EXAMINING THE EFFECTS OF A DNA FINGERPRINTING WORKSHOP 
ON SCIENCE TEACHERS’ PROFESSIONAL DEVELOPMENT AND STUDENT 
LEARNING

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ABSTRACT

The 21st century has become the age of biology with the completion of the human genome project and other milestone discoveries. Recent progress has redefined what it means to be scientifically literate, which is the ultimate goal in science education. “What students should know?” “What needs to be taught?” These questions lead to reformulation of the science curriculum due to the changing nature of scientific knowledge. Molecular biology is increasingly emphasized in the science curriculum along with applications of the latest developments within our daily lives, such as medicine or legal matters. However, many schools and classrooms exclude the latest advances in molecular genetics from science curriculum and even teach biology as a non-laboratory science. Many science educators wonder what can be done to help every child gain meaningful experiences with molecular genetics. Limited content knowledge among teachers due to the changing nature of scientific knowledge, and the rapid discoveries in technology are known to be a part of the problem for teachers, especially for teachers who have been in the workforce for many years. A major aim of professional development is to help teachers cope with the advances in scientific knowledge and provide paths for teachers to continually improve their knowledge and skills. The expectation is that increased knowledge and skills among teachers will be reflected in
student achievement. Professional development is typically offered in a variety of formats, from short-term, one-shot workshop approaches to long term courses. The effectiveness of short-term exposures, though, is in many cases is questionable. One of the issues appears to be the gap between the incidence of teachers’ attendance at professional development programs and the incidence of implementation in participants’ classrooms. This study focuses on this issue by exploring the relationship between teachers’ professional development attendance and their implementation behavior. The goal is to understand what factors affect teachers’ decision making to implement the new knowledge and skills in their classrooms. For this purpose, the study focuses on the effects of a DNA fingerprinting workshop, which has been developed and is regularly offered by a large Midwestern university in the United States for secondary science teachers and their students through cooperation between the university and a large Midwestern public school district. The workshop focuses on the biotechnology applications of genetics—specifically, use of DNA fingerprinting technology in different areas of social life—while forensic science is emphasized.

Results indicate that the teachers’ motivation to attend the DNA Fingerprinting professional development workshop was mainly influenced by two variables: (1) the need to improve content knowledge and skills, and (2) requirements associated with current educational policies. Level of content knowledge was also found to be a factor contributing to teachers’ motivation to implement the workshop. Concerns related to student maturity and classroom management were also identified as factors influencing teachers’ implementation behavior. Evidence that the DNA Fingerprinting workshop can
be successfully implemented by classroom teachers was obtained. The DNA fingerprinting workshop was found to be a successful model for packaging professional development experiences for content intensive areas.
Dedicated to my parents
ACKNOWLEDGMENTS

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VITA

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Faculty-led workshop: This is the original implementation model for the DNA Fingerprinting workshop. In this model, a university team, including faculty and undergraduate students, facilitates the workshop in selected classrooms.

Gel station: A gel station is a set of equipment that is required to conduct the DNA fingerprinting experiment. A station consists of a gel electrophoresis chamber and a power supply accompanied by a mini-centrifuge, pipetmen and consumable items (e.g., DNA samples and a buffer solution).

Mentor: Undergraduate students who assisted in implementing the DNA Fingerprinting Workshop. Their role as mentors was to assist students in using the gel electrophoresis station and guide them throughout the experiment.

Teacher-led workshop: An alternative model of the DNA Fingerprinting Workshop where teachers assume the lead responsibility for implementing the workshop for students in their own classrooms. During this study, teachers received the consumable materials and non-consumable equipment from the university. Undergraduate students were present to provide the expertise if it was required by the teacher.
X-files: One of the most well-known science fiction TV series. The drama premiered in 1993 and has become very popular among young audiences through episodes focusing on the paranormal with elements of the forensics sciences. The DNA Fingerprinting workshop crime movie adapts the sound track of the series as well as the lead characters who are FBI agents.
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CHAPTER 1

INTRODUCTION

Scientific literacy is the ultimate goal of science education. Unfortunately, the history of science education reveals many challenges along the path to scientific literacy, including the changing nature of the knowledge in science and technology. While the goal to achieve scientific literacy remains a constant, the definition of literacy changes along with the expectations. As scientific progress continues, individuals are expected to know increasingly more to be considered scientifically literate and be capable of functioning both in the workforce and social life. The definition of being scientifically literate has changed along with the increasing amount of scientific knowledge. In the past, the ability to read and understand science-related articles was sufficient to be identified as scientifically literate. However, expectations are much higher in today’s world, individuals are required to be able to understand and apply scientific principles into daily life (Burns, O’Connor and Stocklmayer, 2003). The increasingly high standards are reflected in educational policies and reform document.

While scientific knowledge continues to advance and technologies become more sophisticated, the changes are reflected in social life as well, as was also pointed out by Roger Bybee (1993) in his book “Reforming Science Education”. The changing nature of
scientific knowledge has been formally recognized by major educational organizations. A National Science Teachers Association’s (NSTA) 2003 statement acknowledges these rapid changes; “Science knowledge has increased exponentially from the 19th century to the 20th century. With the beginning of the 21st century, this knowledge is increasing even more rapidly”.

In the history of science many discoveries and accomplishments have been identified as milestones, such as the discovery of penicillin, humans walking on the moon, and robots sent to explore the possibility of life on Mars. The 20th century was identified as the age when we opened the doors to space. The 21st century has become the age of biology with the completion of the Human Genome Project (HGP) after 13 years of intense work. When completed in 2003, the HGP identified approximately 20,000-25,000 genes in human DNA and opened seemingly unlimited possibilities in medicine. The HGP also brought a new perspective to daily life with its ethical legal and social implications (ELSI).

Problem Statement

The changing nature of scientific knowledge puts high demands on scientists as well as science educators. The major task faced by scientists in the 1900s “was to obtain more data to confirm classical theories” (Siebert, 2000). Today we see expanding possibilities through applications of scientific knowledge and tools. In the workforce and higher education there is an increasing demand for capable individuals. Scientists need to rise to the occasion with knowledge and skills to function in the world of modern science. Science also brings a complexity to social life requiring citizens to have a deeper and better understanding of sciences in order to be able to make conscious and well-thought-
out decisions. In light of all these changes scientific literacy has been a concern for several decades. Champagne (1989) expressed concerns about scientific literacy, because high school graduates were unable to solve practical problems in the workplace or make intelligent decisions on science related civic issues.

In the 21st century, biotechnology has gone beyond being a complex scientific area that only scientists need to understand to becoming an integral part of our everyday lives. Our society is highly influenced by the latest achievements in molecular genetics and DNA technologies. For example, paternity tests are used widely in court decisions and even in TV shows, DNA is used as evidence in the judicial system, genetically engineered foods are in markets and in our menus (with or without recognition by citizens), and genetic profiling is used as a routine application of medicine to determine inherited diseases which may lead to a couple’s decision about whether or not to have children. All these applications make it vital that the average citizen have a basic understanding of the science and the technology behind all these applications. Only with increased understanding can we gain assurance that informed decision making will improve our loved one’s lives.

An effective science education is the only way to assure that future generations will have the understanding and the skills to meet the needs of society and science. The educational system should guarantee that a high quality education will be provided for all individuals regardless of their location, economic status, gender or ethnicity. In efforts to provide a nationally coordinated science education, the first draft of science education standards was released in 1994 by the National Research Council (NRC). This document
defined what students should learn in their K through 12 education. In 1996, a revised version of the standards was published providing a framework for science educators by describing “the quality of what students should know and be able to do” (NRC, 1996).

The *National Science Education Standards* (*NSES*) define “the social and environmental implications of scientific and technological development” (NCEE, 1983) as a part of the blueprint. The Standards also put an emphasis on molecular biology with the following statement:

> Because molecular biology will continue into the twenty-first century as a major frontier of science, students should understand the chemical basis of life not only for its own sake, but because of the need to take informed positions on some of the practical and ethical implications of humankind's capacity to manipulate living organisms. (p. 181).

Although the importance of molecular biology in the high school science curriculum is emphasized in the *NSES* and other publications we cannot ignore the fact that there are still schools and classrooms that exclude instruction about the latest improvements in molecular genetics from the science curriculum and even teach biology as a non-laboratory science. Reed (2001) comments that “students who leave high school today without having been exposed to some form of DNA technology have been cheated out of an important experience” (p. 437).

> Teacher quality, textbooks, resources such as classroom equipment, and educational policies are some of the various factors that influence educational outcomes. The central role of teachers in promoting student achievement has been of great interest to researchers through the years and continues to be a primary concern. Standards and
level of content knowledge are reported to be issues for both new teachers joining the workforce and teachers who have been in the workforce for some time. Studies investigating the relationship between teacher quality and effectiveness and student achievement indicates a positive relationship (Sanders and Rivers (1996), Hammond (2000), Hawk et al., (1985). Teachers, regardless if they are new or have been in the system for some time, are expected to meet certain criteria in the profession.

Professional development programs are implemented to promote the ongoing education of teachers. Programs may target different audiences or use different educational approaches, but the overall goal is always the same: greater student achievement through teacher education. However, the success and effectiveness of such programs have been a concern since shortcomings have been reported in the research literature (Guskey, 2000). The motivation for teachers to attend professional development programs varies as well. While some teachers consider many professional development opportunities to be a waste of time and attend them only when required, others perceive professional development programs as learning opportunities (Guskey, 2000).

The success of a professional development program is determined by its impact on participants and their classroom behavior. When teachers take the materials from a professional development experience into their own classrooms and implement them, then we can talk in terms of successful outcomes. This study examines teacher behavior for the purpose of better understanding the influences on teacher motivations to attend a professional development workshop and to implement in their own classrooms what they have learned.
The DNA Fingerprinting Workshop described for this study was used to explore teachers’ professional development attitudes and behaviors. The DNA Fingerprinting workshop was developed by a faculty member working at a large Midwestern university in the United States. The workshop focuses on DNA Fingerprinting and its applications. The workshop was originally designed for grade ten students and was then offered to students in their classrooms by the university team. However, the number of workshops available to students each year has been limited to three or four schools due to limited availability of university instructional teams. In order to increase student accessibility to the workshop, the university faculty considered options for teachers to implement the workshop on their own within their classrooms. As a result in 2004 and 2005, the workshop was offered as a professional development opportunity for teachers. The workshop is described in depth in Chapter 3.

Research Question

This study examines outcomes of the DNA Fingerprinting workshop as a professional development experience for teachers. The DNA Fingerprinting professional development workshop represents a model to address the need to broaden the exposure of every student to molecular genetics. The model aims to provide teachers with the necessary knowledge and skills that would enable them to implement the DNA Fingerprinting Workshop in their own classrooms without assistance and achieve the intended outcomes.
The primary research question was: How successful are teacher-led DNA fingerprinting workshops in promoting desired student outcomes? In this case the student outcomes of interest are increased student content knowledge and positive attitudes towards learning genetics.

This research question gives rise to three subsidiary questions:

1. What are the motivations for teachers to attend a DNA Fingerprinting Professional Development Workshop?
2. What factors influence teachers’ decisions to implement the DNA Fingerprinting workshop in their own classrooms?
3. How effective are teacher-led workshops compared to faculty-led workshops in terms of student learning and positive attitudes among students?

Significance of the Study

This study examines teacher professional development behaviors through focusing on the investigation of motivations to (a) attend professional development workshops, and (b) implement workshop activities in classroom environments. The study is exploratory in nature, and findings are not generalizable beyond the population sampled. Findings will first test the workshop implementation model developed by the university faculty to determine its potential as a professional development experience. The problem areas of the model and possible solutions will be identified. Though the findings are not generalizable to schools and the professional development of teachers in
general, they may provide insight to other educators and program developers, and they provide evidence of what can possibly be accomplished through professional development experiences.

Limitations and Concerns

The focus of the DNA Fingerprinting workshop is very narrow in terms of topic and grade level addressed. The workshop was offered as a professional development opportunity within one public school districts. These two limitations are reflected in the number of participants. In an attempt to increase the effective sample size for some measures, participants of two previous workshops were invited to participate in the study.

The self-reported data, low response rate to the mail survey and limited responses to open-ended questions from the participants pose significant limitation to the study. Due to the unique nature of the workshop and the limitations, the results may not be generalizable and conclusions should be considered with caution.
CHAPTER 2

REVIEW OF LITERATURE

Introduction

This study investigates teachers’ motivations to attend a DNA Fingerprinting workshop and then implement the workshop in their own classrooms, and compares teacher-led workshops with faculty-led workshops in terms of their effectiveness in promoting learning and positive attitudes toward genetics among students. This chapter presents the review of literature which provides the conceptual foundation for this study. A context for the study is provided in terms of trends in science education reform, followed by reviews of relevant research regarding teacher education, teacher change and implementation behavior, scientist-teacher collaboration, problem solving and real world problems, and attitudes toward science.

