ABSTRACT

STOTTER, DANIEL EDGAR. Assessment of the Learning and Attitude Modification of Technology Education Students Who Complete an Instructional Unit on Agriculture and Biotechnology. (Under the direction of Richard Peterson and Aaron Clark.)

This study examined the effect of introducing a two-week instructional unit on agriculture and biotechnology issues to a group of 30 Virginia high school technology education students. This study measured the student's knowledge about and attitudes towards agriculture and biotechnology before and after studying the unit. Further, the researcher selected four of the students for structured interviews that focused on learning in the *six facets of understanding* as defined by the book *Understanding by Design* (1998). The instructional unit was taught using education materials produced by the TECH-know project (2003). The students were tested on content material immediately before and after studying the teaching of the unit. The students were also given a 45-item pre-and-post survey regarding their attitudes towards agriculture and biotechnology. Videotapes and transcripts of the interviews were later evaluated by three raters who used the *six facets of understanding* as a rubric for judging the intangible understandings that the students gained from studying the unit and doing a related research project.

The study found indications of learning in all *six areas of understanding* as defined by Wiggins & McTighe (1998). There was particularly strong evidence that the students gained perspective about issues and that they gained understanding about how knowledge related to agriculture and biotechnology could be applied. The study also found that there was a statistically significant gain in student knowledge about agriculture

and biotechnology based on the pre-test and post-test of the information presented in the instructional unit. In addition, there was a statistically significant change in student attitudes towards agriculture and biotechnology in three of 45 items of the attitude survey.

Overall, the two-week instructional unit and research project produced learning about agriculture and biotechnology and increased the levels of understanding for selected students in the sample group. Further study is recommended to determine if these effects can be demonstrated with a larger population.

Assessment of the Learning and Attitude Modification

of Technology Education Students Who Complete an Instructional Unit on

Agriculture and Biotechnology

by

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Biography

Daniel Edgar Stotter was raised in Detroit, Michigan and graduated from Southfield High School in 1969. He received his Bachelor of Science in Psychology from Wayne State University in 1973. After graduating and moving to Ohio, he attended graduate school at Xavier University. In 1978, he graduated with a Master of Business Administration.

While attending Xavier University, Mr. Stotter opened a studio specializing in wedding and portrait photography. He sold this business in 1990 and moved to Virginia Beach, VA. Shortly thereafter, while working in the insurance industry, he began taking computer and industrial arts classes at Tidewater Community College. In 1996, he enrolled in the graduate program in technology education at North Carolina A&T. He graduated from that program in 1998.

After teaching high school for one year, Mr. Stotter entered the doctoral program at North Carolina State University. This gave him the opportunity to be employed as a graduate assistant with responsibility for teaching courses in material processing while working toward a Doctorate in Technology Education.

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There are many individuals who gave me support and encouragement over the past ten years that led to my entering the field of technology education and earning this degree. This acknowledges these individuals in no particular order.

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Chapter 1

INTRODUCTION

This study used quantitative and qualitative research methods to analyze the learning and attitudes demonstrated by two classrooms of Virginia secondary school technology education students who had completed an instructional unit and a research project related to agriculture and biotechnology. The inclusion of agriculture and biotechnology in the technology education curriculum has been supported and augmented by the International Technology Education Association (ITEA) and the Technology Student Association (TSA).

Technology Education and the Inclusion of Biotechnology

The recommendations to include bio-related technology in the technology education curriculum began with the ITEA publication *A Conceptual Framework for Technology Education* which named bio-related technology as one of the four content organizers, along with communication technology, production technology, and transportation technology (1990, p.7). A subsequent ITEA publication, *Technology for all Americans Project* (ITEA, 1996), defined biological systems as being one of three basic technology systems, the other two being informational systems and physical systems. More recently, the ITEA released the publication *Standards for Technological Literacy* that defines twenty areas of study that represent "an essential core of technological knowledge and skills we might wish all K-12 students to acquire." Included in this essential core is Standard 15, "Students will develop an understanding of and be able to select and use agricultural and related biotechnologies" (2000, p.v).

The TSA (2003) is a national non-profit organization that supports K-12 technology education students. The TSA helps technology education teachers set up technology related clubs with the stated mission "to prepare our membership for the challenges of a dynamic world by promoting technological literacy, leadership, and problem solving, resulting in personal growth and opportunity" (Accessed Feb, 28,2004). Beginning in 2002, the TSA events included themes related to agriculture and biotechnology in order to reflect the benchmark topics of Standard 15 of the *Standards for Technological Literacy*: agricultural products and systems, biotechnology, conservation, and engineering design and management of ecosystems.

There is evidence that technology teachers, regardless of the ITEA recommendations, have not readily adopted bio-related curriculum topics such as agriculture and biotechnology. Based on a survey sent to technology education teachers in 1999, Sanders (2001) concluded that bio-related technological processes remained almost non-existent in the curriculum.

Vocational courses in agriculture have a component that parallels the agriculture and biotechnology aspect of technology education. In 1994, the Future Farmers of America (FFA) Foundation published *The National Voluntary Occupational Skill Standards for an Agricultural Biotechnology Technician* for the purpose of assisting educators in writing related courses of study (1994). Five years later, in 1999, a group of North Carolina agriculture education experts developed a course titled *Biotechnology and Agriscience Research* based on the 1994 standards published by the FFA (2000, p.8). The National Council for Agricultural Education 2000 acknowledged the importance of biotechnology in the curriculum when it stated that the mission of agricultural education is "to prepare and

support individuals for careers, build awareness and develop leadership for the food, fiber and natural resource systems." According to Wilson, this mission statement reflects the philosophy that agricultural education plays a role in educating students about the controversial use and issues in agricultural biotechnology" (p.3).

In a study involving vocational agriculture teachers in North Carolina, Wilson (2002) identified factors that may influence the intent of teachers to adopt or not adopt an integrated agriculture and biotechnology curriculum. Although Wilson found that many teachers intended to adopt the course, she found several reasons that many agriculture educators were reluctant to do so. The primary reasons cited were that educators had not participated in training related to biotechnology and that they suffered from a lack of funding and equipment (2000, p.79).

The level of acceptance by students regarding growth in the field of biotechnology was examined by Sohan in 1997-1998. In a study concerning the attitudes and perceptions of college students at Texas A&M University, Sohan (1998) found that despite a low awareness or knowledge of biotechnology, students were accepting of applications or products of biotechnology. Sohan showed that students believed that more biotechnology education was needed and that it was appropriate for secondary school students.

Whereas Wilson (2002) investigated the adoption of new materials from the viewpoint of vocational agriculture teachers and Sohan investigated the attitudes and perceptions towards biotechnology by college students, the purpose of this study is to evaluate the learning and attitude modification that took place in the high school technology education classroom when the curriculum included a unit on agriculture and biotechnology.

Because curriculum materials for agriculture and biotechnology are new to both vocational agriculture courses and technology education courses, it is reasonable to assume that both curricula face similar problems in their implementation. Technology education faces special problems in implementing a new program because of its emphasis on design and problem solving. This type of learning, the development of skill in addressing an open-ended task, is difficult to measure with objective tests. The publication *Understanding by Design* (1998) addresses this assessment issue by investigating "enduring understandings that go beyond discrete facts or skills to focus on larger concepts, principles, or processes" (1998, p.10).

The TECH-know Project

TECH-know is a project funded by the National Science Foundation that was created in response to the need for curriculum resources related to technology education (2003). The TECH-know project has developed co-curricular instructional materials that are consistent with the *Standards for Technological Literacy* and which incorporate selected mathematics and science standards. These materials were first developed by writers and tested by pilot teachers during the 2001-2002 academic year. These same materials provided content for the agriculture and biotechnology instructional unit that was used by a high school teacher in this study.

The TECH-know Agriculture and Biotechnology Instructional Unit

The instructional unit in agriculture and biotechnology that was used by the high school teacher involved with this study was partially written by this researcher as part of the TECH-know project. The content contained was designed to address Standard 4 of the

Standards for Technological Literacy (2000): "Students will develop an understanding of the cultural, social, economic, and political effects of technology" (2000, p.57) and Standard 15: "Students will develop an understanding of and be able to select and use agricultural and related biotechnologies" (p.149).

Assessment

Assessment as defined by Wiggins and McTighe (1998) in *Understanding by Design* is "the act of determining the extent to which curricular goals are being or have been achieved" (p.4). In a different book, *Educative Assessment* (1998), Wiggins explores the question of "why understanding is the achievement that conventional testing cannot adequately test and so does not improve" (p.71).

An often quoted structure for defining types of learning is found in the publication, *Taxonomy of Educational Objectives* (1956). This book outlines a threefold division of educational objectives: cognitive, affective, and psychomotor. Briefly, cognitive objectives involve remembering or reproducing something, which has been learned, affective objectives emphasize a feeling tone or an emotion, and psychomotor objectives emphasize some motor skill. With regard to the affective domain, Bloom acknowledges that "objectives in this domain are not stated very precisely; and, in fact, teachers do not appear to be very clear about the learning experiences which are appropriate to these objectives" (p.7). In contrast, Wiggins & McTighe (1998), divide understanding into six facets. These facets involve the learner's ability to explain accounts of phenomena, interpret ideas and events, and apply what they know to diverse contexts. Further, learner objectives are to have perspective to see

the big picture, to have empathy for what others may perceive, and to have self-knowledge of personal style and prejudices.

The Six Facets of Understanding

In the ITEA (2003) publication, *Advancing Excellence in Technological Literacy* (AETL), student assessment is defined as "the systematic, multi-step process of collecting evidence on student learning, understanding, and abilities and using that information to inform instruction and provide feedback to the learner" (p.18). According to Russell (2003), the developers of AETL adopted concepts from the Wiggins and McTighe (1998) *backward design model* which proposes that curriculum development include student assessment by use of a six category rubric, the *Six Facets of Understanding.* This rubric defines learning as the obtainment of various levels of understanding in the areas of explanation, interpretation, application, perspective, empathy, and self-knowledge. This study, in keeping with AETL, will use this rubric to conduct a qualitative assessment of learning.

Rationale for the Study

The TECH-know project, by field testing new educational materials, has created an opportunity to examine the benefits of teaching an instructional unit in agriculture and biotechnology. Since this topic is now part of the *Standards for Technological Literacy* and the Technology Students Association competition, it is important to know what students are learning. Evidence concerning the achievement, the depth of understanding, and the attitude modification of those students who study an agriculture and biotechnology instructional unit and produce a TSA-related research project could support the TSA organization, help with

the design of TSA competitive events, and contribute to the development of new technology education materials.

Statement of the Problem

The inclusion of agriculture and biotechnology in the secondary school technology education curriculum is a recent development. The problem that this study addressed was to determine what understandings students learned in a Virginia high school technology education class with respect to the standards for agriculture and biotechnology expressed in the *Standards for Technological Literacy* (ITEA, 2000) and to determine if the instruction was accompanied by any attitude modification towards biotechnology issues. In addition, this study addressed the question of what type of intangible learning may be taking place that is not measured in a content test. These determinations were made by the use of pre-and-post tests of subject matter, pre-and-post opinion surveys, and a qualitative assessment based on the *six facets of understanding*.

Principal Research Question

What is the facet and level of understanding (Wiggins & McTighe, 1998) obtained by selected secondary school students in a Virginia technology education class who study an agriculture and biotechnology instructional unit and prepare a Technology Student Association (TSA)-related agriculture and biotechnology research project as part of their coursework?

Subsidiary Research Questions

1. In what ways are student attitudes towards agriculture and biotechnology modified or formulated by the study of an agriculture and biotechnology unit and by the preparation of a TSA-related biotechnology research project?
2. Will students be able to demonstrate the goal of Standard 4 of the *Standards for Technological Literacy,* to "develop an understanding of the cultural, social, economic, and political effects of technology" (ITEA, 2000, p.57)?
3. Will students be able to demonstrate learning of the content material related to Standard 15 of the *Standards for Technological Literacy*, "Students will develop an understanding of and be able to select and use agricultural and related biotechnologies" (ITEA, 2000, p.149)?

Qualitative Purpose Statement

A study of this type needs to be justified in two ways: first, it must concern itself with obtaining information that is useful for the technology education profession and secondly it must provide rationale for the methodology used to determine that information.

The data from this study is important because it provides curriculum designers an indication of the type of learning that occurs among secondary school technology students who study an instructional unit and do a TSA-related research project related to agriculture and biotechnology. This may result in more students becoming interested in biotechnology as a career and more participation in TSA events overall.

The reasons for choosing a qualitative approach for a portion of this research began with an examination of the field of biotechnology itself. Biotechnology is a term that covers many fields of study. Since the range of possible topics and areas of information is so broad, it was not practical to create a single questionnaire that would evaluate the student learning of the concepts pertinent to this field.

In an article on the use of qualitative research by technology education researchers, Hoepfl (1997) writes, "Qualitative research has an interpretive character, aimed at discovering the meaning events have for the individuals who experience them, and the interpretation of those meanings by the researcher" (p.3). In addition, the qualitative approach provides insight into the depth of student learning as defined by Wiggins & McTighe's (1998) *six facets of understanding*.

The qualitative portion of this research was guided by the results obtained from the quantitative pre-and-post tests of the content material and by the amount of change in the participant's attitudes towards biotechnology as indicated by the pre-and-post unit attitude survey. The scores on the pre-and-post tests, the change in attitude as indicated by pre-and-post surveys, and the numeric grades given for the multi-media presentations were used to determine which students would be selected for qualitative interviews.

Definitions of Terms

Achievement. The term achievement will refer to academic achievement. "This has to do with success in educational endeavors. Academic achievement is a measure of a

student's success at school" (2004, http://www.wcdebate.com/1policy/3-educationov.htm, accessed Feb 28, 2004, p.1).

For the purpose of this research, achievement is defined as a participant's gain on his/her test score as measured between the pre-test and the post-test of the content material from the TECH-know instructional module (2003).

Agriculture. "Agriculture is the growing of plants and animals for food, fiber, fuel, chemical or other useful products" (ITEA, 2000, p.149).

Assessment in Educational Systems. "Monitoring progress and serving simultaneously as a catalyst and compass for change; both of the student and system" (Lindstrom, 2003, p.207).

Attitude Modification. For the purpose of this research, attitude modification will be defined as the summation of any changes that exist between the pre-survey and post-survey of attitudes towards biotechnology as measured by the 45-item survey used in this study (Appendix F).

Authentic assessment. "Testing in the kind of work real people do, rather than merely eliciting easy-to-score responses to simple questions; a true assessment of performance" (Wiggins, 1998, p.21).

Biotechnology. There are multiple definitions of this term available. The one referred to in the *Standards for Technology Literacy* (2000) is "any technique that uses living organisms, or parts of organisms, to make or modify products, improve plants or animals, or to develop microorganisms for specific purposes" (p.149). This study will use a broad interpretation of this definition so as to include the manipulation of the

genetic makeup of agricultural crops, biosecurity issues including the protection against the spread of disease and chemical contamination, bioinformatics, stem cell research, and cloning.

High School. Grades 9-12 (ITEA, 2000, p.245).

Likert scale. "Likert scales typically ask for the extent of agreement with an attitude item (for example, a five-point scale ranging from "strongly disagree" to "strongly agree") are a common type of attitude scale" (Gall, 1996, p.297).

Middle School. Grades 6-8 (ITEA, 2000, p.245).

Qualitative Research. "Inquiry that is grounded in the assumption that individuals construct social reality in the form of meanings and interpretations, and that these constructions tend to be transitory and situational. The dominant methodology is to discover these meanings and interpretations by studying cases intensively in natural settings and by subjecting the resulting data to analytic induction" (Gall, 1996, p.767).

Six Facets of Understanding. *The Six Facets of Understanding* is "a multifaceted view of what makes up a mature understanding, a six-sided view of the concept. The six facets are explanation, interpretation, application, perspective, empathy, and self-knowledge" (Wiggins & McTighe, 1998, p.44).

Student assessment. "Refers to the systematic, multi-step process of collecting evidence on student learning, understanding, and abilities and using that information to inform instruction and provide feedback to the learner, thereby enhancing student learning" (ITEA, 2003, p.3).

TECH-know. TECH-know is a project funded by the National Science Foundation that exists for the purpose of creating instructional materials that "will lead to a basic and fundamental understanding of the essential and salient technology concepts, principles, and skills that are necessary for success in today's economy and society. These instructional materials will be student-centered and based on 20 Technology Student Association (TSA) activities" (Peterson, 2003, p.14).

Technology Education. "A school subject specifically designed to help students develop technological literacy" (ITEA, 2003, p.142).

Technology Education Students. "Elementary school, middle school, and secondary school students who are enrolled in or who have completed at least one course defined by their Local Education Authority (LEA) as being that of technology education" (2003, Accessed Feb 14, 2004).

Technology Student Association (TSA). "A non-profit national student organization devoted to teaching technology education to young people. TSA's mission is to inspire its student members to prepare for careers in a technology-driven economy and culture" (2003, Accessed Feb 14, 2004).

Summary

The introduction of agriculture and biotechnologies into the technology curriculum and into the TSA events is a change that has not yet been evaluated with regard to what the students are actually learning. The broad range of topics that biotechnology covers makes it

impractical to define the entire body of knowledge that should be acquired with a single objective test. For this reason, this study used three types of assessment.

1. This researcher used a pre-test and post-test related to the content of the instructional unit. The results of these tests were considered to be an indication of "cognitive domain, which includes those objectives that deal with the recall or recognition of knowledge and the development of intellectual abilities and skills" as described by Bloom's *Taxonomy of Educational Objectives* (Bloom, 1956, p.7).
2. The researcher used pre-survey and post-survey results related to student attitudes towards biotechnology. This survey had been developed by Sohan (1998) in a dissertation about the attitudes of college students. Any changes in a participant's responses to this survey were considered an indication of an attitude change that resulted from exposure to the instructional unit.
3. The researcher conducted, videotaped, and transcribed structured interviews with four of the students in this study. The interview questions were related to the student's TSA-related biotechnology design project. The videotapes and transcripts were evaluated by the researcher and two other teachers. This assessment considered the student's responses using the *Six Facets of Understanding* as a rubric, and concluded with a qualitative analysis of student learning (Wiggins & McTighe, 1998).

The results of this research are intended to provide insight about what students learn and understand as a result of having an instructional unit on agriculture and biotechnology being added to their technology education curriculum.

Chapter 2

REVIEW OF THE RELATED LITERATURE

History of Technology Education

Technology education has evolved from various curriculums in manual arts, manual training, and industrial arts. These early technical training programs were developed in Russia in the early 1800s then later established in the United States during the decades that preceded the beginning of the twentieth century. These curriculums emphasized tool skills along with mechanical drawing, woodworking, and metalworking (Wright, 1995). In the 1880s and 1890s, there was a consensus that public education systems and society should be integrated. Manufacturers demanded that schools teach basic industrial skills and sponsor machine training and industrial arts (Lazerson & Grubb, 1974). One influential proponent of this philosophy was Calvin M. Woodward. In 1883, in an address to the National Teachers Association, Woodward (1883) advocated manual training for all children as an element in general education.

According to Valesey (2003), one of the philosophical foundations for technology education was pragmatism. She describes John Dewey (1859-1952) as the best known pragmatist who suggested that the "purpose of reflective thought is to turn obscurity into clarity, and that this is knowledge" (p.32). Dewey's (1990) belief in practical hands-on education is reflected with this passage from *The Child and the Curriculum*, "we cannot overlook the importance for educational purposes of the close and intimate acquaintance got with nature at first hand, with real things and materials, with the actual process of

manipulation, and the knowledge of their social necessities and uses. The educative forces of the domestic spinning and weaving, of the sawmill, the gristmill, the cooper shop, and the blacksmith forge, were continuously operative" (p.11). In writing specifically about vocational education, Dewey (1944) remarked, "Nothing is more tragic than failure to discover one's true business in life, or to find that one has drifted or been forced by circumstances into an uncongenial calling. The right occupation means simply that the aptitudes of a person are in adequate play, working with a minimum of friction and a maximum of satisfaction" (p.308).

The connection between the technology education courses of today with earlier curriculums is addressed by Reed (2003). He states, "Technology education has historically incorporated inquiry into laboratory instruction. Early forms of this instructional strategy, however, focused more on tools, materials, and technical processes rather than structured cognitive process. The *Maryland Plan*: Industrial Arts Program for the Junior High (Maley, 1970) was one of the earliest programs that utilized an inquiry-based instructional approach in order to focus on the cognitive benefits of technology education" (p.123).

The Maryland Plan, developed by Donald Maley of the University of Maryland focused on reviewing technological approaches involving tools and machines, power and energy, and transportation and communication. In addition, this program engaged students in a time-line of the past, present, and future. Maley believed that technological problems could be incorporated in an anthropological study of modern industry. He introduced the technological systems approach in the design of technology education programs. This basic

curriculum design included communications, production, transportation, and their subsystems (Maley, 1969).

In a paper titled *Technology Education Curriculum Development Efforts* Thomas Wright (1995) indicated that the process of modifying manual and industrial programs so as to include the broader concepts of technology and society began with a publication by William E. Warner's paper *A Curriculum to Reflect Technology* (Warner, 1947). Warner proposed that major subject classifications be based upon six areas of industry; power, transportation, manufacture, construction, communication, and personnel management. A subsequent book by Delmar W. Olson (1963), *Industrial Arts and Technology*, proposed a design approach that put emphasis on the individual student searching for a unique solution instead of building teacher designed projects. Olson went further to recommend that industrial arts be defined as a one-subject-matter program based on six functions of personal life. He identified these functions as being technical, occupational, consumer, recreational, cultural, and social.

In 1966, Paul W. DeVore of the State University of New York-College at Oswego proposed that industrial arts should emphasize the study of man and technology as demonstrated in the areas of products, transportation and communication as well as the utilization of the properties of matter and energy. DeVore postulated that in order to differentiate between science and technology one must first examine both the goals and scope of an activity in order to provide clarification of the differentiation. DeVore also indicated the importance of rejecting the occupational, pre-vocational and industry bases for the development of industrial arts curriculum in favor of long-term goals rather than short-

term goals (1988). DeVore (1970) saw technology as an international phenomena. He described it as, "A global system. Materials production, distribution, transportation, and communication are operated in global networks by organizations extra-national and beyond the human and technological resources of any one nation or region. Man's technological decisions are determining the future for man" (p.117).

The Industrial Arts Curriculum Project (IACP) at The Ohio State University (OSU) advanced another philosophy concerning the industrial arts curriculums in 1968. Its publication, *IACP Rationale*, maintained that there were four domains of human knowledge: "formal, descriptive, prescriptive, and praxiological". This last term, praxiological knowledge, was described as the knowledge of practice and was roughly equivalent to the description of technology proposed by Warner (1995, p.255).

During the same period that the IACP project was being formulated at OSU, the American Industry Project (AIP) was developing curriculum at the University of Wisconsin-Stout. The AIP endeavor suggested that the central focus of industrial arts should be the 13 basic concepts of industry: "communication, transportation, finance, property, research, procurement, relationships, marketing, management, production, materials, processes, and energy" (1995, p.255).

In 1981, the curriculum committee of the American Industrial Arts Association gathered 21 leaders representing all geographical areas of the nation. The purpose of this project, known as the Jackson's Mill Industrial Arts Curriculum Symposium, was an effort to chart a unified direction for industrial arts. The project report was the culmination of three meetings over a two-year period. The resulting model, *The Jackson's Mill Industrial Arts*

Curriculum Theory (Snyder, 1982), was based on the human productive activities. In this model it was determined that the focus of industrial arts should be on the study of industry and technology and their impact on society and culture. Further, the model proposed that industrial arts should include the human productive activities of communicating, constructing, manufacturing, and transporting.

According to Sanders (2003), "technology is not a stand-alone entity but is intertwined with nearly every aspect of our lives. Thus, an interdisciplinary approach to the study of technology is more logical than a segregated approach" (p.79).

