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Agricultural Biotechnology: a Convergence of Timelines

by
Daniel E. Stotter

Modern agricultural biotechnology is an evolving discipline that stems from four sources. These are (1) the breeding of plants, (2) the breeding of livestock, (3) advances in cellular and molecular biology, and (4) public policy consisting of the creation of intellectual property rights combined with the actions of regulatory agencies. Most of today's technological achievements in agricultural biotechnology are a reflection of the knowledge and the public policy decisions that these enabling disciplines have contributed over the last two hundred and fifty years.

A timeline is a commonly used illustration that arranges related events in chronological order. Textbooks are replete with timelines that demonstrate the temporal relationship of scientific discoveries and historical facts. This paper identifies a selection of events that preceded or illustrate the emergence of agricultural biotechnology and divides them into four concurrent chronologies that represent the four disciplines mentioned above. Further, this paper will discuss the commonalities that have led to their convergence.

The following definitions of agricultural biotechnology and of modern agricultural biotechnology are available from the U.S. Department of Agriculture (USDA):

Agricultural biotechnology is a science that includes both traditional plant breeding and genetic engineering techniques to develop, modify, or improve living organisms such as plants, animals and microorganisms. It represents a technology gradient ranging from traditional biotechniques such as artificial insemination and embryo transfer to modern innovations which involve genetic engineering, monoclonal antibody production for diagnostics, tissue-culture methods leading to transgenics, and DNA markers to assess variation. Modern agricultural biotechnology allows a specific gene(s) to be moved from one organism to another unrelated species to confer a desired trait (Smith, 2003, p.1).

The Breeding of Plants

Traditional plant breeding involves the cross breeding of plant varieties to improve their genetic qualities. A cross may be performed by transferring pollen from one plant species to another sexually compatible plant of the same or similar species for the purpose of bringing desirable trait(s) into the plant offspring (Smith, 2003).

Although breeding had been practiced for thousands of years, it became a scientific endeavor only at the beginning of the twentieth century with the rediscovery of Gregor Mendel's observations of the characteristics of garden peas. Mendel's laws of inheritance explained how dominant and recessive alleles (copies of an inheritance factor, now referred to as genes) could produce the traits that appear in plant offspring. In a paper published in 1867, *Experiments in Plants and Hybridization*, Mendel created a mathematical model that explained the laws of heredity. The significance of Mendel's work was not recognized during his lifetime but was rediscovered 30 years later (Borem, Santos, & Bowen, 2003).

Genetic variation is created by the mixing of alleles, (alternate forms of a particular gene) and by sudden changes in the genetic material (mutations). In the late 1920s, plant breeding researchers would increase the frequency of genetic mutations by exposing plants to X-rays. Mutations naturally occur only at low rates and most are not beneficial. In general, the goal of plant breeders is to identify advantageous genetic variations within a species (Center for Life Sciences and Department of Soil and Crop Sciences at Colorado State University, 2003). Corn is the largest crop grown in the United States. It is also a crop whose yield has been significantly increased by the use of hybrid seed (seed created by the crossing of two or more varieties). Prior to about 1930, only open pollinated corn varieties were planted. At the present time hybrid corn seed is used almost exclusively (Larson & Cardwell, 2003). New methods of inducing mutations were made possible with the nuclear techniques introduced after WWII. During the post war years, plant researchers began to expose

plant varieties to nuclear radiation and mutation producing chemicals (Center for Life Sciences and Department of Soil and Crop Sciences at Colorado State University, 2003).

The “Green Revolution” is a term used to describe the dramatic increases in crop yields that occurred between 1950 and 1984. These increased yields were the result of the creation of hybrid varieties and by the application of fertilizers. In the developing world as a whole, wheat and rice production increased dramatically between 1965 and 1980. Wheat production in India tripled between 1966 and 1981. The use of hybrid seed varieties also enabled the production of America’s most important crops to more than double between 1940 and 1980, without a significant increase in farm acreage (Nottingham, 1998).

After 1984, crop yields leveled off or declined due to the cost of agrochemicals, increased irrigation demands, and the need to use more farm machinery than was required for traditional varieties. The increased use of fertilizer and pesticide degraded the environment and the overuse of pesticides resulted in increased resistance to these chemicals (Nottingham, 1998). The concern about effects of pesticide use on wildlife was dramatized by the publication of Rachel Carson’s book, *Silent Spring* (1962). One result of the controversy that followed was the banning of the use of DDT in the United States, although this chemical is still used abroad (Gardner, 2002).

In the 1970’s, mutation breeding continued to be popular in the U.S. Over 1000 mutated plant varieties were released between 1985 and 2000 (Center for Life Sciences and Department of Soil and Crop Sciences at Colorado State University, 2003). In 1995, Monsanto Company introduced a new variety of soybean that had been genetically engineered to tolerate applications of glyphosate (Roundup®), a broad-spectrum herbicide. By 1999, over half the soybeans planted in the United States were varieties that were “Roundup Ready®.” The adoption of this technology was shown to be faster than that of any previous agricultural technology or pesticide (Benbrook, 1999). Another group of genetically engineered crops available from Monsanto Company are those altered with a gene found in bacteria, *Bacillus thuringiensis* (Bt), which produces a natural pesticide. In 1995, Robert Shapiro, president of Monsanto Company, proposed that farmers using Bt seed sign a “technology agreement.” This agreement obliged farmers to (1) pay for the use of the gene and (2) not replant their farms with seed generated from their own crops (Watson & Berry, 2003). In 1998, Monsanto Company acquired the rights to a biotech innovation that would create nongerminating plants. The use of this technology, dubbed as the “terminator gene” would force farmers to buy new seed every year. Public opposition to this technology caused Monsanto Company to publicly disavow the technology (Watson & Berry, 2003).

The Breeding of Livestock

Archaeological evidence indicates that domesticated cattle existed in the Fertile Crescent of Mesopotamia by 4000 B.C. Cattle or bos, the family of bovines, is an Old World animal. No remains have ever been discovered in North America. The American bison is a bovine relative (Carlson, 2001).

In the middle of the 18th century Robert Bakewell (1725-1795), a farmer in Leicestershire, England recognized the market for quality beef as opposed to the consumption of worn-out field oxen or dairy cows. He developed a reputation for his abilities in selective breeding. During this period, animal breeding was a fashionable pastime. King George III took an interest in Bakewell and his livestock which in turn helped encourage the purchase of Bakewell’s livestock by elite landlords. Bakewell shipped animals to New Zealand, Australia, Europe, and the Americas, always leasing his sires for a season at a time. “Bakewell’s work created a landmark change in cattle-raising and a new era in genetic manipulation” (Carlson, 2001, p.177).

The first serious use of artificial insemination (AI) was conducted by Russian scientists as a means of improving reproduction of horses. The leading investigator was E. I. Ivanov. In 1899, under his direction, artificial insemination was practiced on numerous government horse-breeding farms. Under his guidance, the use of AI resulted in a better conception rate than natural service (Herman, 1981).

The introduction of AI (early 1930s) to the cattle industry has been the most effective method for the large-scale improvement of farm livestock (Herman, 1981). With the use of AI, the progeny of outstanding sires can be multiplied thousands of times. In addition, cattlemen can obtain services from an outstanding bull that they otherwise could not afford. Other benefits of AI technology include the virtual disappearance of venereal disease and control of genetic abnormalities in the industry (Hinks, 1983). In 1938, the first farmer-owned cooperative artificial breeding association in the United States began operation in New Jersey, modeled after an existing program in Denmark. In 1946, the managers of early AI organizations assembled the National Association of Animal Breeders (NAAB) composed of AI businesses throughout the U.S. and Puerto Rico (Herman, 1981).

The use of AI allows a single bull to sire thousands of cows, but the average cow will have only one calf per year. This means that it is much more time consuming to use the genetic contribution of a superior cow to increase the genetic quality of the herd. This problem can be overcome by the process of embryo transfer. This set of procedures causes a desired cow to superovulate, releasing multiple eggs in a single estrus. Afterwards, the cow is inseminated and the embryos are non-surgically removed. Embryos that have been harvested are then evaluated and those considered to have the most survivability are implanted in recipient cows. Experimentation with embryo transfer on different animals had been tried repeatedly since it was first demonstrated in 1890, but it was not until 1964 that a non-surgical method of embryo collection succeeded. It was not until the late 70's that embryo transfer grew in popularity (Herman, 1981; Selk, 2003).

In 1993, the FDA approved the use of Recombinant Bovine Growth Hormone (BGH), a pharmaceutical introduced by Monsanto Company (trade name Posilac), to increase dairy cow milk production. The product is also known as recombinant bovine somatotropin (rBST). The use of this hormone can increase milk production by twenty percent, but there are indications that BGH may shorten the cow's life and make it more susceptible to injury (Bourgaize, Jewell, & Buiser, 2000).

Advances in the Development of Cellular and Molecular Biology

An early landmark in molecular biotechnology came in 1839, when Schwann and Schleiden theorized that all organisms, including animals, were made of cells. They were the ones that realized that these cells were capable of carrying on all of the basic processes of life (Watson & Berry, 2003).