Reform Movements in Science Education

Following Sputnik (1957), reform movements started to take place emphasizing what needs to be taught and how (Rutherford, 1998). The NSTA, in 1964, stated that “literate citizenry in science is achieved through carefully planned kindergarten through grade 12 science programs” (NSTA, 2003, p. 1). In 1980’s the terminology included the phrase “scientific
literacy” which referred to the goals of science education (Bybee, 1993). Future publications of NSTA continued to focus on K-12 education. The scientific literacy for all students remained a priority in these publications. In 1983, “A Nation at Risk: The imperative for educational reform” has been published by the National Commission on Excellence in Education (NCEE) stating “Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world”. Different instructional approaches were suggested and studied in an attempt to find the best instructional practices which would promise success towards scientific literacy.

During the 1980s other publications pointed to the disinterest among students towards science and technology. Reports such as the publication by the American Association for the Advancement of Science's (AAAS) and National Science Board Commission continued to highlight the concerns about future generations understanding science and their role as scientists or citizens. With these continued concerns verbalized, a long term effort was initiated to improve the quality of education to guarantee success in economy and industry as well as the intellectual, moral, and spiritual strengths of citizens.

Transforming science education is a complex process and requires a structured approach. Bybee (1993) proposed a model consisting of five steps to reform science education. In this model developing a framework of curriculum and instruction is identified as the third step of the transformation process. A vision of a scientifically literate population applying to all students regardless their gender, age, ethnicity or economic background is defined by “Science Education Standards”. The National
Research Council (NRC) released the first draft of science education standards in 1994. This document was defining what students should know in their K through 12 education. The *National Science Education Standards (NSES)* defines “the social and environmental implications of scientific and technological development”. In 1996, a revised version of the standards was published providing a framework for science educators by describing “the quality of what students should know and able to do.” According to this document K-4 grade students should have an understanding of the foundations of heredity. In grades 5-8; hereditary traits, genes and sexual reproduction and in grades 9-12 molecular basis of heredity, structure and function of DNA, and chemical bases of life are covered.

Following the nationwide efforts to provide more clear guidelines to educators, state level initiatives were formulated. In Ohio, the Department of Education published the *Academic Content Standards* in 2003, providing a blueprint for science curriculum in K-12 classrooms. The *Academic Content Standards* are made up of six standards pertaining to Earth and Space Sciences, Life Sciences, Physical Sciences, Science and Technology, Scientific Inquiry and Scientific Ways of Knowing. The standards are elaborated with benchmarks and indicators for each grade level component. Each standard is followed by benchmarks. The benchmarks are key checkpoints that monitor student progress toward meeting the science standards. The grade-level indicators represent specific statements of what all students should know and be able to do at each grade-level. The academic content standards can be viewed at the Ohio Department of Education website. Genetics is an important component of the Life Science curriculum. At grade ten students should know;
1. Indicator 5: Illustrate the relationship of the structure and function of DNA to protein synthesis and the characteristics of an organism (p. 221).

2. Indicator 6: explain that a unit of hereditary information is called alleles (e.g., gene for pea plant height has two alleles, tall and short) (p. 221).

3. Indicator 27: Describe advances in life sciences that have important long-lasting effects on science and society (e.g., biological evolution, germ theory, biotechnology and discovering germs (p. 222).

4. Indicator 28: Analyze and investigate emerging scientific issues (e.g., genetically modified food, stem cell research, genetic research and cloning) (p. 222).

Defining what students should know and developing curriculums based on the identified framework does not guarantee a scientifically literate population. There are other elements that contribute to academic success. A few of the elements that have impact on the educational outcome include teacher quality, textbooks and having appropriate equipment in the classrooms. The *NSES* (NRC, 1996) also include sections on Science Teaching Standards and Professional Development Standards to address the other components of academic success.

The *NSES* describe the knowledge and understanding teachers should possess at all grade levels. Five assumptions found in the standards for science teaching;

1. The vision of science education described by the *Standards* requires changes throughout the entire system.

2. What students learn is greatly influenced by how they are taught.
3. The actions of teachers are deeply influenced by their perceptions of science as an enterprise and as a subject to be taught and learned.

4. Student understanding is actively constructed through individual and social processes.

5. Actions of teachers are deeply influenced by their understanding of and relationships with students (NRC, 1996)

The second statement points out the important role of teachers on student achievement. Thus the importance of teacher content knowledge and abilities come forward. The changing dynamic in science education and the reform movements challenge teachers to keep up with the changes. Professional development programs provide teacher with opportunities for personal growth in their profession.

Teacher Education

As pointed out in the *NSES*, “Reforming science education requires substantive changes in how science is taught, which requires equally substantive change in professional development practices at all levels” (NRC, 1996) The rapidly changing nature of pedagogical and content knowledge and other aspects of education, such as the reform movements, puts teachers on the spot and it is expected that they will change their views and strategies to facilitate development of an effective educational system. Bybee (1993) compares science educators to the mythological character Sisyphus. Sisyphus was punished by having to roll a huge rock up a hill throughout eternity but every time before he reached the top, the rock fell and he had to start again from the beginning. Every educator faces the similar situation through the advancement of sciences and technology and changes in social life resulting in educational reforms (Bybee, 1993). According to
Melear (1999) while teachers are expected to change their classroom practices the assumption is that teachers are comfortable with laboratory equipment and procedures. In the process of change, teachers have to take a look deep inside and step out of their safe and comfortable classrooms. In a study conducted by Yerrick and Hoving (2003) participants characterized change as having one foot on the dock and one foot on the boat, where the dock represents stability and comfort.

The National Research Council, American Association for the Advancement of Science (AAAS) and National Council of Teachers of Mathematics (NCTM) emphasize that “how students are taught highly affects what they learn”, bringing a new understanding in education with pedagogy as an integral part of educational goals (Kennedy, 1998). The relationship between science teaching practices and student learning outcomes has been studied by various researchers, and research suggests that students learning outcomes are highly correlated with the effectiveness of the teachers. Students who are assigned to several ineffective teachers in a row have significantly lower achievement and gains in achievement than those who are assigned to several highly effective teachers in sequence (Sanders and Rivers, 1996).

Teacher education takes place at two levels: pre-service teacher education and in-service teacher education. It is vital to provide teachers with professional development opportunities at both levels to assure that new teachers who are joining the workforce have the skills and knowledge required and the teachers who have been in the workforce for sometime are keeping up with the educational changes. In teacher research,
researchers have been limiting their scope at three dimensions to be able to control the complexity and the size of the enterprise (Kennedy, 1996). Kennedy (1996) identifies three areas of focus in teacher education research:

a) Concentrating on the student teaching component of teacher education: With its definable timeline and place, this component presents opportunities to researchers to study before and after teacher beliefs, knowledge, and skills. While studying this component provides valuable information for our understanding of student teaching, it does not provide insight on the course element of pre-service teacher education;

b) In-service programs: The focused nature of in-service programs with clearly defined goals makes them easily manageable for researchers. Although such research is fruitful in many ways, its shortcoming is that it does not provide insight into the pre-service component of teacher education, and;

c) Descriptive research: In this component researchers approach teacher education from a definitive point of view to look at the teacher education programs, faculty, educational goals, curriculum requirements, and integration of teaching into the curriculum. (Kennedy, 1996). There is a lack of systemic research in different characteristics of professional development regardless the large amount of research that is conducted. This may be due to size and complexity of the enterprise (Kennedy 1996; Garet, Desimone and Porter, 2001). Regardless of the insight provided by the vast amount of research, there are questions regarding the impact of teacher education and which characteristics of professional development are related to positive outcomes (Kennedy, 1996 and Garet et al., 2001).
In-service teacher education, which is the main focus of this study, has been offered to teachers with different visions by the teacher education community in an attempt to find a remedy to issues identified by the need assessment studies. Several areas of need are identified as they relate to problems teachers face in their profession such as: (a) burnout; (b) inadequate preparation in subject areas, and foremost importance, (c) lack of knowledge of current scientific developments (Bazler, 1991).

Programs developed and delivered as solutions to addressing the issues identified by the needs assessments also turned out to be subject to research to assure that the outcomes are successful. Research focusing on in-service programs in science education identifies some shortcomings of these programs, including:

Lack message and relevance to what actually happens in the teachers’ classrooms, lack incentives and do not respond to teachers’ need and concerns, insufficient intensity and duration to make a positive impact on teachers’ performance and students’ achievement, do not make effective use of business and industry expertise and resources, lack of collaboration on actual implementation as well as networking components, lack of collaboration between colleges of natural science and colleges of education, are not coordinated with pre-service science teacher preparation programs (Barufaldi, 1997, p.3).

The Science Coalition Coordinating Committee and Bay Area school districts representatives’ Need Assessment Meeting, which took place in 2002, identifies the following items as the areas most in need of professional development in science: (1) content areas at all levels, including summer research opportunities; (2) support for efforts in improving participation in AP courses and testing (particularly among
underrepresented students); and (3) promoting analytical thinking and problem-solving skills (UCB Science Coalition (2002). Parsad, Lewis, Westat and Greene, (2000) reported a study conducted by the National Center of Education Statistics investigating teacher quality with the participation of 2,000 elementary, middle school and high school teachers from 50 states. Their findings can also be considered as an indication of teachers’ self-assessment to determine areas of need. They reported the following areas of teacher interest: (1) more than one-half participated in professional development programs focused on the integration of educational technology into the grade or subject taught (74%); (2) in-depth study in the subject area of the main teaching assignment (72%); (3) implementing new methods of teaching (72%) and (4) student performance assessment (62%). Teachers were less likely to have participated in professional development that focused on addressing: (1) the needs of students with disabilities (49%); (2) encouraging parent and community involvement (46%); (3) classroom management, including student discipline (45%) and (4) addressing the needs of students from diverse cultural backgrounds (41%). The professional development area in which teachers were least likely to participate was addressing the needs of students with limited English proficiency (26%).

Subject matter (content) knowledge is reported to be an important element in teacher effectiveness, providing a rationale for professional development opportunities that focus on specific science or mathematics content (Cohen and Hill 1998, Fennema, Carpenter, Franke, Levi, Jacobs and Empson., 1996; cited in Garet et al., (2001). According to the National Commission on teaching and America’s future (NCTAF ) (1996) “what teachers know and can do directly determines what students will learn”
(Westerlund, 2002). While some research, identified above, supports the importance of content knowledge in students learning, other research seems to indicate that there is little or no evidence of a relationship between content knowledge and teacher performance. Studies of teachers' scores on the subject matter tests of the National Teacher Examinations (NTE) have found no consistent relationship between this measure of subject matter knowledge and teacher performance as measured by student outcomes or supervisory ratings.

Byrne (1983) summarized the results of thirty studies relating teachers' subject matter knowledge to student achievement. Teacher knowledge measures were either subject knowledge tests (standardized or researcher-constructed) or estimates based on the number of college courses taken within the subject area. The results of these studies were mixed, with 17 showing a positive relationship and 14 showing no relationship. However, many of the "no relationship" studies, Byrne noted, had so little variability in the teacher knowledge measure that insignificant findings were almost inevitable. Ashton and Crocker (1987) found that only 5 of 14 studies they reviewed exhibited a positive relationship between measures of subject matter knowledge and teacher performance. It may be that these results are mixed because subject matter knowledge is a positive influence up to some level of basic competence in the subject, but becomes less important thereafter. For example, a controlled study of middle school mathematics teachers, matched by years of experience and school setting, found that students of fully certified mathematics teachers experienced significantly larger gains in achievement than those taught by teachers not certified in mathematics. The differences in student gains were greater for algebra classes than general mathematics (Hawk, Coble, and Swanson, 1985).
However, Begle and Geeslin (1972) found in a review of mathematics teaching that the absolute number of course credits in mathematics was not linearly related to teacher performance.

It seems to be a matter of common sense that knowledge of the material to be taught is essential to good teaching. However, the importance of subject matter expertise could grow smaller beyond some minimally essential level that exceeds the demands of the curriculum being taught. This interpretation is supported by Monk's (1994) more recent study of mathematics and science achievement. Using data on 2,829 students from the Longitudinal Study of American Youth, Monk (1994) found that teacher content preparation, as measured by coursework in the subject field, is positively related to student achievement in mathematics and science, but that the relationship is curvilinear, with diminishing returns to student achievement of teachers' subject matter courses above a threshold level (e.g., five courses in mathematics). In a multilevel analysis of the same data set, Monk and King (1994) found both positive and negative, generally insignificant effects, of teachers' subject matter preparation on student achievement. They did find some evidence of cumulative effects of prior as well as proximate teachers' subject matter preparation on student performance in mathematics. Effects differed for high- and low-achieving students and for different grade levels. In a review of 65 studies of science teachers' characteristics and behaviors, Druva and Anderson (1983) found that students' science achievement was positively related to the teachers' course taking background in both education and in science. The relationship between teachers' training in science and student achievement was greater in higher level science courses, a result similar to that found by Hawk, Coble, and Swanson (1985) in mathematics. It may also be that the
measure of subject matter knowledge makes a difference in the findings. Measures of course-taking in a subject area have more frequently been found to be related to teacher performance than have scores on tests of subject matter knowledge. This might be because tests necessarily capture a narrower slice of any domain. Furthermore, in the United States, most teacher tests have used multiple-choice measures that are not very useful for assessing a teacher’s ability to analyze and apply knowledge.

