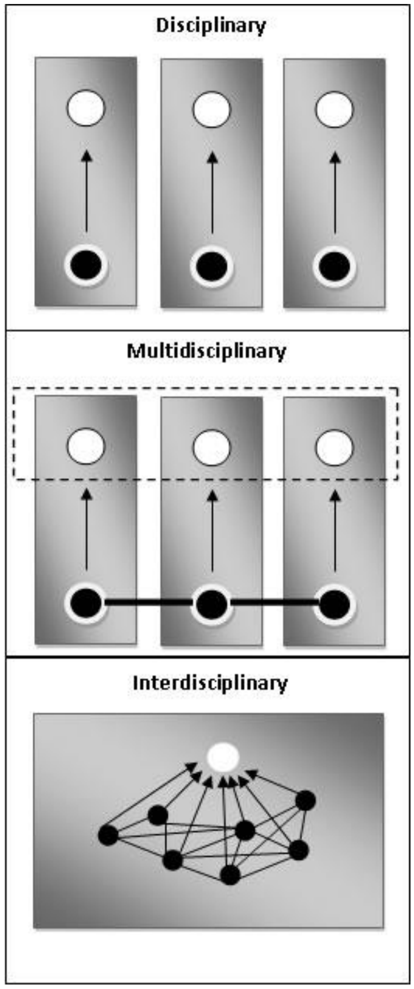


Figure 3. Adapted from “Overview of concepts: disciplinary, multidisciplinary, participatory, interdisciplinary, and transdisciplinary,” by B. Tress, G. Tress, G. Fry, and P. Opdam, 2006, *From landscape research to landscape planning-aspects of integration, education and application*, p. 16.

Figure 3 Overview of integration approaches

Post-secondary institutions who realize the benefits of integrated curriculum for students are beginning to institute changes in degree requirements that reflect this trend. North Carolina State University has introduced an interdisciplinary degree option that will eventually become a degree requirement that mandates students enroll in a specified number of hours from a list of courses that have a focus across multiple disciplines. The rationale for such a requirement is:

> "Interdisciplinary study provides students with the opportunity to synthesize knowledge and skills, to make connections between fields of study, to consider more than one disciplinary approach or methodology, and to bring to bear the insights from two or more disciplines in examining and/or responding to complex problems" (Division of Undergraduate Academic Programs, 2008)

An example might be an animal science in society course that is taught by both an animal science instructor and an ethicist. Students would learn the science behind the issues, and explore the societal and ethical views in a way that incorporates knowledge base from multiple disciplines.

Kozoll and Osborne's study (2004) on the role of science in post-secondary 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 their career choice.

It is also important to understand that the literature is unclear as to what a "model" integrated curriculum looks like. Is integration bringing science concepts to a vocational/technical field? Is it bringing vocational/technical applications to science courses? Contextualized teaching and learning, the foundation of the experimental treatment in the present study, is not "integrating" curriculum in the strictest sense. That is, CTL does not necessarily have to combine two or more content disciplines. For example, music can be taught by memorizing scores, but it is not contextualized until students actually play music. A music curriculum where students play music would be considered contextualized, but not integrated, because it does not collaborate with another discipline.

CONTEXTUAL TEACHING AND LEARNING IN POST-SECONDARY EDUCATION

A form of CTL present at many colleges and universities is the implementation of capstone courses. Capstone courses are often taken during a student's last year of study. These courses "provide an opportunity to incorporate previously learned, often disjointed, information into an interconnected contextual frame of reference from which to transition into a career or further study" (Andreasen, 2004, p. 52). Capstone courses, as argued by Andreasen, should incorporate five main principles: teamwork, problem solving, decision-making, critical thinking, and communication. These five components of a capstone course allow the learner to receive, relate, reflect, refine, and reconstruct the information from the fragmented knowledge of previous courses for a greater understanding.

An example of a capstone course is the Natural Resource Conservation and Management course taught in the College of Agriculture at the University of Kentucky

(Arthur & Thompson, 1999). The students call upon their disciplinary knowledge in ecology, sociology, and economics and apply it to real world issues facing professionals in the field and society as a whole. Efforts such as these are strategies by which post-secondary institutions are demonstrating to their students how years of content-specific course work can be translated into life skills and the foundation for further education.

Capstone courses can provide a way to synthesize and make meaningful a large body of coursework, but the principles of contextualized learning and application can be administered on a course by course basis albeit difficult. In reference to the challenges faced by instructors and curriculum developers to employ contextual teaching and learning, Johnson stated:

> "It is to ask far more than, "What lesson shall we place in context?" … or to establish a partnership that puts lessons in a real-world situation… It is to raise the important question: "Into what larger context shall we place this academic lesson?" (Johnson, 2002, p. 17)

Balschweid and Thompson (2000) analyzed how an integrated agriculture and science program for pre-service teachers affected their own ability to integrate curriculum as educators. Results from the study demonstrated that teachers in the experimental group were more likely to attend in-service training on integration techniques, and held positive attitudes for contextualizing science content in their classrooms.