The hypothesis, now known as the theory of evolution, was put forth in 1859 by Charles Darwin's book *On the Origin of Species*. Charles Darwin explained the theory of natural selection by comparing it to improvements that humans had made in varieties of animals and plants through the process of artificial selection. "Artificial selection, because of its rigorously directed nature, proceeds at a faster rate than natural selection" (Nottingham, 1998, p.2).

In 1902, Walter Sutton discovered that genes are located on the chromosomes. Sutton presented the first clear argument that chromosomes obey Mendel's rules. He showed that chromosomes occur in distinct pairs which segregate at meiosis, the physical basis of the Mendelian law of heredity (Crow & Crow, 2002). In 1928, Fred Griffith showed that genetic material could be transferred from one strain of bacteria to another. This event could be considered the beginning of genetic engineering. In 1944, Oswald Avery and his associates determined that the molecule that transferred traits from one bacteria to another was DNA (deoxyribonucleic acid) (Watson & Berry, 2003). In 1953, James Watson and Francis Crick described the structure of DNA as the double helix (Watson & Berry, 2003). The work done in 1967, by Marshall Nirenberg and Har Gobind Khorana, in deciphering the genetic code is considered by some as the beginning of modern biotechnology. As described by Zhang, "Modern genetics technology began in the 1970's with the development of molecular biology and led to recombinant DNA technology. This technology essentially consists of obtaining a gene from one creature, introducing it into a fast growing type of cell, and harvesting the material encoded by the gene from the cell" (Zhang, 2003 p.201).

In the 1970s, Fred Sanger found a way to use DNA polymerase to read the sequence of a chromosome, creating a genetic map. DNA markers, or genetic markers, are landmarks in a genetic map. DNA polymerase is an enzyme that allows DNA to duplicate itself (Bains, 2003). Sanger and his colleagues developed many of the techniques still used in genomic biology to this day (Watson & Berry, 2003).

Another development of the mid 1970s was the invention of monoclonal antibodies (MAB) at Cambridge University. Antibodies are molecules produced by the immune system to bind to and identify invading organisms. Monoclonal antibodies are those that have been made from a single clone of lymphocytes (B cells) which has been isolated and immortalized for growth *in vitro* (in the laboratory). Current research goals are to use monoclonal antibodies to fight tumors by fusing single antibody-forming cells to tumor cells grown in culture (Bains, 2003; Watson & Berry, 2003). In 1980, Kary Mullis and others at Cetus Corporation were able to multiply DNA sequences in test tubes by a technique called polymerase chain reaction (PCR). With this process, a small sample of DNA is quickly duplicated, thus creating whatever sample size is desired. This process is frequently used in forensics. (Watson & Berry, 2003). In 1993, the FDA approved the first genetically engineered food product, the Flavr-Savr tomato. This product had a much longer shelf life than ordinary tomatoes, but it did not succeed commercially (Nottingham, 1998). In 1997, Dolly the cloned sheep appeared. This was the first cloned mammal from somatic cells of an adult donor (Bains, 2003).

Public Policy: Intellectual Property (IP) Rights and Regulatory Agencies

Intellectual Property is a term that covers patents, trademarks, copyrights, trade secrets, and other means of protecting inventions (Dutfield, 2003). Patent protection is vital to the biotechnology industry. As stated in a law review article, “Biotechnology companies rely heavily on the exclusive rights provided by the patent system to an inventor due to the high costs of research and development in the biotechnology industry” (Zhang, 2003, p.208). A patent system provides potential inventors incentive to invest the time and money necessary to develop new products. Patent protection and trade secrets are necessary to protect the rights of biotechnology innovators (Saliwanchik, 1988).

The United States Patent and Trademark Office is an agency of the United States within the Department of Commerce. Patent law is established by Title 35 of the U.S. Code, the rules and regulations of the Patent and Trademark Office, and by legal decisions handed down by federal courts. In general, the requirements for an invention to be patentable are that it be (1) new, (2) useful, and (3) unobvious (Saliwanchik, 1988). A patent serves to protect the inventor’s investment in time, resources, and money. “The current U.S. patent system provides incentives for the industry to take risks needed to develop products, and encourage public disclosure in order to educate the public so that improvements and alternatives can be explored, which, in turn, foster further invention” (Zhang, 2003, p.198).

There are no federal statutes granting trade secret protection. It is a creation of common law and, in some instances, state law. Any information processed by a business that creates an advantage over competitors that do not know of it could be considered a trade secret (Saliwanchik, 1988).

The primary agency for enacting rules that govern the agricultural biotechnology industry is the U.S. Department of Agriculture (USDA). The Organic Act established the USDA as a cabinet level agency in 1862. Before that date, it existed as the Division of Agriculture in the Patent Office (Nicholas, 2003).

In 1938, Congress enacted the Federal Food, Drug, and Cosmetic Act (FDCA) to protect the public health. Now, called the Food and Drug Administration (FDA), its oversight authority extends to all foods, organically produced as well as genetically modified. For oversight purposes, the FDA treats organic foods and genetically modified foods the same. Current federal regulations fail to distinguish between the two foods based on the method of production, and instead regulate based on the particular food itself (Nicholas, 2003). In 1958, the Food Additives Amendment Act included a caveat for foods

that are Generally Recognized as Safe (GRAS). This allowed the food preparation companies to include these additives without further testing (Watson & Berry, 2003).

As a series of biotechnology innovations was taking place in the early 1970s, a group of scientists met to express their concerns. The outcome of this meeting, called the Asilomar Conference (1975), was a call for a moratorium on recombinant DNA (rDNA) experiments. Scientists at the conference insisted on the development of “safe” bacteria and plasmids that could not escape from the laboratory. The following year Senator Ted Kennedy held a senate hearing on regulating rDNA experiments, but national legislation never came to fruition. As stated in the book, *DNA*, by James Watson, “In practical terms, the outcome of the Asilomar consensus was ultimately nothing more than five sad years of delay in important research, and five frustrating years of disruption in the careers of many young scientists” (Watson & Berry, 2003, p.104).

In a Supreme Court decision of 1980, *Diamond v. Chakrabarty*, the court ruled that a life form, in this case an oil-eating bacteria, could be patented providing that there had been some substantial manipulation of that organism (Zhang, 2003). In 1985, the National Institutes of Health approved guidelines for performing experiments involving gene therapy on humans. This was a watershed event because it meant that animal experimentation could now be taken to the next step. The search for cures and profits followed this ruling (Duarte, 2001). In 1988, a patent was granted to a cancer research group at Harvard University that created a genetically altered mouse prone to developing breast cancer. It was named the “Onco mouse,” but it is often referred to as the “Harvard mouse.” Now owned by Du Pont, it is considered the first patented transgenic animal. A transgenic organism is one that has been altered to contain a gene from another organism, usually from another species. Transgenic animals are a powerful tool for studying gene function and testing drugs, since many human genetic diseases can be modeled by introducing the same mutation into a mouse or other animal. This development was closely related to the procedure for creating tissue culture or the cultivation of tissues, i.e. multicell assemblies, outside the body. The term is usually only applied to animals. The first transgenic animal for food production was the Atlantic salmon, modified for faster growth. This product became available on the U.S. market in 2001 (Bains, 2003).

On November 28, 1990, Congress passed the Organic Food Production Act (OFPA) establishing national standards for organic food in the United States. The OFPA has three purposes: (1) to establish national standards governing the marketing of certain agricultural products as organically produced products, (2) to assure consumers that organically produced products meet a consistent standard, and (3) to facilitate interstate commerce in organically produced products. Although the OFPA allows producers who meet the standards to use a seal of approval on their organic food labels, the seal did not become a reality for twelve years (Nicholas, 2003).

In 1992, the FDA created a policy called the Substantial Equivalence Standard. Its purpose was to allow Genetically Modified Foods (GMF) to be considered as Generally Recognized as Safe (GRAS) if no significant differences could be found between those and their non-GMF equivalents (Nottingham, 1998).

In 2000, the EPA required Aventis to buy back food and seeds containing Starlink corn. Starlink was the trade name for GM corn hybrids produced by Aventis Crop Science. It contained a plant-pesticide protein that protected it from the European corn borer and other pests. At the time of registration, it was believed that Starlink did not contain any known allergens. Later, the EPA’s scientific advisory panel concluded that the protein could survive cooking and that it was hard to digest, so the EPA issued a split registration that allowed the corn to be used as animal feed but not for human consumption. However, there was not any mechanism in place for tracking corn varieties in the food chain. When the protein showed up in processed food items, such as the Taco Bell taco shells, the Aventis Corporation withdrew its product registration (Marden, 2003).

Discussion of the Timelines

Most of the agricultural biotechnology addressed in this paper is involved with the genetic improvement of food. Although there were known efforts to cross breed plants and to mate desirable animals dating back to ancient times, the earliest well-documented success with cattle was obtained by Bakewell in the

1700s, and the earliest in-depth understanding of genetics was achieved by Gregor Mendel in the 1800s. The beginnings of cellular biology could be considered to be the work of Schwann and Schleiden who, in the mid 1800s, theorized that all organisms, plant and animal, were made up of cells. The mid 1800's was also when the U.S. Government found it necessary to establish a cabinet level Department of Agriculture.