Teachers lack of content knowledge, addressed in many studies, led researchers to argue for professional development opportunities focusing on subject matter content knowledge (Garet et al., 2001). Reynolds (1995) in his review concludes that elementary school teachers have limited content specific pedagogical understanding” (Garet et al., 2001 p.214). According to Kennedy (1998) professional development that focuses on specific content and how students learn that content, has a larger positive effect on student achievement, especially achievement in conceptual understandings (Garet et al., 2001). Along with Kennedy (1998) Garet et al., (2001) confirmed the importance of professional development focusing on mathematics and science content and its importance in designing high quality professional development. Garet et al., (2001) concluded that “professional development that focuses on academic subject matter (content) gives teachers opportunities for hands-on work (active learning) and is integrated in daily life of the school (coherence) is more likely to produce enhances knowledge and skills” (p. 935).
Teacher Change and Implementation Behavior

Educational change is systemically taking place at the school level and within the school environment through the actions of individual teachers. Teachers are the ones deploying the policy outputs (Adams, 2000). Teacher change and implementation of new behavior to their teaching environment are proposed as indicators of the success of professional development programs. While some educators identify criteria that leads to teacher change, some focuses on the behavioral models to explain the implementation behavior.

According to Lampert (1988) some of the conditions required for teacher change include: observing new practices being used in actual classroom environments, getting feedback on their performance, peer cooperation on new techniques, and smooth integration of the new material (as cited by Adams, 2000, p. 11). Individual level of implementation is described through a model by Adams (2000). In this model implementation behavior is characterized as an output of teachers’ motivation, skills and environment (Adams, 2000). The analytic framework of this model is presented below in Figure 2.1. According to this framework curriculum implementation is perceived at the individual teacher level. Teacher motivation, capacity and the environment drive the implementation process whereas students, policies and teacher networks contribute to the environment factor. In the model, the term generic skills refer to problem solving, planning and communicating. Specific skills refer to subject-matter knowledge and teaching skills. The student variables include achievement level, maturity, family background and level of cooperation (Adams, 2000).
There are other models that focus on behavior prediction. One of these models was developed by Ajzen (2002). Ajzen’s Theory of Planned Behavior considers three elements as guiding human actions: behavioral beliefs, normative beliefs, and control beliefs. According to this theory behavioral beliefs, normative beliefs and control beliefs lead to intention through attitudes toward behavior, subjective norms (social pressure), and perceived behavioral control. More positive guiding actions lead to stronger intentions. The behavior is expected to take place when there is sufficient actual behavioral control (Ajzen, 2002). Ajzen (2002) also includes the contribution of perceived behavioral control due to the difficulties of execution of behavior.
Two other models of behavior prediction have been commonly used in research to predict human behavior in different areas. These two models are: the Theory of Reasoned Action (Fishbein, 1979) and the Integrative Model of Behavioral Prediction (IMBP) (Fishbein and Yzer, 2003). IMBP is a modified version of the Theory of Reasoned Action focuses on acting on intentions. According to this model “people do not act on their intentions because they lack the skill to perform the behavior, because there are environmental barriers to performing the behavior, or both (p.181) (Fishbein and Yzer (2003), cited in Danter, 2005).

Some of the research utilizing behavioral prediction models focuses on public health such as HIV prevention, driver behaviors and other topics. However, educational implications of the behavior prediction of teacher’s implementation are limited in literature. A study conducted by Danter (2005) focused on the accuracy of predicting a participant’s future use of materials based on a statement of intent. Her study utilized the Integrative Model of Behavioral Prediction (IMBP). The results of the study suggest: (1)
self-efficacy (perceived ease) and attitude were significant predictors of intention; (2) abilities were a low predictor of the behavior while environmental factors were not a significant predictor to either behavior or intention; and (3) there was a significant correlation found with opportunity but not with attitude, self efficacy, control or motivation (Danter, 2005).
Figure 2.3: The integrative model of behavioral prediction (Adopted from Fishbein and Yzer, 2003).
Scientist-Teacher Collaboration

The value of the content knowledge possessed by scientists cannot be ignored in science education for both students and teachers. Lasley, Matczynski and Williams (1992) described the power of collaborative partnerships compared to non-collaborative relationships in achieving the goals for growth of the society. As pointed out by Lasley Matczynski and Williams (1992) collaborative partnerships require an investment of time and energy.

Two different approaches can be used by scientists involved in school science: (1) direct interaction with students, and (2) professional development of teachers to enhance the knowledge and hands on skills of science teachers (Waksman, 2003). Direct interaction can take place in two different settings: in K-12 classrooms or higher education institutions. In most cases scientists’ involvement in science education takes place in the form of summer programs for both students and teachers. Of such programs the University of Rochester’s Environmental Health Sciences Center and the DNA Learning Center of the Cold Spring Harbor Laboratory are two examples of institutions that offer learning opportunities of a week or longer for both students and teachers (Waksman, 2003). The availability of summer programs and other opportunities, raises the question of how student understanding is impacted with these programs when their teachers participate in them. Research conducted by Silverstein and his colleagues at Columbia University sought to find an answer to this question. The study was conducted through the academic years of 1994- 1997 among 112,795 students. Their results showed improvement in the areas of grade point average, class attendance, and participation in science clubs.
Problem Solving and Real World Problems

The basic goal of science education is to develop a scientifically literate population, with individuals who understand and appreciate scientific concepts and are able to function in society in their adult stages with the skills and knowledge needed. Today, all around the world, the educational systems are still characterized by traditional teaching methods. On the way towards better education, educators need to understand how people learn and present different delivery approaches in the classrooms. Research on student learning has resulted in proposals for different instructional approaches with the consideration of learning theories.

Problem-based learning (PBL) was originated in the medical field as a successful method for training physicians compared to the traditional approach in terms of data collection, problem solving, and other skills (Albanese and Mitchell, 1993). The problem-solving approach has been used and studied at different levels since the 1900s. As Wolf (1995) points out, the applications of problem-solving were limited to experiments outside real-world connections and based on research evidence. Transfer of the problem-solving skills to real-life context does not seem to be a successful process. Another point Wolf (1995) makes is the discrepancy between the problem-solving perspectives of scientists and ordinary people.

To understand how students learn, researchers investigated the problem solving skills of successful and talented students. Their goal was to help less successful students with the learning process through the understanding they will get by studying successful students. Participants included physics majors and engineering students. Their results
suggested that 85% of physics students are unable to solve real-world problems, and 90%
of the undergraduate engineering students could not apply the concepts they learn inschool to new problems (Kennedy, 1998).

Learning through PBL is purposeful because it takes place in the context where knowledge is to be used (Chin and Chia, 2004). Problem-based learning integrates constructivism, although it was not a response to educational theory (White, 2001). Constructivist learning of science is defined to be the meaningful way of learning where a dynamic process takes place and there are several methods developed for constructivist biology teaching. According to Lord (1998) the most successful method is the 5E model developed by Bybee, which includes five instructional phases: Engage, Explore, Explain, Elaborate, and Evaluate. The Engage phase includes motivating students to study a topic. Students examine the topic in small groups in the Explore phase. The Explain segment encourages students to share group results with the whole class. The Elaborate phase allows students to expand on the topic, while the Evaluation includes teacher assessments and student self-evaluation. Lord (1998) reports enhanced student learning and a positive change in student attitudes with the model they used in biology courses.

Attitudes Toward Science

A student’s feelings and emotions in science help determine the choices they make that determine whether or not effective learning will take place (Koballa, 1995). Promoting positive or favorable feelings toward science, science learning, and scientist is an important goal in science education. (Koballa, 1995).
In 1960 a different trend was originating in science education research with the influence from psychology; a focus on student attitudes toward science, science education, and scientists. Given the broad use of Likert’s (1932) approach to measurement, it is impossible to ignore his influence on research of attitudes and behavior relationships (Koballa, 1995). Research findings suggest that students’ attitudes toward science develop at early ages. The ages of 8 through 13 seem to be the most critical years and attitudes toward science are quite well established by the time students start secondary education. Therefore, in most cases the research interests in attitudes are directed to elementary and middle school grades. The effect of attitudes toward science on student achievement is recognized but approached with caution by researchers. While some studies (Gardner, 1975; Schibeci, 1984) report a small correlation between achievement and attitudes toward science, other researchers report no evidence suggesting a correlation between these two variables (Koballa, 1995). According to Shrigley (1990) certain criteria have to be met to be able to predict science related behavior through science attitude scales: “when attitude and the behavior of interest are measured at the same level of specificity, when social context and individual differences, including cognitive ones, are considered and when the person’s intention regarding the behavior is known” (Koballa, 1995, p.66). While different factors have been associated in regard to attitudes toward science, gender is one of the factors that are highly studied in attitudinal research. The general conclusion is that females have less positive attitudes toward science. Some studies specify the interest level among gender based on content such as biological sciences or physical sciences. (Koballa, 1995).
Self-efficacy concerns an individual’s belief in his or her ability to achieve a targeted goal in a task. How we approach new tasks is mostly determined by our self-efficacies. In social cognitive theory self-efficacy has been considered as one of the main contributors to student achievement (Bandura, 1998). According to Bandura (1998), individuals with higher self-efficacy levels approach difficult tasks as challenges to be mastered rather than as threats. These people show a strong commitment to accomplishing their tasks. However, individuals with low levels of self-efficacy tend to view challenges as threats and shy away from them. These individuals have weak commitments and easily lose faith (Bandura, 1998). The effects of self-efficacy on human functions were identified by Bandura (1998) as clustering within four categories: behavior choices, thought patterns, humans’ view of behaviors, and efforts applied to a task. For students, these effects present themselves through career choices, motivation for learning subject matter, and attitudes toward science. According to his argument, self-efficacy increases through performance accomplishment, observing others successfully complete tasks, support and encouragement from others, and decreasing the amount of anxiety during a task.
CHAPTER 3

METHODOLOGY

This study employs quantitative research strategies supported by descriptive data collected through interview processes to address the central question of this study: How successful are teacher-led DNA fingerprinting workshops in promoting desired student outcomes? This chapter provides descriptions of the workshop setting and content, workshop participants, instrumentation, research procedures, and techniques used to analyze and display the collected data.

The DNA Fingerprinting Workshop

The DNA Fingerprinting Workshop was developed by a faculty member in the molecular genetics department at a large Midwestern state university in the United States. It was developed with the cooperation of a large a Midwestern public school district in the same city. The content of the workshop was developed with the consideration of state and district standards, and it was aligned with the grade ten biology curriculum. The main content focus of the workshop was DNA fingerprinting and its applications to daily life. The DNA Fingerprinting Workshop provides a learning experience for grade ten students and their teachers where the expertise of scientists is brought into the classroom environment.
The DNA fingerprinting workshop has been offered annually to a limited number of grade ten students in the public school district since 2000. It has been offered during either winter or spring quarters. Undergraduate students took part in the workshops as mentors and worked with students in groups of three to five. Workshop activities span three days and have been implemented through collaboration of the university team and school teachers. Prior to offering the workshop to students, science teachers receive a one-day training session to familiarize them with content and techniques. Teachers are expected to assume responsibility for the first day of the workshop and to prepare students for the following two days of investigation. The second and third days of the workshop are facilitated by the university team of faculty and undergraduate students in public school classroom settings. Although the original design of the workshop targeted grade ten students, the workshop has also been offered as a professional development opportunity for teachers by the same school district with cooperation of the university faculty.

The content of the workshop focuses on DNA Fingerprinting and forensic sciences and targets the grade ten life science curriculum. The DNA Fingerprinting Workshop is built around a mock crime in the X-files fashion where a high school student’s science project has been destroyed. During the workshop students review he science content knowledge necessary to understand the workshop, including: DNA structure, basics of electrophoresis, and restriction enzymes. After watching the crime video, which was produced by the same university’s theater department, and interviews of the suspects, students try to identify who committed the crime among four suspects. During this process they rely on their observational skills and psychological evidence
provided by the video. Later, students do the electrophoresis to solve the crime while being mentored by undergraduate students. It takes 30 to 40 minutes to run the electrophoresis gels. During this time students go through a set of questions on the science content. After running the electrophoresis, the gels are left in the stain overnight to make the bands visible. The next day students receive the results of DNA fingerprinting analysis and analyze their gels to determine who committed the crime. They compare their conclusion based on gel electrophoresis with the previous conclusion which was based on the psychological evidence. Following the results, students discuss socio-ethical issues of gene screening and other biotechnological applications of genetics in an open discussion environment. The DNA Fingerprinting Workshop was developed to give the opportunity to high school students of experiencing science and technology in a social context.