Wiens (1995) writes that there is a movement to make the study of technology part of the liberal arts or general education core at the university level. He notes that the science/technology/and society courses offer opportunities for students to solve problems using technology, and/or to solve technological problems. Wiens advocates that at the college level the interdisciplinary nature of technology and technology decision making requires new courses in most teacher preparation programs "that would integrate sociology, psychology, political science, economics, science, mathematics, ethics, and environmental science" (p.143). According to Bensen (1995), "societal change is both continuous and pervasive. In the field of technology education, change is also dynamic and accelerating; it is a powerful force in the very world and societies within it. It is important to read the future and focus on well established trends" (p.14).

The current status of technology teacher education programs, according to Israel (1995), is the offering of baccalaureate degree programs that prepare people to teach technology education programs at the elementary school, middle school, or high school

levels. In some states, vocational trade and industrial education supervisors may oversee both technology education and vocational education.

The International Technology Education Association (ITEA)

In the 1980s, a group of industrial arts professionals began to advocate changing the curriculum's name from Industrial Arts to Technology Education (TED) in order to reflect contemporary subject matter. To accommodate this movement, in 1984 the American Industrial Arts Association (AIAA) board of directors voted to change the name of the association to the International Technology Education Association (ITEA) (Kennedy, 1999).

In the spring of 2001, ITEA commissioned the Gallup Organization to conduct a poll to determine if "the public's perception of what technology is and what should be taught is congruent with the opinions of national experts in the fields of technology, engineering, and science" (Rose & Dugger, 2002, p.1). This study viewed technological literacy as "one's ability to use, manage, assess, and understand technology" (Rose & Dugger, 2002, p.1). Four major conclusions from the resulting report were that:

1. The American public is virtually unanimous in regarding the development of technological literacy as an important goal for people at all levels.
2. Many Americans view technology narrowly as mostly being computers and the Internet.
3. There is near total consensus in the public sampled that schools should include the study of technology in the curriculum.
4. There is a lack of common understanding of what technology is and how it relates to other fields such as science, mathematics, and engineering

(Rose & Dugger, 2002).

In a related article concerning the ITEA/Gallup poll, Starkweather indicated that "leaders in the technology teaching profession know that technology education cannot be a

stagnant subject if properly taught. Technology is a dynamic, constantly changing subject area in which the teacher must be ready to make frequent changes to stay current with advancing innovations" (Starkweather, 2002, p.31).

Technology for All Americans and the Standards for Technological Literacy

In 1996, the ITEA released the document, *Technology for All Americans: A Rationale and Structure for the Study of Technology*. This document was the product of a project funded by the National Science Foundation and the National Aeronautics and Space Administration. The intention of this document was to provide a new vision for the study of technology. It stated seven universals for the study of technology and advocated integrating technology into the curriculums for K-12 (Dugger & Satchwell, 1996). Four years latter, in April 2000, the ITEA released a curriculum-framework, *Standards for Technological Literacy* (STL), based on the Technology for All Americans project. This K-12 technology literacy curriculum provides a "foundation for content and curriculum in technology education" (Valesey, 2002, p.6).

According to Paul Hook (2001), Curriculum Coordinator for Technology Education, Springfield, MO., the *Standards for Technological Literacy* provide "identity, recognition, organization, and direction" (p.31). Further, Hook states:

> Technology education has been plagued with an identity crisis over the past decade. As many schools and states moved from the old methods and content of shop and forged ahead with the "new" technologies, our field of study became even more varied, complex, and nondescript to those outside the field, both within and outside of education (p.31).

Hook also refers to the *Standards for Technological Literacy* as the result of "years of work leading to the most scrutinized set of educational standards ever produced in any discipline" (p.31). Similarly, Martin (2002) refers to the Standards for Technological Literacy as "a multi-year collaborative and consensus-building effort involving literally thousands of individuals both within and outside the profession" (p.27).

The profound impact of the *Standards for Technological Literacy* is illustrated by the results of an e-mail survey sent to teachers, department heads, and state supervisor who were members of ITEA in the spring of 2002. "Almost everyone (93%) who completed the survey thought the standards were important" (2003, p.29).

Among the chapters in the *Standards for Technological Literacy* (2000) is Standard 4 which suggests that students be made aware of the social, political, and economic impact of technology (p.57). The spirit of this standard is expressed by Wiens (1996) who states "With the current interest in developing technological literacy, the study of the social-cultural, environmental, political-economic, and ethical aspects has become a mandate. The pervasive and powerful nature of technology today, as well as the indirect, unintended, and delayed effects of many technologies raise the importance of including the discussions of the social/cultural/environmental aspects of technology and technological applications" (p.25).

In his concluding remarks in an paper about the *Standards for Technological Literacy*, McAlister (2003) writes, "we now have some clear goals for technology education across the nation. Human beings continue to mold and shape their worlds through the use of technology, and in turn, technology has changed many lives. It is only fitting that students

gain a better understanding of interrelationships between the human-altered world and the cultures and societies that molded them" (p.99).

Technology Student Association (TSA)

The TSA (2003) is a national non-profit organization that supports K-12 technology education students. The TSA helps technology education teachers set up technology related clubs with the stated mission "to prepare our membership for the challenges of a dynamic world by promoting technological literacy, leadership, and problem solving, resulting in personal growth and opportunity" (Accessed Feb, 28, 2004). Regional and national TSA conferences host competitive events where members are able to enter projects that they built during the year as well as participating in on-site competitions. TSA competitions, as explained by Nagel (2003), "are a means to creatively engage the critical thinking of students. With competitions as an instructional strategy, students are allowed to break from the conventional thought process and expand their creativity by exploring the unknown, allowing students to reach higher educational goals through their ideas and knowledge (p.187). Beginning in 2002 the TSA events included themes related to agriculture and biotechnology in order to reflect the benchmark topics of Standard 15 of the *Standards for Technological Literacy*: agricultural products and systems, biotechnology, conservation, and engineering design and management of ecosystems.

The TSA enjoys widespread support within the educational community. The organization has the endorsement of the U.S. Department of Education, the National

Association of Secondary School Principals, the International Technology Education Association, and state departments of education (Peterson, 2003).

Quantitative, Qualitative, and Mixed Methods Research

Creswell (2003) classifies surveys as a research design providing quantitative or numeric descriptions of trends, attitudes, or opinions of a population. Using survey data, the researcher generalizes claims about the population. In contrast, an experiment tests the impact of a treatment or intervention, making use of random assignment of individuals to groups and controlling other factors that influence the outcome.

An issue that affects the ability of a researcher to draw inferences from data is any threat to the validity of the study, either internal or external.

An internal threat to validity is caused by inadequate procedures such as changing the instrument during the experiment or a diffusion effect when members of the experimental and control groups talk to each other. Another internal threat can arise from characteristics of the participants, such as when they change their views during an experiment (Creswell, 2003).

An external threat to validity is when experimenters draw incorrect inferences from the sample data to other persons, other settings, and past or future situations (Creswell, 2003). The example given by Creswell is when a researcher extrapolates beyond the group in the experiment and generalizes about other racial or social groups not under study.

When working with numeric data, the statistical tests available depend upon the scales of measurement. According to Schloss & Smith (1999), the most frequent scheme for

classifying measurement is a taxonomy that includes the nominal scale, the ordinal scale, the interval scale, and the ratio scale.

Nominal data is most basic and least informative level of measurement. A nominal study simply names categories, such as dividing people into male and female. Nominal scales must include two or more mutually exclusive categories that are not numerically related in any manner other than being different. For example, values such as younger v. older should not be relevant to the categories.

In contrast to nominal data, ordinal data does identify relative position. An example would be the rating of sport teams from best to worst. With ordinal data, there is no standard difference between the positions. As stated by Schloss & Smith (1999), "The numbers 1 and 2 are differentiated only in that 1 precedes 2 or possesses less of some characteristic. It is improper to say that the difference between two pairs is the same" (p.145).

Interval measurements provide a greater level of information than ordinal because there is a uniform difference between scale units. "The Fahrenheit scale exemplifies interval measurement. The difference between 30 and 40 degrees is 10 Fahrenheit" (Schloss & Smith, 1999).

The Ratio scale of measurement provides equal intervals, like the interval scale, but also includes a true zero point. With ratio scaling, "all statistical procedures can be used effectively" (Schloss & Smith, 1999).

Qualitative research is that which uses several approaches to evaluate phenomena that occur in natural settings. Further, qualitative researchers rarely try to simplify what they observe. They try to portray the issue in its multifaceted form. Leedy & Ormrod (2001) also

state, "Qualitative researchers believe that the researcher's ability to interpret and make sense of what he or she sees is critical for an understanding of any social phenomenon" (p.147). Although Leedy & Ormrod describe five common qualitative research designs, they also state that there are "only general guidelines based on the experiences of those qualitative researchers who have gone before you. In a qualitative study, the specific methods that you use will ultimately be constrained only by the limits of your imagination" (p.149).

The designs listed by Leedy & Ormrod include the case study, the ethnography, the phenomenological study, the grounded theory study, and content analysis.

> The case study is conducted with the purpose of understanding one person or situation (or perhaps a very small number) in great depth. Data collection includes observations, interviews, and appropriate written documents and/or audiovisual material.
>
> The ethnography is conducted to understand how behaviors reflect the culture of a group. Data collection is done by participant observation, structured or unstructured interviews with "informants" and artifact/document collection.
>
> The phenomenological study is done to understand an experience from the participants' point of view. Data collection involves in-depth unstructured interviews and the purposeful sampling of 5-25 individuals.
>
> Grounded theory study is done to derive a theory from data collected in a natural setting. Data collection is done by interviews and any other relevant data sources.

Content analysis is done to identify the specific characteristics of a body of material. Data involves the identification and possible sampling of the specific material to be analyzed and coding of the material in terms of predetermined and precisely defined characteristics (Leedy & Ormrod, 2001). In the text, *Interviewing as Qualitative Research*, Seidman (1998) states that the purpose of in-depth interviewing "is not to get answers to questions, or to test

hypothesis, and not to "evaluate" as the term is normally used. At the root of in-depth interviewing is an interest in understanding the experiences of other people and the meaning they make of that experience" (p.3).

According to Gall, Borg, and Gall (1996), qualitative research in education has roots in the social sciences and in interdisciplinary studies. They divide qualitative research into three categories; 1) investigation of lived experience, 2) investigation of society and culture, and 3) investigation of language and communication. They further state, "new traditions may blend with existing ones, and can be identified by more than one label" (p.594).

Creswell (2003) defines the mixed methods approach as strategies that involve "collecting and analyzing both forms of data (quantitative and qualitative) in a single study" (p.15). In addition Creswell indicates that in mixed methods research, the researcher "bases the inquiry on the assumption that collecting diverse types of data best provides an understanding of a research problem" (p.21).

Constructivist Theory

Constructivism is a theory about how we learn. Its main proposition is that learning means constructing, creating, inventing, and developing our own knowledge (Marlowe & Page, 1998). Constructivism is a view of learning that sees learners as active participants who construct their own understandings of the world around them. Using past experience and knowledge, learners make sense of the new information that they are receiving (Cates, 2001).

According to *Creating and Sustaining the Constructivist Classroom*, learning in constructivist terms is both the process and result of questioning, interpreting, and analyzing information. It also means using this information and thinking process to develop, build, and alter our meaning and understanding of concepts and ideas. Further, it means integrating current experiences with our past experiences and what we already know about a subject (Marlowe & Page, 1998).

According to Brooks and Brooks (1999), among the characteristics of a constructivist classroom are: teachers seek and value their student's point of view, teachers pose problems of emerging relevance, teachers build lessons around primary concepts and big ideas. According to Martin (2003), constructivist theory can be explained as "students make sense or construct their new learning based on what they already know and believe" (p.18).

Assessment in the Affective Domain

The *Taxonomy of Educational Objectives* defines the affective domain as those "which emphasize a feeling tone, an emotion, or a degree of acceptance or rejection. Affective objectives vary from simple attention to selected phenomena to complex but internally consistent qualities of character and conscience" (Krathwohl & Bloom, 1964).

A revision of the "Taxonomy" titled, *A Taxonomy for Learning, Teaching, and Assessing*, was published in 2001. This edition intentionally omitted the affective domain because "nearly every cognitive objective has an affective component" and "making affective aspects regularly planned parts of instruction would be facilitated if the Taxonomy were better integrated across the domains" (Anderson, 2001, p.258).

The concepts of authenticity in testing is introduced by Wiggins (1993) in *Assessing Student Performance*. Wiggins states that key words concerning evidence of learning are context and judgment. In arguing that it makes no intellectual sense to test for "knowledge" as if mastery were an unvarying response to unambiguous stimuli, Wiggins states "That would be like evaluating court judges on their knowledge of law only or doctors on their memory of biochemistry lectures. Rather, what we should be assessing is the student's ability to prepare for and master the various roles and situations that competent professionals encounter in their work" (p.208). In a subsequent publication titled *Educative Assessment*, Wiggins proposes six standards for "authentic" assessment.

According to Wiggins, authentic assessment:

1. is realistic. The task or tasks replicate the ways in which a person's knowledge and abilities are "tested" in real-world situations.

2. requires judgment and innovation. The student has to use knowledge and skills wisely and effectively to solve unstructured problems.

3. asks the student to "do" the subject. Instead of reciting, restating, or replicating through demonstration what he or she was taught or what is already known.

4. replicates or simulates the contexts in which adults are "tested" in the workplace, in civic life, and in personal life.

5. assesses the student's ability to efficiently and effectively use a repertoire of knowledge and skill to negotiate a complex task.

6. allows appropriate opportunities to rehearse, practice, consult resources, and get feedback on and refine performances and products (Wiggins, 1998, p.22).

Six Facets of Understanding

In the book *Understanding by Design* Wiggins & McTighe (1998) present a theory of the *six facets of understanding* and "explores its theoretical and practical implications for curriculum, assessment, and teaching" (p.3). The development of the teaching concepts offered by this book and the author's suggestions for the implementation of those concepts is previewed by two prior Grant Wiggins publications; *Assessing Student Performance* (1993) and *Educative Assessment* (1998). In addition, there is an accompanying publication for *Understanding by Design*, The *Understanding by Design Workbook* (Wiggins & McTighe, 1999).

The 1993 publication *Assessing Student Performance* begins with a discussion of the morality of testing. A central philosophy of the author is that because the student is the primary client of all assessment, assessment should be designed to improve performance, not just monitor it (Wiggins, 1993). The discussion provided by Wiggins on "more thoughtful assessment" leads to nine postulates. The first of these is that "assessment of thoughtful mastery should ask students to justify their understanding a craft, not merely to recite orthodox views or mindlessly employ techniques in a vacuum." Wiggins explains that "understanding is not displayed by correct answers to questions and problems out of context; on the contrary, misunderstanding is easily hidden behind thoughtless recall" (p.47). Some of Wiggins other postulates include the concept that "self-assessment is central," that "education should develop a student's intellectual style and voice, and that "understanding is best assessed by pursuing students' questions, not by merely noting their answers" (p.58).

One of Wiggins's concepts that is elaborated in his publication *Educative Assessment* is that of "authentic tasks." Another is "authentic performance." Wiggins postulates that assessment is authentic when we anchor testing in the kind of work that real people do, rather than merely eliciting easy-to-score responses to simple questions. The determination of whether or not a task is "authentic" is based on whether or not it meets a series of standards including the following:

1. Is it realistic: Does the task replicate the ways in which a person's knowledge and abilities are tested in the real world?

2. Does it require judgment and innovation? The student has to use knowledge and skills wisely and effectively to solve unstructured problems.

3. Does it ask the student to "do the subject" instead of reciting, restating, or replicating? (Wiggins, 1993).

In the publication *Understanding by Design* Wiggins and McTighe (1998) introduce the concept of "Backward Design." This is where, instead of "beginning with textbooks, favored lessons, and time-honored activities, one starts with the end – the desired results (goals or standards) - and then derives the curriculum from the evidence of leaning (performance)" (p.8).

The following is a brief condensation of the guidelines for teaching using the *six facets of understanding*.

Facet 1: Explanation
Use dialogue or interaction to assess. Have students explain their course of action.

Facet 2: Interpretation
Assess the student's understanding of the story behind an idea. Is the student aware of the history behind the idea or theory?

Facet 3: Application
Use simulations or real applications that require students to use the knowledge that is being taught.

Facet 4: Perspective
Require students to answer the question, "What of it?" Students should be asked to evaluate the value or importance of ideas.

Facet 5: Empathy
Assesses the student's ability to walk in someone else's shoes. Require the student to teach. Assesses the student's ability to empathize with a villain, oddball, or outcast.

Facet 6: Self-knowledge
Require students to asses their past as well as present work. Make the first and last written assignments for any course the same question. Have students describe their sense of progress.

Summarized from *Understanding by Design* Wiggins and McTighe (1998).

Summary

Technology education, as it exists today, is a curriculum that reflects changes that have occurred in the teaching of human skills over the last two hundred years. Programs that preceded the current curriculum for technology education include those that concentrated on tool skills, mechanical drawing, woodworking, and metalworking.

The emphasis on the broader concepts of technology and society began with the publication by William E. Warner *A Curriculum to Reflect Technology* (1928; 1947). A book by Delmar W. Olson *Industrial Arts and Technology* (1963) emphasized the importance of problem solving in the curriculum.

The Jackson's Mill Industrial Arts Curriculum Symposium (Snyder, 1982) was a two-year effort (1981-1982) by the American Industrial Arts Association (AIAA) to create a unified direction for industrial arts. The result was a model for curriculum design that concentrated on the human productive activities of communicating, constructing, manufacturing, and transporting. In 1984, in order to reflect this new content, the AIAA changed the association's name to the International Technology Education Association (ITEA).

The current foundation for the development of curriculum in technology education is the document produced by the ITEA, *Technology for All Americans: A Rationale and Structure for the Study of Technology* (1996). A follow-up document is the *Standards for Technological Literacy* (2000).

This study will use a mixed-method approach to acquiring data. This combination of research methods, quantitative and qualitative approaches, is described by Creswell (2003). Quantitative research, involving the collection of numeric data, may be done by survey or by experimentation. Qualitative research depends on the researcher's ability to interpret and make sense of phenomena that occurs in a natural setting. In a qualitative study, "the specific methods that you use will ultimately be constrained only by the limits of your imagination" (Leedy & Ormrod, 2001, p.149).

The collection of data regarding what students are acquiring with regard to learning objectives is part of assessment. Assessment in the affective domain is the process of evaluating achievement of those objectives that "emphasize a feeling tone, an emotion, or a degree of acceptance or rejection" (Krathwohl & Bloom, 1964, p.7). A useful approach to

classifying learning objectives that includes assessment of the aspects of the affective domain is suggested by the *six facets of understanding* proposed by Wiggins (1998). These are 1) explanation, 2) interpretation, 3) application, 4) perspective, 5) empathy, and 6) self-knowledge.

Chapter 3

METHODOLOGY

Principal Research Question

What is the facet and level of understanding (Wiggins & McTighe, 1998) obtained by selected secondary school students in a Virginia technology education class who study an agriculture and biotechnology instructional unit and prepare a Technology Student Association (TSA)-related agriculture and biotechnology research project as part of their coursework?

Subsidiary Research Questions

1. In what ways are student attitudes towards agriculture and biotechnology modified or formulated by the study of an agriculture and biotechnology unit and by the preparation of a TSA-related biotechnology research project?
2. Will students be able to demonstrate the goal of Standard 4 of the *Standards for Technological Literacy*, to "develop an understanding of the cultural, social, economic, and political effects of technology" (ITEA, 2000, p.57)?
3. Will students be able to demonstrate learning of the content material related to Standard 15 of the *Standards for Technological Literacy*, "Students will develop an understanding of and be able to select and use agricultural and related biotechnologies" (ITEA, 2000, p.149)?

Overview

This study represents the summation of many events that transpired during the 30 months that preceded this paper. The first event was the composition of the agriculture and biotechnology co-curricular materials that was authored by this researcher as part of the TECH-know project. The second event was the correspondence with two educators, Dr. Sohan and Dr. Wiggins, whose writings had provided this researcher with valuable foundation material. The third event was a pilot study that involved videotaped interviews with two high school students who had entered their work in a Technology Student Association Agriculture and Biotechnology Design competitive event. The fourth event was the training of two public school teachers to help with the qualitative coding of videotaped interviews. The fifth event was the actual classroom instruction given to the students by one of the teachers. The sixth event involved analysis of a pre-and-post attitude survey, a pre-and-post content test, and the grading of student multimedia presentations. The seventh event was the interviewing of four high school students. The final component was the coding of the interviews by the two teachers and this researcher. The development of this study involved several other procedural steps that will be mentioned in this chapter.

The TECH-know Agriculture and Biotechnology Instructional Unit

The initial preparation for this paper began with the researcher's participation as a writer for the TECH-know project. As described in the TECH-know Second Year Report, during year one of this project, 20 teachers and 20 writers met at North Carolina State University one week in July 2001 to develop instructional materials related to the Standards

for Technological Literacy, the National Science Standards, and the Principles and Standards for School Mathematics (2003). A follow up meeting took place in July 2002 and another in July 2003. The researcher of this paper was responsible for writing the TECH-know unit on agriculture and biotechnology, which in turn was used by a technology teacher in this study. The unit provided information about the following topics:

1. The History of Agriculture and Biotechnology: a summary of how agriculture and biotechnology both have histories dating back to ancient times. This approach to the topic is consistent with that of the Standards for Technological Literacy, Standard 15.
2. DNA Fingerprinting: the invention of this technique and its importance in criminal investigations. This subject was elaborated on as an example of the application of science.
3. Gregor Mendel and Genetics: the discoveries made in the mid 1800s that became the foundation for the sciences of genetics and biotechnology. This section included a discussion of the mathematical principles for solving genetic problems.
4. The First Genetically Modified Food: a case study about the Flavr-Savr® tomato. The Flavr-Savr® tomato was the first attempt to market a genetically modified food.
5. The Social and Economic Impact of the Cotton Gin: the relationship between agricultural technology and slavery. This discussion stressed the impact on American history that resulted from the introduction of a new technology.

6. Bt Cotton and other Genetically Modified Crops: the use of genetically modified seed to produce insect resistant crops. This section introduced the application of new genetic technologies that have changed the modern approach to agriculture.
7. The Irish Potato Famine (Europe, mid-1800s) and the Dust Bowl (United States, 1930s): two examples that illustrate what can happen as a result of improper application of agricultural technology.
8. The Ecological Decline and Recovery of Lake Erie: an example of the consequences of pollution including the overuse of fertilizer.

Correspondence

After deciding that the attitude survey from Dr. Sohan's research was appropriate for this study, the researcher contacted Dr. Sohan and asked permission for its use. Permission was given in an e-mail dated September 24, 2003. (Appendix E)

On September 26, 2003, the researcher submitted an application to the North Carolina State University Institutional Review Board requesting permission to do a research project involving human subjects. (Appendix G). After agreeing to minor edits, the researcher received approval on October 17, 2003. (Appendix H)

The researcher also contacted Dr. Wiggins and provided him with a summary of the proposal for this paper including the questions that would be asked pertaining to the *six facets of understanding* (Wiggins & McTighe, 1998). In an e-mail dated November 13,

2003, Dr. Wiggins endorsed this research and made suggestions for some minor edits of the questions. (Appendix D)

The Pilot Study

In March 2003, the researcher attended the North Carolina Southeast Regional Meeting of the Technology Student Association held at Sampson Community College in Clinton, NC. At this meeting, he reviewed projects that had been submitted for the High School Agriculture and Biotechnology Design Competition. Five months later, the researcher contacted the teacher of two students who had submitted a winning entry. Arrangements were made to obtain consent from the parents of these two students so that the researcher could come to the school and videotape interviews with them. With this having been accomplished, interviews were arranged for September 5, 2003. The students were interviewed at their school during their regular technology class periods. The interviews were videotaped using two mini-DV camcorders that had been set on tripods. The mini-DV equipment was chosen because it used technology that saves the signal in a digital format that could be easily transferred to a computer hard drive. Two units were used simultaneously as a precaution against equipment failure.