Sears (2002) asserts that more can and should be done in our teacher education programs to equip future teachers to employ contextual teaching and learning. In particular, Sears notes that pre-service teachers need instruction on some of the key foundational concepts of CTL such as self-regulated learning, problem based learning, and authentic assessment. Perhaps by exposure of these concepts in a teacher education course, future teachers would better understand the value of CTL due to the effect it has on their own learning.

SUMMARY

This chapter identified the theoretical framework of the study that provides structure and justification for the curriculum developed for the treatment groups. Related research was reviewed, which generated topics relevant to this study. The following areas were examined: educational reform, educational philosophy, integrated curriculum in post-secondary agricultural education, and contextual teaching and learning in post-secondary education. Landmark educational reforms of the 1980s have provided the spark for interest in integrated curricula. These reforms combined with educational theory of past and present provide the theoretical rational for why integrated curricula has become such an intense focus in educational practice. The ways in which integrated curricula have been implemented and their success at the secondary and post-secondary level provided the comparison for how this study can fit into the body of literature.

CHAPTER III: METHODOLOGY

The purpose of chapter three is to explain the design and implementation of this study. Reasons for selecting the specific research design will be addressed, followed by an in-depth look at the methodology of the study. The purpose of the study was to compare two teaching methodologies for an integrated agricultural biotechnology course at the post-secondary level. The two teaching methods tested were the explanation of the scientific basis for content versus the application of content to a real world agricultural context. The independent variable of the study was the treatment of a specific teaching methodology, and the dependent variable was performance on the assessment that was identical to both treatments.

RESEARCH DESIGN

The research design was a quasi-experimental non-equivalent control-group design (Figure 4). 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 chosen due to the inability to randomly assign research participants.

O X O

O Y O

Key: X= Application to a real world context treatment (experimental) - Fall 2009
Y= Explanation of scientific basis treatment (comparison) - Spring 2009
O= Pretest/Posttest

Figure 4 Research design

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. Figure 5 visually depicts some of the main differences between the methodologies implemented in the treatment groups.