The program has been successful and popular among students, teachers and administrators. There has been high demand from teachers to have the university team in their classroom to conduct the workshops. However, due to time constraints resource limitations, the university has only been able to offer the student workshops at three to four high schools each year. The public school district has twenty-three high school buildings. This means that every year most students in the district are missing out on an important experience when they could take part in a workshop. With these limitations in mind, the university faculty member who offers the DNA Fingerprinting workshop began considering ways to make the workshop more broadly accessible to students. The objective was to develop a collaborative partnership model that makes the equipment, both perishable and non-consumable items, available through the university to teachers
who would be responsible for offering the workshop in their classrooms. The goal was to reach more students and give them the opportunity to benefit from the experience. For these purposes, two different versions of the workshop, a faculty-led version and a teacher-led version, were designed to be offered to students. The faculty-led version is the traditional approach of the DNA Fingerprinting workshop which has been offered for the past 5 years. The teacher-led version is led by classroom teachers and includes the same workshop content.

Professional development workshops were offered during 2005 to prepare teachers for the teacher-led workshops. The professional development workshops were one day long and offered as an option to teachers during the district-wide professional development days of the Midwestern public school district. The professional development workshops took place in a lab environment at the university’s molecular genetics department. Teachers were instructed on the essential content knowledge and had hands-on experience to improve their laboratory skills and become familiar with the equipment.

From the researcher’s standpoint this approach seemed a great opportunity to explore teachers’ professional development behavior by addressing two questions: what drives teachers to attend the workshop and what are the factors that influence their decision to implement related materials in their own classrooms. This study was conducted in two phases. The first phase of the study focused on teachers who participated in the DNA Fingerprinting workshop as a part of their professional
development requirement. The second part targeted students to explore the effectiveness of the teacher-led workshops in comparison to faculty-led DNA Fingerprinting workshops.

Subjects

The subjects of this study were teachers selected from those who took part in the DNA Fingerprinting workshops offered during 2004 and 2005, and their.

The DNA fingerprinting workshop was offered at two levels, teachers who participated in the DNA fingerprinting workshops as part of the district’s professional development program, which were offered by a large Midwestern university, and students who participated in the DNA fingerprinting workshop in the public school classrooms. The workshop contributes to the teachers’ professional development requirement as a one credit hour course. Although there were no eligibility requirements set by the university to participate in the workshop, the public school district employed a screening process to identify eligible participants due to high demand. The content covered during the workshop addresses part of the grade ten curriculum, although it is also aligned with the content in the higher grade levels. The eligibility criteria for the participants were set based on curricular needs of the grade levels, and priority was given to teachers who teach high school life science courses.

The teacher workshops took place during 2005 with the cooperation of a large public school district. There were four workshops offered. The original design of this study was targeted at teachers who were participating in two workshops offered after April 2005. One of these workshops was offered specifically for Advance Placement (AP) teachers. The DNA Fingerprinting workshop was offered twice prior to April 2005,
on September 15, 2004 and January 26 2005. Forty-six teachers who participated in the workshops on September 15, 2004 and January 26 2005 were also included in the study to receive the “DNA Fingerprinting Follow-up Teacher Questionnaire” via permission of the IRB committee. Three of the participating teachers attended the DNA Fingerprinting workshop twice. The DNA Fingerprinting Follow-up Teacher Questionnaire was sent to participants through US mail. A total of seventy-three questionnaires were sent out. Two reminders were also sent out a week apart to teachers who had not returned surveys. Three questionnaires out of seventy-three were returned as undeliverable. A total of 17 teachers returned the survey. The return rate was calculated based on guidelines defined by the American Association for Public Opinion Research (AAPOR). AAPOR describes five different response rate calculations with the consideration of refusals or partial completion of phone interviews. A minimum response rate is defined as “the number of complete interviews divided by the number of interviews (complete plus partial) plus the number of non-interviews (refusal and break-off plus non-contacts plus others) plus all cases of unknown eligibility (unknown if housing unit, plus unknown, other)” (AAPOR, 2006, p 34, 35). The minimum return rate for the DNA Fingerprinting follow-up teacher questionnaire was calculated as 23.288%. The return rate was recalculated to find maximum response rate by excluding the mail surveys that were undeliverable mail questionnaires. Maximum response rate was calculated as 24.286%.

Two workshops were offered after April 2005 and a total of 31 teachers participated in these workshops. Participant teachers in these two workshops were asked to fill out the DNA Pre-Workshop questionnaire inquiring about their background, motivations to attend the workshop and intentions to implement the DNA Fingerprinting
workshop in their own classrooms. The main purpose of the questionnaire was to gather information regarding participants’ background to provide instructional support for the university faculty facilitator. Since the questionnaire also inquired about teachers’ motivations to attend the workshop and future plans, it also provided a base line for the study regarding teacher motivations and intentions.

Eight teachers, who were teaching grade ten AP Biology, participated in the fourth session of the workshop that was specifically offered for AP Biology teachers. Although the content of the workshop was the same as the other sessions the profile of the participants was uniform due to the grade level taught. The suggestion to offer a session specifically to AP teachers came from the school district probably in consideration of the grade ten AP Biology curriculum. There are twelve required experiments in this grade level curriculum, and one of the required experiments is DNA gel electrophoresis. Eight AP teachers attended the workshop, and four of these teachers indicated an interest in implementing the DNA Fingerprinting workshop in their own classrooms. Three of these teachers took the initiative to implement the workshop in their classrooms. The teacher profiles and the implementation process are discussed in depth in the following Chapter 4.

Student workshops were offered in two different formats; a faculty-led version and a teacher-led version. Faculty-led workshops were taught by a university faculty member. Students worked in groups at each gel electrophoresis stations, with each group consisting of two to five students, depending on the classroom size. The maximum number of stations in each classroom was six, and the student groups were mentored by undergraduate students. The undergraduate students took part in the DNA Fingerprinting
workshops as a part of their service learning program. The faculty-led workshop was the original design of the DNA Fingerprinting workshop that has been offered using this approach since 2000. Teacher-led workshops were deployed for the first time in the context of this study. This approach required teachers to assume the lead facilitator role. The equipment and materials were provided by the university, so there was no financial demand on teachers or the school district. Teachers requested undergraduate student assistants as mentors, since this was their first attempt to implement the workshop.

The selection of schools and students who would participate in the faculty-led workshops was on a first come/first served basis. Since the university faculty member was able to offer only a limited number of workshops, teachers who signed up first had the faculty-led workshops in their classrooms. The university was able to conduct the faculty-led workshops for the students at only three high schools during this study. Four teacher-led workshops were conducted by teachers who volunteered to implement it in their classrooms, and they received support from the university during the process. The support provided by the university consisted of supplying non-consumable materials (chambers, power supplies and pipetman) and perishable items (DNA, buffers and stains), as well as providing undergraduate support as requested.

Students who participated in the workshops were from various grades, not just high schools, due to the teachers who implemented the workshop in their classrooms. A total of four teachers implemented the workshop in their classrooms. Teacher 9, teacher 41 and teacher 37 (see profiles in chapter 4) were high school teachers and implemented the teacher-led workshop in their grade 10 AP classrooms. Teacher 64 was a middle school teacher who implemented the workshop with his summer school students. The
summer school students were a mixed group that included grade 7 and grade 8 students taking an elective course. Faculty-led workshops were offered to grade ten biology students.

Students’ participation in the study was on a voluntary basis. Regardless of students’ choices to participate in the study or not, all students were eligible to attend the DNA Fingerprinting workshops. All participating subjects of the study were required to provide a signed consent form. For students who were younger than 18 years of age, a parent’s or legal guardian’s signature was also a prerequisite for eligibility to take part in the study. The data from subjects who were not able to provide a consent form were excluded from this study. It was essential for the study that each student’s responses to the instruments could be matched. Therefore students were asked to include their names on the instruments which were later replaced with an identification number during data coding to preserve anonymity.

Instrumentation

The target population of the study consisted of two groups: teachers and students. The data collection was conducted separately for each group. This section describes the instrumentation for each target group.

Instrumentation for Teachers

The methodology for the collection of data from teachers was developed with the consideration of participant access. Prior to the teacher DNA Fingerprinting Workshop, which was a professional development workshop, the researcher did not have any knowledge of the identity of the participants, thus the teachers were not accessible until
they came to the professional development day. Therefore, three different data collection methods were employed during the study to collect data at different stages of the teachers’ professional development process.

*Pre-workshop questionnaire*

The DNA Pre-workshop questionnaire was chosen as the first instrument of the research. The questionnaire was administered when teachers arrived at the site of the workshop. They were asked to respond to the questionnaire before the workshop started. The DNA Pre-workshop questionnaire was designed to provide a profile of the participants’ backgrounds as well as their intention to take part in the professional development opportunity. The DNA Pre-workshop questionnaire consisted of seven items (See Appendix D). Four items required open-ended responses about the teachers’ purposes for attending the workshop, their experience with DNA technologies, and their intention to integrate the DNA fingerprinting workshop into their classrooms. The remaining three items of the questionnaire referred to demographic information: grade level taught, years in teaching and educational background. The length of the items was limited out of consideration for the limited time that was allowed during the workshop.

*Follow-up Teacher Questionnaire*

The need for an additional questionnaire was evident due to fact that a total of seventy-three teachers participated in the DNA Fingerprinting workshop through four sessions and only the teachers who participated the last two sessions received the DNA Pre-workshop questionnaire. The number of teachers who received the DNA Pre-workshop questionnaire was thirty-one. To address this need the DNA Fingerprinting follow-up teacher questionnaire was developed. The questionnaire consisted of two
sections (See Appendix E). The first section inquires about the background of the participating teachers. This section of the questionnaire was adapted from the TIMSS 2003 Teacher Questionnaire which is publicly available at http://nces.ed.gov/timss. The second part of the questionnaire includes open-ended questions and inquires about the teachers’ motivations to attend the workshop and their implementation intentions. The DNA Fingerprinting follow-up teacher questionnaire was sent to every participant after all four workshops were completed. The DNA Fingerprinting follow-up teacher questionnaire served to provide the first set of data from the teachers who attended the workshops on September 15, 2004 and January 26 2005, while serving as a post-workshop questionnaire for teachers who attended the workshops after April 2005.

The third method of data collection employed in the study was individual interviews with teachers. Interviews are reported to be an integral part of most social research (Breakwell, 2000, p. 239). Interviews were conducted with teachers who participated in the DNA Fingerprinting workshop and volunteered to take part in the interview process. Each teacher who received the DNA Fingerprinting follow up teacher questionnaire was asked if he or she would be willing to participate in interviews. Eight teachers responded positively to the request for an interview, but circumstances allowed only six teachers to be available for an interview during the study. Interviews were conducted without a rigid structure to give more control to the interviewee in his or her responses as well as to provide flexibility in questions that were posed. The general protocol for the interviews is provided in Appendix C. The interviews took place after the second nine weeks of the 2005-2006 school year. The timeline for the interviews was determined by two factors. The content on DNA is covered during the second nine-week
period of the grade ten curriculum and waiting to finish the second nine weeks would allow teachers to have more opportunity to implement the workshop aligned with the curriculum. The second reason was related to the Ohio Graduation Exam (OGT); teachers were focusing on the OGT and did not have any time to focus on activities outside the curriculum and were reluctant to schedule the interviews prior to the OGT. The settings for the interviews were chosen by the interviewees based on convenience. Most of the interviews were conducted after school as the teachers requested. The interviews were tape recorded with the permission of the interviewees and then transcribed by the researcher.

**Instrumentation for Students**

Student data were collected through two instruments: a content test, the Genetic Content Survey, and an attitude survey, the Attitudes Towards Genetics Survey. The two instruments are described below in depth.

**Genetics Content Inventory**

The Genetics Content Inventory was derived from a content test which was developed locally by the researcher and a graduate associate for a different project. The original instrument included thirty items addressing broad molecular genetics content. Seven items of this instrument address the content of the DNA Fingerprinting workshop. These items were selected to be part of the Genetics Content Inventory for this study. The complete Genetics Content Inventory used in this study consists of fifteen items. One item, Item 3, was later removed from the inventory since the content of the question was not covered during the workshop. Upon completion of the development stage of the Genetics Content Inventory the instrument was reviewed by two high school teachers and
one university faculty from Molecular Genetics Department for content validity. Content validation is considered an important step in test construction. Asking experts to provide the validation of items is a strategy that was applied for this study (Hammond, 2000).

The reliability analysis was conducted to test the instrument’s reliability. Data from 329 student subjects were available for the reliability analysis. Cronbach’s Alpha value was calculated as .551 for the Genetics Content Inventory.