The concept for the interview was to follow the procedures for *structured interviewing* as described by Fontana and Frey (2000). "In structured interviewing, the interviewer asks all respondents the same series of pre-established questions with a limited set of response categories. The interviewer records the responses according to a coding scheme that has already been established" (p.649).

During the pilot interviews the researcher asked the students questions that had been written by the researcher for the purpose of uncovering achievement in each of the *six facets of understanding* (Wiggins & Mctighe, 1998). These questions were later reviewed and endorsed by Grant Wiggins in e-mail correspondence. (Appendix D) These facets, and the questions intended to uncover achievement of them, were as follows:

1. Explanation: sophisticated and apt explanations and theories, which provide knowledgeable and justified accounts of events, actions, and ideas.

   What is the main question that you addressed in your research or project?

   What information or results did you expect to obtain?

   What steps did you take in choosing and researching your project?

2. Interpretation: interpretations, narratives, and translations that provide meaning.

   Are the results of your research or project consistent with your initial impressions of your topic?

   Did you uncover any facts that you found particularly interesting? Explain.

   What is the most significant item that you learned from this research or project?

3. Application: ability to use knowledge effectively in new situations and diverse contexts.

   What circumstance can you visualize that would involve using what you have learned?

   Is there any real world practice that you think should be changed based upon what you have learned?

   Based on what you have learned, do you think that you would be better able to handle a related real world issue?

4. Perspective: critical and insightful points of view.

   Do you think that anybody working on the same project as you or studying the same information would reach the same conclusions?

   How has your personal background affected how you view the information you have learned?

5. Empathy: the ability to get inside another person's feelings and worldview.

   Assume that somebody looks at this same issue and feels differently about it than you do. Propose a different attitude or conclusion and explain why another person might think or feel that way about your issue.

6. Self-knowledge: the wisdom to know one's ignorance and how one's patterns of thought and action inform as well as prejudice understanding.

   Evaluate how you have approached this project. Have you used knowledge that you have gained in this class?

   Were you influenced by knowledge and attitudes that you held beforehand?

   How do you think that you acquired the basic attitudes that you had when you first approached this subject?

The researcher made transcripts of the pilot interviews by using a series of steps involving two computers. First, the sound portion of each interview was copied onto the hard drive of computer # 1 by using Windows Movie Maker (1999) software and a direct connection between the camcorder and the computer. The researcher chose to copy only the sound portion of the video tape in order to reduce the required disk space. The next step was

to set up a headset with the earpiece connected to the sound output jack of the first computer (#1) while the microphone part of the headset was connected to the sound input jack of a second computer (#2). Computer #2 employed Dragon voice recognition software (2002) that was "trained" to understand the researcher's voice. Using the Movie Maker software that had come bundled with the Windows ME upgrade, the researcher was able to play back the sound recording from computer #1 through the headset, one line at a time. After each line, the researcher would repeat the sentence into a microphone connected to computer #2. This process created a rough draft of a transcript. The researcher then made corrections in the transcript by typing in revisions while using the sound recording as a reference.

Training of the Raters

Two of the individuals that were pilot teachers for the TECH-know project assisted the researcher by being raters of the student interviews. Their bibliographies appear in the appendix. (Appendix B and C) One teacher had already piloted the TECH-know High School Agriculture and Biotechnology instructional unit and the other teacher had already piloted the TECH-know Middle School Mechanical Challenge instructional unit. In addition, the high school teacher supported this study by having his students cover the instructional unit in class. He administered the pre-test and post-test of content material and the pre-and-post attitude survey. He and the researcher were the two individuals who graded the student projects.

On October 27, 2003, the researcher met both teachers for the purpose of initial training and orientation with regard to this study. At this meeting the assistants received

instruction concerning the *six facets of understanding* (Wiggins & Mctighe, 1998) and a rubric for assessing student learning. (Table 4.1) They were also provided with a transcript of one of the interviews the researcher had conducted at the pilot high school. Each assistant reviewed the transcript and performed an initial assessment based on the rubric. Immediately afterwards, the researcher and the two assistants (the three raters) compared their collective notes to determine if they concurred on the assessments. The three raters identified the same passages in the transcript as being indications of understanding. There was no immediate agreement on how those passages should be rated with regard to the correct facet and level. The three raters discussed each passage until they concurred. By the end of the meeting, the raters had agreed that all *six facets of understanding* (Wiggins, 1998) were demonstrated by the participant during the interview. In addition, they found that these facets were demonstrated at a very high level.

The discussion amongst the raters at this meeting led to refinements in the interview process and the coding process.

The decisions made for conducting the interviews were:

1. The interviews would be limited to 30 minutes. The pilot interviews had not been timed. One was much longer than the other was.
2. The list of specific questions to ask the participants was shortened because in the pilot interview the researcher's attempt to ask a specific question for each facet resulted in the questions sounding repetitive instead of conversational.

The decisions regarding the coding process were:

1. All of the raters would view the original videotape before coding the transcript. The raters made this decision because they realized that viewing the videotape, that included voice and expression, would provide a more vivid communication of the student's understanding. As stated by Roschelle (2000), "video is becoming the medium of choice for collecting data for educational and social science research projects. Videotape can preserve more aspects of interaction including talking, gesture, eye gaze, manipulatives, and computer displays" (p.709).

2. The objective when coding the transcripts would be to identify the highest level of understanding revealed in each of the six facets. For example, if a student provided an insightful answer that the raters coded under a particular facet there would not be any reduction in that coding due to a superficial reply that came before or afterwards.

3. The raters would code the student's responses according to the most appropriate facet for identifying that response and not according to the intent of the question that was asked. For example, if the researcher asked a question intended to uncover the student's level of *explanation*, but the student's answer demonstrated *self-knowledge*, the coding would be for *self-knowledge.*

4. The raters agreed that the most insightful coding would be that which was the result of the discussion between the raters following their individual initial codings of the transcripts. The raters agreed that their discussions would be

videotaped so that the researcher could create a summary transcript that included pertinent comments made by the raters.

5. The researcher would provide copies of the book *Understanding by Design* (Wiggins, 1998) to the other two raters and the book would be studied before the next meeting.

On December 10, 2003, the three raters had their second and final training meeting. By this time, they all had studied the book *Understanding by Design* (Wiggins, 1998). At the meeting, the three raters watched the video of the second student that had been interviewed on September 5, 2003. After viewing the video, they reviewed the transcripts together, verbally identifying and rating pertinent passages as they read them. When a passage was identified, the ideas expressed by the student were compared to the rubric from the book (p.76-77). Using this technique, the three raters were able to determine ratings and levels that they all agreed on for each passage they identified.

The Classroom and the Student Participants

The participants in this study consisted of 30 students enrolled in two high school technology education classes during the fall semester, 2003. The classes were taught at Turner Ashby High School in Bridgewater, Virginia, a town ten miles south of Harrisonburg, VA. The total enrollment in these classes was 43 students but the only data considered were from those students who had submitted both student and parental permission forms.

(Appendix I and J) Either thirteen students failed to return the permission form or their parents had specified that their child should not participate.

Before beginning any instruction on agriculture or biotechnology, the teacher administered a pre-test that covered the content material of the unit. (Appendix A) Following the administration of the pre-test, he also had the students fill in the attitude survey instrument. (Appendix F)

After having completed both the pre-test and the pre-survey, the teacher spent two weeks of class time covering the unit. The instruction included the distribution of handouts copied from the TECH-know instructional unit and a laboratory demonstration in which DNA was extracted from a banana. The last four days were set aside for the students to work in three person teams on a TSA-related project. These teams were given class time to use the Internet for researching a biotechnology topic and for preparing a multi-media presentation according to the design brief included in the instructional unit. In order to save research time, the teacher assigned each group their topic. Three days, December 16 through December 18, 2003 were allocated for the student presentations and for the post-test on content and the post-survey on attitude. The presentations were graded by both the researcher and by the teacher using the rubric from the 2003 TSA design competition.

The Interviews

The selection of the four subjects for interviews was made by using a weighted score that considered each participant's increase of score on the content test, the amount of each participant's change in attitude as indicated by the survey instrument, and the grades given to

each participant on his/her multimedia presentation by both the teacher and the researcher (Table 3.1).

The researcher had learned from the pilot study that making transcripts and coding them was a demanding process that required lengthy amounts of time from all of the raters. Further, the researcher assumed that the objective of the interviews, to determine if there was an acquisition of the *six facets of understanding,* could be accomplished by interviewing only four students. The researcher sought, for the purpose of these interviews, those students who took an active interest in learning the material, doing their research projects, and who showed evidence of having been influenced by the experience. The researcher assumed that those students would provide the best indication of the impact of the instructional unit. A determination of who would be a good interview candidate was done by analyzing the results of the other data collected in this study. This data consisted of the pre-test and post-test scores, the pre-survey and post-survey on attitude, and the numeric grades given to each student for his/her team's research presentation. The researcher selected four students to participate in the qualitative portion of this study after analyzing the grades on the projects, the grades on pre-and-post tests of content material, and the scores on the attitude survey.

On the pre-test and post-test on content material, the researcher considered a gain in score to be an indicator of the student having learned new material. On the pre-survey and post-survey of attitudes (Appendix F), the researcher sought students who demonstrated a large change in attitude. Changes in each student's responses to the 45-question pre-and-post attitude surveys were determined by calculating the absolute value of the difference in the response for each of 45 survey questions (measured on a five point Likert scale). These

differences were then totaled for each student. The results ranged from 12 to 54. The mean of the changes was 28.43 (Table 3.1).

Table 3.1 is the spreadsheet that the researcher used to determine which students would be interviewed. It uses a weighted score that considers the student's improvements on the content tests, his/her grades on the research presentations, and the amount of change that was shown by the before and after attitude surveys.

(All names are fictitious)

Table 3.1
Interview Selection Scores By Rank

Student #		Content Pre Test	Content Post Test	Change in Score	10 X Change in Score	Research Project Grade 1	Research Project Grade 2	Total Research Grade	Change in Survey	3 X Change Survey	Weighted Summary Scores
35	Jack	6	14	8	80	59	50	109	36	108	297
28	David	8	13	5	50	59	50	109	42	126	285
1		7	12	5	50	82	90	172	20	60	282
17		6	10	4	40	85	70	155	27	81	276
34	Chuck	10	16	6	60	62	65	127	27	81	268
2	Kate	9	12	3	30	82	90	172	21	63	265
20		10	14	4	40	62	80	142	27	81	263
8		7	14	7	70	47	55	102	30	90	262
18		14	17	3	30	50	65	115	38	114	259
21		10	16	6	60	62	80	142	18	54	256
23		11	14	3	30	62	80	142	28	84	256
6		6	15	9	90	50	65	115	16	48	253
3		12	16	4	40	47	55	102	36	108	250
26		9	6	-3	-30	67	60	127	51	153	250
7		18	20	2	20	85	70	155	23	69	244
9		13	17	4	40	76	50	126	24	72	238
25		11	17	6	60	68	50	118	20	60	238
37		6	9	3	30	67	60	127	26	78	235
16		8	12	4	40	76	50	126	21	63	229
19		6	12	6	60	68	50	118	17	51	229
24		11	8	-3	-30	53	40	93	54	162	225
22		10	14	4	40	68	50	118	21	63	221
14		14	19	5	50	54	65	119	16	48	217
10		8	14	6	60	54	65	119	12	36	215
30		10	4	-6	-60	62	65	127	46	138	205
5		8	8	0	0	47	55	102	34	102	204
38		13	16	3	30	59	50	109	20	60	199
36		5	8	3	30	52	30	82	28	84	196
31		9	5	-4	-40	52	30	82	50	150	192
32		6	7	1	10	53	40	93	24	72	175
Averages				3.267	32.67			121.5	28.43	85.3	239.47
			STD=	3.493							

The researcher considered the numeric grades assigned by the teacher and the researcher for the PowerPoint (Microsoft, 2002) presentations to be an indication of the student's level of achievement with regard to conducting research on his or her team's

assigned topic. Every member of each team received the same grade. The teacher and the researcher graded each presentation independently using the 2003 TSA Design Competition rubric. The grades given for the presentations by the teacher and the researcher were then added together to create a total score for each team. These scores ranged from 82 to 172 with a mean score of 121.50 (Table 3.1).

Given three different sources of data, the researcher determined that the best method for determining which students would be interviewed was by creating a weighted summary score for each student. After examining the three data sets, the researcher chose to use the following formula in order to give scores from each data set the same approximate weight. (Gain in content test score x 10) plus (total of change in all survey questions x 3) plus (total presentation score). This calculation yielded summary scores ranging from 175 to 297 with a mean of 239 (Table 3.1).

On December 18, 2003, the students with the highest four scores were initially selected for interviews. Two students were not available due to class conflicts, so the next two students on the list were chosen. Their names (altered for this study) were Kate, Jack, David, and Chuck (Table 3.1).

The student participants volunteered to be the subjects of a structured videotaped interview that took place during the regular school day. The interview questions written by the researcher were intended for the assessment of learning according to the *six facets of understanding* as they are described in the publication, *Understanding by Design* (Wiggins and McTighe, 1998).

The interviews were conducted in a room that was arranged with two mini-DVD cameras focused towards the chair where each participant sat. The researcher was seated at a nearby table. Before the end of the interview, each participant was asked all of the 13 questions below.

1. **What is the main question that you addressed in your research or project?**

Question #1 was asked to orient the interviewer to the participants research project and to offer the participant an opportunity to demonstrate the facet 1: Explanation: "sophisticated and apt explanations and theories, which provide knowledgeable and justified accounts of events, actions, and ideas" (Wiggins & McTighe, 1998, p.45).

2. **What information or results did you expect to obtain?**

Question #2 was also intended to probe for facet 1: Explanation: "sophisticated and apt explanations and theories, which provide knowledgeable and justified accounts of events, actions, and ideas" (Wiggins & McTighe, 1998, p.45).

3. **Are the results of your research or project consistent with your initial impressions of your topic?**
4. **Did you uncover any facts that you found particularly interesting?**
5. **What is the most significant item that you learned from this research or project?**
6. **Do you think that anybody working on the same project as you or studying the same information would reach the same conclusions?**
7. **Did you come across any web pages where you had difficulty interpreting the data/facts/text/events? How confident are you of their meaning(s)?**

8. **How did you go about making sense of the data/facts/text/events?**

Questions #3 through #8 were all intended to probe for facet 2: Interpretation: "interpretations, narratives, and translations that provide meaning. What does it mean? What does it matter? What of it? How does it relate to me? What makes sense?" (Wiggins & McTighe, 1998, p.48).

9. **Can you visualize the situation where you would use what you have learned either from the project or from the instructional unit?**
10. **Is there any real world practice that you think should be changed based upon what you have learned?**
11. **Based on what you have learned, do you think that you would be better able to handle a related real world issue?**

Question #9 through #11 were intended to probe for facet 3: Application: "ability to use knowledge effectively in new situations and diverse contexts" (Wiggins & McTighe, 1998, p.51).

12. **I would like you to do a role-play for me. Imagining yourself to be a person with a different attitude and explain why that person might think or feel that way about your issue.**

Question #12 was intended to probe for facet 4: "Perspective: critical and insightful points of view" (Wiggins & McTighe, 1998, p.53), facet 5: "Empathy: the ability to get inside another person's feelings and worldview" (1998, p.55), and facet 6: "Self-Knowledge: the wisdom to know one's ignorance and how one's patterns of thought and action inform as well as prejudice understanding" (1998, p.57).

13. Do you think that it is important for tech-ed to include a section on agricultural biotechnology?

Question #13 was included as a way of giving the student the opportunity to make a statement about the agriculture and biotechnology unit in general. The researcher thought that answers to this question would encourage additional comments regarding achievement in any of the *six facets of understanding* (Wiggins & McTighe, 1998) while also serving as an appropriate way to end the interview.

Coding the Data

The most critical aspect of this study was the process of "coding" the interviews. According to Ryan and Bernard (2000), "coding is the heart and soul of whole-text analysis. Coding forces the researcher to make judgments about the meanings of contiguous blocks of text" (p.780). The general process of coding qualitative data, according to Glaser and Strauss (1967), is to "convert qualitative data into crudely quantifiable form. He codes the data first and then analyzes it" (p.101). The initial categories of data for this study will already have been predetermined by the *six facets of understanding* rubric (Wiggins & McTighe, 1998, pp.76,77).

According to Lesh and Lehrer (2000), to improve the quality of videotape analysis the researcher's interpretations should use "cross-checking or triangulation techniques to produce stable and consistent interpretation of the results" (p.674).

The steps taken to code the data in this study were as follows:

1. The transcripts were made into rough drafts using voice recognition software and MovieMaker (Microsoft, 2002) software.

2. The researcher made changes to the transcript to correct errors that had been made by the voice recognition software.

3. The original video of the interviews was played to the raters.

4. The raters each read the transcripts and made their own notes.

5. The three raters discussed the transcripts during a series of videotaped meetings.

6. The researcher transferred the sound tracks from the rater meetings onto computer #1.

7. With the transcript document file open on computer #2, the researcher listened to the sound track stored on computer #1. This allowed the researcher to enter the rater's remarks into the chronologically appropriate places in the transcript. The result was a document that included all of the information from the original interview plus the remarks and coding determined by the raters.

8. The researcher reviewed the transcript of each of the participants and identified the highest level of achievement that was coded for each of the *six facets of understanding* (Wiggins & McTighe, 1998).

Summary

This paper used three research methods to assess the achievement and attitudes demonstrated by two classrooms of secondary school technology education students who had completed an instructional unit and a research project related to agriculture and biotechnology.

The first of these three assessments measured the achievement of 30 students using a 25 question pre-test and post-test of content material. This test was provided by the TECH-know Project Agriculture and Biotechnology unit (2003).

The second type of assessment measured attitude modification by use of a 45-question Likert scale pre-survey and post-survey of attitudes of the same 30 students. The

survey instrument was one that had been used in a previous study involving the attitudes of college students towards biotechnology (Sohan, 1998). (Appendix F) According to Brown, the Likert scale developed by Rensis Likert in the 1920s, measures the extent to which a person agrees or disagrees with a statement. Today, the most common scales allow a person to choose from five degrees of attitude ranging from Strongly Disagree to Strongly Agree. The scale that was developed by Sohan (1998) and used in this study was arranged in the following manner:

1=Strongly Agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Strongly Disagree

This particular arrangement, with the number 1 indicating Strongly Agree, was consistent with illustrations developed by Likert (Brown, 2000, University of Hawaii Website).

The third type of assessment used a qualitative assessment of structured interviews that had been conducted with four of the participants. These four participants were selected for interviews by calculating a score that considered changes between the pre-test and post-test, changes between the pre-survey and post-survey, and grades on the research project. The questions, the method of recording the interviews, and the assessment process were all tested and refined by doing a pilot study.

Chapter 4

Findings

This study used quantitative and qualitative research methods to evaluate the learning and attitudes demonstrated by two classrooms of Virginia secondary school technology education students who had completed an instructional unit and a research project related to agriculture and biotechnology. The research was conducted during the fall semester, 2003.

The student participants were 30 students enrolled in a technology education course in a northern Virginia high school. The data collected on the participants included qualitative assessment of interviews that were conducted with four students, a pre-and-post Likert survey of attitudes towards agriculture and biotechnology, and the scores on pre-and-post tests of content material from the instructional unit. In addition, numeric grades were given to student research projects by two of the raters. A weighted score that considered the amount of change in content material scores, the amount of change in attitude, and student performance on his/her research project provided an indicator that the researcher used to select four students for qualitative interviews.

The qualitative portion of this investigation involved using the *six facets of understanding* (Wiggins & Mctighe, 1998) as a rubric for coding transcripts of the interviews. The coding was done by three raters who viewed videotapes of the interviews and reached a consensus on their observations.

Characteristics of Research Participants

The student participants of this study were tenth and eleventh grade students at Turner Ashby High School in Bridgewater, VA. Their teacher contributed to this study by administering the pre-and-post tests, the pre-and-post-surveys, and by being one of two graders for the student research presentations. In addition, the teacher taught a two week unit on agriculture and biotechnology that was based on instructional materials from the TECH-know Project (2003) and he was one of three raters who evaluated the interview transcripts.

All of the students involved in this research were enrolled in two classes. The total enrollment of the two classes was 43 students. The teacher provided all of his students pre-written permission papers (Appendix I and J) and asked all of his students to return them with parental signatures so that they could participate in this research. Thirty of these forms were returned with affirmative responses so the collection of data was limited to these 30 students. The participating students consisted of 2 females and 28 males. Of these, 23 students were in the tenth grade and the remaining seven were in the 11th grade.

Qualitative Data

The qualitative data collected by this study provides evidence related to the principal research question: what is the facet and level of understanding, as described by the book *Understanding by Design* (1998) obtained by secondary school students in a Virginia technology education class who study an agriculture and biotechnology instructional unit and prepare a TSA-related agriculture and biotechnology research project as part of their coursework?

Table 4.1 is the rubric used by the raters to determine the facet to assign to student comments. A rank of (A) indicates the highest level of obtainment possible for that facet and a level (E) is the lowest level of obtainment of that facet. All of the observations made by the raters were for levels (A-D).

Table 4.1
Interview Rubric (Wiggins, 1998)

Level	Facet 1 Explanation	Facet 2 Interpretation	Facet 3 Application	Facet 4 Perspective	Facet 5 Empathy	Facet 6 Self-Knowledge
A	Sophisticated	Profound	Masterful	Insightful	Mature	Wise
B	In-depth	Revealing	Skilled	Thorough	Sensitive	Circumspect
C	Developed	Perceptive	Able	Considered	Aware	Thoughtful
D	Intuitive	Interpreted	Apprentice	Aware	Developing	Unreflective
E	Naïve	Literal	Novice	Uncritical	Egocentric	Innocent

Explanation	Deep and broad knowledge. Sophisticated theory, evidence and argument. Sophisticated and apt explanations and theories, which provide knowledgeable and justified accounts of events, actions, and ideas.
Interpretation	Subtle and thorough grasp of meaning of texts, events, and data. Ability to assess interpretations, narratives, and translations that provide meaning.
Application	Authentic use of ideas and processes. Technical skill in content. Ability to use knowledge effectively in new situations and diverse contexts.
Perspective	Critical analysis. Awareness of diverse yet plausible points of view. Critical and insightful points of view.
Empathy	Sensitivity. The ability to get inside another person's point of view.
Self-Knowledge	Awareness of one's ignorance - the limits of one's knowledge. Sensitivity to the interference of one's beliefs and habits. The wisdom to know one’s ignorance and how one's pattern of thought and action inform as well as prejudice understanding.

Table 4.2 is a summary of the qualitative ratings made concerning the student interviews. The ratings shown for each student are the highest-level ratings that were observed with regard to that facet. The paragraphs that follow Table 4.2 describe the meaning of each level observed and indicate the specific comments that motivated the raters to assign that level.

(All student names are fictitious)

Table 4.2

Coded Qualitative Data

	Facet 1: Explanation	Facet 2: Interpretation	Facet 3: Application	Facet 4: Perspective	Facet 5: Empathy	Facet 6: Self-Knowledge
Kate	D Intuitive		B Skilled	A Insightful	A Mature	B Circumspect
Jack	B In-depth	B Revealing	A Masterful	A Insightful		B Circumspect
David		C Perceptive	B Skilled	A Insightful		
Chuck	C Developed	B Revealing	A Masterful	A Insightful		

Facet 1 was "Explanation." According to Wiggins & McTighe (1998), a student who really understands can explain. The ratings of the student participants showed very little obtainment of this facet. For the first student, Kate, the highest rating obtained in Facet 1 was 1-D "intuitive: an incomplete account but with apt and insightful ideas – account has limited support" (Wiggins & McTighe, 1998, p.76). Of the five possible levels of explanation available in the rubric, this was fourth from the top. The raters gave Kate this rating for her comments about using bacteria to clean up oil spills. She learned that the bacteria turned the oil into gasses that were less harmful than the oil, but she did not know what those gasses were. The second student participant, Jack, was rated higher. He was given a rating of 1-B "in-depth: an atypical and revealing account, going beyond what is obvious or what was explicitly taught" (1998, p.76). This rating was given for his comment about insulin being used to help fight diabetes and that it was composed of amino acids. There were no observations of Facet 1 for the third student, David. The fourth student, Chuck, was given a rating of 1-C "developed: an account that reflects some in-depth and personalized ideas – supported theory but insufficient evidence and argument" (1998, p.76). This was the third level from the top. He was given this rating for his knowledge of groundwater pollution and his use of specific terms such as pH scales, acidity, and nitric levels.