Beginning with Mendel and moving forward along the plant breeding timeline, it is clear that the researchers trying to induce mutations by using X-rays in the twenties understood the implications of Mendel's work. The planting of hybrid corn in the thirties demonstrated a practical application of Mendelian concepts. The combining of agriculture with the use of nuclear particles demonstrated the persistent belief that agricultural production could be further improved by genetic science. The period known as the "Green Revolution (1950-1984)," showed that by combining the hybridization of crops with the benefits of fertilizers and pesticides food production could be increased dramatically, while the book by Rachel Carson, *Silent Spring*, showed that all this progress could have a down side.

It is not possible to travel any further up the plant breeding timeline without noticing connections to the timelines of molecular biology and public policy. The Roundup Ready® soybeans (1995) were a product of genetic engineering that could not have been marketed without approval from the FDA. It was only two years earlier that the FDA had approved the first genetically engineered food, the Flavr-Savr tomato. The introduction by Monsanto Company of a "Technology Agreement" controlling the replanting of seed would not have been possible if the Supreme Court had not decided in *Diamond v. Chakrabarty* (1980) that it was legal to patent an organism.

The early part of the livestock timeline began with the purposeful cattle breeding by Bakewell and jumped to the experiments with artificial insemination (AI) that took place a hundred years later. The connection between these two items is that both were concerned with improving the quality of the breed. The creation of AI organizations and the establishment of the NAAB were based upon widespread understanding about how important it was for dairy farmers and cattle ranchers to cooperate in an effort to increase the genetic quality of their herds. The use of embryo transfer techniques was the next innovation in the genetic manipulation of cattle, and the next step will probably be an adaptation of the cellular biology made famous by the cloning of Dolly the sheep.

The advancement of knowledge in the cellular and molecular biology timeline has brought more change to agriculture and medicine than any other science. It was the work of Charles Darwin (1859) that made it clear that species could be changed over time through natural or artificial selection. The discovery by Walter Sutton in 1902 that genes were located on the chromosomes and that they followed the rules of inheritance formulated by Mendel connected the science of plant breeding to all other life forms.

The timeline involving public policy has impacted the rate that progress occurs in agricultural biotechnology. The need to encourage and regulate the production of food in the U.S. was recognized at least as far back as 1862, with the establishment of the Department of Agriculture. Legislation to protect public health, the Federal Food, Drug, and Cosmetic Act, was created in 1938. A law designed to encourage the food preparation industry by waiving investigation requirements for certain ingredients, the Food Additives Amendment Act, was passed in 1958.

The first time that public policy worked to slow down advances in biotechnology research was when the 1975 Asilomar Conference attempted to create a moratorium on recombinant DNA research. The recommendations from this conference created a temporary reduction of public funding for research. However, this recommendation was soon followed by the 1980 *Diamond v. Chakrabarty* court decision that opened the floodgates for private funding by allowing life forms to be patented. Further encouragement for conducting research was provided by the 1985 National Institutes of Health guidelines for performing gene therapy experiments on humans.

The pattern of legal and legislative support appears to have continued for the last fifteen years with the 1988 patent approval of the "Harvard Mouse," and the 1992 FDA ruling that allowed genetically modified foods to be considered as "generally recognized as safe." Even the 1990 Organic Food Production Act was

intended to benefit a segment of the agriculture community, those wishing to specialize in foods grown without genetic modification or pesticides.

The most recent item mentioned in this paper, the Environmental Protection Agency's demand that Aventis buy back food and seeds containing Starlink corn, illustrates that the use of genetically modified products invites involvement from multiple agencies of the government.

Two Reasons that the Four Timelines should be the basis for a unit in Agricultural Biotechnology

The first reason that this approach is valid is that it illustrates how historical innovations in different technologies have made parallel advances. For example, the widespread introduction of hybrid corn and the use of artificial insemination for breeding cattle do not appear to be related events unless they are viewed as parallel efforts to genetically improve food production.

The second reason that the four timelines should be the basis for curriculum is that this organization of events helps to illustrate the interaction between science, technology, and society. Plant breeding, animal breeding, and molecular biology are all scientific or technological pursuits. Public policies are a reflection of the general values within our society. Through legal actions society advances or hinders research and change.

Insert Figure 1.

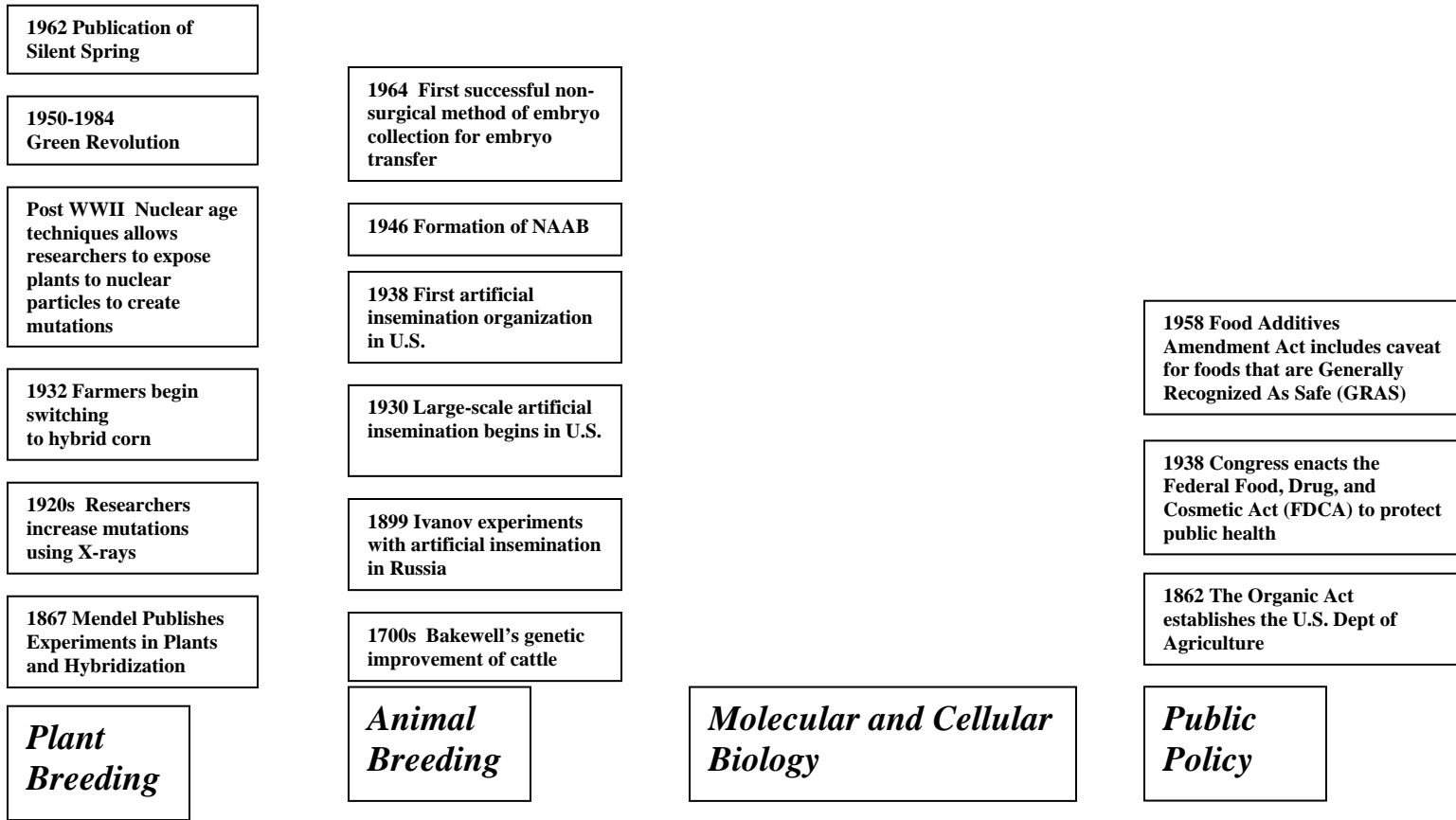


Figure 1. Four Timelines 1700s to 1970

Insert Figure 2.