**Attitude Towards Genetics Survey**

Student attitudes toward the workshop were of interest to the researcher to help understand the impact of the workshop. A modified version of the Test of Science Related Attitudes 2 (TOSRA2) was used to measure student attitudes toward genetics. TOSRA was developed by Fraser (1981). It is a 70-item survey with a 5-point Likert scale, consisting of strongly agree, agree, not sure, disagree and strongly disagree. It was designed to measure seven distinct attitudes through the following subscales:

1- Social implications of science: This subscale science measures a facet of the expression of favorable attitude towards science. The aspect that is covered includes attitude towards social benefits and problems of scientific progress;

2- Normality of scientists: This subscale measures the realization that scientists are normal people rather than eccentrics;

3- Attitude toward scientific inquiry: This subscale measures attitude toward scientific experimentation and inquiry as ways of obtaining information about the natural world;
4- Adoption of scientific attitude: This subscale measures an attitudinal aim where open mindedness, willing to revise opinions, and similar specific attitudes that are deemed desirable;

5- Enjoyment of science lessons: This subscale measures the level of enjoyment of science-related experiences;

6- Leisure interest in science: This subscale measures the level interest in science and science-related activities: and

7- Career interest in science: This subscale focuses on development of interest in science-related careers (Fraser, 1981, p. 2).

TOSRA was tested with grade 7 through 10 students in Australia and reported to have an internal consistency ranging between .64 to .93 via Cronbach’s alpha (Fraser, 1981). In the second version of TOSRA, the number of items is reduced to 35. Prior to modifying the survey for this study the authors’ permission to modify TOSRA was received through an e-mail communication. The items of the instrument were rewritten to address genetics attitudes rather than general science attitudes. Item 27 was rewritten to address the forensic science nature of the DNA Fingerprinting Workshop, and item 36 was added to the survey which was not in the original version. A pretest and posttest approach was used for this measure. A pretest was administered before the DNA Fingerprinting workshop was offered to students. Upon the completion of the workshop a posttest was administered within two weeks period. Teachers’ classroom availability determined when the test was administered. Demographic information, gender, ethnicity, teacher name and class period information were also collected with this instrument.
The reliability analysis was conducted for the instrument. Data from 334 student responses were used for the analysis and Cronbach’s alpha for the instrument was calculated as .902 for pretest and .912 for the posttest. The values indicate a consistency of the reliability over time. The subscale reliability values were calculated as follows:

(S) social implications of science: pretest: .697, posttest: .743

(N) normality of scientists: pretest: .47, posttest: .582

(A) attitude toward scientific inquiry: pretest: .733, posttest: .773

(A) adoption of scientific attitudes: pretest: .584, posttest: .548

(E) enjoyment of science lessons: pretest: .824, posttest: .785

(L) leisure interest in science: pretest: .661, posttest: .655

(C) career interest in science: pretest: .762, posttest: .765

The reliability analysis produced similar internal consistency in comparison to the original instrument, TOSRA. The reliability for the subscale focusing on the normality of scientists was of concern based on the pretest reliability analysis. However, since the posttest values indicated a more reliable subscale and the overall instrument reliability was high, the analyses were continued.
CHAPTER 4

RESULTS

Introduction

The primary purpose of this study was to answer the following questions: How successful are teacher-led DNA fingerprinting workshops in promoting desired student outcomes? This chapter presents the results related to that primary question. First, data are presented that describe workshop participants who served as subjects in this study, followed by data related to each of the three subsidiary research questions (see page 23).

Description of Subjects

The DNA Fingerprinting workshop was offered as a professional development opportunity for teachers in conjunction with district-wide professional development days. The school district offers 5 professional days per year, and teachers employed by the school district are required to attend these professional days. The DNA Fingerprinting Workshop was offered as a professional development experience for teachers during four of the five professional development days scheduled during the 2004-2005 school year.

Since the DNA Fingerprinting workshop was developed with the consideration of the high school curriculum and addressed the grade ten biology curriculum content, the expectation was to have participants who were responsible for teaching the relevant
content within their classrooms. Although some level of screening was employed by the public school district due to high demand for the workshops and limited seat availability, the demographic data from the mailed surveys as well as questionnaires indicate considerable diversity in terms of grade level taught as well as content specialties among participants. The only information available for teachers who participated in the first two professional development workshops during the year was teachers’ names and the school buildings where they taught. Sign-up sheets provided this information and were used to identify teachers’ grade levels. As shown in Table 4.1, 33 teachers were from middle schools, 33 were from high schools, and 7 participants reported being from administrative buildings of the school district, possibly teachers who are on administrative assignments. None of these seven administrative participants responded to the surveys, so the researcher has no further information regarding their school positions and responsibilities.

<table>
<thead>
<tr>
<th></th>
<th>Middle School</th>
<th>High School</th>
<th>Administrative</th>
</tr>
</thead>
<tbody>
<tr>
<td>numbers</td>
<td>33</td>
<td>33</td>
<td>7</td>
</tr>
<tr>
<td>percentage</td>
<td>45.20%</td>
<td>45.20%</td>
<td>9.59%</td>
</tr>
</tbody>
</table>

Table 4.1: Participating teachers’ demographic information in terms of grade levels.

Thirty-one teachers attended the two professional development workshops that were scheduled during the time of this study in April and May of 2005. Participating teachers filled out the DNA Pre-workshop Questionnaire that was distributed during the
workshops. Eight of the participating teachers identified themselves as special education teachers, and of these were high school teachers, three were middle school teachers, and two did not identify the grade level responsibilities. Two of the participating teachers were high school mathematics teachers, and one was a middle school physical education teacher. One participant was from evaluation services and one identified herself as an instructional assistant. Of 15 participating science teachers, 11 were biology teachers (See Table 4.2).

The DNA Fingerprinting Follow-up Teacher Questionnaire was sent to the 31 participants of the April and May workshops during the second nine weeks of the following school year. Sixteen teachers responded to the questionnaire. Seven of the responding teachers had also responded to the DNA Pre-workshop Questionnaire. The seven teachers who had completed both questionnaires included four high school biology teachers, one middle school teacher who teaches both mathematics and science, and two special education teachers. One of the middle school teachers identified herself as not being in the classroom at the time of the research. The other nine teachers who responded to the DNA Fingerprinting Follow-up Teacher Questionnaire included three middle school teachers responsible for all content areas; one social studies teacher; two middle school science teachers; one generalist teaching mathematics, science and English in the juvenile system; one high school teacher responsible for physical science and environmental education; and, one other high school teacher responsible for earth science, biology, and chemistry (See Table 4.2).
As is evident in Table 4.2, the participating teachers represented a wide range of content areas. This was unanticipated by the researcher, since the specific content focus of the DNA Fingerprinting professional development workshop was expected to be of interest to high school science teachers, particularly life science teachers. Since the professional development workshop was focusing on the grade 10 life science curriculum, teachers attending the professional development workshop from other grade levels were considered to have limited or no opportunity to implement the DNA Fingerprinting workshop in their own classrooms.
Among the 16 participants responding to the DNA Fingerprinting Follow-up Teacher Questionnaire, eight teachers indicated an interest in taking part in the interview process. Six of the eight teachers were available to be interviewed, and four of these were high school teachers. The other two were teaching at the middle school grade levels. Following are profiles of the teachers who participated in all phases of the study.

1. Teacher 5 is a middle school teacher who teaches 7th grade content. She has been a teacher for twenty-two years and has been teaching at the current grade level for nineteen years. Her undergraduate background is in education, and she holds a masters degree in education. During the interviews she stated that she has not implemented the DNA Fingerprinting Workshop in her classroom.

2. Teacher 13 is a high school teacher. She teaches grades 10 through 12 biology and AP biology courses. She has been a teacher for 23 years and has been teaching the current grade level for 5 years. Her undergraduate background is in education, and she holds a masters degree in education. She had implemented the DNA Fingerprinting Workshop in past years but not during the time of the study.

3. Teacher 36 is a grade ten biology teacher. She has been a teacher for two years and has been teaching at the current grade level for one and a half years. Her educational background is in exercise science. She did not implement the DNA Fingerprinting workshop in her classroom.

4. Teacher 37 teaches grades 10 through 12 biology and environmental science. He also teaches AP biology. He has been a teacher for nine years and he has been teaching at the current grade level for seven years. He holds a bachelors
degree in science education. He implemented the DNA Fingerprinting workshop in his grade ten AP class in 2005 before the school year was over.

5. Teacher 41 teacher biology and AP biology in grades 10-12. She has been teaching these grades for twenty years, seven years as a full-time teacher and 13 years as a part-time teacher. Her bachelor’s degree is in biology, and she holds a masters degree in education.

6. Teacher 64 is a middle school teacher. He was the only teacher whose primary responsibility was mathematics. He was teaching science during summer school in another school district. He has been a teacher for four years, with three years being full-time. He teaches grades 5 and 7 and holds a masters degree in education.

The demographic data for the teachers who took part in the interview process are summarized in Table 4.3.

<table>
<thead>
<tr>
<th>Teacher ID</th>
<th>school</th>
<th>Years in teaching</th>
<th>education</th>
<th>implementation</th>
<th>gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher 5</td>
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<td>22</td>
<td>Masters in education</td>
<td>no</td>
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</tr>
<tr>
<td>Teacher 13</td>
<td>high</td>
<td>23</td>
<td>Masters in education</td>
<td>no</td>
<td>F</td>
</tr>
</tbody>
</table>

Table 4.3: Interviewed teachers’ background information.
Table 4.3 continued

<table>
<thead>
<tr>
<th>Teacher ID</th>
<th>school</th>
<th>Years in teaching</th>
<th>education</th>
<th>implementation</th>
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</thead>
<tbody>
<tr>
<td>Teacher 36</td>
<td>high</td>
<td>2</td>
<td>bachelors in exercise science</td>
<td>no</td>
<td>F</td>
</tr>
<tr>
<td>Teacher 37</td>
<td>high</td>
<td>9</td>
<td>bachelors in science education</td>
<td>yes</td>
<td>M</td>
</tr>
<tr>
<td>Teacher 41</td>
<td>high</td>
<td>20</td>
<td>Masters in education</td>
<td>yes</td>
<td>F</td>
</tr>
<tr>
<td>Teacher 64</td>
<td>middle</td>
<td>4</td>
<td>Masters in education</td>
<td>yes</td>
<td>M</td>
</tr>
</tbody>
</table>

Four of the teachers who participated in the DNA Fingerprinting Workshops were able to implement the workshops in their own classrooms. Three of these teachers; teacher 41, teacher 64 and teacher 37 were interviewed along with three other teachers who did not implement the workshop during the time of the study. Teacher 64 was the only middle school teacher who implemented the DNA Fingerprinting workshop in his classroom. One of the teachers who implemented the workshop was not available to be interviewed during the time of the study because she was hired by another high school for the 2005-2006 school year.

The success of a professional development workshop is determined by several criteria. One important criterion is subsequent implementation of the professional development content in one’s own classroom. The DNA Fingerprinting workshop was developed with a very narrow content focus on DNA and its forensic applications, and it specifically addresses the grade ten biology curriculum. The diverse backgrounds noted
for the teachers participating in this study leads to questioning the likelihood that many of them could implement the workshop content within their classrooms. In middle school grade levels, the relevant curriculum for the district is limited to sexual reproduction and heredity. However, grade ten science content standards focus on DNA in depth, as does the AP Biology course in grades 11 and 12.

What are the motivations for teachers to attend a DNA Fingerprinting Professional Development Workshop?

Teachers’ motivation to attend the workshop was ascertained through the questionnaires and interviews. Teachers who participated in the study expressed a variety of different reasons as their motivation to attend the workshop, and the reasons can be grouped into the following four general categories: (1) Content knowledge (capacity); (2) HQT requirements; (3) opportunity, and (4) interesting topic (See Figure 4.1).

One reason participants gave for attending the workshop is to meet the district’s professional development requirements. For many teachers, the DNA Fingerprinting workshop provided an opportunity to meet professional development requirements related to attaining status as a “highly qualified teacher (HQT)”. Effective as of 2002, the Federal No Child Left Behind Act (NCLB) requires all teachers to be highly qualified in the core academic content specialty they teach: English, language arts, reading, science, mathematics, arts (including music, visual arts, dance and drama), foreign language, government and civics, history, economics and geography. The definition for HQT is described as follows by the US Department of Education.
1. Highly Qualified Teachers: To be deemed highly qualified, teachers must have: 1) a bachelor’s degree, 2) full state certification or licensure, and 3) prove that they know each subject they teach.

2. State Requirements: NCLB requires states to 1) measure the extent to which all students have highly qualified teachers, particularly minority and disadvantaged students, 2) adopt goals and plans to ensure all teachers are highly qualified and, 3) publicly report plans and progress in meeting teacher quality goals.

3. Demonstration of Competency: Teachers in middle and high school grades must prove that they know the subject they teach with: 1) a major in the subject they teach, 2) credits equivalent to a major in the subject, 3) passage of a state-developed test, 4) High, Objective, Uniform State Standard of Evaluation (HOUSSE) (for current teachers only, see below), 5) an advanced certification from the state, or 6) a graduate degree.