Facet 2 was "Interpretation." According to Wiggins & McTighe, a student who really understands can interpret (Wiggins & McTighe, 1998, p.66). The raters found Kate did not demonstrate interpretation at all. The second student, Jack, had a rating of 2-B "revealing: a

nuanced interpretation and analysis of the importance/meaning/significance; tells an insightful story" (1998, p.76). This was the second level from the top of the rubric scale. Jack was given this rating for his comments on cloning. He was concerned about scientists trying to clone plants to see if they could "make them from scratch." He expressed the opinion that we should not eat them until we find out that there is nothing wrong with them.

The third student, David, had a rating of 2-C "perceptive: a helpful interpretation or analysis of the importance/meaning/significance; tells a clear and instructive story; provides a useful history or context; sees different levels of interpretation" (Wiggins & Mctighe, 1998, p.76). This was the third level from the top. David also was given this rating for his comment on cloning. He was agreeable to the idea of therapeutic cloning, but not for cloning all human beings. He did not elaborate further.

The fourth student, Chuck, had a rating of 2-B "revealing: a nuanced interpretation and analysis of the importance/meaning/significance; tells an insightful story" (Wiggins & Mctighe, 1998, p.76). This was the second level from the top of the rubric scale. This rating was given for his comments about his research of manganese. He learned that it was sometimes harmful to plants and humans who have certain allergies or are taking certain medicines. This was information that was a side issue to the pollution he was studying.

Facet 3 was "Application." According to Wiggins & McTighe (1998), a student who really understands can apply. She uses knowledge in context, has know-how, and can employ her knowledge effectively in diverse, authentic, and realistically messy contexts (p.66). The first student, Kate, was rated at 3-B "skilled: competent in using knowledge and skill and adapting understandings in a variety of demanding contexts" (p.76). This rating

was given because Kate stated her position on the use of pesticides. She considered the misuse of pesticides to be a real world problem where practices should be changed.

Jack was given a rating of 3-A "masterful: fluent, flexible – able to use knowledge in novel, diverse, and difficult contexts" (Wiggins & Mctighe, 1998, p.76). This very high rating was given because Jack had a sophisticated view of cloning. When the interviewer questioned Jack regarding his answers to the attitude survey, he explained that genetically modified animals could change the balance of nature by "acting differently or changing from what they want to eat." He had a different attitude towards plants because they could not become diseased by eating other animals.

David was given a rating of 3-B "skilled: competent in using knowledge and skill and adapting understandings in a variety of demanding contexts" (Wiggins & Mctighe, 1998, p.76). This rating was given for his remarks about using biotechnology to find cures for more diseases while at the same time objecting to cloning animals for fear of creating a defective species.

Chuck was given a rating of 3-A "masterful: fluent, flexible – able to use knowledge in novel, diverse, and difficult contexts" (Wiggins & Mctighe, 1998, p.76). The raters considered it an excellent example of application when Chuck spoke about joining a "water control team checking farms to make sure that their BMPs (Best Management Practices) are up to par."

Facet 4 was "Perspective." According to Wiggins & McTighe (1998), a student who really understands sees in perspective. "He can see a position as a point of view – know the history of an idea to place discussion and theory in context – see and explain the importance

or worth of an idea" (p.66). The raters placed all four students at the highest level in this area, 4-A "insightful: a penetrating and novel viewpoint – effectively critiques and encompasses other plausible perspectives – takes a long and dispassionate critical view of the issues involved" (p.77). Kate was given this high assessment because of her thoughtful remarks about "reproducing fertilized eggs and giving them to people." She was agreeable to cloning animals only when there was a valid reason to do so, with the caveat that "animals are meant to be different and not meant to be all the same." Jack was also rated 4-A because of his role-play comments, where he stated (in opposition to his own point of view), "I would rather believe in cloning an animal because maybe we'll have less disease or other things. We'll have to expand the food supply because we'll probably need the food." The third student, David, also brought up a surprising twist to the cloning issue. He was concerned that cloning would be used to expand a family's genetic line. He stated, "One family could die out while another family that is richer can multiply so their family name keeps on going. It would be an unfair advantage." The raters agreed that this also was a novel and penetrating viewpoint, 4-A. Chuck was asked a specific role-play question about what he would do if he were a farmer who had been told by a government agent to change his farming methods. Seriously taking on the role of the farmer, Chuck imagined himself in that situation and proposed, "The government guy had probably never been on a real farm." The raters considered this a very high level of perspective.

Facet 5 was "Empathy." According to Wiggins & McTighe (1998), a student who really understands demonstrates empathy. She has the ability to sensitively perceive. She can project herself into, feel, and appreciate another's situation, affect, or point of view. The

only student that the raters felt demonstrated empathy was Kate. The interviewer asked her to role-play somebody with a different point of view from her own regarding her negative attitudes towards cloning. She responded with, "For people whose child had died, they might want to reproduce their child. Maybe if they lost their dog, they might want another one." All of the raters saw this as 5-A "mature: disposed and able to see and feel what others see and feel; unusually open to and willing to seek out the odd, alien, or different" (p.77).

Facet 6 was "Self-Knowledge." According to Wiggins & McTighe (1998), a student who really understands reveals self-knowledge. He can recognize his own prejudices and style and how they color understanding – question his own convictions – accurately self-assess and effectively self-regulate. This facet was observed being demonstrated by Kate and Jack. When Kate was asked if she could better handle a real world issue now based on what she learned in the instructional unit, she responded, "Probably. I'm more informed about things now, cleaning up oil spills, and I am more informed about some views and can make better opinions." Although this was a short answer, the raters felt that it fit the category of 6-B "circumspect: knows the strengths and limits of one's understanding" (p.77).

Jack was also rated at 6-B "circumspect" because of his answer to how he used the Internet. When Jack was asked if he was confident about his understanding of the material on technical web pages, he replied, "If one was too technical we would just go to another one we understood – some talked about molecules and stuff that I haven't learned everything about yet and how they all bind, but I knew enough about it."

The Quantitative Data

Table 4.3 shows the results of the attitude survey listed by item number for all students. It is arranged in descending order according to the amount of greatest difference between the means of the pre-survey and the post-survey results. Because these were non-parametric results, the statistical test applied was the Wilcoxon procedure for paired data. This statistical operation examined each of the 45 survey items individually to determine if the change between the pre-survey and the post-survey means was significant. The only items that showed a significant change at an alpha level of .05 were numbers 22, 41, and 43. Two additional items, number 1 and number 13, were also of interest because they were the only items on the survey for which the class mean was in the range of Strongly Agree (Table 4.3).

1. Attitude Survey item # 22. "Information about biotechnology is sufficient to reduce fears about this science." The mean answer to this question changed from a pre-test mean of 2.83 to a post-test mean of 2.47. On the Likert scale, this was a significant change from agree towards strongly agree (Table 4.3).
2. Attitude Survey item # 41. "Cloning plants is acceptable for medical purposes." The mean answer to this question changed from a pre-test mean of 2.43 to a post-test mean of 2.07. On the Likert scale, this was a significant change from agree towards strongly agree (Table 4.3).
3. Attitude Survey item #43. "It is acceptable to patent a genetically altered plant." The mean answer to this question changed from a pre-test mean of 2.73 to a post-

test mean of 2.33. On the Likert scale, this was a significant change from agree towards strongly agree (Table 4.3).

Table 4.3
Attitude Survey Results Sorted by Amount of Change

Item Number	Pre Survey Mean	Post Survey Mean	Difference Post - Pre	Standard Deviation	Pr > I t I
43	**2.73**	**2.33**	**-0.40**	**0.93218**	**0.0258**
11	3.47	3.10	-0.37	0.99943	0.0539
13	1.77	1.40	-0.37	1.12903	0.0858
22	**2.83**	**2.47**	**-0.37**	**0.88992**	**0.0317**
41	**2.43**	**2.07**	**-0.37**	**0.71840**	**0.0091**
7	2.70	2.43	-0.27	1.11211	0.1994
39	2.80	2.53	-0.27	0.86834	0.1033
14	3.37	3.13	-0.23	0.81720	0.1287
19	2.57	2.33	-0.23	0.77385	0.1094
23	3.40	3.17	-0.23	0.93526	0.1823
35	2.93	2.70	-0.23	0.77385	0.1094
38	2.93	2.70	-0.23	0.93526	0.1823
21	2.47	2.27	-0.20	0.71438	0.1360
5	2.43	2.23	-0.20	1.09545	0.3256
26	2.93	2.73	-0.20	0.71438	0.1360
31	2.30	2.10	-0.20	1.03057	0.2966
9	3.07	2.90	-0.17	1.20583	0.4551
24	3.13	2.97	-0.17	0.74664	0.2313
4	2.20	2.07	-0.13	0.97320	0.4591
12	2.70	2.57	-0.13	0.93710	0.4421
18	2.27	2.13	-0.13	0.62881	0.2550
29	2.37	2.23	-0.13	1.13664	0.5256
32	2.93	2.80	-0.13	1.07425	0.5020
34	2.73	2.60	-0.13	1.22428	0.5555
36	2.90	2.77	-0.13	0.77608	0.3545
40	2.60	2.47	-0.13	0.89955	0.4235
1	1.60	1.50	-0.10	0.84486	0.5219
10	3.00	2.90	-0.10	1.15520	0.6390
25	2.73	2.67	-0.07	0.69149	0.6015
42	2.87	2.80	-0.07	1.14269	0.7516
8	3.17	3.10	-0.07	0.94443	0.7019
28	2.77	2.70	-0.07	1.48401	0.8074
17	2.43	2.40	-0.03	0.66868	0.7868
16	2.30	2.30	0.00	0.83045	1.0000
30	2.63	2.63	0.00	0.87099	1.0000
33	3.17	3.17	0.00	0.83045	1.0000
27	2.20	2.23	0.03	0.51609	0.8012
44	2.97	3.00	0.03	0.85029	0.8315
20	2.93	2.97	0.03	0.85029	0.8315
15	2.70	2.77	0.07	0.94443	0.7019
6	2.77	2.83	0.07	1.01483	0.7216
37	2.77	2.93	0.17	0.87428	0.3050
2	3.30	3.53	0.23	0.85836	8.1473
3	3.23	3.47	0.23	1.10433	0.2566
45	3.00	3.23	0.23	0.85836	0.1473

With regard to the mean responses from the students in this study, there were only two attitude survey items for which the student participants had indicated a response of *strongly agree* on the Likert scale. These items were the following two statements.

Item 1. An individual's genetic profile should be available to the individual.

Item 13. Genetically-altered food should be labeled.

There was no significant difference between the scores on the pre-survey and on the post-survey. These items are illustrated below in Table 4.4.

Table 4.4

Attitude Survey Items Marked Strongly Agree

Question Number	Pre Survey Mean	Post Survey Mean	Likert Scale Response
1	1.60	1.50	Strongly Agree
13	1.77	1.40	Strongly Agree

1=Strongly Agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Strongly Disagree

Table 4.5 is a list of the 30 student participants listed by student number along with the pre-and-post-test scores on content material that each obtained on a 25-question content knowledge test. The table is arranged in descending order according to the greatest difference between the pre-test scores and the post-test scores. Table 4.6 shows the means, the standard deviations, the minimum and the maximum scores. Based on this data, a Means procedure (a paired t test) was employed to determine if there was a significant difference between the pre-test and the post-test results. The result (Table 4.7) was that there was a significant difference for ($Pr > |t|$) with an alpha level of .0001.

Table 4.5

Pre-and-Post Test Results on Content Knowledge

Level Grade	Student Number	Pre Test Content	Post Test Content	Post - Pre Difference
10	6	6	15	9
10	35	6	14	8
10	8	7	14	7
10	10	8	14	6
10	19	6	12	6
10	21	10	16	6
10	25	11	17	6
10	34	10	16	6
10	1	7	12	5
10	14	14	19	5
10	28	8	13	5
10	3	12	16	4
11	9	13	17	4
10	16	8	12	4
10	17	6	10	4
11	20	10	14	4
10	22	10	14	4
10	2	9	12	3
11	18	14	17	3
11	23	11	14	3
11	36	5	8	3
11	37	6	9	3
10	38	13	16	3
10	7	18	20	2
10	32	6	7	1
10	5	8	8	0
10	24	11	8	-3
10	26	9	6	-3
11	31	9	5	-4
10	30	10	4	-6
Average score		9.367	12.633	3.267
Std Deviation		3.034	4.189	3.493

Table 4.6 is the content scores means analysis of the pre-and-post test of content knowledge.

Table 4.6

Content Test Means

Variable	Label No.	Mean	Std Dev	Minimum	Maximum
diff	30	3.2666667	3.4931789	6.0000000	9.0000000
pre	30	9.3666667	3.0340974	5.0000000	18.0000000
post	30	12.633333	4.1893406	4.0000000	20.0000000

Table 4.7 is an Analysis of Variance (ANOVA) of the pre-and-post test of content knowledge. The analysis showed that the Pr > t was less than .0001.

Table 4.7

Student Content Means ANOVA

Analysis Variable : diff

Mean	N	t Value	Pr > | t |
3.266667	30	5.12	<.0001

Table 4.8 (Number of Pre-test and Post-test Correct Responses to Each Question Listed In Order Of The Greatest Gain) shows the total pre-and-post-test of content scores for all students according to question number. The Table is arranged in descending order according to the question item that produced the greatest difference between the pre-test and post-test scores.

Table 4.8

Number of Pre-test and Post-test Correct Responses to Each Question Listed In Order Of Those Showing The Greatest Improvement

Question	Pre-test Total	Post-test Total	Difference
21	6	17	11
1	7	16	9
24	8	17	9
8	6	13	7
10	4	11	7
5	7	13	6
14	12	18	6
2	6	11	5
4	14	19	5
11	4	8	4
23	12	16	4
9	9	12	3
18	13	16	3
20	5	7	2
13	8	9	1
15	5	5	0
17	21	21	0
19	20	20	0
3	14	13	-1
7	25	24	-1
12	15	14	-1
16	19	17	-2
22	8	6	-2
6	23	19	-4
25	16	12	-4

Summary

The collection of data from this study is illustrated by seven tables and a selection of excerpts from the student interviews.

Table 4.1 (Interview Rubric) is a summary of the *six facets of understanding* (Wiggins & McTighe, 1998) and the levels within each facet.

Table 4.2 (Coded Qualitative Data) is a summary of the *six facets of understanding* (Wiggins & McTighe, 1998) that were demonstrated by the four students that were interviewed. Each row of the table represents one of the students that were interviewed. The ratings listed within the squares of the table are the highest ratings given to that individual in each of the *six facets*. The researcher assigned letters (A-E) to the levels indicated by the chart in order to establish an easy to use hierarchy. Although the hierarchy appears the same as a typical grading system with (A) being the highest and (E) being the lowest, the levels should not be interpreted in this manner. The intent was to assess the impact of the instructional unit; not to assess the students. Given the five levels that Wiggins had described for each of six facets, the raters had to choose from 30 intangible ratings. For each student, these rating were determined by watching a videotape and reading the transcript of a single 30-minute interview.

The section that followed Table 4.2 was a reporting of the specific comments from the student interviews that were identified by the raters as being significant enough to deserve assessment. In each case, the arrangement of this data follows the columns of Table 4.2. First, the facet is given along with a short general description of what it represents. This

is followed by the name of the student and the comments made that caused the raters to choose a specific level within that facet.

Table 4.3 (Attitude Survey Results Sorted by Amount of Change) shows the results of the pre-and-post attitude surveys. There were only three questions that showed a significant amount of change given an alpha level of .05. These three items (22, 41, and 43 shown in bold face type in Table 4.3) are discussed in Chapter 5. Two other items were deemed important because there was not any significant change in the mean score between the pre-survey and the post-survey, and because they were the only items for which the mean score was in the range of *strongly agree* on the Likert scale, items 1 and 13. The details pertinent to these items are shown in Table 4.4 (Attitude Survey Items Marked Strongly Agree).

Table 4.5 (Pre-and-Post Test Results on Content Knowledge) shows the gains and losses in student knowledge between the time that the instructional unit began and when it ended.

Table 4.6 (Content Test Means) is the means analysis of student scores on content knowledge pre-and-post tests.

Table 4.7 (Student Content Means ANOVA) indicated that the Pr > t, comparing the pre-test and post-test scores, was less than .0001.

Table 4.8 (Number of Pre-test and Post-test Correct Responses to Each Question Listed In Order Of The Greatest Gain) shows the change in student knowledge on a question by question basis, listed in descending order so that it is possible to identify those questions for which the content knowledge was learned and those for which it was not.

Chapter 5

Conclusions and Recommendations

Principal Research Question

What is the facet and level of understanding (Wiggins & McTighe, 1998) obtained by selected secondary school students in a Virginia technology education class who study an agriculture and biotechnology instructional unit and prepare a Technology Student Association (TSA)-related agriculture and biotechnology research project as part of their coursework?

An assessment based on interviews with four selected student participants revealed that each student gained something different from the learning experience. However, there is one facet, that of *perspective* that emerged as the one for which all four students interviewed were rated as having acquired the highest level available, *perspective-insightful*.

Subsidiary Research Questions

1. In what ways are student attitudes towards agriculture and biotechnology modified or formulated by the study of an agriculture and biotechnology unit and by the preparation of a TSA-related biotechnology research project?

   This research question is answered by the results of the attitude survey and by the assessment of comments made by four selected students during their interviews. The attitude survey consisted of 45 items. The analysis of the data determined that there were

three items for which a statistically significant change occurred between the pre-survey and the post-survey. These were item 22, "information about biotechnology is sufficient to reduce fears about this science," item 41, "cloning plants is acceptable for medical purposes," and item 43, "it is acceptable to patent a genetically altered plant." In all three cases, the students agreed with the statements on both the pre-survey and the post-survey. The difference between the pre-and-post surveys was a small but statistically significant increase in the level of agreement. These changes suggest that the teaching of the instructional unit was accompanied by a pattern of greater acceptance towards biotechnology. The four interviews produced comments that were consistent with the attitude survey of the class. The students interviewed indicated a cautious acceptance of genetic engineered products in those situations where it was necessary or beneficial.

2. Will students be able to demonstrate the goal of Standard 4 of the *Standards for Technological Literacy*, to "develop an understanding of the cultural, social, economic, and political effects of technology" (ITEA, 2000, p.57)?

The analysis of interviews from four selected students and the data from the pre-and-post surveys suggest that the goals of *Standard 4* (ITEA, 2000) were achieved by the students. In order to uncover the answer to this question the researcher qualitatively coded the students interviews with regard to the goals of *Standard 4* (ITEA, 2000), analyzed the results from the attitude survey used in this study (Table 4.3) and reviewed the student's scores on the content test questions (Table 4.5).

3. Will students be able to demonstrate learning of the content material related to Standard 15 of the *Standards for Technological Literacy*, "Students will develop an understanding of and be able to select and use agricultural and related biotechnologies" (ITEA, 2000, p.149)?

According to the definitions of this study, the evidence of student learning is defined by the results of the pre-and-post tests provided by the TECH-know instructional unit. The statistical analysis of these results indicated a significant gain between the pre-test scores and the post-test scores with an alpha level Pr > t of .0001 (Table 4.7).

Research Results Pertaining to Principal Research Question

The procedure used by the raters for determining the facet of understanding and the level of each facet was to first analyze student comments according to the summary rubric prepared by the researcher (Table 4.1). After a facet was determined, the raters looked at the levels of each facet described in the book *Understanding by Design* (Wiggins & McTighe, 1998, pp.76-77). The raters did not consider it necessary to demonstrate all of the components of any level shown for each facet. If one of the components was present, the requirements of that level were considered to be fulfilled. Further, the raters were very liberal in their assessment of the transcripts because they recognized that the students were only in the tenth grade and had never been prepared for this type of an interview.

In chapter 4 of this study, the levels of understanding obtained by each of the students was discussed (pp.61-66). In this chapter, only the highest level of understanding demonstrated by any one of the participants is discussed (pp.79-87). This changes the focus

of chapter five from individual student learning to the overall learning by these selected students with regard to the *six facets of understanding*.

Facet 1 was *explanation.* The raters gave low assessments to the four students in the facet of explanation. The highest ratings assigned were at the second or third levels. For this facet, there were no ratable comments from the third student, David.

Facet 2, *interpretation*, also showed a limited amount of obtainment during the interviews. There were no ratable comments from the first student, Kate, and the ratings for the other three students were at the second, third, and fourth levels.

Facet 3 was *application*. The raters were more impressed by the student's comments related to this facet, with all of the students making ratable remarks at a high level. Two of the students were rated at the highest level, *masterful*. The other two students were rated at the second level, *skilled*.

The first student rated under the *application* facet at the *masterful* level was Jack. The raters were impressed by Jack's discussion of how genetically modified animals could act differently or "change from what they want to eat." The raters classified this as "able to use knowledge and adjust understanding well in novel, diverse, and difficult contexts."

The second student rated under the *application* facet at the *masterful* level was Chuck. He was given this rating for his comments about changing the way that companies dispose of waste chemicals. He thought it was mainly a money issue.

Facet 4 was *perspective*. This was the only facet for which the raters indicated that each of the four students expressed the highest level of obtainment. Each student was rated at the level of *insightful* facet. Understanding in the facet of *perspective* is the realization

that attitudes are often determined by one's vantage point. According to Wiggins (1998), "this type of understanding is not about any student's particular point of view but about the mature recognition that any answer to a complex question typically involves a point of view; hence, an answer is often one of many plausible accounts. A student with *perspective* is alert to what is taken for granted, assumed, overlooked, or glossed over in inquiry or theory". The importance of a student gaining perspective is that it is the aspect of critical-thinking that allows that individual to "gain a critical distance from the habitual or knee-jerk beliefs, feelings, theories, and appeals that characterize less careful and circumspect thinkers" (p.53). The highest level obtainable for perspective was the one described as "insightful: a penetrating and novel viewpoint; effectively critiques and encompasses other plausible perspectives; takes a long and dispassionate, critical view of the issues involved" (1998, pp.76-77). The following passages illustrate why each student was considered to be at this level.

Student 1, Kate, illustration of *Perspective*

> **Interviewer**: Are there any other subjects in the biotech unit that you thought might be controversial and that maybe you have an opinion and other people might feel differently?
>
> **Kate**: Probably when we talked about reproducing fertilized eggs and giving them to people. Maybe animals are okay as long as it's for purposes, not just for cloning. To do it just to clone them, I don't think that's right.
>
> **Interviewer:** Let's say that you own a dairy cow and that dairy cow produces twice as much milk as other cows and you would like a whole herd of them. Would you want to reproduce the good cow?
>
> **Kate**: If we needed more milk or if the demand was there, I think that would be all right.

Interviewer: Let's just say because it's more profitable."

Kate: Maybe to a certain point but not so many that we have like all the same cow because animals are meant to be different and not be all the same. We shouldn't all have the same one thing.

It was clear in this passage that Kate felt that humans and every other animal, including cows, were meant to be individuals. At the same time she was trying to reconcile that belief with practical considerations about cows existing for the purpose of fulfilling a human need; milk production. It was the fact that she did not have a clear answer for solving this dilemma that demonstrated her critical-thinking about the issue.

Student 2, Jack, illustration of *Perspective*

Interviewer: You're kind of uncomfortable with genetically modified foods aren't you?

Jack: Yeah.

Interviewer: What about people who say "that's nonsense; it's as safe as any other food ?

Jack: Just based on things I already know, I don't see the point in modifying food if we already have food. I don't know why we should start making stuff we already have.

Interviewer: Let's say that somebody else has the opposite point of view. With genetically modified foods we can grow food faster, we can use less pesticide, we can make it healthier, we can make it more abundant in Third World countries. Why do you think that they would see the material in a different way than you?