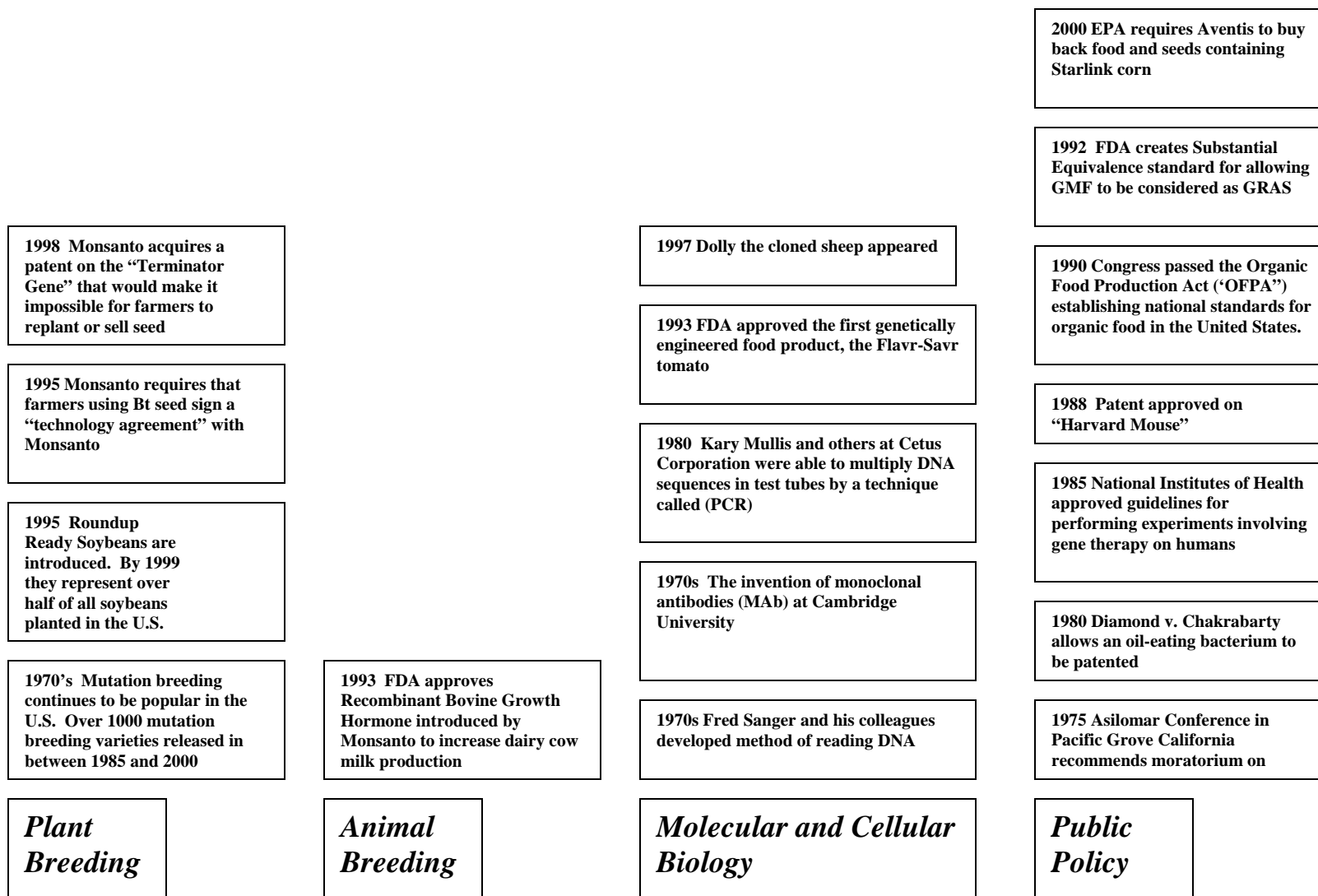


Figure 2. Four Timelines 1970 to 2000

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Effects of Pre-Tests and Post Tests
On Delayed Retention Learning
In Technology Education

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September 2002

Running Head: Delayed Retention Learning

Abstract

This research investigated the effects of multiple-choice pre-tests and post tests upon retention in a technology education setting. Undergraduate students studied information booklets without additional instruction. Experimental groups were tested by differing methods as part of their treatment. All groups were administered an unexpected delayed retention test three weeks later. Delayed retention test scores were evaluated to determine which types of tests promoted retention best. A multiple-choice pre-test in combination with a post test was not shown to be superior to the post test alone in promotion of retention. Results were not significant and students in the control group who expected a test but were not actually tested retained the information about as well as the tested groups.

Effects of Pre-Tests and Post Tests

On Delayed Retention Learning

In Technology Education

Testing has been shown to be beneficial in a number of studies in various settings. This study examined a pre-test and a post test in comparison to a no test (control) condition to determine their relative effectiveness as aids to retention learning in a technology education context. Retention learning is defined as learning that is still retained weeks after the initial instruction and testing have occurred. The investigation involved a pre-test of one group, instruction via self-paced texts, initial testing of learning, and delayed testing 3 weeks later. The delayed tests, which included both previously tested information and novel information, provided the experimental data for the study.

Background

The importance of testing and issues surrounding it make testing an important research topic. Historically, most of the research on testing has concerned standardized tests, but a large amount of evaluation in the schools is accomplished via teacher-made tests (Haynie, 1983, 1990a; Herman & DorrBremme, 1982; Mehrens, 1987; Mehrens & Lehmann, 1987; Moore, 2001; Newman & Stallings, 1982; Stiggins, Conklin, and Bridgeford, 1986). Some issues of teacher-made tests which should be investigated include frequency of use, quality, benefits for student learning, optimal types to employ, and usefulness in evaluation. Previous findings cast some doubt on the ability of teachers to develop effective tests (Carter, 1984; Fleming & Chambers, 1983; Gullickson & Ellwein, 1985; Haynie, 1992, 1995b, 1997a; Hoepfl, 1994; Moore, 2001; Stiggins & Bridgeford, 1985). Still, Mehrens and Lehmann (1987) correctly pointed out the importance of teacher-made tests in the classroom and their ability to be tailored to specific instructional objectives. Teacher-made tests remain important in technology education and continue to be a fruitful area for research (Haynie, 1990b; Mehrens and Lehmann 1987).

The effectiveness of tests in promoting delayed retention has been the focus of several studies in various settings (Haynie 1990a, 1990b, 1991, 1994, 1995a, 1997b, 2002a, 2002b; Nungester & Duchastel 1982). In general, all of these studies have shown test taking to enhance delayed retention learning. Many vocational courses and instructional units in technology education based on the modular approach make frequent use of pre-tests. Though some studies have found that pre-testing has mixed effects on immediate retention, no formal investigation of the effects of pre-tests on delayed retention has been reported in technology education.

Purpose and Definition of Terms

The purpose of this study was to investigate the value of multiple-choice pre-tests and post tests as aids to retention learning within a technology education context. *Retention learning* as used here refers to learning which lasts beyond the initial testing and is assessed with tests administered 2 or more weeks after the information has been taught and tested. A delay period of 3 weeks was used in this study. *Initial testing* refers to the commonly employed evaluation via tests which occurs at the time of instruction or immediately thereafter. *Delayed retention tests* are research instruments which are administered 2 or more weeks after instruction and initial testing to measure retained knowledge (Duchastel, 1981; Haynie, 1990a, 1990b, 1991, 1994, 1995a, 1997b, 2002a, 2002b; Nungester & Duchastel, 1982). The delayed retention test results were the only experimental data analyzed in this investigation.

In addition to studying the relative learning benefits of pre-tests and post tests, researchers attempted to determine if it was exposure to the initial tests or the benefits of time spent studying that enhanced delayed retention. The following research questions were addressed by this study:

1. If delayed retention learning is the objective of instruction, does initial testing of the information aid retention learning?
2. Does pre-testing aid retention learning as effectively as initial post testing with multiple-choice tests?
3. Will information which is not reflected on the pre-tests or post tests be retained equally well by students?

Methodology

Population and Sample

Undergraduate students in 9 intact technology education classes were provided a booklet on new “high tech” materials developed for space exploration. There were 190 students divided into three groups: (a) no pre-test, multiple-choice post test (Group A, $n=62$), (b) pre-test, post test (Group B, $n=65$), and (c) no pre-test, no post test (Control, Group C, $n=63$). All groups were from the Technology Education metals technology (TED 122) classes at North Carolina State University. Students were freshmen and sophomores in Technology Education, Design, or in various engineering curricula. Students majoring in Aerospace Engineering were deleted from the final sample because the material that was new to other students had previously been studied by this group.

Group assignment to instructor was not randomized due to scheduling constraints; however, all sections were taught either by the researcher or his graduate assistants—each teaching some control and some experimental sections. The course instructor gave no instruction or review to any of the groups except the booklets, and all announcements and directions were provided via scripted standard statements. Three intact class sections were combined to form each experimental or control group. Class sections had between 18-22 students. Random assignment of treatments to sections, deletion of Aerospace Engineering majors, and absences on testing dates resulted in unequal final group sizes.

Design

At the beginning of the course it was announced that students would be asked to participate in an experimental investigation about different types of tests while they studied subject matter about high tech materials reflected in the newly revised course outline. All other instructional units in the course were studied by students working in self-paced groups and taking subtests on the units as they learned them. Three examination dates were used for administration of these regular subtests. The experimental study began the class meeting following the first examination date, so students could see that none of the eight regular subtests covered the information in this unit of study. After the regular subtests which had been taken were discussed and results given to students, the instructions for participation in the study were read. Following the instructions, the pre-test was exclusively administered to Group B.

All students were given copies of a 34-page study packet prepared by the researcher. The packet, entitled *High Technology Materials*, discussed composite materials, heat shielding materials, and nontraditional metals developed for the space exploration program. Uses of these materials in consumer products were also illustrated. The packet was in booklet form. It included the following resources typically found in textbooks: (a) a table of contents, (b) text (written by the researcher), (c) halftone photographs, (d) quotations from other sources, (e) diagrams and graphs, (f) numbered pages, (g) excerpts from other sources, and (h) an index with 119 entries correctly keyed to the page numbers inside. Approximately one third of the information in the text booklet was actually reflected in the tests. The remainder of the material appeared to be equally relevant but served as a complex distracting field to prevent mere memorization of facts. Students were instructed to use the booklet as if it were a textbook and study as they normally would.