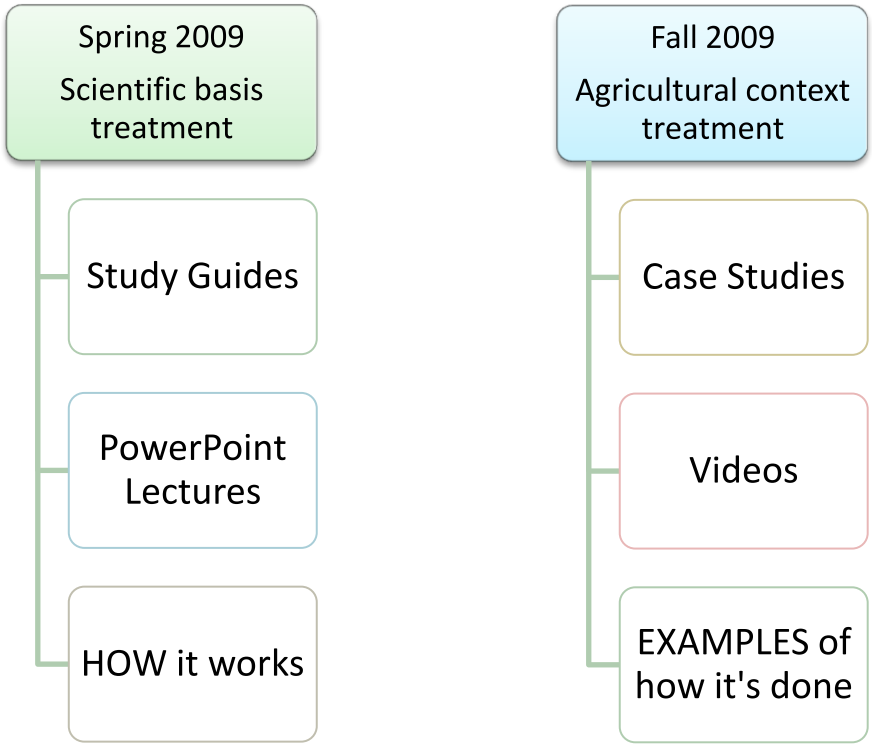


Figure 5 Schematic of key differences in treatment group methodology

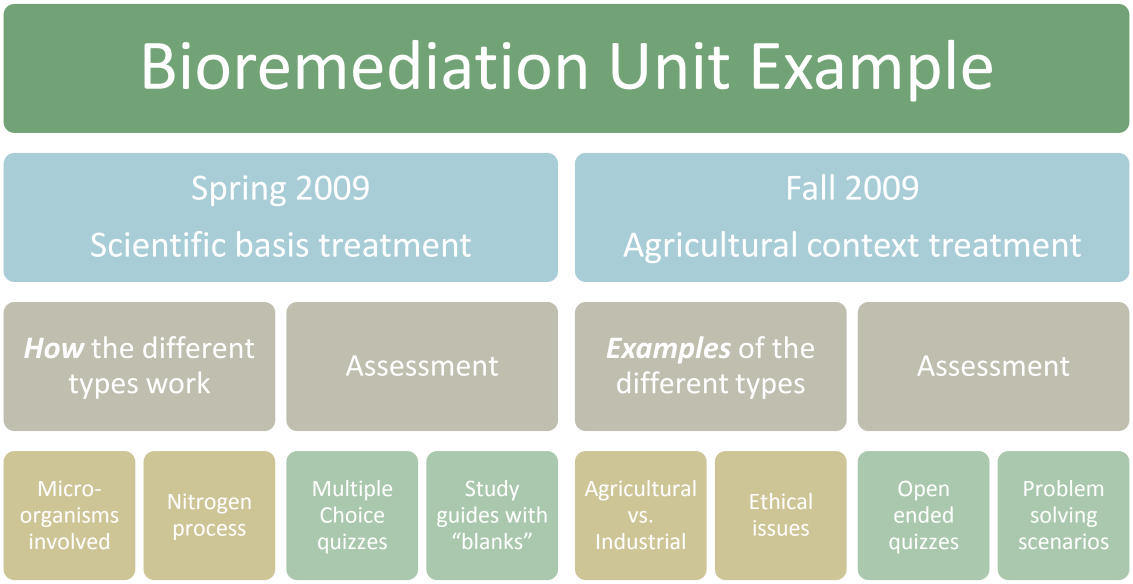


Figure 6 Methodology/assessment differences

SCIENTIFIC BASIS TREATMENT (COMPARISON) - SPRING 2009

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 (Figure 6). 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 (Appendix B- Example Study Guide) and traditional multiple choice based quizzes for each lesson.

APPLICATION TO A REAL WORLD CONTEXT TREATMENT (EXPERIMENTAL) - FALL 2009

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 present in the theoretical framework previously described (Figure 1). 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 aforementioned example of the bioremediation unit, (Figure 6) 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 (Appendix D- Example Problem-Based Activity), and team based exercises (Appendix E- Example Cooperative

Learning Activity) with several requiring the students to produce things an agriculture teacher would have to create in a job-related scenario (Appendix F- Reporter Inquiry Assessment). All teaching and assessment materials utilized during the experimental treatment were designed to include the various components of contextual teaching and learning.

A checklist was used to identify which specific characteristics of CTL were used in each lesson of the experimental treatment (see Figure 2).

CONTROL OF EXTRANEOUS VARIABLES

To control for any changes in teaching methodology performed by the other two instructors in the course, the environmental biotechnology section, which is the focus of this study, was implemented at the beginning of each treatment semester. As well, the researcher of the study was the instructor for both treatment implementations.

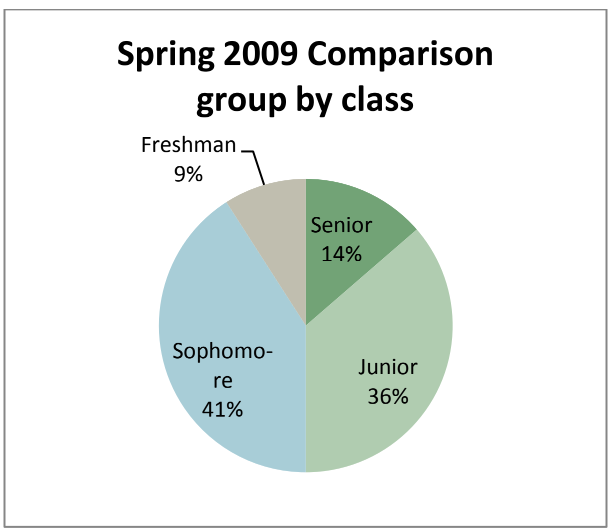
POPULATION AND SAMPLE

Students enrolled in the AEE/PB/ANS 495 Y course entitled "Agricultural Biotechnology in Today's Society" 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. It was cross listed in three different departments (Agricultural and Extension Education, Plant Biology, and Animal Science) within the College of Agriculture and Life Sciences in order to help attract students in diverse disciplines. Not every student enrolled in the course participated in the study. Although participants and nonparticipants in the study still underwent the same treatment because it was a part of the course itself, participation in the study was voluntary in accordance with IRB regulations due to the need to collect existing academic information. Students were asked for their participation at the beginning of each semester, and only those students who granted permission were included in this study. 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.