4. High, Objective, Uniform State Standard of Evaluation (HOUSSE): NCLB allows states to develop an additional way for current teachers to demonstrate subject-matter competency and meet highly qualified teacher requirements. Proof may consist of a combination of teaching experience, professional development, and knowledge in the subject garnered over time in the profession (U.S. Department of Education, 2004).

The State of Ohio follows the federal requirements of NCLB Act as a condition of receiving federal funds (ODE, 2005) and expects all teachers to fulfill the expectations to be identified as HQT. Personal communications with participants, interviews and
questionnaire responses suggest that the DNA Fingerprinting workshop was an opportunity for teachers who are in need for credit hours to meet the HQT requirements. A total of 9 teachers identified HQT as their motivation to attend the professional development workshop. The distribution of the teachers identifying HQT as their motivation was as follows: five special education teachers, 2 middle school teachers, 1 high school teacher and 1 physical education teacher. HQT appeared to be one of the main motivating factors for teachers to attend the workshop, and in some cases, without really considering the content of the workshop. The significant number of special education teachers attending the workshop was also an indication of the need to complete HQT requirements before the deadline. Critical element 1.5 of the monitoring indicators of the Highly Qualified Teachers and Improving Teacher Quality State Grants (ESEA Title II, part A) Monitoring Report, published by ODE, states that “All veteran middle and secondary teachers (including special education teachers, as appropriate) required to demonstrate subject-matter competency in each core academic subject they teach…”

Since most special education teachers teach more than three core courses, consequently, they face more pressure to meet the HQT requirements in each core course they teach as identified by the critical element 1.5 of the Highly Qualified Teachers and Improving Teacher Quality State Grants (ESEA Title II, part A) Monitoring Report. It would not be a wrong assumption to think that special education teachers who are
teaching several contents would be more likely to consider available professional
development opportunities due to the HQT demands. Teachers who took part in the study
voiced their need of meeting the HQT with the following statements.

“Public school’s professional development day. I am using this seminar to earn credit for NCBL; special educ-Highly qualified teacher certification.”

“Professional development requirement”

“To use toward credit for HQT”

“To fulfill Professional development requirement. Last minute class sign-up left me to choose this class because it sounded very interesting…”

“To get credits to apply to Highly Qualified and …”

“Spec. Ed. Highly Qualified”

The second and most often expressed motivational factor for attending the workshop was to gain needed content knowledge. The positive correlation between teachers’ content knowledge and students’ academic achievement has been reported through various research studies (Sanders and Rivers, 1996; NCTAF, 1996; Monk 1994). During this study the need to promote increased content knowledge related to DNA and molecular biology was emphasized by teachers as well. A total of 19 teachers identified the opportunity to gain needed content knowledge as their motivation to attend the professional development workshop. This emphasis on content knowledge was conspicuous in two dimensions. While the majority of teachers were identifying self-knowledge and their need to increase it, a few teachers also identified their students’ content knowledge needs.
Some teachers, such as AP teachers, reported attending the workshop with specific goals in mind. AP teachers reported the need to learn the workshop content and improve their content knowledge as well as lab skills. Grade ten AP teachers are expected to teach the DNA Fingerprinting experiment as one of the twelve experiments of the curriculum required by the school district. Three of the participating teachers were teaching grade ten AP biology at the time of the study. The teachers were participants 13, 37 and 41.

Teacher 13 had experience with the DNA Fingerprinting experiment prior to the professional development workshop. She had also implemented the DNA Fingerprinting experiment with her students in the past, but reported having experienced problems with the set up and outcome of the experiment. As she described it, she either had problems or concerns when she was preparing the materials for the experiment or at times the experiment yielded results other than what she was expecting. Her motivation for attending the workshop was to learn more about the content, equipment and short cuts of laboratory procedures if any and find ways to deal more effectively with issues she faced in the past. She explained that her motivation to participate in the DNA Fingerprinting professional development workshop as follows:

Because I was an AP biology teacher just to get better knowledge myself on how they worked and how they should run and any short cuts I can learn through the procedures… the most difficult part for me was the general set up, not knowing the equipment as well, not knowing if there is shortcut, I was overly cautious,
took too much time setting stuff up. I mean really once you know what you are doing everything is like boom boom boom. Everything was too time consuming and I was double checking myself too much (teacher 13).

Teacher 41’s motivation was similar in terms of content. She has been teaching for 20 years and her biology background has not been updated since college years. She was one of the eight AP teachers who attended the fourth session of the DNA Fingerprinting workshop. This was the last workshop that was specifically offered to AP teachers, and required them to teach the experiment DNA Fingerprinting. She commented on the changing nature of scientific knowledge and how her own content knowledge is not up to today’s standards. It was important for her to catch up with the latest content related to curriculum requirements and students’ needs, as well as the recent, significant changes in sciences and technology.

I feel like its technology and its biology that my students need to know and I'm just not I don't feel coming out of college in mid 80's we weren't doing that so I'm not prepared ...I just don't feel like I have the experience so .. (teacher 41).

The DNA fingerprinting experiment is not a part of the curriculum for mainstream grade ten students and middle school students. For teachers who are teaching at these grade levels, including special education teachers, the workshop offered an opportunity to learn something new and possibly enhance instruction within their own classrooms. Some teachers stated that their motivation to attend the workshop was to find ways to implement the DNA Fingerprinting workshop in their classrooms, although they were not teaching courses that require them to teach the content. One of those teachers was teacher 19. She identified herself as a middle school teacher of gifted and talented students in
grades 7 and 8. She has never attempted the experiment in her classroom before, but she stated that she “…bought a DNA kit from the Disc. School and wanted to know how to use it”.

Teacher 64’s motivation was more goal related compared to other middle school and mathematics teachers. Though he teaches mathematics during the school year, he was searching for possible new experiences for his summer school science students. He stated his reason for attending as follows:

Although at the time I was focusing mainly teaching math, I thought it was opportunity of integrating science and math possibly on some level. But I also was thinking in the back of my mind there wasn’t gonna necessarily be in a position I was in and may be with something I can use in the future. And I was even looking ahead at that time because I knew I was gonna teach an advance class in summer school. And it was going to be a focus in science and I was thinking may be its something cool that I can use with then. I went into it with that perspective (Teacher 64).

Other teachers also stated reasons related to improving their content knowledge. However, many of their reasons seem less focused in terms of future goals and more focused on options with potential. The teacher statements below are examples of their content-related reasons for attending the workshop.

To learn more about lab based education” (high school biology and AP teacher) “…and to learn about DNA fingerprinting. Hopefully take something back to my classroom” (middle school special education teacher).
“To gain knowledge –fingerprinting, DNA analysis… to find yet another way to connect math and science to the world outside of the classroom” (high school math teacher).

“Because I am totally illiterate in sciences. So I wanted to take advantage of this class offer” (instructional assistant)

“Learn to apply this experiment in the classroom and sharpen my skills to help involve my student” (grade ten biology teacher).

“My purpose of attending this workshop is to improve my knowledge about DNA Fingerprinting in order to be able to use it in my classroom.” (grade ten biology teacher)

“Take back to classroom to engage students w/regard to DNA”. (middle school special ed.)

“Gain ideas to use in my 8th grade science class” (middle school)

“Hopefully to utilize this in my 8th grade health class” (middle school teacher).

The following statements related to student needs were expressed by two teachers as their motivation to attend the workshop.

“.. interested in forensics to provide more updated info to students..” (Teacher 70).

For my AP kids its required so they are gonna take AP test in May and if I don't cover it then it gives them a huge disadvantage and I am not doing my job. But for the regular biology its not in our content but I just feel like you know doing it with my AP kids that I think a lot of schools do it… (Teacher 41).
Some teachers identified the topic of the workshop as “being interesting” and this was a reason for attending the workshop. Various choices of workshops were available for teachers to participate. Some teachers stated that since the title of the workshop sounded interesting it led them to choose the DNA Fingerprinting workshop.

“I thought it would be interesting and teach me something that I did not know a lot about” (Teacher 36)

“Looked interesting and different” (Teacher 30).

“It sounded interesting” (Teacher 67).

Figure 4.1 illustrates the factors identified as teachers’ motivations for attending the DNA Fingerprinting Workshop. The DNA Fingerprinting Workshop was originally developed as an outreach program for high school students, has been offered for years and is well known by many teachers, especially those who are teaching the content in their classrooms. In 2004-2005 the workshop was offered as a professional development opportunity. For some teachers this was a great opportunity where they could learn the content but have a university team present in their classrooms.

Well I think it was university did an excellent job outreaching that it was an opportunity that wow you know if we can do this it was so available and a to help me and guide me and facilitate not only was I trained but students from the university coming out to help that you can't just pass that out. So it was really the outreach. I think the outreach provided has been the best I've ever seen. Every now and then I get a letter on something reaching out to me as a science teacher in 20 years I thought but I don't think anything has been effective as what the university done as genetics and with the gel, DNA technology lab. So I feel like
what is being done is effective. I mean to reach down to our system in our professional development days as a science teacher, I've had invitations and inconsistently and uhm outreach has been very effective… ” (teacher 41).

The students’ need to learn the content for increase performance on the Graduation Test (OGT) was also another factor. Some teachers stated that they need to meet the needs of the students so the students will not be disadvantaged.

Figure 4.1: Factors affecting teachers’ motivation to attend the workshop.
Figure 4.1 presents a map of the factors influencing participating teachers’ motivation to attend the professional development workshop. This map was developed on the bases of teacher data collected throughout the study with the consideration of behavioral models in the literature. Factors emerging from a review of the data included concern regarding teacher content knowledge, professional development requirements for teachers as defined by educational policies, and environmental factors, including the availability of the opportunity and the interesting nature of the workshop content.

What factors influence teachers’ decisions to implement the DNA Fingerprinting workshop in their own classrooms?

Thirty-one teachers received the DNA Pre-Workshop questionnaire when they attended the DNA Fingerprinting workshop. Out of thirty-one teachers, twenty-two of them indicated a positive intention to implement the DNA Fingerprinting workshop in their classrooms. There were eight grade ten AP teachers among the participating thirty-one teachers. Five of the AP teachers were positive about implementing the workshop in their classrooms. One of the high school teachers also indicated a possibility with a response of “may be”.

In 2005 after the fourth professional development workshop session three of the five AP teachers made arrangements to borrow the DNA Fingerprinting equipment from the university and have undergraduate students assist in their classroom during the implementation of the workshop. The three DNA Fingerprinting workshops were implemented during the 2005 school year, but no other participating teacher reported implementing the workshop through the duration of the study’s data collection period which concluded in April 2006. Three teachers who implemented the workshop in their
classrooms during the spring of 2005 reported that they had not implemented the workshop by themselves again during the following school year. However, three of the teachers had the university team conduct the DNA Fingerprinting workshop for their students. The data collection for this study was concluded during April of 2006 and to the best of the researcher’s knowledge none of the teachers implemented this workshop by themselves during this period. The rationale for teachers to choose to implement the workshop or not and their experiences are discussed further in this chapter.

<table>
<thead>
<tr>
<th></th>
<th>AP teachers</th>
<th>Mainstream teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>intention to implement</td>
<td>5</td>
<td>28</td>
</tr>
<tr>
<td>Implementation in 2005</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Implementation in 2006</td>
<td>0</td>
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</tbody>
</table>

Table 4.4: Teacher numbers based on intention and implementation.

In Table 4.4, AP teachers are identified separately from teachers who are teaching mainstream classes, since the grade ten AP curriculum includes the DNA Fingerprinting workshop as one of the twelve required experiments. For some of the teachers, implementing the workshop was not a possibility, although they had indicated an intention to implement the workshop. One of these teachers was teacher 70. He teaches various subjects, including science, to junior high and high school kids in the juvenile correctional system. He stated that due to the nature of the students, juvenile detention has restrictions in terms of what can be done in a classroom environment; glassware and
similar laboratory equipment are not allowed. Teacher 70 inquired about ways to modify the DNA Fingerprinting workshop so that he can overcome the restrictions and provide students with the experience. The implementation status of teacher 70 is unknown to the researcher. One of the high school special education teachers who also indicated an interest in possibly implementing the workshop stated that she is not in a classroom at the moment and does not have any means to implement the workshop.

The equipment for the DNA fingerprinting experiment can be costly. Although some school buildings, mostly high schools, or teachers have the equipment in their possession, access to equipment is limited for the majority of teachers. The university faculty always announces the availability of the DNA Fingerprinting equipment for teachers to borrow. Teachers can borrow the non-consumable items from the university and consumable items are also provided without the expectation of replacement. Even so, the costs of the experiment was still a concern raised by the teachers and a factor influencing their implementation behavior. “Possibly, the cost is a big factor with this decision…” (Teacher 36). This concern raises the question how the opportunities can be affectively announced to teachers if it has not been so far?