Students in all three groups were told to study the materials in preparation for an in-class objective test to be given in two weeks. On the announced test date, all booklets were collected and initial testing was conducted according to treatment group. Groups A and B were given the multiple-choice initial post test, but Group C (Control) was not tested initially. Group C had been told to prepare for the in-class test just as the other groups had been directed, so it is assumed that they studied in much the same manner and depth as the other groups. However, when the test date arrived, they were told that the test simply was not ready and they were just “lucky” and would not have to take the test. Three weeks later, all groups were asked to take an unannounced delayed retention test on the same material. They were told at this time that the true objective of the experimental study was to determine if the pre-test, post test, or no test promoted delayed retention best. It was also explained that their earlier test scores were not study data. Students were asked to do their best and assured that the scores on this surprise test did not affect their grades.

Though informed that participation was fully voluntary, all students who had been present for the earlier sessions did participate cooperatively by taking the delayed retention test.

All groups used the same laboratory complex during instructional and testing periods. This helped to control extraneous variables due to environment. All directions were read by either the researcher or his graduate assistants from standard scripts. The course instructor did not provide any instruction or review on the subject in addition to the text booklets. Students were asked not to discuss the study or the text materials in any way. All class sections met for 2 hours on a Monday-Wednesday-Friday schedule. Each group was made up of a mixture of sections meeting from 8:00 a.m. to 10:00 a.m. and sections meeting from 10:00 a.m. to 12:00 noon. So, neither time of day nor day of the week should act as systematic confounding variables. Likewise, each group also included some sections from Fall and some from Spring semesters. Normal precautions were taken to assure a good learning and testing environment.

Instrumentation

The pre-test and initial post test were parallel forms of a single 20-item multiple-choice test. The multiple-choice items had five response alternatives. These tests had been used in numerous previous studies using variations of the protocol of this investigation. The same information was reflected by both tests and they operated primarily at the first three levels of the cognitive domain: (a) knowledge, (b) comprehension, and (c) application.

The delayed retention test was a 30-item, multiple-choice test. Twenty of the items in the retention test were alternative forms of the same items used in the pre- and post tests. These served as a subtest of previously tested information. The remaining ten items were similar in nature and difficulty, but they had not appeared in any form on either of the initial tests. These were interspersed throughout the test, and they served as a subtest of new information. The subtest on new information was used to determine if students' learning gains resulted from exposure to a scenario involving studying for and then taking a test or from exposure to a test.

The delayed retention test was developed and used in a previous study (Haynie, 1990a). It had been refined from an initial bank of 76 paired items and examined carefully for content validity. Cronbach's Coefficient Alpha procedure was used to establish a reliability of .74 for the delayed retention test. Thorndike and Hagen (1977) assert that tests with reliability approaching .70 are within the range of usefulness for research studies.

Data Collection

Students were given initial instructions concerning the learning booklets and were directed to return them on the announced date of their test. Group B took the pre-test before they received the booklets, the other groups did not take the pre-test. Groups A and B were tested with the multiple-choice post test on the announced test date. On the announced test date, Group C (Control) was informed that they would not be tested. All learning booklets were returned on the announced test date by all groups. The unannounced delayed retention test was administered 3 weeks later. Data were collected on mark-sense forms from National Computer Systems, Inc.

Data Analysis

The data were analyzed with SAS (Statistical Analysis System) software from the SAS Institute, Inc. The answer forms were scanned and the data were stored on a floppy disk. The General Linear Models (GLM) procedure in SAS was chosen for omnibus testing rather than analysis of variance (ANOVA) because it is less affected by unequal group sizes. A simple one-way GLM analysis was chosen because the only data consisted of the Delayed Retention Test means of the three groups. The means of the two subtest sections of the retention test were then similarly analyzed by one-way GLM procedure to detect differences in retention of previously tested and novel information. Follow-up comparisons were conducted via Least Significant Difference *t*-test (LSD) as implemented in SAS. Alpha was set at the $p < .05$ level for all tests of significance.

Findings

The means, standard deviations, and final sizes of the three groups on the delayed retention test (including the two subtests and the total scores) are presented in Table 1. The overall difficulty of the test battery and each subtest can be estimated by examining the grand means and the range of scores. The grand mean of all participants was 16.88 with a range of 4 to 27 on the total 30-item test. The grand mean on the 20-item subtest of previously tested material was 12.66 with a range of 3 to 19, and the grand mean on the 10-item subtest of new information was 4.22 with a range of 0 to 9. No student

scored 100% on any test, and the grand means were close to 50% on each test, so the tests were relatively difficult. The grand means, however, were not used in any other analysis of the data.

Table 1

Means, Standard Deviations, and Sample Sizes for Delayed Retention Test Scores

Treatment	Total Test		Subscale A Previously Represented		Subscale B Novel Information	
	Mean	SD	Mean	SD	Mean	SD
Group A No Pre-Test Post Test <i>n</i> =62	17.39	4.8	13.02	3.2	4.37	2.1
Group B Pre-Test Post Test <i>n</i> =65	17.15	4.2	12.94	3.1	4.22	1.8
Group C No Pre-Test No Post Test Control <i>n</i> =63	16.09	4.5	12.02	3.0	4.07	2.1
Overall <i>n</i> =190	16.88	4.5	12.66	3.1	4.22	2.0

The GLM procedure was used to compare the three treatment groups on the means of the total delayed retention test scores. A finding of $F(2,187) = 1.46, p < 0.2360$ (see Table 2) indicated that there were no significant differences among the scores on the total delayed retention test means. The GLM procedure was again employed to examine the means of each subtest. No significant differences were found among the means of the subtest of previously tested information, $F(2,187) = 2.03, p < 0.1344$ (Table 3), or among the means on the subtest of new information, $F(2,187) = 0.34, p < 0.7124$ (Table 4).

Table 2
Comparison of Group Means on the Total test Via GLM Procedure

Source	D.F.	Sum of Squares	Square	Mean <i>F</i>	<i>p</i> -value	Findings
Treatments	2	59.62		29.81	1.46	0.2360 ns
Error	187	3830.60	20.48			
Total	189	3890.22				

Table 3
Comparison of Group Means on the Subtest of Previously Tested Information Via GLM Procedure

Source	D.F.	Sum of Squares	Square	Mean <i>F</i>	<i>p</i> -value	Findings
Treatments	2	39.04		19.52	2.03	0.1344 ns
Error	187	1799.72	9.62			
Total	189	1838.76				

Table 4
Comparison of Group Means on the Subtest of New Information Via GLM Procedure

Source	D.F.	Sum of Squares	Square	Mean <i>F</i>	<i>p</i> -value	Findings
Treatments	2	2.66		1.33	0.34	0.7124 ns
Error	187	732.06	3.92			
Total	189	734.72				

Follow-up comparisons via *t*-test (LSD) procedures in SAS were originally intended. However, this researcher takes the conservative traditional view that such individual comparisons are unwarranted and increase the potential for Type I errors when they are conducted following non-significant findings in an omnibus test. So, to prevent the possible rejection of a true null hypothesis due to excessive “data-snooping”, the intended LSD follow-up comparisons were abandoned. The null hypothesis could not be rejected in any of the three GLM tests which were conducted.

Discussion

Three research questions were addressed by this study:

1. If delayed retention learning is the objective of instruction, does initial testing of the information aid retention learning? Within the constraints and limitations of this study, there was no clear support for the finding of numerous previous studies that students retain more learned information if they are tested (see Haynie 1990a, 1990b, 1991, 1994, 1995a, 1997b, 2002a, 2002b; Nungester & Duchastel 1982). Though no significant differences were found, it should be noted that the non-significant trend in the means on the total delayed retention test and both of its subscales was in harmony with the findings of the previous studies, but the apparent (slight) difference did not reach the level of significance. Since this study used a variation of a protocol which had been used to attain significant findings numerous times before, and it had large enough *n* to render adequate statistical power, the lack of significant finding on this research question should not be attributed to poor design, but to chance occurrences explained by probability theory. Informal examination of

the Control group mean for this study reveals that it is over a point higher than for most of the studies reported earlier—without conducting unwarranted follow-up comparisons it is impossible to be certain, but it appears that (by chance) a slightly brighter Control group may have participated in this particular study. More study will be needed to answer this research question.

2. Does pre-testing aid retention learning as effectively as initial post testing with multiple-choice tests? Unfortunately, the researcher must admit that this research question cannot be clearly answered due to the non-significant findings and a serious design flaw in the study. If the findings had been clearly significant and the pre-tested group had scored significantly higher than the group which took only the post test, then one might have argued that the post test aided retention and the pre-test significantly extended the gain in retention. However, since there was no group in this study which took the pre-test and then was not given the initial post test, any potential gains in retention due to the pre-test could only be identified if they were in excess of those due to the post test. In the face of the non-significant results, however, the point is moot and the researcher must simply conclude that no finding is possible here. The researcher apologizes to the research community for this error.

3. Will information which is not reflected on the pre-tests or post tests be retained equally well by students? In this case, there was no significant finding. However, again, the non-significant trend is in harmony with the findings of the previous studies (Haynie 1990a, 1990b, 1991, 1994, 1995a, 1997b, 2002a, 2002b; Nungester & Duchastel 1982) which showed that all types of tests except take-home tests promote retention of information not reflected on the initial test.

Conclusion

Since testing is both time-consuming and value-charged, it is important to learn as much as we can about testing and the effects of tests on learning. Much research has been conducted concerning standardized tests and the effectiveness of tests for evaluation, but little has been done to examine questions related to the effects of teacher-made tests on learning and retention. With pre-testing in such frequent use in modular instruction and across the vocational curriculum, it is important to determine whether or not pre-tests aid retention learning.