The population of this study was students enrolled in the AEE/PB/ANS 495 Y course during spring and fall semesters of 2009 at North Carolina State University. Of the 38 students included in the study, 35 were identified as agricultural education majors and 3 were identified as plant biology majors. All three of the plant biology majors were enrolled in the spring 2009 (comparison) group. The course was designed to be implemented with sophomores, but any NC State student was eligible to enroll. A breakdown of each treatment group for the class status of the students can be found in Table 1 and in Figure 7. The comparison group was comprised of 13 females (60%), and 9 males (40%), while the experimental group contained 12 females (75%) and 4 males (25%).

Table 1 *Breakdown of treatment groups by class*

Classification	Spring 2009 Comparison Group	(%)	Fall 2009 Experimental Group	(%)
Freshman	2	9%	0	0%
Sophomore	9	41%	4	25%
Junior	8	36%	6	38%
Senior	3	14%	5	31%
Graduate Student	0	0%	1	6%



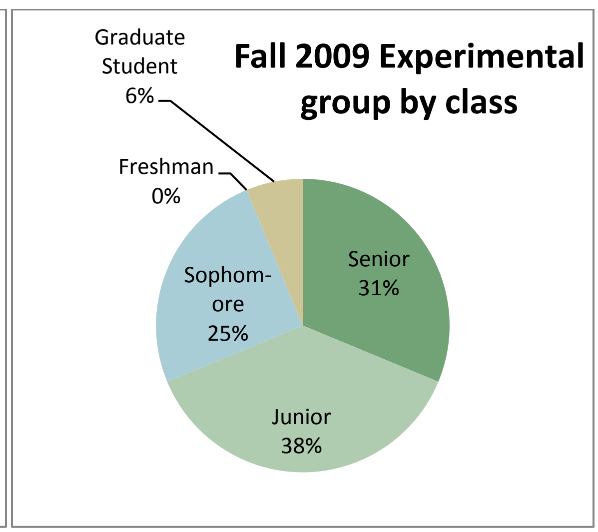


Figure 7 Breakdown of treatment groups by class

INSTRUMENTATION

The instrument used to determine achievement pertaining to the content taught to both treatment groups was a twenty five 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 (see Appendix C- Instrument). 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 the inability to find a group that would perform similarly given the specificity of the questions.

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 anytime. 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.

DATA COLLECTION

Participants in both treatment groups completed the pretests and posttests in the "quiz" feature within the learning management system Moodle. All grading of the multiple choice questions was completed electronically by the learning management system. 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 were to assess for any pre-existing differences in the treatment groups and to adjust group means based upon any differences found. Data for purposes of analysis were only collected on those students in the course that consented to participate in the study in accordance with IRB regulations.

ANALYSES OF DATA

Data were analyzed using SPSS. Mean gains in student achievement on the pre/posttest were calculated, and an independent samples t-test was utilized to determine if there was a statistically significant difference between the level of achievement among the treatment groups. T-tests were also performed on college GPA, high school GPA, high school class rank, and SAT scores to determine if preexisting differences between the treatment groups existed. The alpha level was set at .05 for all significance tests. If any significant differences were found on the predictors for academic success, an ANCOVA would be utilized to adjust the means to reflect the preexisting differences.

SUMMARY

Chapter three detailed the research design implemented in this study along with an overview of the population and sample. The instrument used to determine student achievement was explained, and methods for collecting and analyzing data were described. A quasi-experimental non-equivalent control-group design was utilized in an integrated post-secondary biotechnology course to test the differences in student content achievement between two teaching methodologies. Data on the pre/posttest were analyzed with T-tests to check for any significant differences in mean gain based on treatment.

CHAPTER IV: RESULTS

PRELIMINARY ANALYSES

The total sample consisted of 38 students. Of the 38 students, 25 were female, and 13 were male. The college GPA average for the group was a 3.0, the high school GPA average was a 3.95, the SAT score average was a 1084, and the average student was at the 18th percentile in their high school graduating class. This data is summarized in Table 2.

Table 2 *Average academic indicator statistics*

	College GPA	High School GPA	High School Class Rank	SAT Score
Total Sample Average	3.0	3.95	.18	1084

THE IMPACT OF INDICATORS OF STUDENT SUCCESS ON STUDENT ACHIEVEMENT

Several indictors of student success were collected to determine if there were any preexisting differences among the treatment groups that could have had an effect on the assessment performances. These indicators were college GPA, high school GPA, high school class rank, and SAT score. Data on each indicator was not available for every participant. T-tests were performed on each of these indicators between treatment groups, and no significant differences were found (Table 3). Therefore an ANCOVA was not used to adjust means, since there were no significant preexisting differences between the treatment groups.

Table 3 *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			
H.S GPA	Experimental	10	4.21	0.11	1.87	24	.07
	Comparison	16	3.88	0.16			
H.S 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 IMPACT OF TREATMENT METHODOLOGY ON STUDENT ACHIEVEMENT

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 (Table 4). A t-test showed that even though the experimental treatment had a greater gain score, it was not a significant difference (p=.48). Thus, the null hypothesis was not rejected.