Jack: With what I just heard, those are great reasons why you probably should make them, but I feel different. Probably based on information that's been passed down to me.

Interviewer: I would like for you to do a role play for me. Imagine yourself to be a person with a different attitude and explain why that person might think or feel that way about your issue.

> **Jack:** I would rather believe in cloning an animal because maybe we'll have less disease or other things. We'll have to expand the food supply because we'll probably need the food.

It is clear that Jack realizes that his viewpoint is subjective. He is not swayed by the interviewer's arguments, but he acknowledges that they are just as valid as his own are. When asked to role-play, he includes an argument that the interviewer had not made; he adds in that with cloned animals we will have less disease.

Student 3, David, illustration of *Perspective*

> **Interviewer:** How do you feel about cloning?
>
> **David**: I don't think cloning (people) is such a good idea because I think it might get in the wrong hands and will be used for bad things. Genetically engineering foods is a good idea because they can help us with medicines and help people eat healthier.
>
> **Interviewer:** What kind of bad things do you imagine?
>
> **David:** Cloning people multiple times. One family could die out while another family that is richer can multiply so their family name keeps going. That would be an unfair advantage.

There was no question among the raters that David had a novel viewpoint. None of the raters had ever encountered that concern about an unfair population of family lines before. According to the methods used by the raters, having a novel viewpoint alone qualified David for the level classification of *insightful.*

Student 4, Chuck, illustration of *Perspective*

> **Interviewer**: Can you visualize a situation where you would use what you've learned either from the project or from the entire instructional unit?
>
> **Chuck:** I would say that if I joined a team like a water control team that goes around checking farms to make sure that their BMPs (best management practices) are up to par. Like figuring out the chemical levels and trying to create new BMPs.

> **Interviewer:** I would like you to do a role-play about somebody with different attitudes. Let's say you're talking to somebody who's been managing a farm and doing things the same way for three generations, and they think that the people talking about best management practices don't have the same kind of experience that they do. Kind of role-play that position for me.
>
> **Chuck:** I would understand how I've done it for generations and it would be pretty hard to change my ideas. Maybe if I were to listen to a few small ideas I could maybe help just a tiny bit. It would probably help out the world and probably my income if I was raising cattle and I was able to give them pure water.
>
> **Interviewer:** Let's say that the government man comes to your farm and says, "You know that those acres you've been herding cattle on or planting for the last 20 years We think it's bad for the river and we want you to stop."
>
> **Chuck:** That would be tough because if I was working the same land for all these years and still making an income, I would tell the government to make sure that their information's right. The guy who's been doing it for generations, they came over here for farming, I don't think they would want to change that, and they have all that background and the government guy probably has never been on a real farm.

Perspective is the realization that attitudes are often determined by one's vantage point. Chuck had clearly identified with the government inspector telling farmers how to manage their operations in ways that would help the environment. When asked to role-play as a farmer, he became emotional about the government guy that has probably never been on a real farm.

The observation that all the students interviewed demonstrated that they acquired *perspective*, as described by Wiggins, is important because this is among the most valued of human characteristics; and yet, this facet of understanding is usually not measured.

Facet 5 was *empathy*. Only one of the students, Kate, was given a rating for this facet and that rating was A; the highest level available. The raters did not find that the other three students made any comments that were applicable to that facet.

Empathy, as described by Wiggins (1998), is "the ability to get inside another person's feelings and worldview." Wiggins describes this as "the ability to walk in another's shoes, to escape one's own emotional reactions to grasp another's. It is not simply an affective response or sympathy. *Empathy* is a learned ability to grasp the world from someone else's point of view. It is the discipline of using one's imagination to see and feel as others see and feel. It is different from seeing in *perspective*, which is to see from a critical distance, to detach ourselves to see more objectively" (pp. 55-56).

There was only one passage to which the raters assigned the facet of *Empathy*, and the level designated was the highest in the Table, *Mature*. This facet is shown by the following passage from the interview with Kate. These words immediately follow the passage where Kate had expressed her dislike of cloning; even for cows and other animals that she said, "were meant to be different."

Kate, illustration of *Empathy*

> **Interviewer:** Role-play again somebody who might have a different feeling about it.
>
> **Kate:** For people whose child had died, they might want to reproduce their child. Maybe if they lost their dog they might want another one."

This short passage that is being provided here without providing the reader the benefit of seeing the student's expression or hearing her voice, may not convey the intensity that was observed by the raters. When the raters listened to this passage, there was no question that this student felt tremendous *empathy* for somebody who had lost a child or a pet. So much so that she was willing to soften the attitudes she held that were opposed to cloning.

The lack of any other passages being rated as e*mpathy* does not mean that no other e*mpathy* existed. The raters had a challenging task to classify comments as properly fitting into one of 30 possible choices of facets and levels. There is obvious overlap between what comments the raters had classified as *perspective* and what comments could have been classified as *empathy*.

Facet 6 was *self-knowledge*. Two of the students made ratable comments in this facet. The first was Kate, who was rated at the second level, *circumspect*. The second student was Jack, also rated at the second level, *circumspect*. The raters found the facet of *self-knowledge* was the most difficult to identify. Wiggins (1998) described it as "the wisdom to know one's ignorance and how one's pattern of thought and action inform as well as prejudice understanding. To understand the world we must first understand ourselves. In daily life, or capacity to accurately self-assess and self-regulate reflects understanding" (pp.57-58). The highest level described for this facet of understanding was "Wise: deeply aware of the boundaries of one's own and others' understanding: able to recognize his prejudices and projections; has integrity: able and willing to act on what one understands" (p.77). The raters did not believe that any of the comments made by any of the students approached this level. However, the second level under *self-knowledge* was more obtainable. "Circumspect: aware of one's ignorance and that of others; aware of one's prejudices; knows the strengths and limits of one's understanding" (p.77). In the following short passage, Kate makes it clear that she perceives herself as becoming more *circumspect* from having done her research project on oil spills.

Kate, illustration of *Self-knowledge*

> **Interviewer:** Based on what you have learned, do you think that you would be better able to handle a real world issue?
>
> **Kate:** Probably. I'm more informed about things now, cleaning up oil spills, and I'm more informed about some views and can make better opinions.

It was apparent to the raters that Kate was able to see how learning about oil spills had altered her sense of self. She understood that her knowledge was more limited before and that now her opinions had more validity. She also saw that the answers to real world issues were made up of views and not just cold facts.

Jack, illustration of *Self-knowledge*

The aspect of *self-knowledge, circumspect* that was observed for Jack was "knows the strengths and limits of one's understanding" (Wiggins & McTighe, 1998). In the passage that follows, Jack commented about his limitations in chemistry.

> **Interviewer:** (Talking about use of the Internet) "The sites that you used, were you pretty confident about what they were saying?
>
> **Jack:** I did understand for the most part what they were saying. Some talked about molecules and stuff that I haven't learned everything about yet and how they all bind, but I knew enough about it.

The raters determined that Jack was aware of personal limitations but was doing his best to work with the knowledge he had.

In reviewing the results shown for the four students it must be remembered that these interviews had followed only two weeks of class time dedicated to the subjects of agriculture and biotechnology. The students had little time, only two weeks, to acquire a great deal of content knowledge. This could account for the relatively low assessments in the facets of

explanation and *interpretation*. The ratings for *application* and *perspective* were higher and more consistent between all four students. During the short period of this instructional unit, the students were able to form opinions on issues and develop understandings of other points of view. The facets of *empathy* and *self-knowledge* were much less consistent. The expression of these two facets may have been related to the student's personalities since, in comparison to *explanation*, the demonstration of empathy or self-knowledge requires a greater level of openness about one's feelings. The only ratable comment made for *empathy* was from Kate, while both Kate and Jack made comments that revealed *self-knowledge*.

Analysis Regarding Subsidiary Research Question 2

The expectations in the STL regarding *Standard 4* in grades 9-12 includes specific benchmarks. These are that students in grades 9-12 should learn:

> Benchmark H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious (For coding purposes, the researcher recorded items that referred to impacts of technology).
>
> Benchmark I. Making decisions about the uses of technology involves weighing the trade-offs between the positive and negative effects (For coding purposes, the researcher recorded items that referred to positive or negative effects of technology).
>
> Benchmark J. Ethical considerations are important in the development, selection, and use of technologies (For coding purposes, the researcher recorded items that included words such as belief, right, wrong, ethical, etc.).
>
> Benchmark K. The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees (for coding purposes, the researcher looked for any items that referred to an international impact but none were found)
>
> (ITEA, 2000, pp.62-63).

The researcher coded the transcripts by listing those remarks that were pertinent to any of the benchmarks or to the more general goals of *Standard 4*. In addition, the questions from the attitude survey that had a significant amount of change between the pre-survey and post-survey were coded according to the benchmarks or general goals of *Standard 4*. A review of the content material test (Appendix A) uncovered three questions relevant to *Standard 4*. All of these items are listed in the following paragraphs that are divided into five groups: general goals of *Standard 4* and benchmark items H, I, J, or K.

General Goals of *Standard 4:* "Students should explore these emerging technologies and develop the skills to evaluate their impacts. They should learn to reason and make decisions based on asking critical questions, not on the basis of fear or misunderstanding. The goal is to equip them with the necessary knowledge and the proper mental tools to be able to examine technological issues and come to their own conclusions in a responsible, ethical manner" (ITEA, 2000, p.62).

1. Attitude Survey item # 22. "Information about biotechnology is sufficient to reduce fears about this science." The mean answer to this question changed from a pre-test mean of 2.83 to a post-test mean of 2.47. On the Likert scale, this was a significant change from agree towards strongly agree (Table 4.3).
2. Attitude Survey item # 41. "Cloning plants is acceptable for medical purposes." The mean answer to this question changed from a pre-test mean of 2.43 to a post-test mean of 2.07. On the Likert scale, this was a significant change from agree towards strongly agree (Table 4.3).

3. Attitude Survey item #43. "It is acceptable to patent a genetically altered plant." The mean answer to this question changed from a pre-test mean of 2.73 to a post-test mean of 2.33. On the Likert scale, this was a significant change from agree towards strongly agree (Table 4.3).
4. Interview with David. When he was asked if there was anything he thought would become a political issue he replied, "Maybe cloning or something like that. And genetically engineering different foods and things."
5. Interview with Chuck. When asked if there were changes he thought should be made to the curriculum he replied, "Maybe more on the opinion they have on cloning. They look at it in good ways that it scientifically could be used for. There's probably a lot of people out there that disagree with that. They probably should just try to give plain facts out instead of trying to change people's minds."

Benchmark H. "Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious" (ITEA, 2000, p.62). For coding purposes, the researcher recorded items that referred to impacts of technology.

1. Interview with Jack. When asked about the most significant thing he learned about biomanufacturing he replied, "I think that it was combining and using our technology and stuff to better improve the community."
2. Interview with David. When asked if his impression of biomanufacturing had changed, he replied, "I realize that there's more to it and that it helps us in a lot of different ways and a lot of different things. Instead of using fossil fuel, we can use biotechnology to make different products.

3. Interview with David. When asked if there was any real world practice he thought should be changed, he replied, "I think medicine should use more biotechnology. It could be used to find cures for more diseases."

Benchmark I. "Making decisions about the uses of technology involves weighing the trade-offs between the positive and negative effects" (ITEA, 2000, p.62). For coding purposes, the researcher recorded items that referred to positive or negative effects of technology.

1. Interview with Kate. When asked about any real world practices she thought should be changed she replied, "Well, some pesticides can be harmful to humans when they're put on food or not used right. On one of the PowerPoints I saw, some places they put it on food we eat and it can be harmful and cause diseases."
2. Interview with Jack. When asked about any real world practices he thought should be changed he replied, "I think that what they're doing is not all bad. They're trying to see what is going on but I don't think they should take it to the next step with humans because we don't need to clone ourselves."
3. Interview with David. When asked how he felt about cloning, he replied, "I don't think cloning is such a good idea because I think it might get in the wrong hands and be used for bad things. Genetically engineering foods is a good idea because they can help us with medicines and help people to eat healthier."
4. Interview with David. When asked to do a role-play of someone with a different attitude, he replied, "I think that some people would see the advances in the negative way. Instead of me seeing advantages, they might see disadvantages;

thinking maybe the medicine can hurt more people than it helps-maybe that's something that should be left alone such as maybe cloning or genetically engineered food."

5. Interview with David. When asked why he had a negative attitude towards cloning he replied, "I just don't think it would be a good idea, the thing to do in society. There's a lot more bad things that can happen. Maybe I get that from movies or something."
6. Interview with Chuck. When asked about real world practices that should be changed he replied, "Probably the waste that is dumped by companies. They have direct sources that pump right into the river and I was thinking that they could change that to a tank where the chemicals could be neutralized, reused, or purified."

Benchmark J. "Ethical considerations are important in the development, selection, and use of technologies" (ITEA, 2000, p.63). For coding purposes, the researcher recorded items that included words such as belief, right, wrong, ethical, etc.

1. Interview with Kate. When asked if there were subjects she thought might me controversial or in which she had an opinion she replied, "Probably when we talked about reproducing fertilizing eggs and giving them to people. I think that cloning people was wrong. Maybe animals are okay as long as it's for purposes, not just for cloning. To do it just to clone them, I don't think that's right."
2. Interview with Jack. When asked if there was any real world practice that should be changed based upon what he learned he replied, "I think that what they're doing

is not all bad; they're trying to see what is going on, but I don't think they should take it to the next step with humans because we don't need to clone ourselves."

3. Interview with David. When asked how he felt about cloning he replied, "I don't think cloning is such a good idea because I think it might get in the wrong hands and will be used for bad things. Genetically engineering foods is a good idea because they can help us with medicines and help people to eat healthier."
4. Interview with Chuck. When asked why, on the post-test, he did not find the cloning of animals acceptable for human consumption he replied, "It just went against my beliefs and I do not see why anyone would have to clone animals. I think things are ok the way they are. I don't see why you would have to clone something if everything can come naturally if you just leave it be."

Quantitative Data Analysis

Table 4.3 showed the results of the pre-and-post survey of attitudes towards agriculture and biotechnology. The Table is arranged in descending order according to the amount of change that occurred among the 30 students. Since this was non-parametric data based on responses to a Likert style test, the Proc-Univariate Wilcoxon paired statistical analysis was used (Appendix N, O, and P). The result of this analysis was that at an alpha level of .05, the items showing significant change were numbers 22, 41, and 43.

Item 22 of the attitude survey asked the participants if information about biotechnology is sufficient to reduce fears about this science. The mean pre-survey response to this item was 2.83, which was in the range of *agree* on the Likert scale. The mean post-

survey response was 2.47, which was still in the range of *agree*, but significantly closer to *strongly agree* (Table 4.3).

Item 41 of the attitude survey stated that cloning plants was acceptable for medical purposes. The mean pre-survey response to this item was 2.43, which was in the range of *agree* on the Likert scale. The mean post-survey response to this item was 2.07, which was significantly closer to the range of *strongly agree* (Table 4.3).

Item 43 of the attitude survey asked the participants if it is acceptable to patent a genetically altered plant. The mean pre-survey response to this item was 2.73, which was in the range of *agree*. The mean post-survey response to this item was 2.33, which was still in the range of *agree*, but significantly closer to *strongly agree* (Table 4.3).

By considering only those questions showing a significant change in attitude, it appears that the general movement of the student participants in this study was towards greater acceptance of biotechnology. However, it is also meaningful to note those items where there was a strong opinion that did not significantly change. Table 4.4 shows the two items from the pre-and-post surveys in which the mean response for both the pre-survey and the post-survey were in the *strongly agree* range. Item one stated that an individual's genetic profile should be available to the individual. Item 13 stated that genetically-altered food should be labeled. For both of these items there was no significant change between the pre-survey and the post-survey.

An analysis of the content knowledge data (Table 4.6) shows that there was a statistically significant gain in content knowledge between the pre-test and the post-test. This would be expected in any situation where new material is presented to students. The average

difference between the two means, the pre-test and the post-test scores, was 3.267 on a 25 question scale. However, it was observed that the lowest scoring six of the 30 student participants actually had gains ranging from a positive one to a negative six (Table 4.5). This indicated virtually either no achievement or random test answers. This led the researcher to have a conference with the teacher to inquire about these six students.

According to the teacher, Student 32, who had a gain of one correct answer between the pre-test and post-test, was one with learning disabilities who had an individual education plan (IEP) on file. Student 5, who had a zero gain, was one who often missed school and was absent two days during the two-week unit. Student 24, who showed a decrease of three correct answers, in the teacher's opinion, simply did not take the test seriously because it was a very small part of his overall course grade. Student 26, who also showed a decrease of three correct answers, was also described by the teacher as having learning disabilities, as well as poor attendance. Student 31, with a decrease of four correct answers, had been absent for 3 days of the unit and, according to the teacher, had a serious drug problem. Student 30, with a score decrease of 6 correct answers, is one with serious emotional problems whose student file indicated that he was being evaluated by both the school counselor and by a private psychiatrist. In addition, he had been absent for two days of the unit.

It is worth noting that without these six students, the average gain shown by the content post-test for the remaining 24 students was 4.70 correct answers.

Table 4.8, arranged according to the question numbers that had the greatest improvement between the pre-tests and post-tests, indicates those questions for which the

21, with 11 more students marking the correct response on the post-test. This question, a science item, asked the students to identify the correct term to use when referring to the chemicals guanine, cytosine, thymine, and adenine. The correct response was nucleotides. Question number 1 was a technology item that asked the students to identify that the brewing of beer was an early use of biotechnology. This question had nine more students marking the correct response on the post-test. Question number 24 was based on a classroom demonstration involving extracting DNA from a banana. This question also had nine more correct responses on the post-test. There were no noticeable gains on the five math questions that were on the test, questions 16 through 20. This is consistent with the teacher's statement to the researcher that, because of time restraints, he did not cover any of the math that was in the instructional unit.

Summary

There was evidence that the instructional unit produced learning in all *six areas of understanding* as defined by Wiggins & McTighe (1998). There was particularly strong evidence that the students gained perspective about the issues and that they gained understanding about how knowledge about agriculture and biotechnology could be applied. The students demonstrated an understanding of the cultural, social, economic, and political effects of biotechnology and showed indications of a greater level of acceptance towards the use of genetically engineered products.

Recommendations

1. In this study, the definitions of the *six facets of understanding* were found to be useful in assessing the *affective domain* (1998). Their use as an *affective domain* rubric could be applicable to other areas of education.
2. The preliminary findings from this study indicate that students learn content plus other understandings that we should try to measure. Since an effort to assess the intangible understandings that were gained by students worked in this case, an effort should be made to broaden this research into other areas.
3. This study should be redone on a larger scale with more teachers and more students to determine if the results obtained in this case study can be generalized to a larger population.
4. A similar study should evaluate what understandings are gained and what attitude modifications may be incurred by TSA contestants who devote additional time to doing a research project.
5. A similar study could determine if students who spend more than two weeks on the instructional unit gain more content knowledge or incur a greater change in attitude towards agriculture and biotechnology.

Epilogue

The researcher of this study gained two insights that are beyond what has been discussed in the preceding pages. The first of these is that issues related to biotechnology should be included in the technology education curriculum. The second is that the book by Wiggins & McTighe (1998) *Understanding by Design* offers concepts that can be used as a rubric for assessing student learning in the affective domain, and these concepts should be made part of all teacher education programs.

The four students interviewed in this study indicated that learning about biotechnology issues was an important part of their education. In addition, the students claimed that biotechnology issues were not being covered in any of their other classes. They all expressed concerns about the ethics, the safety, and the future prospects related to genetic engineering and cloning. Since stories related to these topics abound in the daily news, there is an urgent need for technology educators to embrace the inclusion of these issues in their curricula.

The affective domain, described in Bloom's (1964) *Taxonomy of Educational Objectives* has long been considered the most difficult to assess. Wiggins and McTighe (1998), in writing about teaching for the *six facets of understanding,* have created definitions of learning in this domain. This study used these definitions as a learning rubric, and in doing so, created an opportunity for this researcher and the two other teachers serving as raters for this study to reexamine what students are learning. This experience made the three raters more aware of what the students gain from formal education and presumably will make

the raters better educators. Additional research would be valuable in determining whether assessing student learning in the affective domain, if made part of the teacher education curriculum, could create better teachers.

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APPENDICES

APPENDIX A

TECH-know Agriculture and Biotechnology Test

2003 PreAssm: AB11 Agriculture and BioTechnology

Directions For Numbers 1-25 : Read each of the following multiple-choice items and the possible answers carefully. Mark the letter of the correct answer on your answer sheet or as instructed by your teacher. Remember: Make no marks on this test.

1 One early use of biotechnology occurred in the Middle East. This involved:

- **A** Growing better peas.
- **B** Brewing beer.
- **C** Burial mummification.
- **D** Manufacturing linen.

2 Rachel Carson is credited with starting:

- **A** The green revolution.
- **B** The environmental movement.
- **C** Modern biotechnology.
- **D** The development of genetically modified foods.

3 The entire genetic code of an organism is called its:

- **A** Genetic fingerprint.
- **B** Sugar-Phosphate matrix.
- **C** Genome.
- **D** Nucleotide index.

4 The person referred to as the father of the Green Revolution is:

- **A** Norman Borlaug.
- **B** Rachel Carson.
- **C** Gregory Mendel.
- **D** Ingo Potrykus.

5 The invention of the cotton gin led to:

- **A** More use of slave labor.
- **B** Less use of slave labor.
- **C** The industrialization of the South.
- **D** The ending of the Civil War.

6 What was the first approved genetically modified food?

- **A** Banana
- **B** Peach
- **C** Cucumber
- **D** Tomato

7 A substance that can be broken down into organic molecules by microorganisms is said to be:

- **A** Transgenic.
- **B** Biodegradable.
- **C** Arable.
- **D** Recombinant.

8 In the nineteenth century, the center of the American textile industry was in:

- **A** San Francisco, California.
- **B** New York, New York.
- **C** Chicago, Illinois.
- **D** Lowell, Massachusetts.

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TECH-know Agriculture and Biotechnology Test

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9 A possible consequence of fertilizer runoff is:

A Acid rain.

B Unwanted algae growth.

C Increased insect population.

D Decreased nitrogen content in surface water.

10 Recombinant Bovine Growth Hormone (rBGH) has the purpose of:

A Making livestock grow faster.

B Increasing the nutritional value of beef.

C Eliminating the need for antibiotics.

D Causing cows to produce more milk.

11 Integrated Crop Management (ICM) is a system whose approach maintains that:

A Pests should be completely eradicated.

B The complete eradication of pests is undesirable.

C Biotech foods will make fertilizer and pesticides obsolete.

D No agricultural method can be sustained for long periods.

12 Bt Cotton is identified with:

A Where it is grown.

B The color of the lint.

C Its genetic modification.

D The type of the fiber.

13 The **MOST** important tools used to control the outbreak of SARS have been:

A Quarantines and infection control.

B Genetically engineered vaccines and free inoculations.

C Spraying for mosquitoes and draining standing water.

D Sex education campaigns and free distribution of condoms.

14 Which scientist first used a homemade microscope to observe bacteria?

A Gregory Mendel

B Alexander Fleming

C James Watson

D Von Leeuwenhoek

15 The first commercially successful product of genetic engineering was:

A Blood antigens.

B Tomatoes with longer shelf lives.

C Human insulin.

D Seedless cotton.

16 Which statement reflects the prediction of Thomas Malthus?

A An arithmetic progression will increase faster than a geometric progression.

B War and disease will tend to put limits on the world food supply.

C In time, the growth in human population will exceed the available food supply.

D In time, humans will have greater and greater food surpluses.

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TECH-know Agriculture and Biotechnology Test

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For Numbers 17-19 , use the following Punnett square.

A capital **P** indicates a dominant allele for purple flowers. A lower case **p** indicates a recessive allele for white flowers.