Limitations of the Study. This study was limited to one setting within technology education. It used learning materials and tests designed to teach and evaluate a limited number of specified objectives concerning one body of subject matter. The sample used in this study may have been unique for unknown reasons. The study had a serious design flaw which precluded the researcher from attaining a clear answer to one of its three research questions. The design was adequate for investigation of the other two research questions, but (though there were non-significant trends supporting previous findings) no statistically significant differences were found.

Recommendations. Therefore, it is recommended that a study of a similar design be conducted that includes the three groups used here and a fourth experimental group which is pre-tested but does not take an initial post test. It is also recommended that future studies probe issues associated with instruction and testing in technology education via computer and distance learning approaches.

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The Cultural Climate in Technology Education:

Ethnicity & Race Issues

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Though the traditional "industrial arts" programs of the 1950's which involved woodworking, metalworking, and other "shop" areas were heavily male dominated. Particularly in the south, industrial arts was taught in racially segregated schools. Modern technology education is taught in culturally mixed schools and appears to be more appealing to females. At one time there were very few female students and almost no female teachers in industrial arts courses, but as the discipline began to evolve towards a study of technology during the 1960's and 1970's a trickle of females joined our ranks. This trend has continued, and now there is a growing female influence in our various programs in the USA and in other countries as well (Haynie, 2003).

In the 1950's, the boys who enrolled in industrial arts shop courses, and the men who taught those courses, viewed them as a "man's world" and there was little effort to be "politically correct" in the modern sense of that phrase. In racially segregated schools, there was no opportunity for students of different ethnic or cultural background to mingle in these classes. Though there was great variety, some shops had an atmosphere in which speech patterns and jokes that would be unacceptable in general public were largely ignored. After school integration became the norm in the 1960's teachers in previously segregated schools began to learn how to teach and manage students in more culturally diverse settings. Likewise, as females began to enter the field of industrial arts, male teachers and students had to become more sensitive about what they said and how they expressed themselves. Now that there are many more females in technology education and a culturally diverse student population exists in most technology classes, to what degree have we established a common understanding of what should be said or done within our profession? In other words, are there recognizable cultural mores for acceptable inter-ethnic interaction in technology education upon which the people in our profession can agree?

Though some research has been done concerning fairness of opportunity, attractiveness of topics/approaches, and ways to encourage more females to enter the profession (ITEA, 1994; Liedtke, 1995; Markert, 1996; Silverman & Pritchard, 1996; and Zuga, 1998), and some work has been completed concerning cultural diversity in technology education (Barnette, 1998; Rider, 1998; Robb, 1998; and Trautman, 1998), there is still a need to determine how people from different races and ethnic groups feel about the

cultural atmosphere within our profession, our classrooms and laboratories, and how teachers and students interact.

This study was a beginning in the effort to assess how professionals in technology education feel about certain issues and whether the perceptions African Americans and other people differ on those issues concerning social interaction in technology education. It follows a protocol established in a 1999 study by Haynie on cross-gender interaction in technology education. That study surveyed men and women in various roles within the profession. Although the findings of the study are considered weak due to poor rate of return, the responses provide a starting place for further work. Since some of the topics in this study are sensitive in nature, perhaps some are even taboo for some people, this work and its findings must be viewed as establishing a starting place rather than as etching permanent conclusions—in fact, the sensitive nature of the material may itself have been a factor limiting the response rate. The cultural mores of our society and within our discipline are continually changing, so continuing work will be needed to track the evolving cultural climate within our discipline as it relates to the world around it.

Methodology

A survey of technology education professionals was conducted at the 2003 International Technology Education Association (ITEA) national conference in Nashville, TN, March 13-15, 2003. Volunteer participants were sought by the researcher and his wife by distributing survey instruments in several public areas during registration, at meetings, and in the corridors of the conference facility. Respondents were asked to complete the form while at the conference and return it or to complete it later and return via the self-addressed stamped envelope provided in the packet. The packet also included two small gifts to thank the respondents: A pencil marked with the NC State University colors and logo and a packet of instant hot chocolate. The cover letter assured participants of full anonymity and provided complete instructions for responding directly on the printed instrument copy. To insure full anonymity, there was no provision for any follow-up or means to contact non-respondents. Of the 100 questionnaires distributed, only 23 were returned. Nine of those 23 were incomplete, so the final sample consisted of 14 (7 Blacks and 7 Whites) for a resulting response rate of 14%. Since it is recognized that there is a large white majority in TE, special effort was made to give questionnaires to mostly Blacks, Asians, and non-Whites. Whites were primarily ignored except when the social setting made it difficult not to give them an instrument without making the non-White recipients appear conspicuous. For example, if a group of three Black people and one White person were walking together, they would all receive a questionnaire. It was informally estimated, however, that well over half of the instruments went to Black people, a large number to Asians, a few to other non-Whites, and less than 20 or so went to Whites. This highlights the problem area of return rate, because it is clear that the Asians did not return it (only one) and a very low percentage of Blacks did either (perhaps estimated at as low as 5-7%) while

nearly half of the Whites returned the survey. Was there something about the instrument or its distribution that offended Black people? Due to low return rate, this is considered a failed study and the remainder of this paper reports findings that can only be examined for the questions they pose rather than the conclusions that can be drawn.

The only item on the instrument that identified respondents in any way was labeled "Ethnicity" and it asked them to "Please enter the word or words which YOU prefer to use to identify/describe your own Race/Ethnicity/Cultural Background". This option was chosen in hopes to avoid potentially offending people or limiting their choices. It was also hoped that enough consensus might be found that a preferred identifier for use in TE literature could be selected based on the actual wishes of the respondents instead of simply following a formula of usage found appropriate in some other settings.

Though it was hoped that the perceptions of several subgroups could be analyzed, only one (incomplete) survey was returned with an identification other than White, Black, African American, or other descriptive term for Black peoples. That one instrument was marked Asian. The comments will be reported here, but the data has not been analyzed leaving only two groups for analysis: White and Black.

In addition to the item on ethnicity, the questionnaire included a brief demographics section to find respondents' gender, age, marital status, years of technology teaching experience, and ages of students they taught. These demographic factors were intended to be used in analysis of some issues considered in the survey.

Most of the survey consisted of items intended to determine respondents' perceptions on issues or situations. As in the 1999 study by Haynie, rather than using traditional Likert scales for these items, each statement was followed by a continuum and respondents were instructed to mark each continuum with an "X" to indicate their perception. This was a variation of a technique used by Thurstone nearly 70 years ago and altered by others following him (Mueller, 1986). Each continuum was marked "0" on the left end, "100" on the right end, and had the center marked with "50". These three points on each continuum also had verbal descriptors related to the item. Participants' responses were scored by actually measuring the position of their "X" on each continuum and entering the measured point (any whole number from 0 to 100) into the computer. Some respondents actually circled the keywords occurring at the 0, 50 or 100 points on the continuum for some items, and their scores for those items were entered as 0, 50, or 100 respectively.

Since participants' response marks could vary between 0 and 100, the data were treated as continuous and were averaged and analyzed via comparison of means with SAS statistical software. Omnibus tests used the GLM variation of ANOVA. The .05 level of significance was used for all tests.

A series of open response items at the end of the questionnaire also provided opportunities for respondents to comment more freely. The entire instrument was lengthy and the four colleagues who field tested it required an average of just over 14 minutes to complete it. Many respondents did not respond to the open response items or only commented on one or two of them. The four colleagues who helped to field test the instrument agreed that it was long but that the difficult nature of the problem and its importance outweighed the time required. Minor editorial revisions were made after the initial field test.

Findings

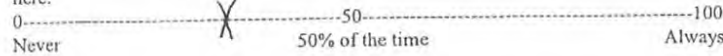
The demographic section of the questionnaire found that there were 23 forms returned and 14 were complete. Eight forms were returned by Whites (7 complete), 9 by Blacks (7 complete), 3 forms identified other non-White groups, and 3 did not respond to this item at all (all three of these forms had very little information at all). Only 3 of the returned forms identified the respondents as female. By far, the largest group of respondents was teacher educators (6 usable and 2 non-usable) followed by students (4 usable and 3 unusable). Only 2 teachers returned usable forms and one respondent each marked “supervisor” or “other” as identifying their role in TE on a usable survey instrument. Perhaps university students and teacher educators, having higher appreciation for the value and methods of research in TE, were more prone to aid this research effort. The study was intended to be national in scope, but proved to be very regional in results. Six of the usable returned forms were from the northeastern USA and 5 were from the southeastern USA. The respondents returning the remaining 3 usable forms failed to answer this item. There are two potential explanations for this regionalized response: First, the ITEA conference at which the survey was conducted was in Nashville, TN and it is well known that attendance is highest among people who reside near each year’s conferences. The other factor is a speculation by the researcher that, due to the sensitive nature of the items in the questionnaire, it is possible that a feeling of trust in the researcher himself and his integrity would encourage people to return the instrument. Since the researcher (and his wife) are well known in the eastern end of the USA (having lived and worked in 4 states in this region) it is possible that some sense of loyalty to the researcher was present among easterners that was not present in people from other areas of the country. The other demographic data was not helpful with such a low response rate.