Table 4 *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	.480
Scientific Basis (Comparison)	22	59.64	86.36	26.72	2.79			

CHAPTER V: SUMMARY, CONCLUSION, IMPLICATIONS, AND RECOMMENDATIONS

The purpose of chapter five is to review the methodology and findings of the study, as well as to make conclusions and recommendations for practice and future research.

SUMMARY OF PROCEDURES

A distance education, integrated agriculture biotechnology course at the post-secondary level was chosen to test the effect of teaching methodology on student achievement. Two separate curriculums were created for two different implementations of the course. The explanation of scientific basis treatment (comparison group) was administered during the spring semester of 2009 to twenty-two students. The application to a real world context treatment (experimental group), based out of the principles of CTL, was administered during the fall semester of 2009 to sixteen students. A twenty-five item assessment was developed to determine content achievement and was administered in a pre/post test fashion to both treatments. Indicators of student success were analyzed to account for any preexisting differences among the treatment groups. In addition, mean gains on the pre/post test were compared and a t-test was performed to assess if the differences were significant.

SUMMARY OF FINDINGS

The experimental and comparison groups exhibited a pre/post test gain of 30, and 26.72 points respectively. This three point difference in mean gain score was not significant, however, so the null hypothesis was not rejected.

CONCLUSIONS

Conclusions were drawn after analyzing the data in the context of the research question guiding the study: Is there a difference in the content achievement 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 post-secondary level. This indicates that the contextualized curriculum performs comparable to the traditional alternative in terms of student achievement.

DISCUSSION

Caution should be used when interpreting the results due to the low reliability of the instrument. However the instrument was content valid, and was designed to measure a very basic level of achievement similar to both treatment groups. 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.

Small sample sizes within experimental groups reduce the ability of the researcher to detect differences that may result from a treatment. With small samples the differences have to be much larger in order to reach statistical significance. In this study the experimental treatment posted an advantage in gain scores over the comparison group that could potentially be significant with greater sample sizes.

Nonetheless, the findings of this study are similar to those found in a high school mathematics study designed to test a contextualized curriculum (Parr, Edwards, & Leising, 2009). In the study, the researchers wanted to see 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. Like the present research study, these authors found no significant differences between the experimental and "traditional" treatments.

Studies that examined the achievement of post-secondary students as a result of a CTL curriculum in an experimental fashion were not identified as a result of the review of literature. Nonetheless, these findings seem to support the CTL project implemented in a Georgia teacher education program (Lynch & Pydilla, 2000). In the Georgia study, it was demonstrated that post-secondary students have positive ratings of the CTL approach. Was this increased appreciation for the curriculum at the detriment of students' achievement in core subject matter? The findings of the present study support the notion that this is not the case; indeed students can learn core curricular content in the CTL approach the same as they would in a traditional manner.

RECOMMENDATIONS

RECOMMENDATIONS FOR PRACTICE

The results of this study show there were no significant differences between the achievement of students in a contextualized curriculum when compared to a traditional design. However, due to this similarity in achievement, it can be seen as a call to implement contextual teaching and learning in post-secondary curriculum. 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 want to reap the benefits that contextualized teaching and learning provides can implement CTL with more peace of mind that students will still learn the basics.

If teacher education programs wish to instill upon their student teachers the ability to develop contextualized curriculum in classrooms, then they should be effective models themselves. Courses such as the one in this study are good opportunities for student teachers to recognize the importance of contextualized teaching and learning, because they reap the benefits themselves as students. More can be done at the post-secondary level with teacher education programs to address this concern.

RECOMMENDATIONS FOR FUTURE RESEARCH

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 post-secondary course. If replicated, a preexisting instrument for fundamental biotechnology concepts that has favorable reliability estimates would be preferred. Applying this research design in other science and non-science disciplines would help in determining the consistency of CTL as a broad educational approach.

The review of literature returned several studies and opinions regarding student attitudes, retention, and motivation in a curriculum of CTL. However, there was little evidence found to empirically support the posit that CTL increases student achievement in post-secondary settings. This study contributes to the body of literature on the subject, but more work is still needed to better ascertain the effect CTL has on student achievement. Even still, additional achievement research would benefit from accompanying attitude surveys. Determining student attitudes toward CTL would offer more information as to whether any advantages would be practically significant.

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 to a real world context, or do they perform better when we as educators make the connection for them?