During the 2005 school year, immediately after the teachers’ professional development workshops, four teachers, teachers 41, 9, 64 and 37, made arrangements to implement the workshop in their classrooms. With the exception of teacher 64, all teachers implemented the workshop in their AP classrooms. They received both instructional and equipment support from the university. Instructional support included provision of a PowerPoint presentation and transparencies. The presentation included the content necessary to understand the scientific background of the gel electrophoresis, and
teachers were free to use the provided instructional materials as needed. Undergraduate students provided assistance during the activity at the request of teachers, since this was their first attempt to implement the workshops in their classrooms. All AP teachers; teachers 9, 41 and 37, except teacher 64 received the undergraduate support. Only three of these teachers provided feedback regarding their experience. One teacher, teacher 9, took part in the study with her students but was inaccessible during the interviews. Teacher 13 was included in the interview process as one of the teachers who implemented the DNA Fingerprinting workshop, since she had implemented the experiment in her classroom in previous years. Teacher 13 had the university team present during the study to offer the workshop to her AP students but she did not implement it herself.

All four teachers, (teachers 41, 9, 64 and 37) chose to use the instructional materials as they were provided by the university. While teacher 9 chose to use the PowerPoint presentation, teachers 41 and 37 choose to use transparencies to present the content. Teachers 9, 41 and 37 conducted the experiment in their AP classrooms while their mainstream biology students had the DNA Fingerprinting workshop provided by the university team. Teachers 9 and 41 had the opportunity to observe the faculty-led workshop offered to the mainstream grade ten students prior to implementing it in their AP classrooms. Teacher 64 was a unique case due to the content and grade level he teaches. During the school year teacher 64 teaches mathematics to middle school students. However, during this study he implemented the workshop during summer
school with middle school students whom he considered above average. The researcher was present to observe all four of the DNA fingerprinting workshops implemented by the participating teachers.

The observations revealed that teachers 9 and 41 followed an instructional pattern similar to that used by the university faculty when they were instructing students. Their instructional approach seemed very similar to that of the university faculty, and they referred to examples that were introduced by the faculty. They used phrases such as “as Dr. X from the university describes it” Teacher 37 did not use similar references, possibly because he had not seen the faculty-led workshops. The observations of teachers’ instructions during the student workshops reflected the apprenticeship in professional development. However, since there are no data available regarding teachers’ instructional practices in their regular class sessions, comments on the apprenticeship aspect of the professional development practices are speculative. More data are required before any assertions can be made, since there was not an opportunity to compare workshop implementation behavior with teachers’ daily teaching practices or in-depth observations on their implementation. During the AP workshops, each learning station was mentored by an undergraduate student, but teachers were expected to take the lead instructional responsibilities during the workshops. Since the groups were assisted by undergraduate students, it is not possible to predict how teachers would handle the implementation of the workshops by themselves.

Teacher 64 distributed the content over two full days in consideration of middle school students’ limited background in science. All his students were from middle school grade levels, and their content knowledge on DNA and genetics was very limited.
Therefore, teacher 64 preferred to cover the content by first implementing the DNA extraction activity, followed by day one of the DNA fingerprinting workshop. In this way the teacher laid the conceptual groundwork for students. On the second day the DNA Fingerprinting workshop was implemented by the teacher, and was observed by the researcher. Teacher 64 had 6 stations to run the experiment, but had no support from undergraduate students. He was very capable of managing the groups during the experiment and kept all of them on the same track. Based on the observations it seemed to be a successful workshop regardless of the students’ limited understanding of key concepts. Teacher 64 reported a successful outcome from the experiment.

Teachers 37, 41, 64 and 13 were asked to describe their experiences with the implementation process. Each teacher was interviewed individually. Teachers 41, 37 and 64 reported their experience of implementation as positive; while teachers 41 and 37 acknowledged the value of the undergraduate students’ presence in their experience. Teacher 37 reported having few laboratories and the limitation in laboratory practices either due to restraints in materials or in some cases students. The students’ role in the teachers’ decision making process to implement the DNA Fingerprinting workshop also came into account during the interviews. Both teachers 37 and 64 talked about students’ maturity and motivation as one of the elements that would affect their decision to either implement the workshop or not. For both middle and high school teachers, student maturity was a concern.

Like I said it was a really good experience. If I think the kids are mature enough to handle it and motivated enough to try something like this, it is something that I want to do again  (teacher 37, teaches in high school).
I would be afraid to do it unless because the materials involved seem very expensive so I only do it with the kids I trust. Because unfortunately I've been in several situations where for whatever reasons the students just weren't disciplined enough to be trusted with lab materials and they would break them and steal them. I mean I've had it all happen to me before. I'd make sure number one I trusted the kids (Teacher 64 teaches in middle school)

You have to consider classroom dynamics; I probably wouldn't have done this last year with my kids. They just weren't mature enough (Teacher 36, teaching high school biology).

Classroom management was also mentioned as a limiting factor for implementation which was also a part of the students’ maturity issue. However, regardless of who the students were, managing five or six stations at the same time seemed a difficult task to teachers. Without having an extra hand to help with the stations, teachers would have more responsibility to keep every station on track and this was interpreted as a challenge to implementing the workshop in a regular biology class. Teacher 64, who did not have undergraduate students to work with him, explains his experience as;

it was impossible to be in any one group the whole time. So I was kind of trusting them. So it was a matter of rotating between each group of students so they are doing their own individualized version of the experiment so I was kind of running back and forth a lot. So I can definitely see that it would be helpful to have somebody at each station with them but I still think it worked out pretty well.
While all AP teachers were positive about doing the DNA Fingerprinting experiment with their AP students, they were reluctant to implement it with their regular biology students. For instance, teacher 37 implemented the DNA Fingerprinting workshop with his grade ten AP students in the spring of 2005 but not with the mainstream 10th graders. The following school year he did not implement any workshop stating that he “had finished the unit DNA and DNA technology. It would be inconsistent with the curriculum to reintroduce DNA”. However, a faculty-led workshop was offered to the teacher’s students in spring of 2006 at the teacher’s invitation. The same teacher also stated that he thinks:

it gets a little bit over the heads off my grade ten biology students and I’m not teaching an AP class right now and I’m just doing the general biology and the main focus is to get the kids ready for the materials going to be on the Ohio Graduation test. This is above and beyond right now so it’s not something I’m really focusing on. If I had an AP class and had more electives and had more electives yes I would be doing this.

Teacher 36 voiced concerns regarding time limitations in terms of both curriculum and personal time commitment when she was explaining her inability to implement the workshop in her classroom. Holidays, absences and getting ready for the OGT were her biggest time constraints during the time frame that they cover the DNA in the curriculum. As with many teachers, teacher 36 was also favoring the idea of having the university team come in to teach the workshop rather than trying to implement it by herself. When she was asked how she would implement the workshop, she referred to getting students ready for the university team to come in and teach the class. Similar
responses were received from teachers 13, 37 and 41 as well. This may be due to content knowledge competency issues among teachers. Another possibility may be having a university team that can assume the responsibility and teach the workshop. Some teachers stated that it is a better experience for students to have the workshop from the university team rather than from their own teacher in their usual classroom setting. However, there is no guarantee given to teachers that the university team can teach the workshop in their classrooms. Teacher 41 pointed out the fact that the content covered in the workshop is beyond what is expected from students in regular biology classes. According to her, without encouragement it would be easy to choose not to implement the workshop rather than try going through the time consuming process of preparation and implementation. Teacher 36 reported that she does not feel confident that she can cover the content of the workshop in as much depth as the university faculty, but she can do the basics by refreshing her knowledge.

Implementation behavior was in some cases influenced by the combination of different factors coming together. One of these factors was the grade level and the curriculum. Teacher 5’s implementation behavior was limited by the grade level taught. She is a middle school teacher and she identified ancient history as the topic in which she was able to talk about DNA.

I told them about my family, what I did with the DNA with my family. We talked about DNA a lot for example I teach ancient history and I have to teach the origins of cultures. Origin of peoples and it always comes up and understanding
about DNA. We talk about it in ancient history, when we study the ice man, found in Italy or Switzerland whoever wants to claim him and there is always information in the newspaper about it; we read about it.

Although teacher 5 was not able to implement the whole DNA fingerprinting workshop in her classroom she was able to do a partial implementation of the content. Her teaching was limited to base pairing “I showed some visuals and how it matches up.” An awareness of the need for her to teach more content was noted during the interview: “But I think I need to more thoroughly explain it. We didn't do the lab in here though. I think I would need someone to come help me with that”. The teacher verbalized her concerns when the content knowledge was the topic of the conversation. She stated that she would definitely need someone helping her to implement the workshop. Teachers such as teacher 36, 41 and 64 also stated similar concerns for future implementations. They stated that they would need to refresh their knowledge before they implemented the workshop in their classrooms.
In summary, teacher implementation behavior was affected by five groups of elements: educational policies, environmental factors, control behaviors, teacher capacity and the university (workshop provider). Figure 4.2 shows the relationship between implementation behavior and motivational factors. The university was identified both as a positive and negative factor contributing to teacher implementation behavior. Long-term relationships preserved after the workshop was identified as a factor that encourages teachers to implement the workshop. However, the ongoing availability of workshops offered by the university team appeared to be a factor that leads teachers to opt for having...
the workshop taught by the university team. The factors grouped within “control behavior” included teacher’s concerns regarding classroom management or size, having a classroom in which to teach or level of student’s maturity or appreciation.

Two factors seemed most influential, both in promoting workshop attendance and workshop implementation: teacher content knowledge, workshops as learning opportunities, and curricular requirements.

**Difficulties and Suggestions for Teachers**

Content knowledge of teachers was identified as an influential element in teacher behavior regardless whether a teacher has implemented the workshop or not. For teachers such as teacher 5 or teacher 36 who did not have the experience of implementation, content knowledge was one of the main factors identified to be a difficulty. Teacher 5 and teacher 36 have different career backgrounds, grade level responsibilities, and educational backgrounds. However, both teachers expressed concerns regarding their depth of knowledge and the need to have support for future implementation. Teacher 13 identified herself as knowledgeable in terms of content knowledge. However, she indicated self-efficacy issues in regard to the preparation phase of the workshop and the necessary skills required. The need for support from the university workshop provider was also found as a factor affecting teacher implementation behavior in a study conducted by Danter (2005). Familiarity with the workshop equipment and knowing procedural shortcuts were important for teacher 13, who would then be able to spend less time on the preparation phase of the workshop and would gain self-confidence, which would prevent her from becoming over-cautious and double checking herself during preparations.
How effective are teacher-led workshops compared to faculty-led workshops in terms of student learning and positive attitudes among students?

The student participants of this study were from a large Midwestern public school district. During the 2005-2006 school year a total of 4091 students were enrolled in biology classes (Looney, 2006). In this school district, 48.6% of the grade 10 students were identified to be at or above the proficient level in science achievement based on the 10th grade Ohio Graduation Test results. The OGT for science was administered for the first time during the 2005-2006 school year. To be considered proficient in science, a student must score at least 75% on the science portion of the OGT, and the state average is 73.1% for the school year of 2005-2006 (ODE, 2006).

The student data were collected from four teacher-led sessions of DNA Fingerprinting workshops. The instruments that were used for the data collection include the Genetics Content Inventory and the Attitude Towards Genetics Survey. Participation in the study was voluntary, and some students did not respond to both of the instruments. Therefore, the data from these two instruments were analyzed independently.

The purpose of the student data analyses was to investigate the outcomes of the teacher-led workshops in comparison to faculty-led workshops. During the workshops, students were asked to work in groups of 6 individuals or less. Taking group interactions into consideration, these student groups were used as the unit of analysis for comparing workshop outcomes. The student data were aggregated for further analysis of the instruments themselves. The reason for changing the unit of analysis from individual student, which was used for the instrument reliability tests, to student group for testing workshop outcomes was because of the differences in the nature of analyses. Reliability
analyses were aiming to explore the consistency of the instrument with the population sample, therefore it was more appropriate to use all available data. On the other hand, student participants worked in groups, so the analyses focusing on the success of the workshops are more appropriately based on student groups as the unit of analysis.

The aggregation of the data into student group decreased the number of data points for each teacher who implemented the workshop. Since the number of students in AP classrooms was considerably less than the number in regular biology classrooms from the very beginning, sample size was one of the concerns for the data analysis.

Before analyzing the available student data, data sets were screened for missing data. Cases with missing pretest or posttest results or with more than 60% missing data were excluded from the data sets. Students who were not identified with a group number were also excluded from the study. Out of 426 students who provided data 265 of them were included in the analysis for the Attitude towards Genetics Survey. There was not enough information about students to identify the reasons for missing data. A total of 409 students provided data for the Genetics Content Inventory, and data for a total of 241 students were included in the analysis. All the analyses were conducted using SPSS version 14.0.