Responses on the Continuum Items --

Rather than chance misinterpretation, the researcher has chosen to present the responses of participants on the items requiring the marking of a continuum by simply reprinting the actual items, providing the statistics for each one, and actually marking key points on the accompanying continuum. These data appear below. The first item is the example that was provided (pre-marked) in the questionnaire to show respondents how to indicate their

perceptions.

EX *Example:* If I were asked to mark the point 30% on this continuum, I would mark about here:



1 Concerning ethnicity, culture, race, and equity issues, I consider myself to be:
 0-----50-----100
 Disinterested Moderately concerned An activist

Mean = 73.4
 Black = 73.0 Range: 42-93
 White = 73.7 Range: 52-91
 $F(1,13) = 0.01$ $p = 0.934$ NS

2 Concerning ethnicity, culture, race, and equity issues, my friends and colleagues would likely consider me to be:
 0-----50-----100
 Disinterested Moderately concerned An activist

Mean = 64.6
 Black = 69.3 Range: 42-93
 White = 60.0 Range: 43-79
 $F(1,13) = 1.07$ $p = 0.322$ NS

3 To what degree do you feel that whites and people of color or those with easily identifiable ethnicity other than Anglo-American are treated as equals within the technology education profession?
 0-----50-----100
 Advantage whites Fairness Advantage non-whites

Mean = 41.4
 Black = 39.9 Range: 8-56
 White = 43.0 Range: 27-53
 $F(1,13) = 0.17$ $p = 0.691$ NS

4 I, personally, feel that people of my own ethnic background are accepted and well treated in the technology education profession:
 0-----50-----100
 No! OK Yes, Very Much!

Mean = 70.1
 Black = 53.9 Range: 41-93
 White = 86.3 Range: 68-100
 $F(1,13) = 14.65$ $p = 0.0024$ * Significant Difference

5 I, personally, feel that my own race, ethnic group, cultural group is treated:
 0-----50-----100
 Most Poorly in TE OK Poorly in General Society

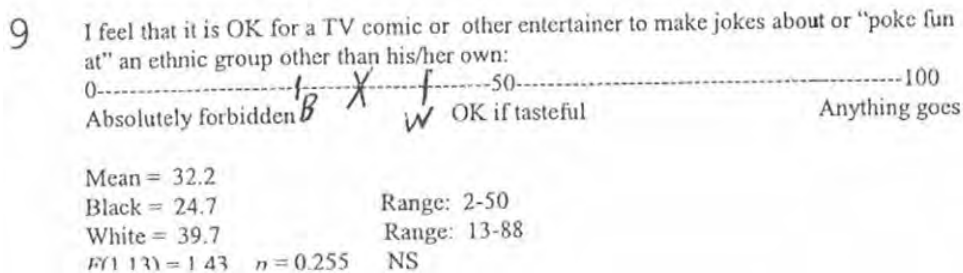
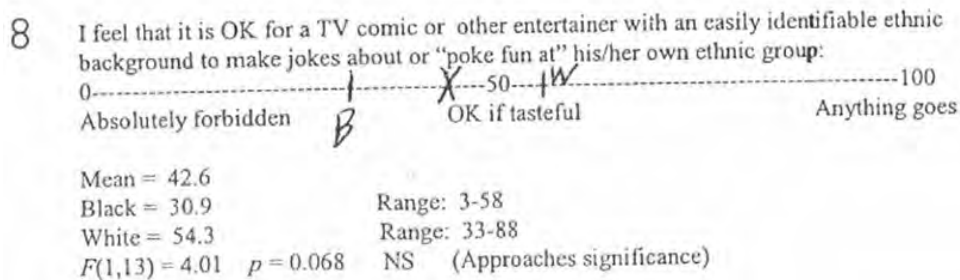
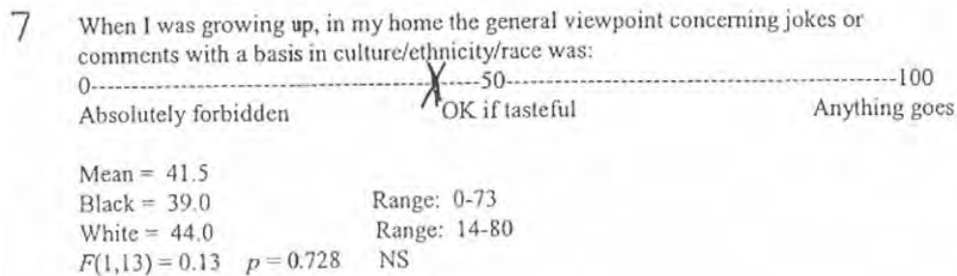
Mean = 61.1
 Black = 63.1 Range: 45-91
 White = 59.1 Range: 50-88
 $F(1,13) = 0.22$ $p = 0.647$ NS

6 I, personally, feel that people of my own ethnic background are avoided and neglected in the technology education profession:
 0-----50-----100
 Never 50% of the time Always

Mean = 28.9
 Black = 37.3 Range: 16-62
 White = 20.6 Range: 0-88
 $F(1,13) = 1.61$ $p = 0.229$ NS

Items 1 and 2 showed that respondents do care about diversity issues, but neither Blacks nor Whites were on the extreme end of the continuum. There were no significant differences.

A series of items (3-6, above) give perceptions of respondents concerning fairness of treatment and general level of acceptance. The only statistically significant difference was that Whites appear to “feel” more accepted than Blacks in the technology education profession, but despite the magnitude difference both groups gave positive responses.



A series of related items (7-15, above and below) concerns racial/ethnic jokes, slurs, and comments in a number of settings both within the profession and in society at large.

10 When I am in non-professional or social settings and in the company of people of diverse backgrounds, I consider jokes or comments with a basis in culture/ethnicity/race to be:

Mean = 32.2
 Black = 19.4 Range: 3-50
 White = 45.0 Range: 25-54
 $F(1,13) = 8.49$ $p = 0.013$ * Significant Difference

11 When I am in non-professional or social settings and in the company of people of my own race/ethnicity (exclusively), I consider jokes or comments with a basis in culture/ethnicity/race to be:

Mean = 29.6
 Black = 24.3 Range: 2-53
 White = 34.9 Range: 11-55
 $F(1,13) = 1.02$ $p = 0.333$ NS

12 I enjoy telling and hearing jokes based on culture/ethnicity/race jokes in general.

Mean = 16.8
 Black = 11.6 Range: 0-36
 White = 22 Range: 4-50
 $F(1,13) = 1.92$ $p = 0.191$ NS

13 When in professional settings where there are students present (class, hallways, lunchroom, TSA, other similar), I consider jokes or comments with a basis in culture/ethnicity/race to be:

Mean = 6.3
 Black = 3.0 Range: 0-10
 White = 9.6 Range: 0-17
 $F(1,13) = 6.08$ $p = 0.022$ * Significant Difference

14 When in professional settings where there are no students present, but I am considered "on-duty" (conferences, meetings), I consider jokes or comments with a basis in culture/ethnicity/race to be:

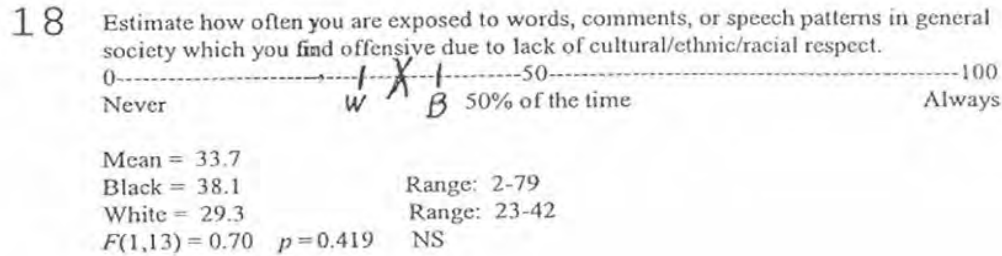
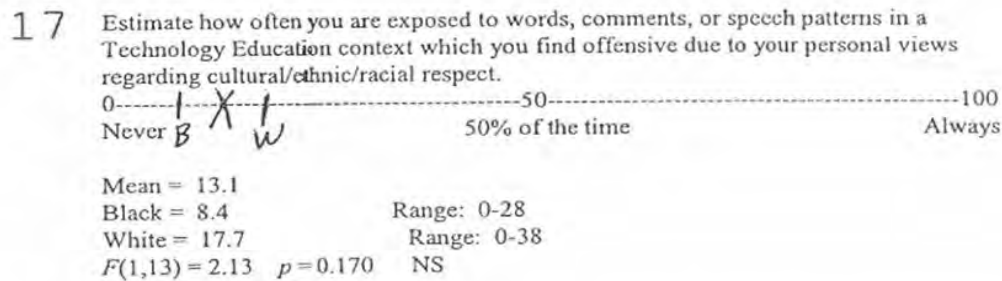
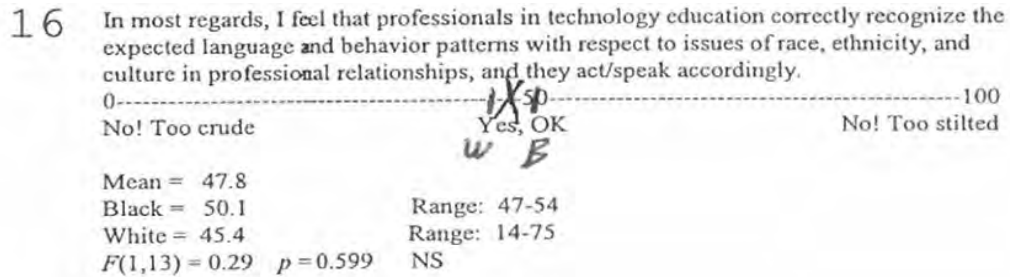
Mean = 7.9
 Black = 7.6 Range: 0-37
 White = 8.1 Range: 0-14
 $F(1,13) = 0.01$ $p = 0.917$ NS

15 When in professional settings where there are no students present and I am considered to be "off duty" (teacher's lounge, breaks, eating out at a conference), I consider jokes or comments with a basis in culture/ethnicity/race to be:

Mean = 12.0
 Black = 10.3 Range: 0-51
 White = 13.7 Range: 8-25
 $F(1,13) = 0.23$ $p = 0.642$ NS

Though Whites demonstrated more acceptance of humor with an ethnic basis than Blacks, these items were almost universally marked with negative

responses. It appears that Blacks would generally prefer that jokes about race or ethnicity not be shared in most of these situations. There was some progression showing more tolerance for this sort of humor when no students are present and when the situation is more informal and less professional in nature.