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APPENDICES

APPENDIX A- IRB HUMAN SUBJECTS APPROVAL

North Carolina State University is a land-grant university and a constituent institution of The University of North Carolina

Office of Research and Graduate Studies

NC STATE UNIVERSITY

Sponsored Programs and Regulatory Compliance
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From: Joseph Rabiega, IRB Coordinator
North Carolina State University
Institutional Review Board

Date: December 15, 2008

Project Title: Science vs. Application: The Preferred Method of Integrated Curriculum Delivery

IRB#: 608-08-12

Dear Kevin:

The research proposal named above has received administrative review and has been approved as exempt from the policy as outlined in the Code of Federal Regulations (Exemption: 46.101.b.2). Provided that the only participation of the subjects is as described in the proposal narrative, this project is exempt from further review.

NOTE:

1. This committee complies with requirements found in Title 45 part 46 of The Code of Federal Regulations. For NCSU projects, the Assurance Number is: FWA00003429.
2. Any changes to the research must be submitted and approved by the IRB prior to implementation.
3. If any unanticipated problems occur, they must be reported to the IRB office within 5 business days.

Please provide your faculty sponsor with a copy of this letter.

Sincerely,

Joseph Rabiega
NCSU IRB

APPENDIX B- EXAMPLE STUDY GUIDE

Introduction to Environmental Science: Lesson Study Guide

I. Detecting and Monitoring Pollutants
   a. Importance
   b. Environmental Biosensors
      i. Briefly describe what a biosensor is, and state why the use of biosensors for the detection of explosives is advantageous to alternative methods.

II. Bioremediation
   a. Etymology
   b. Purpose/Use
   c. Example
      i. Explain the differences between aerobic and anaerobic processes of bioremediation including their end products.
      ii. Cite three examples of *ex situ* solid-phase bioremediation.

III. Phytoremediation
   a. Purpose/Use
   b. Example
      i. Explain how the scientists in the article genetically modified tobacco to serve their specific purpose.

IV. Biomining
   a. Purpose/Use
   b. Examples
      i. Explain what specific advantage Thermophiles have over traditional mesophile bacteria with regard to biomining and the habitat.

ii. List the four main commercial grade biomining processes being used, and the main form of ore associated with each.

V. The Agricultural Connection
  a. Waste Management
    i. Why has production of bio-ethanol not been an economically efficient alternative in recent years?
  b. Herbicide Tolerant Crops
    i. Discuss two of the ethical issues behind the implementation of HT crops.
  c. Bt/Genetically Modified Crops
    i. Describe 3 specific advantages that the planting of Bt and other Genetically Modified crops has for the environment.
    ii. Explain why Bt crops are not accepted and thought of as ideal by everyone.

VI. Reducing and Preventing Contamination
  a. Phosphorus levels in farm animal waste
    i. Define “phytase” and describe two ways researchers have developed to produce it.
  b. Aluminum Toxicity
    i. The University of Florida publication details the work of scientists

who have overcome aluminum toxicity by genetically engineering plants to produce what?

VII. Limiting Environmental Impact

a. Alternative Fuels

i. Describe two of the advantages of producing “green plastics” compared to the petrochemical alternative.

b. Sustainability

i. What does BOD stand for, and why is it being addressed by biotechnology?

c. Bioreactors

i. List and briefly describe the three different types of bioreactor landfills.

APPENDIX C- INSTRUMENT

1. Thermophiles provide the biomining industry an organism that can withstand extreme __________.

- a. Temperatures
- b. Salinity
- c. Humidity
- d. Darkness

2. Bt crops contain a genetic modification that makes them tolerant to __________.

- a. Pesticides
- b. Insects
- c. Drought
- d. Toxicity

3. In a traditional biotechnology ELISA, you are assaying *directly* for the presence of an antigen

- True
- False

4. In this type of phytoremediation, plants take up organic compounds and release the contaminants in a reduced form into the atmosphere.

- a. Phytoaccumulation
- b. Phtyodegradation
- c. Rhizofiltration
- d. Phytovolatization

5. The best type of bioremediation to use when both the soil and groundwater are contaminated is Ex-situ bioremediation

- True
- False

6. When waste lagoons are aerated to promote specific types of microbial proliferation, managers are carrying out a form of:

- a. Intrinsic bioremediation
- b. Bioaugmentation
- c. Biostimulation
- d. Extrinsic bioremediation

7. A biofuel is a broad term for a variety of fuels that are derived from at least 80 percent _______.

- a. Plant material
- b. Renewable sources
- c. Ethanol
- d. Alcohol

8. Which of the following is an example of a procedure that a producer spreading agriculture wastes SHOULD follow?

- a. Apply wastes upgradient from a potable well
- b. Apply wastes to shallow, permeable soils
- c. Conduct waste and soil tests for nutrient analysis
- d. All of the above are correct
- e. None of the above are correct

9. Sustainable agriculture is often described as a balance of three areas. Which of the following is *not* one of those areas?