Second Generation

This row and column show all the alleles from two parents	**P**	**P**	**p**	**p**
P	**PP** Purple Flower	**PP** Purple Flower	**Pp** Purple Flower	**Pp** Purple Flower
P	**PP** Purple Flower	**PP** Purple Flower	**Pp** Purple Flower	**Pp** Purple Flower
p	**Pp** Purple Flower	**Pp** Purple Flower	**pp** White Flower	**pp** White Flower
p	**Pp** Purple Flower	**Pp** Purple Flower	**pp** White Flower	**pp** White Flower

17 The Punnett square shown indicates that, in this generation, the probability of a plant having white flowers is:

A One in eight.

B One in six.

C One in four.

D One in two.

18 If the garden represented by the Punnett square shown has 600 plants, approximately how many will have purple flowers?

A 300

B 350

C 400

D 450

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TECH-know Agriculture and Biotechnology Test

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19 A Punnett square is useful for:

A Predicting with certainty the color of the next flower that blooms.

B Approximating the number of times that a specific trait will appear when given the number of occurrences.

C Predicting the rate of pollination.

D Determining the total yield of the harvest.

20 In the period between 1790 and 1808 about 80,000 Africans were brought to America as slaves. The total population of America in the early 1800s was about 5 million people. About what percentage of the total population was the result of this historical event?

A 0.625 %

B 1.60 %

C 6.25 %

D 16.0 %

21 The chemicals Guanine, Cytosine, Thymine and Adenine are known as:

A Genes.

B Chromosomes.

C Nucleotides.

D Isotopes.

22 The individuals credited with discovering the structure of DNA were:

A Mendel and Darwin.

B Watson and Crick.

C Whitney and Potrykus.

D Borlaug and Carson.

23 Organisms that are modified by transferring traits from one species to another are called:

A Transgenic.

B Clones.

C Domesticated.

D Inbred.

24 Before extracting DNA from plant matter, lysis solution is added to the mixture in order to break down the:

A Cell membrane.

B Cell wall.

C Chlorophyll.

D Cellulose.

25 The banana must be liquefied in a blender before extracting its DNA in order to:

A Break down the cell membrane.

B Improve its viscosity.

C Release the nitrogen and phosphates.

D Break down the cell wall.

Stop here

TECH-know Agriculture and Biotechnology Test

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Page 1 of 2
Scoring Key

?	⊙	Answer/ Scale	Objective	?	⊙	Answer/ Scale	Objective
1	1	B	AB11.03 Technology	14	14	D	AB11.03 Technology
2	2	B	AB11.03 Technology	15	15	C	AB11.03 Technology
3	3	C	AB11.03 Technology	16	16	C	AB11.01 Math
4	4	A	AB11.03 Technology	17	17	C	AB11.01 Math
5	5	A	AB11.03 Technology	18	18	D	AB11.01 Math
6	6	D	AB11.03 Technology	19	19	B	AB11.01 Math
7	7	B	AB11.03 Technology	20	20	B	AB11.01 Math
8	8	D	AB11.03 Technology	21	21	C	AB11.02 Science
9	9	B	AB11.03 Technology	22	22	B	AB11.02 Science
10	10	D	AB11.03 Technology	23	23	A	AB11.02 Science
11	11	B	AB11.03 Technology	24	24	A	AB11.02 Science
12	12	C	AB11.03 Technology	25	25	D	AB11.02 Science
13	13	A	AB11.03 Technology				

Total questions on test: 25

Minimum points required to achieve mastery category

Objectives measured: 3	Items	Points	●	◒	Questions measuring this objective
AB11.03 Technology	15	15	11	10	1 2 3 4 5 6 7 8 9 10 11
AB11.03 Technology					12 13 14 15
AB11.01 Math	5	5	4	3	16 17 18 19 20
AB11.02 Science	5	5	4	3	21 22 23 24 25
Totals		25	19	16	

? = Test Question Number ⊙= line on GP Form

APPENDIX B

Biography of Kevin Lipscomb

Kevin Lipscomb attended Southern Adventist University in Tennessee where he graduated in 1975 with an A.S. in Construction Technology and in 1979 with a B.S. in Industrial Education and Behavioral Science.

His teaching experience includes teaching at Collegedale Academy. From 1980 to 1983 he taught at Shenandoah Valley Academy in New Market, VA. Later, from 1983 to 1986, he taught at Adelphian Academy in Holly, Michigan. After leaving education to work in the insurance industry, Mr. Lipscomb returned to teaching in 1991 to teach at Wilbur S. Pence Middle School in Dayton, Virginia where he currently teaches technology education, grades 6, 7, and 8.

While teaching at Wilbur S. Pence Middle School Mr. Lipscomb enrolled in graduate school at James Madison University in Harrisonburg, VA. where in 1995 he earned a M.S. in Education with a major in human resource development (technology education). He continued on to Shenandoah University and in 1997 completed a second M.S. in Education with a major in school administration.

APPENDIX C

Biography of Jerry Ridgeway

Jerry Ridgeway has been a technology education teacher for twenty years. He taught at the middle school level for six years and has been a high school teacher the other fourteen. He serves as TSA advisor at Turner Ashby High School in Bridgewater, VA. He serves as the Valley Region of Virginia TSA Coordinator and is currently his school's Career and Technical Education Team Leader.

As a Technology Student Association advisor, he has overseen his students holding numerous regional offices and at least ten state offices including three state presidents. He believes that the most profound influence TSA has on students is leadership development.

Mr. Ridgeway holds a BS in Agriculture Education from Virginia Polytechnic Institute in Blacksburg, VA. and a MS in Vocational Education from James Madison University in Harrisonburg, VA. In addition to a degree in agriculture education he has an endorsement in technology education. He is currently teaching Technology Foundations (a first year high school level technology education class), Technology Transfer (the second year course), Materials and Processes Technology, and Construction Technology.

APPENDIX D

Correspondence with Grant Wiggins

The following item is an attachment from an email from Grant Wiggins to the researcher. The italic script indicates where Dr. Wiggins made suggestions regarding the questions for the interviews.

Questions related to "Six Facets of Understanding."

1. Explanation: sophisticated and apt explanations and theories, which provide knowledgeable and justified accounts of events, actions, and ideas.

What is the main question that you addressed in your research or project?

What information or results did you expect to obtain?

What steps did you take in choosing and researching your project?

2. Interpretation: interpretations, narratives, and translations that provide meaning.

Are the results of your research or project consistent with your initial impressions of your topic?

Did you uncover any facts that you found particularly interesting? Explain.

What is the most significant item that you learned from this research or project?

These are fine questions, but they don't reflect my idea about what interpretation in this sense means. The questions might be more like these:

Where did you have the most difficulty interpreting the data/facts/text/events? How confident are you of their meaning(s)? How did you go about making sense of the data/facts/text/events?

3. Application: ability to use knowledge effectively in new situations and diverse contexts.

What circumstance can you visualize that would involve using what you have learned?

Is there any real world practice that you think should be changed based upon what you have learned?

Based on what you have learned, do you think that you would be better able to handle a related real world issue?

4. Perspective: critical and insightful points of view.

Do you think that anybody working on the same project as you or studying the same information would reach the same conclusions? This seems more like an interpretation question. The issue here is the particular stances taken. So, the question should be: From what other perspectives might this issue be considered? What assumptions have you made, and are there others? From which/whose point of view have you drawn your conclusions? How has your personal background affected how you view the information you have learned?

– *This belongs in facet 6*

5. Empathy: the ability to get inside another person's feelings and worldview.
Assume that somebody looks at this same issue and feels differently about it than you do. Please do a role play for me imagining yourself to be a person with a different attitude or conclusion and explain why another person might think or feel that way about your issue.

6. Self-knowledge: the wisdom to know one's ignorance and how one's patterns of thought and action inform as well as prejudice understanding.
Evaluate how you have approached this project. Have you used knowledge that you have gained in this class? Were you influenced by knowledge and attitudes that you held beforehand?
How do you think that you acquired the basic attitudes that you had when you first approached this subject?

The very general nature of the questions is intended to allow for the fact that every student will be doing a research project on a different topic. The scoring will not be on a numeric scale; the rubric will be used as a guide to remind the raters of the levels of understanding for each facet.

Thank you for looking at this study. Any feedback you provide would be greatly

appreciated.

Sincerely yours,

Daniel Stotter

APPENDIX E

Correspondence with Dr. Sohan

Hotmail® dstotter@hotmail.com

Inbox | Previous Page

From : Donna Balint Sohan <donna.p@pcisys.net>

To : daniel stotter <dstotter@hotmail.com>
Subject : Re: Sohan Dissertation Question
Date : Wed, 24 Sep 2003 20:47:12 -0600

After those compliments, how can I refuse? :)

Seriously...you are more than welcomed to use the survey with any modifications as you see fit. Thank you for considering it worthy to serve in your research design. If I can be of further assistance, please don't hesitate to contact me again.

Sincerely,
Donna Sohan

daniel stotter wrote:

Dear Dr. Sohan,

9/24/03

I have read your dissertation and found it to be well done, informative, and of great interest to me. I am a doctoral student at North Carolina State University doing a dissertation on what students in a high school technology education class are learning from a biotechnology module and their entries into a biotechnology design competition. I am investigating their level of achievement and any attitude modification that takes place.

I wish to use your attitude survey, with only minor modifications, as a pre-test and post-test. I may compare the scores with those listed in your dissertation. In order to do this I wanted to first obtain your permission.

I believe that a simple e-mail will satisfy my committee chair. If you agree to allow my use of your survey, please respond to this e-mail with a short letter. Of course, I will give credit to your contribution in my thesis.

I am attaching to this letter a copy of the questionnaire as I have recreated it.

Thank your for responding. Daniel Stotter

dstotter@hotmail.com ----Original Message Follows---- From: Donna Balint Sohan To: dstotter@hotmail.com Subject: Sohan Dissertation Question Date: Wed, 24 Sep 2003 18:59:21 -0600 Hello, Mr. Stotter-- How may I be of assistance regarding my dissertation? If you need to reach me by phone, by work # is 719-262-4101 and I'm usually in my office in the afternoon. Look forward to hearing from you. Sincerely, Donna Soha

---

Thank you very much for your permission and your quick response. I am trying very hard to go through the steps of getting university permission for human-subjects research, approval of my first three chapters, and the rest of the steps necessary to finish my thesis finished in time for graduation in May, 2004. Again, I appreciate having your permission to make use of some of your work. Daniel Stotter

APPENDIX F

Student Survey Regarding Attitudes Towards Agriculture and Biotechnology

Please indicate your reaction to the statements below.
SA=Strongly Agree, A=Agree, N=Neutral, D=Disagree, SD=Strongly Disagree

	SA	A	N	D	SD
An individual's genetic profile should be available to:					
1. the individual.					
2. prospective employers.					
3. insurance companies.					
4. medical researchers.					
It is acceptable to combine genes between:					
5. the same plant species.					
6. different plant species.					
7. the same animal species.					
8. different animal species.					
Cloning animals is an acceptable form of reproduction for:					
9. food for human consumption.					
10. food for animal feed.					
11. maintaining purity of show breeds.					
12. medical research issues.					
Genetically-altered food:					
13. should be labeled.					
14. is superior to traditionally-bred food.					
15. should not include animals.					

Please indicate your reaction to the statements below.
SA=Strongly Agree, A=Agree, N=Neutral, D=Disagree, SD=Strongly Disagree

	SA	A	N	D	SD
Biotechnology may:					
16. enhance the quality of life for all Americans.					
17. alleviate world food shortages.					
18. create many job opportunities.					
19. contribute to the disappearance of small farms.					
Information about biotechnology:					
20. is accurately depicted by TV and magazines.					
21. should be discussed at the high school level.					
22. is sufficient to reduce fears about this science.					
It is acceptable to direct the genetic material of an organism by:					
23. inserting a foreign gene.					
24. blocking expression of an existing gene.					
25. using selective breeding programs.					
26. artificial insemination.					

Please indicate your reaction to the statements below.
SA=Strongly Agree, A=Agree, N=Neutral, D=Disagree, SD=Strongly Disagree

	SA	A	N	D	SD
Early diagnosis of a genetic disorder should be made:					
27. whether treatment is available or not.					
28. only if the disorder is likely to affect the individual.					
29. to expecting parents regarding their unborn child.					
It is acceptable to genetically engineer plants:					
30. for food.					
31. for medical purposes.					
32. for landscape design..					
Genetically altered organisms					
33. such as animals are safe to eat.					
34. disrupt the balance of nature.					
35. present a health hazard to humans.					
The risk of genetic engineering is:					
36. outweighed by the benefits.					
37. that society's tolerance of people with disabilities will decrease as genetic advances are made.					
38. is minimal due to strict safety regulations.					

Please indicate your reaction to the statements below.
SA=Strongly Agree, A=Agree, N=Neutral, D=Disagree, SD=Strongly Disagree

	SA	A	N	D	SD
Cloning plants is acceptable for:					
39. food for human consumption.					
40. non-food products such as cotton.					
41. medical purposes..					
It is acceptable to patent a genetically altered:					
42. bacteria.					
43. plant.					
44. animal such as a mouse.					
45. animal such as a monkey.					

APPENDIX G

Application to Internal Review Board for the Use of Human Subjects in Research

North Carolina State University

Institutional Review Board for the Use of Human Subjects in Research

SUBMISSION FOR NEW STUDIES

Title of Project: *Evaluation of the Achievement and Attitude Modification Of Technology Education StudentsWho Complete Instructional Units on Agriculture and Biotechnology*

Principal Investigator: *Daniel Stotter* Department: *Technology Education*

Source of Funding (required information): *TECH-knowProject*

Campus Address (box number): *502 Poe Hall*

Email: *dstotter@hotmail.com* Phone: *(919) 510-8752* Fax:

Rank: Faculty

Student: Undergraduate Masters; or PhD

Other:

If rank is not faculty (i.e. student or other), provide the name of the faculty sponsor overseeing the research:

Faculty Sponsor's email: *dick_peterson@ncsu.edu* Campus Box: Phone: *(919) 515-1741*

Investigator Statement of Responsibility

"As the Principal Investigator, my signature testifies that I have read and understood the University Policy and Procedures for the Use of Human Subjects in Research. I assure the Committee that all procedures performed under this project will be conducted exactly as outlined in the Proposal Narrative and that any modification to this protocol will be submitted to the Committee in the form of an amendment for approval prior to implementation."

_____ _____

Principal Investigator's Signature* Date

Faculty Sponsor Statement of Responsibility

"As the Faculty Sponsor, my signature testifies that I have reviewed this application thoroughly and will oversee the research in its entirety. I hereby acknowledge my role as principal investigator of record."

_____ _____

Faculty Sponsor's Signature* Date

*electronic submissions to the IRB are considered signed via an electronic signature

PLEASE COMPLETE IN DUPLICATE AND DELIVER TO:
Institutional Review Board, Box 7514, NCSU Campus (lower level of Leazar Hall)
****

For IRB office Use Only

Review Received**:** **Administrative** **Expedited** **Full Board**

Review Decision: **Approve** **Approve with Modifications** **Table** **Disapprove**

Reviewer_____ Signature_____Date _____

North Carolina State University
Institutional Review Board for the Use of Human Subjects in Research
PROPOSAL NARRATIVE

If at any time you have questions or difficulties while completing IRB forms, please feel free to contact Deb Paxton at debra_paxton@ncsu.edu or 919-515-4514.

In your narrative, please address each of the questions below. Keep in mind that the more details that you provide, the easier an IRB reviewer will be able to understand your research and reach a prompt decision.

A. INTRODUCTION

1. In lay language, please briefly describe your research, its purpose, procedures, and expected contribution to its field or to the general population.
   This research will use quantitative and qualitative research methods to evaluate the achievement and attitudes demonstrated by two classrooms of secondary school technology education students who have completed an instructional unit and a self-directed project related to agriculture and biotechnology. Achievement and attitude modification will be measured with three types of assessment. The first of these three assessments will measure achievement using pre-tests and post-tests provided by the TECH-know project Agriculture and Biotechnology unit (TECH-know Project, 2003). The second type of assessment will be to measure attitude modification by use of a pre-test and post-test of attitudes and perceptions that is also part of the TECH-know instructional unit. The third type of assessment will be a qualitative evaluation of structured interviews with four of the subjects. The questions for these interviews will probe for "understandings" as described in the book, Understanding by Design (Wiggins & McTighe, 1998).

2. If this is student research, indicate whether it's for a course, thesis, or dissertation.
   Dissertation

B. SUBJECT POPULATION

3. How many subjects will be involved in the research?
   43

4. Describe how subjects will be recruited. If flyers, advertisements, or recruitment letters will be used, please attach copies of those documents.
   Subjects will be high school students enrolled in a technology education course in Bridgewater, Va. The teacher of the course is a pilot teacher for the TECH-know project.

5. List specific eligibility requirements for subjects, describe screening procedures, and justify criteria that will exclude otherwise acceptable subjects.
   Subjects will be the all students (43) enrolled in either of two classes.

6. Explain and justify and sampling procedures that exclude specific populations.
   Not applicable.

7. Disclose any relationship between researcher and subjects, such as teacher/student or employer/employee.
   The researcher has no relationship to subjects.

8. Check any vulnerable populations that you will intentionally include in the study:
   - Minors (under the age of 18) – if you will involve minors in your study, you must make provisions for parental consent and minor assent to the research
   - Pregnant women
   - Persons with mental, psychiatric, or emotional disabilities
   - Persons with physical disabilities
   - Elderly
   - Students from a class taught by the Principal Investigator
   - Prisoners

Other vulnerable populations:

APPENDIX H

Letter of Approval from Internal Review Board

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

Sponsored Programs and Regulatory Compliance

Campus Box 7514

1 Leazar Hall

Raleigh, NC 27695-7514

919.515.7200

919.515.7721 (fax)

From: ***Debra A. Paxton, IRB Administrator***

North Carolina State University

Institutional Review Board

Date: October 17, 2003

Project Title: Evaluation of the Achievement and Attitude Modification of Technology Education Students who Complete Instructional Units on Agriculture and Biotechnology

IRB#: 215-03-10

Dear Mr. Stotter;

The project listed above has been reviewed in accordance with expedited review procedures under Addendum 46 FR8392 of 45 CFR 46 and is approved for one year. **This protocol expires on October 16, 2004, and will need continuing review before that date.**

NOTE:

1. This board complies with requirements found in Title 45 part 46 of The Code of Federal Regulations. For NCSU the Assurance Number is: FWA00003429; the IRB Number is: IRB00000330.

2. The IRB must be notified of any changes that are made to this study.

3. Your approval for this study lasts for one year from the review date. If your study extends beyond that time, including data analysis, you must obtain continuing review from the IRB.

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

Sincerely,

Debra Paxton
NCSU IRB

APPENDIX I

Student Consent Letter

October 17, 2003

Dear Students,

We are conducting a research study on what students learn from TSA events. The study will involve some pre-and post unit surveys, and videotaped interviews with students. The videotaping session will be no longer than 30 minutes. You may end the interview whenever you like. The surveys won't have your name on them.

Your name will not be used when we report the results of the study. You don't have to be interviewed, and a decision not to participate will not affect your grade.

If you feel that your rights have been violated in any way you may contact the North Carolina State University Institutional Review Board at (919) 515-4514. Please contact me if you have any questions about the study.

This study is very important. Learning about what students are gaining from TSA events will help design better events in the future. Thank you for your assistance.

Sincerely,

Daniel Stotter
(919) 510-8752 or dstotter@hotmail.com
++

Please indicate whether or not you are willing to participate in this study by checking one of the statements below and signing your name.

_____ YES, I am willing to participate in this research study.

_____ (Student signature, date)

_____NO, I do not want to participate in this research study.

_____ (Student signature, date)

APPENDIX J

Parental Consent Letter

October 17, 2003

Dear Parent or Guardian,

The Technology Education Department of North Carolina State University is working under a grant from the National Science Foundation to develop learning materials related to Technology Education and the Technology Student Association (TSA) conferences. I am a participant in this project, called TECH-know, and I am also doing related research for my dissertation regarding what students learn from TSA events. The study will involve some pre-and post-unit surveys, and videotaped interviews with students about their TSA project. The videotaped session will last no longer than 30 minutes. Your child may end the interview whenever he or she wishes to.

The research will be conducted during regular instruction time. The surveys won't contain any information that will identify your child. I am asking your permission to interview and videotape your child for this research. The questions and discussion will be about what was learned from the preparation and entry of a project in the TSA competition.

If you feel that your child's rights have been violated in any way you may contact the North Carolina State University Institutional Review Board at (919) 515-4514. If you have any questions about the research, please contact me.

All information collected by the videotaped interviews will be used only for this research study and will not affect your son's or daughter's grade. No identifying names will be used in any future reports of this research. When this study is finished the videotapes will be destroyed. If you have any questions or desire further information, please do not hesitate to call. Thank you in advance for your cooperation and support.

Sincerely,

Daniel Stotter
(919) 510-8752 or dstotter@hotmail.com
++
Please indicate whether or not you are willing to have your child participate in this study by checking one of the statements below and signing your name and having your child return this page to school.

_____ YES, I grant permission for my child, ______________________________ to participate in this research study.

_____ (Parent signature, date)

_____NO, I do not grant permission for my child, _____ to participate in this research study.
_____ (Parent signature, date)

APPENDIX K

Coded Transcripts of Student Interviews

(All student names are fictitious)

Kate 10th grade

1. What is the main question that you addressed in your research or project?

Our main question was how to most effectively clean up oil spills.

2. What information or results did you expect to obtain?

None. I really wasn't sure much about oil spills.

What steps did you take in choosing and researching your project?

Mr. Ridgeway picked the one that would probably be most interesting to our group.

Ok, what would make oil spills interesting to you as opposed to another group?

I'm not sure really. Probably because I'm still in biology, some of the other kids are older. I'm in ecology also.

3. Are the results of your research or project consistent with your initial impressions of your topic?

Not really because I really haven't had stuff on bacteria and I wasn't really sure what bacteria did to the oil or how they used the cleanup oil.

So what did you learn?

I learned that bacteria is one of the most effective ways because it changes it into oxygen and I think CO2. And they're pretty much harmless compared to oil the way it just gets spilled.

Kevin: She was saying what she didn't know before.
Jerry: And she knew it was being made into gas which was less harmful than oil.

Explanation - Intuitive knowledge. 1-D

We chose to categorize the remark about changing oil into oxygen and CO2 because she volunteered the remark that "I learned that." The concept that bacteria was used to make the oil into gasses less harmful than the spilled oil was central to her project and she was willing to explain this. However, she was unsure of the specifics about what gasses were produced so all three raters felt that this understanding was best classified as Explanation - Intuitive: "an incomplete account but with apt and insightful ideas. There is a theory, but one with limited testing and evidence" (1998).

4. Did you uncover any facts that you found particularly interesting?

That they actually light oil spills on fire right after it spills. I guess to cleanup some of it somehow. I'm not sure about that. I learned that they lit it on fire right after. I thought that was pretty cool.

5. What is the most significant item that you learned from this research or project?

That they're finding new technologies to cleanup oil spills and it doesn't take as much manpower to do it today. The bacteria just breaks things down.

6. Do you think that anybody working on the same project as you or studying the same information would reach the same conclusions?

Maybe, I'm not sure, it just depends on what kind of interest they take in biotechnology.
How did you do most of your research?
Online

7. Did you come across any web pages where you had difficulty interpreting the data/facts/text/events? How confident are you of their meaning(s)?

Yes, I found plenty of them.

8. How did you go about making sense of the data/facts/text/events?

Mostly I just went back and found things that I could actually understand.

When you finally went back and zeroed in on what you could understand were you pretty confident that you were interpreting the material correctly?

I think so because they show pictures on what's happening.

Dan: I was glad that they learned to find different levels of material on the web. I don't know if they learned it in your class.
Jerry: I think they learn it throughout school. Computers are second nature to them.

9. Can you visualize the situation where you would use what you have learned either from the project or from the instructional unit?

If I ever took a class in college or decide to major in technology or get out in the field and do what scientists do.

Do you see it strictly as reinforcing other academic studies?

Yeah.
What about general knowledge where you're not taking science class. Do you think you'll be able to use any of it?