In item 16 (above) there was a high degree of agreement among both Blacks and Whites that the speech and behavior patterns among technology education professionals is currently “OK”. In items 17 and 18 a trend is evident that Blacks feel offended by the speech of others more often in general society than within the technology education profession. Combining this finding with those of item 16 leads to the inference that mutual respect is typically being shown in regards to how technology education professionals interact.

Responses to Free Response Items --

The responses to free response items 19-40 are presented below. In this table, each written response was characterized by the researcher as positive or negative—neutral and missing responses were ignored. The stems given in the table are greatly truncated so more details are given in the text

where needed. Most of the data speaks for itself, but the following items warrant discussion here.

Item #	Stem	Black Yes	Black No	White Yes	White No
19	Is TE content ethnically biased or distasteful?	1	5	2	5
20	Career in TE = success & upward mobility?	3	4	5	2
21	Chastise colleagues for offensive speech?	5	2	7	0
22	Are there universal signs to use for above?	5	0	6	1
23	Are those signs effective in TE?	4	1	4	2
24	Do you punish students who offend ethnically?	7	0	7	0
25	Is student speech a problem (ethnic slurs)?	3	2	3	3
26	Have you been embarrassed ethnically in TE?	5	1	3	2
27	Did the offending person know they offended you?	1	4	1	0
28	Did you tell them they offended you?	2	3	2	2
29	Did telling them eradicate future offenses?	0	0	1	1
30	If offense continued would you file a grievance?	1	4	1	2
31	If a colleague asked to tell an ethnic joke, would you feel comfortable answering truthfully?	2	5	2	5
32	Would you let them tell it?	2	5	5	1
33	Do you feel comfortable among colleagues from other ethnic groups within TE?	5	2	7	0
34	Do colleagues of your ethnic group behave well?	7	0	6	1
35	Do ethnic slurs & slang keep people out of TE?	0	7	0	6
36	Does lack of ethnic sensitivity repel people in TE?	2	5	2	3
37	Have you ever overheard offensive ethnic slurs in TE?	2	5	2	6
38	Is this a serious problem?	1	6	0	6
39	Is the TE profession more healthy ethnically than when you first entered it?	5	0	5	0
40	Would you encourage your child to enter TE?	7	0	6	0

In items 26 and 27 it appears that some people (Blacks more often than Whites) have been offended within the TE profession by racial/ethnic slurs and comments, but that in most cases the offending party did not even realize that they had caused offense. Item 32 reinforces the findings of items 10-15 that Blacks in general prefer not to hear or share jokes with a basis in race and ethnicity. Though there are several findings indicating that ethnic slurs and similar speech is offensive to Blacks, in items 35 and 38 both Blacks and Whites agreed that such speech is not a significant problem keeping people of diverse backgrounds out of the TE profession. In item 39 there was agreement that progress has been made in terms of diversity issues in the TE profession and most respondents would encourage their own child to enter the profession (if interested) as indicated in item 40.

Since the above items required written “free responses”, they generated some significant comments reported here. One item asked respondents to “Please enter the word or words which YOU prefer to use to identify/describe your own Race/Ethnicity/Cultural Background.” This item

was intended to see if there was a preference among any groups toward a particular word. All Whites except one used the word "White" in their responses, though two added second words ("American" or "Jewish"). The one White person who answered differently responded "Caucasian". Black people responded thusly: "Black" 5, "African American" 1, "African Decent" 1. The researcher has chosen to use "Black" most often in writing this report.

In response to item 26 which asked respondents to describe any events in TE that "embarrassed, offended, or threatened you" in regard to culture/race/ethnicity seven pertinent events were related:

"I was offended by a racial joke" (Black respondent)

"A fellow professor still says 'colored' occasionally" (White respondent)

"Someone told a sex joke in front of opposite gender. I was embarrassed" (White respondent)

"I took off for a Jewish holiday and my chairman made an inappropriate comment" (White respondent)

"There was a tech. ed. crawfish boil that we heard about, sent our money for, and when we arrived we were treated as though we were not invited. Everyone else segregated themselves from the 3 of us." (Black respondent)

"Credit for an innovation was given to Euro-American instead of an African" (Black respondent)

"Some classmates (white or mixed) refer to each other as 'my n-----' as a gesture of saying 'hello'. I am personally offended, but as the only visible minority in the class, I feel intimidated to speak up." (Black respondent)

In answer to a related item (37) concerning offensive ethnic slurs or slang which was overheard (not intended for the offended party) four people indicated that they had experienced such comments (2 Black and 2 White). One Black respondent related that "one teacher overtly stated he was not a racist and does not see color". The respondent further indicated that such statements often belie a truth that the person likely does covertly hold some prejudicial views and feels a need to justify their own self. Another Black respondent wrote "There are less issues with ethnic/race jokes and more based on gender and cultural/geographic background (i.e. Southern VS Northern and 'blonde' jokes)".

When asked if people "in your racial/cultural/ethnic group view TE as a road to success and upward mobility" one Black respondent clearly said "No" and indicated that it still seems like "shop work" into which people are tracked. Since three other Black respondents gave negative responses to this item (though not as explicit), there could be an image problem still hampering TE recruitment efforts among Black people. One White respondent

commented that our curriculum is “totally U.S. consumption focused with no investigation of who owns/controls technical means and their goals.”

When asked about ways to improve TE to encourage recruitment of a more diverse population, the following ideas were posited: Require TE courses in public schools (noted by 4 respondents); begin with TE as early as kindergarten; scholarships for minorities to enter the field; and continue to upgrade and live down the “dumping ground” image of the shops. One White respondent had entered brief comments with a related theme in answer to several items. He concluded them here to indicate that there is not a major problem with making diverse peoples unwelcome, rather there should be more proactive outreach efforts to draw more women and underrepresented people into the profession.

The last open-ended free response item asked for “final thoughts and comments”. Three very insightful responses were:

“Act and perform like a professional, get treated like a professional”
(White respondent)

“Relationships are much improved; 25 years ago jokes about other cultural/ethnic backgrounds were told often.” (Black respondent)

“Do unto others as you would have done unto you” (Black respondent)

Points to Ponder

Having recognized that this is a failed study due to the low return rate, the researcher feels reluctant to posit “conclusions”. However, at this point in any report of research the reader expects to learn what the author has deduced from the work. The title “Points to Ponder” accurately reflects this researcher’s perception of the resulting summative statements from this work.

It appears that the technology education profession is, as Sanders (2001) concluded, “still taught mostly by middle-aged white men”. The first indication of this fact was the low number of Blacks and other persons of color attending the ITEA conference at which the survey was conducted. It is possible that the study was doomed from the start due to this factor alone. Though few people responded, there seems to be a reasonable comfort level for Blacks within TE. Several disturbing events were reported, but none of the respondents indicated a pervasive or pronounced consistently negative environment. A few suggestions for improvement were offered including most notably the benefits that would ensue if TE were required of all students. As was found in the 1999 study on gender issues by Haynie, the cultural climate in TE with respect to speech patterns and actions is relatively in step with the expected mores and expectations of the current society at large—perhaps the TE profession is even a little kinder and more accepting than some other segments of our society. The most negative finding is that 5 of the 7 responding Black people had experienced an event that offended them. On the other hand, the most positive findings were that 5 of the 7 Black

respondents felt that the TE profession is more ethnically healthy now than when they first entered it and all 7 of them would feel comfortable about their own child entering the profession.

Still, there were some negative perceptions which deserve follow-up study. Questions remaining include: How can TE be made more attractive to people of color? How can our content and learning activities reflect a more global and inclusive perspective? Are there regional differences that this study could not detect?

One question for which the researcher wishes to find an answer is why did so few people (especially minority group members) respond to this study—did the questionnaire itself offend them? Further study in this area is needed. This researcher seeks collaborators from underrepresented groups to continue the work in some new way. With the large influx of people of Hispanic/Latino decent into the USA, it is apparent that the perceptions of those persons must also be found to prepare for the next decade in our profession.

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