- a. Economy
- b. Politics
- c. Environment
- d. Community

10. A plant that has the ability to absorb up to 100 times more toxin than an average plant is called a:

- a. Hyperaccumulator
- b. Hyperphytoextractor
- c. Hyperstabilizer
- d. Hyperfiltrator

11. All of the following are types of bioremediation that are possible *except*:

- a. In-situ bioremediation of soil
- b. Ex-situ bioremediation of soil
- c. In-situ bioremediation of groundwater
- d. Ex-situ bioremediation of groundwater

12. Vermicomposting is a method of composting utilizing what organism?

- a. Grasshoppers
- b. Worms
- c. Microorganisms
- d. Veal

13. Which of the following is *not* a biofuel currently being researched for implementation?

- a. Ethanol
- b. Biodiesel
- c. Biokerosine
- d. Biogas

14. Commercial bioremediation is becoming economically feasible because of:

- a. High costs of traditional treatment
- b. Public dislike for traditional treatments
- c. Stringent requirements for traditional treatments
- d. All of the above are correct

15. Herbicide Tolerant crops are resistant to broad-spectrum herbicides due to

- a. Genetic selection
- b. Genetic modification
- c. Evolutionary adaption
- d. Fertilizers

16. The concept of " ____________" is a form of conservation tillage that employs a system of planting crops on the previous year's crop residue in an effort to prevent soil erosion.

- a. No-Till
- b. Under-Till

- c. Ridge Tillage
- d. Sustainability

17. Most biofuels require the use of microorganisms to ______ sugars from the biological source.

- a. Dissolve
- b. Ferment
- c. Degrade
- d. Produce

18. Greywater contains much less Nitrogen and fewer human pathogens that blackwater.

- True
- False

19. Which of the following is *not* considered when trying to create a hospitable environment for soil biota?

- a. Organic matter
- b. Color
- c. Ph
- d. Soil consistency

20. Large amounts of swine waste in North Carolina's closed confinement swine operations can lead to the economically feasible production of onsite:

- a. Ethanol
- b. Biogas

c. Biodiesel

d. Propane

21. Which of the following is a biotechnology currently used to detect and track pollutants in soil.

a. Accumark

b. Biomarkers

c. Biotool

d. Biosensors

22. Bioassays can be used to detect pollutants by testing for the particular genes of an organism.

True False

23. Due to incomplete digestion, _________ is a prominent environmental contaminant from the runoff of animal waste and has received much attention for viable solutions.

a. Calcium

b. Phosphorus

c. Aluminum

d. Copper

24. In contrast to traditional landfills, _________ accelerate the decomposition of waste with the injection of leachate to stimulate the natural biodegradation process.

a. Bioreactors

b. Biovats

c. Deep-wells

d. Biogenerators

25. Byproducts of the human food processing industries are extensively used as economical sources of _________ for ruminants such as beef cattle.

- a. Bedding
- b. Animal Feed
- c. Housing
- d. Medication

APPENDIX D- EXAMPLE PROBLEM-BASED ACTIVITY

Lesson 7/8 Bioremediation Activity

By now you have learned, and seen the applied use of phytoremediation and bioremediation. In this activity we will put your knowledge of these biotechnologies to work. Below, you will be given some hypothetical scenarios in which you will be asked to provide the best method of remediation. You need to choose between bioremediation or phytoremediation or possibly a combination of both, whether you will be performing it ex-situ or in-situ, and further detail the specific type (Phytoaccumulation, Biostimulation, etc.) that you will be using. You learned six types of phytoremediation, and three types of bioremediation in the lectures; they are outlined on slide 6 and slide 10 respectively.

For each, you need to fill out the main information in the chart, ***and*** provide an explanation for your chosen method. There can be more than one correct answer for each, so you will be graded more on your justification/explanation for why you chose your particular method.

1. A local water supply is being threatened by a contaminated underground aquifer. The aquifer is located beneath an abandoned mining operation which has leached hazardous copper and arsenic levels into the soil, which are making their way into the water supply.

Bioremediation, Phytoremediation, or a combination?	Ex-situ or In-situ?	Specific Type(s)

Justification:

2. A natural gas pipeline has ruptured and gone unnoticed for a long period of time. Thousands of gallons contaminate a plot of land that is scheduled to be developed by a local contractor. The contractor states that the majority of the land needs to be hauled away for grading purposes, but says nonone will take his polluted“dirt”.

Bioremediation, Phytoremediation, or a combination	Ex-situ or In-situ?	Specific Type(s)

Justification:

3. A swine producer in eastern North Carolina is looking into alternative ways for managing is hog wastes. He has a traditional lagoon system, but is under heavy scrutiny from community leaders to bring down the odor and pathogenic load of his lagoon. Cost is important, so the producer is looking for a solution that will not make him abandon his current lagoon system.

Bioremediation, Phytoremediation, or a combination	Ex-situ or In-situ?	Specific Type(s)

Justification:

4. A massive tanker spill contaminates 10 miles of ocean habitat off the shores of the North Carolina outerbanks with hundreds of tons of crude oil.