Probably in some way.

Can you think of any example?

Knowing something about genetically modified foods.

How do you feel about genetically modified foods?

I don't really have any views on that right now except as long as it's not harmful to anything in the environment.

Dan: I think that this would be application, taking knowledge to the grocery store.

Self-knowledge - Thoughtful. 6-C
In stating that she didn't have any views on genetically modified foods except her concern about it being harmful to the environment, she actually stated a viewpoint. Because the remark did not demonstrate any knowledge that extended beyond her own thoughts on the subject, the only classification that applied was self-knowledge. She knows that the specifics of her viewpoint could change with the acquisition of more knowledge, so the raters chose the level of thoughtful, "generally aware of what is and is not understood" (1998).

10. Is there any real world practice that you think should be changed based upon what you have learned?

Using pesticides maybe.

Tell me about that.

Well, some pesticides can be harmful to humans when they're put on food or not used right. One of the PowerPoints I saw some places they put it on food we eat and it can be harmful and can cause diseases.

Dan: So you were affected by one of the presentations that one of the other students in your class did?

Yes.

Dan: I thought that this point was great because she was learning from other students. I don't know if that's on our rubric.

Application - Skilled. 3-B
Kate was quite sure of herself when stating that pesticides can be harmful to humans. Further, she acknowledged that this concept was the result of seeing other students in the class do a presentation on a topic other than the one that had been assigned to her. Since she had made the leap, from being aware of pesticides causing disease when not used correctly to where she saw this as a real world practice that should be changed, the raters felt that this was an application of knowledge. The level that best defined her statement was skilled, "competent in using knowledge and skill and adapting understandings in a variety of appropriate and demanding contexts" (1998).

11. Based on what you have learned, do you think that you would be better able to handle a related real world issue?

Probably, I'm more informed about things now, cleaning up oil spills, and I'm more informed about some views and can make better opinions.

Jerry: I think that the line about views shows a sense of self.

Self-knowledge-Circumspect. 6-B
The raters saw Kate's confidence in being able to make better opinions as evidence of self-knowledge. She evaluated what she now knew, so the level was that of Circumspect: "aware of one's ignorance; knows the strengths and limits of one's understanding" (1998).

What about practices that lead to oil spills, did you have any opinions about that?

Were you affected by anything you read?

What do you mean by practices?

Shipping the oil and big tankers things like that; drilling in Alaska.

Well, accidents happen, they just need to be ready to cleanup just in case.

12. I would like for you to do a role-play for me. Imagining yourself to be a person with a different attitude and explain why that person might think or feel that way about your issue.

Probably that there's not much oil left. I'm not really sure.

Dan: I was impressed that she brought up there not being much oil left. Jerry, was that brought up in your class at all?
Jerry: Not in context to biotechnology. But there was a group in that class that discussed bio-diesel. So that may have had some affect.

Any other subjects in the biotech unit that you thought might be controversial in that maybe you have an opinion and other people might feel differently?

Probably when we talked about reproducing fertilizing eggs and giving them to people. I think that cloning people was wrong. Maybe animals are okay as long as it's for purposes, not just for cloning. To do it just to clone them, I don't think that's right.

Let's say that you own a dairy cow and that dairy cow produces twice as much milk as other cows and you would like a whole herd of them. Would you want to reproduce the good cow?

If we needed more milk or enough demand was there, I think that it would be all right.

Let's just say because it's more profitable.

Maybe to a certain point but not so many that we have like all the same cow because animals are meant to be different and not meant to be all the same. We shouldn't all have all the same one thing.

Jerry: She pointed out that it would be ok only if there was enough demand and not enough farms. Then it would be all right if it was necessary. She didn't want animals all the same.
Kevin: This would be a penetrating and novel viewpoint.
Dan: I was impressed that she brought up the idea of demand making it ok.

Perspective-insightful. 4-A
The raters were impressed that Kate had viewpoints that none of the raters had ever considered such as "animals are meant to be different and not meant to be all the same." She brought up that she felt cloning people was wrong and surprised the raters by being aware of and having an opinion about embryo transplant procedures. The raters all

agreed that these remarks were best described by the definition of Perspective – Insightful: "a penetrating and novel viewpoint; takes a long and dispassionate critical view of the issues involved" (1998).

Role play again somebody who might have a different feeling about it.

For people whose child had died, they might want to reproduce their child. Maybe if they lost their dog, they might want another one.

Empath-mature. 5-A
It took surprisingly little prompting to get Kate to propose that, in spite of her dislike of cloning, others may want to recreate a dead child or even a lost pet. All of the raters saw this as Empathy – Mature: "Disposed and able to see and feel what others see and feel; unusually open to and willing to seek out the odd, alien, or different.

Dan: All of the students kept going back to the issue of cloning people. They really don't like it. This is when I felt an awareness of family issues and reproduction. Maybe they see that in the future.
Jerry: And how easily this can get out of hand.

What about therapeutic cloning? Let's say you have a diseased liver and they want to take a few cells from it and grow you a new liver. Would that be okay?

I think so.

What have you learned in this class that makes you think differently than you did before hand?

Maybe genetic modification, I didn't know that much about it and I didn't know the different plants that were modified with the active genes from other plants.
I didn't think anything of it before, but now I think that if they are going to affect us in any way, in any bad way, we shouldn't be reproducing them.

Do you think you're more concerned about genetically modified foods than you were before?

I'm more informed. I don't know if I'm more concerned.

Dan: That's biotech learning right there. She wasn't aware of this information and now she knows. Where should we put that?
Kevin: She goes back to the impact of biotechnology.
Jerry: That would be perspective.
Dan: Is understanding that genes are moved an indication of perspective?

Jerry: I love the statement she made, "I'm more informed, I don't know if I'm more concerned." This was specific to genetically modified foods.
She knows where she stands on this issue. Genetically modified foods are not a big deal.
Kevin: She seems better able to take a stand. This could fall under Perspective – Considered 4-C

Perspective – Considered 4-C

The raters agreed that Kate had shown evidence of perspective with her remarks about what would be ok with regard to therapeutic cloning and genetically modified foods. Given that she understood that she was now more informed than before and she knew that there were issues involved and that she knew where she stood on those issues, the raters chose the level of Considered: "a reasonably critical and comprehensive look at all points of view in the context of one's own" (1998).

Is there anything about your personal background that you can think of that help you decide how to deal with information that you've learned?

Not really, I don't think so.

Looking at your survey there weren't a lot of questions where you shifted a lot.
Question 28 was that early diagnosis of a genetic disorder should be made only if the disorder is likely to affect the individual. You went from disagree to strongly agree. Do you remember that question?

If something is going to affect them, they should know about its effects. If it's not going to affect them that much, there's no reason to be giving them something else to worry about.

So how did this class change your attitude on that?

It may not have been the class.

Dan: I think she did a good job of explaining her answer on question 28. Why worry about testing for something that might not affect you.
Jerry: I think she's being sensitive.
Jerry: The first time she read the question in the pre-survey she didn't realize the extent that remedy might be available. She's saying that if it could be fixed then they should know about it.

Did you think the survey itself was an educational experience?

Yes, the pre-test, it was like getting us ready for what we would be learning about.

Another one that you shifted a lot on was No. 29, genetic information should be given to expectant parents regarding their unborn child, you went from disagree to agree.

Probably because if it's genetically wrong maybe they can fix it and if they can't they should be aware of that and not totally surprised.

Why do you think you disagreed with that in the beginning?

Because I didn't know that they could be genetically modified.

Empathy – Sensitive. 5-B
The raters felt that Kate was acknowledging that she had changed her attitude, and indicated that it was do to something that may have come from outside the classroom. Her concern about when people should be given information and how it might affect them could clearly be classified under Empathy- Sensitive: "disposed to see and feel what others see and feel" (1998).

13. Do you think that it's important for tech-ed to include a section on agricultural biotechnology?

Yes, I think so.

If you're going to make any changes to the curriculum or give advice on what should be taught or how much time they should spend on it, do you think it should be more science and less issues or more issues and less science?

Maybe we should do more hands-on things where people can interact with each other.

Do you consider the research project, the PowerPoint, to be an activity?

Yes, because you're not just sitting around.

Dan: She thought, like all the others, that the module was important.
Kevin: Just like the first tape, after we look at the tape together we see more things she learned.
Jerry: And that she changed her views on some things.
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Jack 10th grade

1. What is the main question that you addressed in your research or project?

We did a project on biomanufacturing. We looked up information on it and looked up why it was important for us and what it did for the community.

Kevin: That was a good statement.
Dan: That is going right into application.
Jerry: What about interpretation? Under revealing, it says diverse interpretations.

Interpretation- Interpreted. 2-D
The raters were surprised at how quickly into the interview Jack stated how important his topic was. He had already decided and was willing to state that biomanufacturing was important to his community. After some discussion about the best classification of this understanding, the raters agreed that "what it did for the community" was more about interpretation than application. The level of interpreted included "makes sense of a story; provided a history or context"(1998). For Jack, the context was the community.

Did you choose the subject or was it assigned to you?

It was assigned to us.

2. What information or results did you expect to obtain?

I really just expected to learn what bio-manufacturing was. I wasn't really sure what it was. I learned some uses for it.

3. Are the results of your research or project consistent with your initial impressions of your topic?

I had no idea what it was when I just heard the word. Now I know some new uses, like insulin.

4. Did you uncover any facts that you found particularly interesting?

Well, I wasn't really sure what insulin was but I found out that it's used to help diabetes and we found out that it's made up of amino acids.

Kevin: It sounds like he learned more than he thought he would learn. He goes on about how it was made up of amino acids.

Explanation, (atypical) In-depth. 1-B

The raters were impressed that Jack learned a little about the disease of diabetes and about the makeup of the drug to treat it. Jack himself seemed impressed over how much he had learned from his research. As factual knowledge gained, the classification chosen was Explanation. The level of In-depth is described as "an atypical and revealing account, going beyond what is obvious" (1998). *Explanation, (atypical) In-depth, 1-B.*

5. What was the most significant thing you learned about biomanufacturing?

I think that it was combining and using our technology and stuff to better improve the community.

Dan: I think that we're into a high level of explanation. I thought that it was interesting that he saw the whole world as his community. If somebody in California has diabetes, he sees that person as a member of his community.
Kevin: That might be a high level of empathy. He's able to see the value of what he studied.
Jerry: I like it a little better under Application. Skilled.

The raters thought that the comment about community was important but did not come to a consensus about how to rate it, so no rating was given.

6. Do you think that somebody else studying the same material that you did would come to the same conclusion about it that you did?

Perhaps. I had two other partners and one of them was only there half the time. I think that if they had paid attention they would understand the way that I do.

Did you come up with any information that you might have had an opinion about?

I really don't think so. Basically, what we found out was facts.

So it was pretty straight science?

Yeah.

How did you do your research, was it mostly on the Internet?

Yes.

7. Did you come across any web pages where you had difficulty interpreting the data/facts/text/events?

Not really. We decided what we needed to present on, not too much hard-core science words. We used a web site that breaks it down for us. Google.

8. How did you go about making sense of the data/facts/text/events?

We would go down the list of sites and if one was too technical we would just go to another one we understood.

Dan: Same sophisticated use of the Internet.

The sites that you used, were you pretty confident about what they were saying?

I did understand for the most part what they were saying. Some talked about molecules and stuff that I haven't learned everything about yet and how they all bind, but I knew enough about it.

Dan: I was real impressed that he didn't let any of the information intimidate him.
Jerry: He said that there's things in front of him that deal with biotechnology and biomanufacturing. He's now aware of how broad that topic is.
Kevin: Combining that with earlier comments, does that bump his remarks up to a higher level.
Dan: So you're saying that it is Self-knowledge. Circumspect, 6-B.
Kevin: His deep understanding of his own boundaries pushes him up to wise.

Self knowledge-Circumspect, 6-B

There was not agreement on the level of wise because there wasn't enough indication of any kind of deep understanding. However, all the raters agreed that he did qualify for the circumspect description, Self knowledge-Circumspect, 6-B: "knows the strengths and limits of one's understanding" (1998).

Did you have people on your team that were stronger or weaker?

They're very smart, both of them. I would like to do another project with them.

9. Can you visualize a situation where you would use what you have learned either from the project or from the instructional unit?

Probably if I became a scientist I could go back and look at facts but right now I don't think I would do this.

What about just reading newspapers? Do you think this material would come up again for you?

Yes probably.

10. Is there any real world practice that you think should be changed based upon what you have learned?

I think that what they're doing is not all bad; they're trying to see what is going on, but I don't think they should take it to the next step with humans because we don't need to clone ourselves.

Dan: Again they jumped backed into cloning. Jerry, did your class zero in on cloning?
Jerry: No, I don't know where it came from.
Kevin: He thinks that scientists are trying to figure out what's going on, but they shouldn't take it to the next step. That would be Perspective, Considered. 4 C
Perspective-Considered, 4-C:

All of the raters agreed that the firm opinion expressed about cloning humans qualified as Perspective-Considered, 4-C: "A reasonably critical and comprehensive look at all points of view in the context of one's own" (1998).

Other than cloning humans, do you have any strong feelings about anything else in the unit?

The plants; they were trying to clone plants to see if we could make them from scratch. I don't know if we should actually eat those. I don't think we should eat them before we find out that there's nothing wrong with them.

Interpretive–Revealing, 2-B
The raters felt that the opinion Jack expressed about cloning plants included an "interpretation and analysis of the importance/meaning/significance" (1998).

Let's say that in the grocery store you see food that is marked that it is not genetically modified; would you pay extra for that?

How much extra do you mean?

Lets say you go into a grocery store and see a box of cornflakes for 3 dollars and another one that says that it is organically grown not using the GM products for 4 dollars, would you pay the difference?

I think I would. Unless I knew otherwise that people have been using the other cornflakes and nothing was happening to them, then I would probably try them myself.

Dan: He's much more skeptical about GM foods than the others. He's willing to pay more money for the non GM.
Kevin: That would be Perspective, Considered.
Dan: We've already given him that rating on a similar topic.

11. Based on what you have learned, do you think that you would be better able to handle a related real world issue?

I think so; basically we are learning stuff that's really important. In the future I'll come back to that and realize that I know some things that other people don't about what's better to do.

Jerry: I had that down as self-knowledge. I would call that wise.
Dan: He is even saying that he now knows more than other people. I'd like to see more before giving him another rating.

I'm interested in how you might see other people's perspectives. You're kind of uncomfortable with genetically modified foods aren't you?

Yeah.

What about the people who say that's nonsense, it's as safe as any other food, we've been eating it for years. Why do you think that you start out with one attitude while somebody else might start out with another attitude.

Just based on things I already know. I don't see the point in modifying food if we already have food. I don't know why we should start making all that stuff we already have.

Let's say that somebody else has the opposite point of view. With genetically modified foods we can grow faster, we can use less pesticide, we can make it healthier, we can make it more abundant in the Third World countries. Why do you think they would see the same material in a different way than you?

With what I just heard, those are great reasons why you probably should make them, but I feel different. Probably based on information that's been passed down to me.

Dan: That's self-knowledge
Kevin: We already rated him high in that area.

12. I would like for you to do a role-play for me. Imagine yourself to be a person with a different attitude and explain why that person might think or feel that way about your issue.

I would rather believe in cloning an animal because maybe we'll have less disease or other things. We'll have to expand the food supply because we'll probably need the food.

Jerry: Empathy or perspective. He was showing empathy, mature. Able to see and hear what others see and hear. Maybe,
Perspective, Insightful. 4-A

Perspective, Insightful. 4-A

This was an interesting role-play. Jack initiated an idea that had not been brought up before. "we'll have to expand the food supply because we'll probably need the food." All of the raters agreed that this was "a penetrating and novel viewpoint" as listed under Perspective- Insightful, 4-A (1998).

Do you think that you've learned a lot in this section?

I basically learned about what manufacturing is and how it can help us, what it can make, and why we should use it.

What about your attitudes? Have many of your attitudes changed?

Not really, but I didn't have the point of view on the subject so now I do. I haven't really changed.

Jerry: I thought that was perspective.
Dan: That is change, going from no opinion to having an opinion.

On the survey questions, you initially agreed with the practice of cloning for medical research, were neutral on show breeds, and were against it to make more food. Later you agreed that it was ok for show breeds and became neutral on cloned food for human consumption. In other words, you are moving more towards more acceptability.

I think there's less chance of getting diseases from plants since they don't consume other animals.

On question 34: Genetically modified organisms disrupt the balance of nature. You strongly agreed the first time through and then you were neutral on it.

I think with animals they could disrupt the balance of nature. They can start acting differently or changing from what they want to eat.

Jerry: I didn't discus this in class. He inferred it himself.
Kevin: He was able to tie it into this discussion.

Jerry. How would you classify that?
Kevin: I see that as interpretation or application. Confident in applying skills in various contexts.
Application, Masterful. 3-A

The raters were startled by the idea of animals "acting differently or changing from what they want to eat." This was a concept that none of us had ever thought about. The best facet was believed to be Application. Further, the definition identified was "able to use knowledge and adjust understanding well in novel, diverse, and difficult contexts" Application-Masterful, 3-A (1998).

Would you be more open to the idea of modified animals now?

Yeah, if I had more information on it than my answer could change a lot.

Do you think that this section on biotechnology was an important part of this tech-ed class?

Definitely, we're learning more about technology that we have now, the technology, the earth, and how to use plants and animals. We're going to learn a lot more and go back to it in later years.

13. Do you think that it's important for tech-ed to include a section on agricultural biotechnology?

Yes, I think it is actually.

How would you change it?

I like the projects that we did. Maybe if we just did more research on it.

Do you think that you should have spent more time on biotech and gotten deeper into it?

Yeah, probably.

Did you cover this material in your other classes, like in your science classes?

Not the stuff I just learned. I hadn't learned any of it in my other classes. We might not have gotten to that point.

What would be the big message that you'd like to say about this module?

I learned a lot and I wouldn't mind learning more information. The stuff they gave us was good.

Do you think it's important to spend time on the issues instead of just science?

Yes, I think we should learn about the issues and not just science.
It’s a great topic and I wouldn’t mind learning more.

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David 10th grade

1. What is the main question that you addressed in your research or project?

What is biomanufacturing?

2. What information or results did you expect to obtain?

I thought that it had something to do with reusing products.

3. Are the results of your research or project consistent with your initial impressions of your topic?

There was something a little different.

Do you remember any specifics, anything that is bio manufactured?

Insulin.

So your impression was changed?

I realize that there's more to it and that it helps us in lot of different ways and a lot of different things. Instead of using fossil fuel we can use biotechnology to make different products.

4. Did you uncover any facts that you found particularly interesting?

Not really. Oh, that it's used to make medicine.

5. What is the most significant item that you learned from this research or project?

That we can make different medicines for different things. When we learn more about it we can use it to cure different diseases.

Kevin: He has already identified several points. His impression about what bio-manufacturing was has changed, and he sees it as making medicine.
Dan: These things seem to fit under Interpretation–Interpreted, 2-D.
Interpretation–Interpreted, 2-D.

The raters all agreed that it was higher than literal since David understood the significance. It was less than Perceptive because his comments lacked levels of interpretation.

6. ***Do you think that anybody working on the same project as you or studying the same information would reach the same conclusions?***

Probably.

Where did you find your material?

The Internet.

7. **Did you come across any web pages where you had difficulty interpreting the data/facts/text/events? How confident are you of their meaning(s)?**

We tried to look at the difficult material and tried to simplify it a little bit, but some of it was just too hard so we went to a different web site.

8. **How did you go about making sense of the data/facts/text/events?**

Was there any process in terms of making sense of the material or the tables or charts? Did you work with your team or work by yourselves?

We worked together on that.

Did that help?

That helped.

Could you give an example of that?

When something might be somebody's weakness but another person's strength. When we were trying to read the stuff on the Internet that was hard to read, there was one person that could read it easier than the rest of us could.

Dan: I was impressed that he said that they worked together and that helped.
Jerry: It was interesting that all three of these boys (the ones on this project) were athletes. When you talk about biomanufacturing, these guys are all very well versed in supplements.
Dan: Because the resources were so difficult, much of the material lent itself to tables and charts, like the increase in the use of biofuels. They did a significant amount of learning from each other. (synergy) This type of cooperative learning was not one of the six facets.
Jerry: they approached this as a problem solving activity. They had to work through it. Problem solving is one of the standards. Learning the ability to work together as a team is a

type of knowledge that there should be a classification for, but none are included in six facets rubric.

9. Can you visualize the situation where you would use what you have learned either from the project or from the instructional unit?

Yes, once they further their knowledge more, it will come up in politics or something like that.

Is there anything that you thought was a political issue or will become a political issue?

Maybe cloning or something like that. And genetically engineering different foods and things.

Jerry: I thought it was interesting that he brought up the whole idea of the impact of this topic regarding politics.
Dan: I would call that application, wouldn't you?
Kevin: He sees that as an issue and becoming an issue in the political arena.
Application- Apprentice, 3-D

The raters saw the insertion of politics into the discussion by David as Application. However, there was no depth to the discussion at this point, so it was left at the level of Apprentice, 3-D " relies on a limited repertoire" (1998).

How do you feel about cloning?

I don't think cloning is such a good idea because I think it might get in the wrong hands and will be used for bad things. Genetically engineering foods is a good idea because they can help us with medicines and help people to eat healthier.

What kind of bad things did you imagine?

Cloning people multiple times.

One family could die out while another family that is richer can multiply so their family name keeps ongoing. Unfair advantage.

Dan: I interviewed four kids altogether, and everyone of them brought up the subject of cloning, and in particular, human cloning. I want to know Jerry, did you make that a lecture topic or did they pull this out of the material and decide that this is where it's going?
Jerry: I don't know that I made it a lecture topic. We mentioned dolly the sheep and the potential for growing organs. We said that because of so many unanswered questions that it was currently illegal to clone humans. Other than that, I didn't mention it a lot.

Kevin: I wonder if that might be a hot topic in their biology class.
Jerry: They had studied a little bit about genetics before we got into this, but I don't think they studied it in great detail.
Kevin: He called it an unfair advantage.
Dan: Definitely some strong moral concerns here; where do you want to put that? (six facets).
Kevin: (reading from six facets book). Perspective-insightful, 4-A, " A penetrating and novel viewpoint. Takes a long and dispassionate critical view of the issues involved." (1998).
Dan: We're good with that?
Jerry: Yeah, that would be good!
Perspective-insightful, 4-A

Perspective-insightful, 4-A, " A penetrating and novel viewpoint. Takes a long and dispassionate critical view of the issues involved." (1998).
David was less prone to give lengthy answers that could be easily evaluated.

What about therapeutic cloning, like if you had a diseased liver and they grew a new one for you?

That would be okay, but not cloning all human beings.

Jerry: I noticed that he sees a definite difference between cloning to repair an organ as opposed to cloning a whole human being. That would be interpretation, profound.
Dan: It's certainly something that he's pondered, but I don't think that he said enough to justify the highest rating in that facet. I saw his remarks as literal; a simplistic or superficial reading.
Interpretation-Perceptive, 2C

The raters all agreed that the remarks about cloning were a significant expression of an opinion that belonged under interpretation. The consensus finally reached was that the best level was Perceptive, 2-C, "A helpful interpretation or analysis," (1998).

What about cloning food, do you see any problems with that?

Not really.

10. Is there any real world practice that you think should be changed based upon what you have learned?

I think medicine should use more biotechnology. It could be used to find cures for more diseases.

Is there anything that they're doing now that you think they should stop.

Cloning animals, I don't think they should do that.

What is your objection to cloning animals?

They can create a whole species of defective animals.

Kevin: He brought up the possibility of creating defective animals. He mentioned the possibility of a genetically modified species intermingling with a natural species, and the problems that could cause. We did go over that in class.
He also mentioned coming up with cures for diseases that we might not have medicines for now.
Dan: I would call that application-skilled 3-B.
Application-skilled 3-B.

The raters all agreed that David's remark about creating a species of defective animals their intermingling with natural species, and new medicines indicated the facet of Application-Skilled, 3-B: "Adapting understanding in a variety of appropriate and demanding contexts" (1998).