Bioremediation, Phytoremediation, or a combination	Ex-situ or In-situ?	Specific Type(s)

Justification:

5. Find an additional example of bioremediation or phytoremediation NOT presented in the lectures. Fill out the chart, and provide a url link to the source.

Bioremediation, Phytoremediation, or a combination	Ex-situ or In-situ?	Specific Type(s)

URL:

APPENDIX E- EXAMPLE COOPERATIVE LEARNING ACTIVITY

Lesson 5 Assignment- Phytoremediation I

For this assignment you will be working with a partner to develop materials that will convince a group of county commissioners to fund a phytoremediation project at a contaminated site. You will be sent an email with the name of your person you will be working with. Out of respect to your partner, please stay in communication, and pull your weight. How you wish to work with your partner (in person, over the phone, via email) is fine, just make sure to split the work up appropriately.

Here is the scenario: You and your partner represent a group of concerned citizens who are trying to clean up a large 200 acre abandoned farm site. The farm site is heavily embedded with insecticides and fertilizer residue after decades of improper farming techniques. The site is being sold back to the county for future development into a public park. The county plans on having the site remain as-is until a logical solution to the contamination presents itself. You have recently heard of some applied research being done at the local university that involves a species of poplar tree that cleans up the exact contaminants your farm site contains. It just so happens, these poplar trees grow very well in your local community, so you hope to seek funding from the county commissioners to get the financial resources to begin some in-situ phytoremediation on the site.

You will develop two things:

1. A letter addressed to the county commissioners advocating that they fund your proposed phytoremediation project. In this letter, outline the benefits/advantages of implementing phytoremediation and make a convincing argument for them to fund this project. Draw upon the material presented in the lecture when possible.

2. A brief powerpoint that would be used in a public meeting as a presentation defending the letter you wrote. Remember that you are selling this idea, so it needs to be appealing and convincing.

You will be graded on how well you convey your point that phytoremediation would be the proper way to go. Once again, there is no length requirement to this assignment, just that you adequately address what you are asked to do. Both the powerpoint and letter should have the name of both members of the group in a title page/ title slide, and should be submitted by both students in the appropriate place in Moodle.

APPENDIX F- REPORTER INQUIRY ASSESSMENT

Lesson 9/10 Plant and Cropland/Animal Waste Management Activity

Being the agriculture teacher at a high school, you are often seen as the agriculture "guru" by others in the school and community. Agriculture teachers are frequently asked to speak on behalf of the profession on a variety of topics. A reporter for the local newspaper has stopped in on your agriculture program to write up a piece on some current trends in agriculture and biotechnology. The reporter has heard a lot in the news about biotechnology but wants your expertise to make sure she gets an informed message across.

For each of the four questions the reporter asks, compose a response. You are encouraged to include examples from the lecture where appropriate. Your responses will be in the featured article of the Sunday newspaper and included in a 5 o'clock news segment, so you want to make sure you represent your school and profession well! Once again, you will not be graded on the length of your response, but rather how well you address the questions.

1. Meat animal production is concerned with growing animals to produce muscle tissue. It seems like a big waste to not use the rest of the carcass that isn't steaks, chops, etc. What is done with the rest of the animal?

2. I have heard reports of ethanol, biodiesel, and other alternatives to fossil fuel- derived gasoline. Is there going to be a nationwide feedstock that will be used to produce the biofuel of the future that we should be gearing up to implement here in NC? What can I tell the public to expect in the next decade?

3. Many members of society picture farming operating the same way it did hundreds of years ago; having to till up the soil each year which then has the potential to run off into nearby water sources taking all of the chemicals and nutrients with it. Is that how crop production operates today?

4. Swine farms produce a lot of manure waste that emits a very unpleasant odor to the nearby community, and has the potential to leach out into the environment where it can cause harm to wildlife and the human water supply. Shouldn't NC phase out hog farms since there doesn't seem to be any solutions to these problems?

APPENDIX G- INDICATORS OF STUDENT SUCCESS CORRELATION DATA

Correlations between indicators of student success and student achievement

		Gain
College GPA	Pearson Correlation	.057
	Sig. (2-tailed)	.740
	N	36
High School GPA	Pearson Correlation	-.032
	Sig. (2-tailed)	.876
	N	26
SAT Score	Pearson Correlation	.093
	Sig. (2-tailed)	.637
	N	28
High School Class Rank	Pearson Correlation	.165
	Sig. (2-tailed)	.512
	N	18

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX H- PUBLICATIONS TO DATE

Curry Jr., K., Wilson, E., Flowers, J., Farin, C.E. (2010). Scientific basis vs. contextualized application of knowledge: the effect of teaching methodology on the achievement of postsecondary students in an integrated agricultural biotechnology course. *Proceedings of the 2010 Southern AAAE Research Conference*, Orlando, Florida, 406-419. Retrieved from http://aaaeonline.org/allconferences.php