11. Based on what you have learned, do you think that you would be better able to handle a related real world issue?

If anybody asked me questions about it I would better be able to understand or have a discussion about different topics, like cloning.

What about if a family member would tell you that they were going to be treated with some high-tech biotechnology, would you have a better idea what it's about?

Yes. I would have a better idea what they're talking about. Like therapeutics, I'd know what they're talking about.

12. I would like for you to do a role-play for me. Imagining yourself to be a person with a different attitude and explain why that person might think or feel that way about your issue.

I think that some people would see the advances in the negative way. Instead of me seeing advantages, they might see disadvantages. Thinking maybe the medicine can hurt more people than it helps.

Yes in general. Its general advances are good.

I don't know someone with the exact opposite of what I thought. Maybe that's something that should be left alone such as maybe cloning or genetically engineered food.

If you were to see GM free foods selling at premium price, would you pay more for them?

No, I wouldn't pay more.

Let's say you want food that was not genetically modified, give me an argument on why you feel that way.

Because I don't know what's been done to make it genetically modified. I don't know if it could hurt me or how it could affect our environment.
Interpretation- Interpreted, 2-D

David had straightforward ideas and opinions, but did not elaborate very much. He did connect bio-manufacturing with cures for more diseases. The raters agreed that this was a lower level than he was given to the remarks about cloning since it lacked the differentiation that the cloning remark included. The consensus was for the facet of Interpretation- Interpreted, 2-D: "a plausible interpretation" (1998).

Some people have approached this stuff, bio manufacturing, and genetically modified foods, with the negative feelings about it. What I want to know is can you zero in on why you had the attitude you had. Why do you have your attitudes? Can you think of anything in your own personal background?

Not really. Some things are against what I think like the cloning.

Where do you get your feelings from?

I just don't think it would be a good idea, the thing to do in society. There's a lot more bad things that happen, maybe I get that from movies or something.

Can you think of any TV shows or movies?

No, not really.

13. Do you think that it's important for tech-ed to include a section on agricultural biotechnology?

Yeah, I think it was so we can better understand these topics when it comes up.

Or maybe it should be covered in biology class.

This material talked a lot about issues as opposed to hard science. A little different than in biology class in that you weren't memorizing a lot of chemicals or doing sophisticated labs. Do you think it was worth talking about issues as opposed to just getting into the nuts and bolts of the science?

I think that issues are important but the nuts and bolts need to be more in the science class.

What science classes have you done? Earth science, biology

Were the other classes nuts and bolts or did they cover issues?

We learned the nuts and bolts but we also talked about the issues so we learned the nuts and bolts and if we had questions about the issues we talked about them.

Like cloning mostly. Talk about maybe cloning liver or fingers or something.

Getting a message to the people who design curriculums, what would you tell them about this instructional unit?

That it's a pretty important thing we should really learn more about it. We need to study more of the nuts and bolts than the issues so we can better understand issues.

Would you like to spend more time on this unit?

Probably I would like to spend more time in my science class.

Do you think that you'll look back on this class or this research project and think of it as an important part of education?

Yes I do.

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Chuck 10th grade

1. What is the main question that you addressed in your research or project?

The main question was about groundwater pollution and how it's caused and how we can prevent it.

2. What information or results did you expect to obtain?

Mainly like practices that scientists have discovered for taking bad nutrients out of the water to help purify it.

3. Are the results of your research or project consistent with your initial impressions of your topic?

Yes, we've been going over this in ecology class so we are really comfortable with it, so I was pretty much not as surprised since I already had a pretty good background in the subject.

Dan: Self Knowledge, Innocent or unreflective
Kevin: He identified the main problem. That would be Explanation-Developed, 1-C.
Explanation-Developed, 1-C.

Chuck seems like more of a scientist than the other participants in that he stated that he was comfortable with the science concepts, even though his terminology didn't seem quite right "removing bad nutrients." The level chosen was Explanation – Developed, 1-C "there is supported theory but insufficient or inadequate evidence and argument" (1998).

Did you pick that subject yourself or did Jerry pick it for you?

He assigned it to us.

When he went over the subjects, I said we had just learned that in ecology class.

So you suggested that he give you that topic?

Yes.

Tell me about your ecology class. Do you study issues or do you study hard science?

We pretty much study everything. That class is pretty much a hands on class. We go down to North River where we do pH scales, acidity, and nitric levels.

You like that class?

Yeah, it's a new class like a mix between biology and agriculture it's called ag-ecology. We usually have a good amount of field trips like to farms and hands-on experience to know exactly what it feels like. It's a pretty good class.

4. Did you uncover any facts that you found particularly interesting?

I found out more about pollutants that come from manufactured products like pesticides and dishwasher detergents. I didn't realize that there was that high level of nitrates and phosphates in that kind of sources. It was pretty good to know.

Jerry and Kevin: Understanding about pollutants.
Application: Masterful, confident in using skills in demanding contexts.
Dan: I just don't see that as mastery of the information.
Jerry: I think skilled.
Dan: I do too. Let's knock it down a notch. Application-Skilled, 3-C.
Application-Skilled, 3-C.

There was agreement among the raters that the discussion about pollutants was Application, but some discussion about the level. Where Jerry and Kevin considered the mention of specifics, pesticides and dishwasher detergents, as mastery, "fluent, flexible, and efficient," Dan saw it as Skilled, "competent in using knowledge." In general, Dan was concerned that the ratings were becoming a bit inflated, and he persuaded the other two raters to agree to a lower level.

Was what you found consistent with what your initial impressions were?

Yes, it was pretty much on the same lines of what I was thinking.

5. What is the most significant item that you learned from this research or project?

Probably about how much water can actually get polluted. I saw this picture on the web site where this lake was completely red from all the waste that was dumped into it. It was pretty interesting because I never knew that water can get that bad.

Dan: He saw a picture and now he understands. That's interpretation.
Kevin: What level?
Jerry: The Interpreted level reads, "analysis of the importance/meaning/significance."

The raters stayed with the rating of Interpretation-Interpreted, 2-D. "makes sense of a story," (1998).

What do you think was the most significant thing about that?

Probably about the BMP's.

Tell me about the BMP's.

Like they found new ways to balance water levels by the chemicals. I thought that was pretty big.

Kevin: That was a significant statement. He sees the importance of this.
Dan: He's talking about remedial chemistry, like limestone. That's application.
Kevin: He goes on about BMPs. That's masterful.
Application-Able, 3-C

The raters noted that Chuck was specific about BMPs and about treating pollution with limestone. Once again, Dan was concerned about the ratings becoming inflated. Kevin suggested application, masterful which was defined as using knowledge in "novel, diverse, and difficult contexts." The final agreement was on
Application-Able, 3-C "Able to perform well with knowledge and skill in a few key context" (1998).

Tell me what that stands for.

Best Management Practices

Could you expand on that for me?

BMPs are used to keep pollutants out of the water.
Some are fences that farmers have to put up around the streams to keep the cattle out and like dumping limestone in some water will help neutralize it.

Who issues BMPs or who comes up with them?

Usually just like biologists and scientists in the area of water. There's a bunch of organizations that usually help.

6. Do you think that anybody working on the same project as you or studying the same information would reach the same conclusions?

Probably not. Like if it was someone who didn't have the background that I got prior to this year they would probably have different opinions on things and they might think of more out of the ordinary facts instead of just big facts. I think we would probably come to different conclusions.

Dan: I think we are ignoring that perspective facet.
Jerry: I think that it shows discrimination and qualification.
Kevin and Jerry: Perspective thorough, Self-knowledge.

Perspective-Thorough, 4-B

The raters all saw it as significant that Chuck saw himself as reaching different conclusions than others would. This had to do with his own self-image. They identified this as Perspective-Thorough, 4-B "Makes own view more plausible by considering the plausibility of other perspectives" (1998).

Kind of role play for me somebody reaching a different kind of conclusion, what kind of conclusion might they reach.

They would probably conclude that it's mainly just that big things are needed to help water quality, like BMPs and stuff, instead of little organisms that take up big amounts of water and stuff. They might look more into how chemicals effect it and what practices clean the water.

Kevin: Perspective: Insightful, "a long and dispassionate view of the issues."
Perspective-Thorough, 4-B

Kevin suggested raising the rating to a higher level. Perspective-Insightful 4 A "takes a long and dispassionate critical view of issues involved" (1998). Dan asked for that level be reserved for more developed ideas, so the raters left the level at 4 B, Perspective-Thorough, 4-B "Makes own view more plausible by considering the plausibility of other perspectives" (1998).

7. Did you have any trouble interpreting the information you found?

Some of that like different chemicals, I don't know about the chemicals so that was kind of confusing.

8. How did you go about making sense of the data/facts/text/events?

I usually tried my best to just read through it and try to figure it out for myself. I went to other sites to find out about the chemicals and help me better understand that.

Kevin: He went from site to site to learn more information.
Dan: the question was about interpretation. He's looked up what he didn't know. That's interpretation.

Did you ever come across like a separate item that you didn't understand and try to separately research that?

When the chemical list for water came up that had manganese on it and I didn't really know what that was, so I went to Google and typed up manganese and found the table/ chart of what the element does.

So what did you find out about manganese?

It does a lot of stuff.

I found out that it was sometimes harmful to plants and sometimes humans who have certain allergies or certain medicines they're taking.

When you did interpret the information that you found on the web how confident were you that you got it right?

I was pretty confident. I'm pretty good with computers. I know what's good information and what's bad information.

Could you tell me what you mean by good information and bad information.?

Good information would be exact textbook information and not just a short paragraph definition. With good information it goes into depth sometimes a few pages long.

So you like the technical information.
Interpretation-Revealing, 2-B

Interpretation-Revealing, 2-B "interpretation and analysis of the importance/meaning/significance" (1998). In particular, the raters note that Chuck had gone to another source to look up manganese and to interpret what he found with regard to pollution.

9. Can you visualize the situation where you would use what you've learned either from the project or from the entire instructional unit?

I would say that if I joined a team like a water control team that goes around checking farms to make sure that their BMPs are up to par. Like figuring out the chemical levels and trying to create new BMPs.

Kevin: That would be Application, Masterful 3-A

Jerry: Let's see where he goes with it first.

10. Is there any real world practice that you think should be changed based upon what you have learned?

Probably the waste that is dumped by companies. They have direct sources that pump right into the river and I was thinking that they could change that to a tank where the chemicals could be neutralized, reused, or purified.

Why do you think they don't do that now?

Probably a money issue. Because it's pretty expensive to figure out ways to neutralize waste with the tanks in the ground. I think it's mainly the money issue.

Application, Masterful 3-A

Application, masterful 3-A "Able to use knowledge and skill in novel, diverse, and difficult contexts," (1998). The raters agreed that being specific about neutralizing waste and it being a money issue warranted the highest level rating in application.

11. If you encounter one of the related real world issues, you think based on what you learned you'd be better able to handle it?

Probably, since I didn't know anything before this. From what I've learned I think I could better handle it and maybe give ideas and just try to give the right opinion on it.

Let's say you have an opinion on something and somebody else sees it differently. Can you visualize an illustration of that?

Probably what I would do is listen to their idea and relate it to mine and differentiate between them and try to figure out what were the good parts of each. If they're right they're right. If not I would help them to understand my idea.

Did you start out with any basic assumptions that kind of define who you are or what your perspective is?

Kind of, like in some web sites I saw that scientists solve a problem like I did.

What is there in your background that you think makes you think along the same lines?

I'm more into agriculture and I think it's good to help me understand more about different spots of agriculture and study more on it.

Do you think you would like to work in agriculture?

I'm thinking about it. I think it would be cool to be a teacher like my ecology teacher and teach kids how to do it. Spread the word on BMPs and help them understand it.

What kind of education do you think you need for that?

Probably a teaching degree, and if I want to get into agriculture some kind of agriculture degree.

Have you thought about specific college programs that you might get into?

Right now I've requested information about colleges just to see what kind of minors and majors they offer and determine which would be the best for me. Right now I'm just trying to look at my options.

12. I would like you to do a role-play about somebody with different attitudes. Let's say you're talking to somebody who's been managing a farm and doing things the same way for three generations. And they think that the people talking about best management practices don't have the same kind of experience that they do. Kind of role-play that position for me.

As the farmer?

Yes, as the farmer.

I would understand how I've done it for generations and it would be pretty hard to change my ideas. Maybe if I were to listen to a few small ideas I could maybe help just a tiny bit. It would probably help out the world and probably my income if I was raising cattle and I was able to give them pure water.

Let's say that the government man comes to your farm and says, "You know that those acres you've been herding cattle on or planting for the last 20 years, we think it's bad for the river and we want you to stop."

That would be tough because if I was working the same land for all these years and still making an income I would tell the government to make sure that their information's right.

The guy who's been doing it for generations, they came over here for farming, I don't think they would want to change that, and they have all that background and the government guy probably has never been on a real farm.

The interviewer was more specific in his questions towards this participant. The raters felt that Chuck was particularly insightful, the highest level possible under the facet of perspective. 4 A Perspective - Insightful. "A penetrating and novel viewpoint, effectively critiques and encompasses other plausible perspective; takes a long and dispassionate view of the issues involved" (1998). Chuck was able to talk a great deal about pollution and at the same time discuss that clean-up was a money issue. He was also able to understand the difficulty involved in instituting change.

Do you think that you'll use the knowledge you gained in this class?

Probably it will help my research to have a better background when I go to college and it will help make sure I take the right courses, it helps spread the word.

The raters were impressed that Chuck was specific about how this course would benefit him in saying that it would help him to choose the right courses in college. They agreed that this illustrated Application-Able 3 C. "Able to perform will with knowledge and skill in a few key contexts," (1998).

Were you influenced by knowledge and attitudes you had beforehand? Other than ecology class.

Probably not. I got stuff from Internet sites. The class really opened me up.

You're talking about the ecology class.

Yes.

I wanted to go over some questions on your survey.

Question 10. The cloning of animals is an acceptable method of reproduction for animals and human consumption.

You started out neutral. On the post-test, you went to disagree. Do you disagree with that now more than when you started the unit?

It just went against my beliefs and I do not see why anyone would have to clone animals. I think things are ok the way they are. I don't see why you would have to clone something if everything can come naturally if you just leave it be.

Dan: I thought that was surprising. Most people became more accepting of biotech as they went through the program. He clearly went the other way.

I would like to know why you had a changed attitude.

At first, I didn't know anything about it. It was the packet of information that changed my attitude. After reading the packet, I liked it less than before.
Application, Masterful 3-A

Application-masterful, 3-A. The raters were convinced by Chuck's remarks about his attitude being changed by the packet of information that he was "able to use knowledge and to adjust understanding well in difficult contexts" (1998).

On whether or not genetically modified organisms are safe to eat, you went from disagree to agree.

I think along the lines of animal products. Everything should come naturally. You shouldn't mess with nature.

What do you think you got out of this instructional module?

I think I got a lot about how they clone plants. I learned a lot about how cloning works from dissecting the banana. I thought it was pretty good.

Dan: So he saw a presentation and was impressed by it. It wasn't a table or a graph, but it was still interpretation. What do we have for a lot of interpretation?
Jerry: We don't know what he go out of it. Leave it at interpreted?
Kevin and Dan: Agreed.

When the raters discussed how to evaluate Chuck's statements about dissecting the banana, it was agreed that this was interpretation of a demonstration, but not at a higher level than Chuck had been given for earlier remarks. 2-D. Interpretation, Interpreted "A plausible interpretation or analysis of the importance." (1998).

What about your research project?

Do you think you learned a lot from the research project vs. class work?

I think I do. I go research what I'm looking for and it helps me understand better.

Do you think you learned anything outside the material, like about how to do research for things like that?

Yeah, like when I did the PowerPoint's. I've only done one before. The practice will help with later activities.

If we're going to go back to the people who design curriculum that you did in this class, what changes should be made?

Maybe more on the opinion they have on cloning. They look at it in good ways that it scientifically could be used for. There's probably a lot of people out there that disagree with that. They probably should just try to give plain facts out instead of trying to change people's minds.

Dan: Chuck clearly does not like cloning. Because of his strong opinion that we need to put under Perspective, aware.
Kevin: On his opinion of cloning, is he making any allowances for other points of view?
Jerry: He's aware of other points of view.
Kevin: That would be aware or considered.
Perspective-Aware, 4-D

As indicated by the rater's discussion shown above, the facet chosen for Chuck's remarks about cloning animals was Perspective-Aware, 4-D, "Knows different points of view and somewhat able to place own view in perspective" (1998).

When you talk about the module are you talking about the material that Mr. Ridgeway already had or were you talking about the unit?

Maybe just the largest material I think.

Do you think it's important to cover issues as well as just nuts and bolts.

I think it is important because it is important to have young minds understand that they can explain that to others. I think it is good to have young generations know about that now.

13. Do you think it's important to keep biotech in the tech-ed curriculum?

I think it is.

APPENDIX L

Statistics on Survey Item 1

The UNIVARIATE Procedure
Variable: diff

Moments

N	30	Sum Weights	30
Mean	0.1	Sum Observations	3
Std Deviation	0.84486277	Variance	0.7137931
Skewness	-0.198496	Kurtosis	0.41348967
Uncorrected SS	21	Corrected SS	20.7
Coeff Variation	844.862772	Std Error Mean	0.15425013

Basic Statistical Measures

Location		Variability	
Mean	0.100000	Std Deviation	0.84486
Median	0.000000	Variance	0.71379
Mode	0.000000	Range	4.00000
		Interquartile Range	1.00000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	0.648298	Pr > |t|	0.5219
Sign	M	1.5	Pr >= |M|	0.6072
Signed Rank	S	10.5	Pr >= |S|	0.6509

Location Counts: Mu0=0.00

Count	Value
Num Obs > Mu0	9
Num Obs ^= Mu0	15
Num Obs < Mu0	6

Quantiles (Definition 5)

Quantile	Estimate
100% Max	2
99%	2

95%	1
90%	1
75% Q3	1
50% Median	0
25% Q1	0

question 1
The UNIVARIATE Procedure
Variable: diff

Quantiles (Definition 5)

Quantile	Estimate
10%	-1
5%	-1
1%	-2
0% Min	-2

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
-2	15	1	19
-1	24	1	22
-1	14	1	25
-1	12	1	28
-1	3	2	21

APPENDIX M

Statistics on Survey Item 13

The UNIVARIATE Procedure
Variable: diff

Moments

N	30	Sum Weights	30
Mean	0.36666667	Sum Observations	11
Std Deviation	1.12903173	Variance	1.27471264
Skewness	1.35692451	Kurtosis	3.06159818
Uncorrected SS	41	Corrected SS	36.9666667
Coeff Variation	307.917744	Std Error Mean	0.20613205

Basic Statistical Measures

Location		Variability	
Mean	0.366667	Std Deviation	1.12903
Median	0.000000	Variance	1.27471
Mode	0.000000	Range	5.00000
		Interquartile Range	1.00000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	1.778795	Pr > |t|	0.0858
Sign	M	3	Pr >= |M|	0.2379
Signed Rank	S	34.5	Pr >= |S|	0.1383

Location Counts: Mu0=0.00

Count	Value
Num Obs > Mu0	12
Num Obs ^= Mu0	18
Num Obs < Mu0	6

Quantiles (Definition 5)

Quantile	Estimate
100% Max	4
99%	4

95%	3
90%	1
75% Q3	1
50% Median	0
25% Q1	0

question 13
The UNIVARIATE Procedure
Variable: diff

Quantiles (Definition 5)

Quantile	Estimate
10%	-1
5%	-1
1%	-1
0% Min	-1

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
-1	23	1	25
-1	22	1	29
-1	20	1	30
-1	10	3	24
-1	8	4	19

APPENDIX N

Statistics on Survey Item 22

The UNIVARIATE Procedure
Variable: diff

Moments

N	30	Sum Weights	30
Mean	0.36666667	Sum Observations	11
Std Deviation	0.88991799	Variance	0.79195402
Skewness	-0.1961755	Kurtosis	0.81675342
Uncorrected SS	27	Corrected SS	22.9666667
Coeff Variation	242.704905	Std Error Mean	0.16247605

Basic Statistical Measures

Location		Variability	
Mean	0.366667	Std Deviation	0.88992
Median	0.000000	Variance	0.79195
Mode	0.000000	Range	4.00000
		Interquartile Range	1.00000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	2.256743	Pr > |t|	0.0317
Sign	M	4.5	Pr >= |M|	0.0352
Signed Rank	S	34.5	Pr >= |S|	0.0507

Location Counts: Mu0=0.00

Count	Value
Num Obs > Mu0	12
Num Obs ^= Mu0	15
Num Obs < Mu0	3

Quantiles (Definition 5)

Quantile	Estimate
100% Max	2.0

99%	2.0
95%	2.0
90%	1.5
75% Q3	1.0
50% Median	0.0
25% Q1	0.0

question 22
The UNIVARIATE Procedure
Variable: diff

Quantiles (Definition 5)

Quantile	Estimate
10%	-0.5
5%	-1.0
1%	-2.0
0% Min	-2.0

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
-2	19	1	24
-1	27	1	28
-1	9	2	13
0	30	2	15
0	29	2	23

APPENDIX O

Statistics on Survey Item 41

The UNIVARIATE Procedure
Variable: diff

Moments

N	30	Sum Weights	30
Mean	0.36666667	Sum Observations	11
Std Deviation	0.7183954	Variance	0.51609195
Skewness	0.50400441	Kurtosis	0.32037114
Uncorrected SS	19	Corrected SS	14.9666667
Coeff Variation	195.926019	Std Error Mean	0.13116046

Basic Statistical Measures

Location		Variability	
Mean	0.366667	Std Deviation	0.71840
Median	0.000000	Variance	0.51609
Mode	0.000000	Range	3.00000
		Interquartile Range	1.00000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	2.795558	Pr > |t|	0.0091
Sign	M	4.5	Pr >= |M|	0.0225
Signed Rank	S	33.5	Pr >= |S|	0.0164

Location Counts: Mu0=0.00

Count	Value
Num Obs > Mu0	11
Num Obs ^= Mu0	13
Num Obs < Mu0	2

Quantiles (Definition 5)

Quantile	Estimate
100% Max	2
99%	2
95%	2

90%	1
75% Q3	1
50% Median	0
25% Q1	0

question 41
The UNIVARIATE Procedure
Variable: diff

Quantiles (Definition 5)

Quantile	Estimate
10%	0
5%	-1
1%	-1
0% Min	-1

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
-1	25	1	22
-1	12	1	26
0	30	1	28
0	29	2	13
0	27	2	21

APPENDIX P

Statistics on Survey Item 43

The UNIVARIATE Procedure
Variable: diff

Moments

N	30	Sum Weights	30
Mean	0.4	Sum Observations	12
Std Deviation	0.9321832	Variance	0.86896552
Skewness	-0.0985179	Kurtosis	0.51059401
Uncorrected SS	30	Corrected SS	25.2
Coeff Variation	233.0458	Std Error Mean	0.17019259

Basic Statistical Measures

Location		Variability	
Mean	0.400000	Std Deviation	0.93218
Median	0.000000	Variance	0.86897
Mode	0.000000	Range	4.00000
		Interquartile Range	1.00000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	2.350279	Pr > |t|	0.0258
Sign	M	4.5	Pr >= |M|	0.0352
Signed Rank	S	36	Pr >= |S|	0.0406

Location Counts: Mu0=0.00

Count	Value
Num Obs > Mu0	12
Num Obs ^= Mu0	15
Num Obs < Mu0	3

Quantiles (Definition 5)

Quantile	Estimate
100% Max	2.0
99%	2.0

95%	2.0
90%	2.0
75% Q3	1.0
50% Median	0.0
25% Q1	0.0

question 43

The UNIVARIATE Procedure
Variable: diff

Quantiles (Definition 5)

Quantile	Estimate
10%	-0.5
5%	-1.0
1%	-2.0
0% Min	-2.0

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
-2	7	1	29
-1	27	2	1
-1	11	2	13
0	30	2	21
0	28	2	24