**Attitude towards Genetics Survey**

Student attitudes were an interest in this study because existing outside beliefs and attitudes prior to participation plays an important role. As Koballa (1995) states these existing beliefs and emotions toward science are reflected into learning. Attitude Towards Genetics Survey was used to measure students attitudes toward genetics. This section reports on the findings.
The missing value analysis was conducted to identify the missing values for both the pretest and posttest. Questions were screened for missing data individually, and analysis indicated that among 265 students with pretest and posttest responses, the missing data percentage for 36 questions ranged between 0% - 8.3%. In order to preserve the greatest number of student cases, a missing data imputation technique was employed rather than list-wise or case-wise deletion. A maximum likelihood estimation was the choice of technique due to limitations caused by replacing missing values with a mean score. Mean score substitution is known to reduce the variation and is therefore not the preferred method to account for missing data (Garson, n.d.). The data were collected from four different instructors: three teachers who implemented the DNA Fingerprinting workshop in their own classrooms, and one university faculty member who offered the workshop for a large number of students. Faculty-led workshops were implemented within the regular biology classrooms of four different teachers. Two of these teachers were also teachers who implemented the workshop themselves in their AP classrooms. The number of students in AP classes was limited compared to the number of students in the regular biology classes, so this affected the size of student groups. During the DNA Fingerprinting workshops the gel electrophoresis experiments were conducted with a maximum of 6 stations in each classroom. Students worked in groups at each gel electrophoresis station in numbers ranging from 2 to 6. The students were asked to remain in the same group throughout the duration of the workshop.
The null hypothesis being tested for the study was there is no difference in student achievement outcomes between the faculty-led workshops and teacher-led workshops. The repeated measure of multivariate analysis of variance (MANOVA) was employed for differential data analysis.

Descriptive Analysis

The Attitude towards Genetics Survey contains seven subscales as identified by Fraser (1981): social implications of science, normality of scientists, attitude toward scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science and career interest in science. Each subscale consists of 5 questions with the exception of the social implications of science subscale which consists of 6 questions. The mean pretest and posttest scores for each subscale were calculated and reported by teacher, and descriptive statistics for each subscale are provided in Table 4.5. The number of student groups for each teacher is presented in row N. As indicated on the graph, the group numbers are 3, 4, 8 and 80. The high number of student groups noted for the faculty-led workshops is due to the fact that more than one classroom of students participated in the faculty-led workshops. All of the faculty-led workshops, however, were facilitated by the same university faculty member. For each teacher, the mean score differences between pretest and posttests for each subscale were computed. The differences were found to be no more than ±.30 points for any given teacher, which indicates no significant change between pretest and posttest scores. The mean scores were also compared across teachers. For the Attitudes Toward Scientific Inquiry subscale, a pretest mean score difference of .47 between teacher 41 and 64 and mean score difference of .54 between teacher 64 and the university faculty facilitator indicate
possible differences. Teacher 64 is a middle school teacher and his students were middle school students. Teacher 41 was teaching a grade 10 AP group while the university faculty facilitator was teaching regular grade 10 students. Lower group scores were noted for teacher 64 for two subscales, Adoption of scientific attitudes and enjoyment of science lessons, compared to other participating teachers. The age and grade level differences may account for the noted score differences.

### Table 4.5: Means and standard deviations for each participating teachers’ pretest and posttest results based on subscales of the attitude survey.

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<tr>
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Table 4.5 continued

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**Assumptions**

Several assumptions were tested prior to employing repeated measures of MANOVA including normality of distribution, homogeneity, random assignment, and independence of observations. The variance ratio between groups was calculated and the values range between 11.37 and 1.3 which indicates heteroscedasticity. Skewness and kurtosis values were calculated to be less than two for all teachers which is a stress point identified by Loadman (2001). The univariate normality assumption was tested by Q-Q plots which indicated a normally distributed population. However, since heteroscedasticity was a concern based on the variance ratio, Levene’s test of Equality was conducted. The test of factor normality failed to support the assumption of equal group variances.

This study was conducted with the participation of 431 student subjects. The subjects providing both pretest and posttest responses were included in the data analyses,
and the data were data aggregated based on the student group membership. None of the students were randomly assigned within this study, since their involvement was due to their teachers’ choice to take part in the study. Therefore this study violates the assumption of random assignment and cannot be generalized beyond the teachers and students who participated in the described DNA Fingerprinting workshops.

Verification of the assumption of independent observations must be considered with caution. Although there is a dependency to the teacher, the assumption of independent observation is here considered to be verified for the following two reasons. It is assumed that student responded to the surveys instrument without interaction with other subjects. Second the data were aggregated by groups, with the consideration of student interaction limited to student dynamics within groups. Students did not interact across student groups during the workshops.

The Attitudes Towards Genetics Survey uses a Likert-type scale with a 5-point range for each scale item. However, it cannot be assumed that the point-distances between scale values of a Likert scale is equal measurement intervals.

As described above, the homogeneity assumption is violated as well as the normality assumption. The sample sizes for teacher 9, teacher 41 and teacher 64 and the university faculty facilitator were 3, 4, 8 and 80 respectively, which presents a limitation in terms of the power of the study. Due to low power, the likelihood of a type II error is increased. Regardless of the consequences, however, in consideration of these violations of assumptions, the alpha level was reduced to 0.025 as suggested by Keppel. Keppel suggests changing the alpha level to .025 or .01 to compensate for violations of the normality assumption, especially when sample sizes are not equal (Keppel, 1991). This
action increases the risk of Type II error and the possibility of not finding a difference even if one exists. Due to unverified assumptions of repeated measures MANOVA and the increased risk of a type II error, it is acknowledged that the reported results must be interpreted with caution.

Repeated measures of MANOVA

To reduce the risk of a Type I error, repeated measures of multivariate analysis of variance (MANOVA) was used to test the null hypothesis. Wilks’ Lambda was used to determine the statistical significance of the multivariate analysis, since it is known to have good power and is considered immune to violations of assumptions. A repeated measures of MANOVA procedure was conducted to investigate the student scores of the four workshop instructors for all seven dependent variables, and the analysis indicated that there was no statistically significant differences in outcomes between four instructors. The Wilk’s $\Lambda$ was 0.671; $F_{(21, 244)} = 1.736; p<.025$. Additionally the within subject, pretest and posttest differences and the instructor interactions, were also found to be not statistically significant. Wilk’s $\Lambda$ was 0.925; $F_{(7, 85)} = 0.987; p<.025$. and Wilk’s $\Lambda$ was 0.885; $F_{(21, 244)} = 0.505; p<.025$ respectively. Therefore we are unable to reject the null hypothesis, and there is no difference found between student attitude scores across instructors. There is also no significant interaction effects or differences between pretest and posttest scores.
Genetics Content Inventory

The original instrument designed for this study consisted of 15 items. Item 3 was removed from the instrument prior to analysis, since it was determined to be unrelated to workshop instructions. The analysis, therefore, was conducted for the instrument based on 14 questions.

The Genetics Content Inventory was administered to students before and after the workshop as a pretest and posttest instrument. Student data from three different instructors were available for the analysis. The three workshop instructors who provided data were teachers 64 and 41 and the university faculty member. The technique of choice for the statistical analysis was repeated measures of analysis of variance (ANOVA).

Descriptive Analysis

Mean scores on the Genetics Content Inventory were calculated for each teacher. (See Table 4.6). As noted in Table 4.6, there is an increase between pretest and posttest in mean scores for all three instructors. While the mean scores for Teachers 41 and 64 exhibit more increase from pretest to posttest than do those of the university faculty member, the range of scores for the faculty member is much broader, ranging from 2 to 11 for pretest scores and from 1 to 11 for post test scores. The standard deviations of the groups are relatively similar, indicating homoscedasticity in the distribution of scores. The skewness values for each group were calculated to range between 0.001 and 1.96. Since the values are less than 2, which is an accepted stress point, the population is considered normally distributed based on the skewness values. For teacher 41 the kurtosis values are higher than 3, which is considered a stress point, and poses a concern.
regarding the distribution of the sample. The number of student groups for each teacher was not equal and raises concerns regarding statistical power and the risk of committing a type II error.

<table>
<thead>
<tr>
<th>Teacher 41</th>
<th>Teacher 64</th>
<th>University</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>pre</td>
<td>post</td>
</tr>
<tr>
<td>Mean</td>
<td>7.92</td>
<td>9.33</td>
</tr>
<tr>
<td>SD</td>
<td>1.95</td>
<td>1.47</td>
</tr>
<tr>
<td>Skewness</td>
<td>-1.96</td>
<td>1.79</td>
</tr>
<tr>
<td>SE of skewness</td>
<td>1.01</td>
<td>1.01</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>3.84</td>
<td>3.21</td>
</tr>
<tr>
<td>SE of kurtosis</td>
<td>2.62</td>
<td>2.62</td>
</tr>
<tr>
<td>Minimum</td>
<td>5</td>
<td>8.33</td>
</tr>
<tr>
<td>Maximum</td>
<td>9</td>
<td>11.5</td>
</tr>
</tbody>
</table>

Table 4.6: Teacher means scores on Genetics Content Inventory.

Pretest and posttest mean scores were plotted to inspect the data. Figure 4.3 presents the mean scores by workshop instructor. As evident on the graph, the student groups of teacher 64 received the lowest pretest scores among the three groups. This is not an unexpected outcome considering the profile of the students who participated in the study. Teacher 41 and the university instructor facilitated DNA Fingerprinting workshops for students who are in grade 10, and study of DNA is a part of the grade 10 science
curriculum. Hence, these students were already somewhat familiar the workshop content. However, the students of teacher 64 included students in grade 7 and grade 8. The topic of DNA is not a part of the science curriculum presented at these grade levels.

The students of Teacher 41 achieved the highest scores as indicated by the graph. Considering that these students were in AP classes and considered to be high achievers compared to mainstream grade 10 students the observed high mean scores are not surprising. Posttests mean scores indicate an increase in genetic content knowledge for the students of teachers 41 and 64. The group scores for both teachers exhibit a similar increase, in both samples students are considered to be high achievers by their teachers. Student scores for the faculty-led workshop group also exhibit a slight increase which does not appear to be educationally significant. The university group shows a slight increase which may not be significant. The graph also indicates an interaction effect between students of teacher 64 and the faculty-led workshop groups. As the graph indicates, gains among students reflect similar trends for teachers 41 and teachers 64, but the effect appears different for students in the faculty-led workshops, a trend that needs to be explored.
Assumptions

Several assumptions were tested prior to employing repeated measures of ANOVA, including normality of distribution, homogeneity, random assignment and independence of observations. The subjects providing both pretest and posttest responses were preserved for analysis, and the data were aggregated based on groups membership. None of the student subjects were randomly assigned within this study, since their involvement was due to their teachers’ choice to take part in the study. Therefore the
assumption of random assignment is not valid for this study, and results presented here cannot be generalized beyond the teachers and students who participated in the DNA Fingerprinting workshops.

The assumption of independent observations is considered to be verified for two reasons: Students were assumed to have responded independently to the survey instrument, without the interaction with other subjects. Second, the data were aggregated by groups with the assumption that student interactions were limited to student dynamics within group. Students did not interact across groups during the workshops.

The variance ratio between groups was calculated and the values range between 1.31 and 2.17 which indicates homoscedasticity. Levene’s test of Equality was conducted to test this assumption as well. The hypothesis that was tested is expressed as follows:

$$H_0: \sigma_1^2 = \sigma_2^2 = \sigma_3^2$$

$$H_1: \text{not all } \sigma^2\text{'s are equal.}$$

The Levene’s test of Equality was to be found statistically nonsignificant and therefore failed to reject Ho. $P_{\text{pre}} = .991, \alpha = .05$ and $P_{\text{post}} = .402, \alpha = .05$ The assumption is met and the population is assumed to be homoscedastic.

Due to the unverified assumptions of repeated measures ANOVA results of this analysis must be interpreted cautiously.

Repeated Measures of ANOVA

The null hypothesis to be tested was as follows;

$H_0$: There is no difference in student Genetics Content Inventory mean scores between workshop instructors. Repeated measure ANOVA was used to test the null hypothesis.
The repeated measures of ANOVA results indicates a significant interaction effect between teachers and the pretest and posttest scores, which also confirms the outcome of Figure 4.3. An interaction is observed between students of the faculty-led workshop and students in the workshop led by teacher 64. Due to the presence of an interaction effect, the statistical analysis were continued with the employment of univariate analysis of variance. Pretest and posttest scores were analyzed separately. The results of the analyses are summarized in Table 4.8

<table>
<thead>
<tr>
<th>source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>51.64</td>
<td>2</td>
<td>25.82</td>
<td>386.07*</td>
</tr>
<tr>
<td>Error</td>
<td>449.76</td>
<td>80</td>
<td>5.62</td>
<td></td>
</tr>
<tr>
<td>Pre-post</td>
<td>20.76</td>
<td>1</td>
<td>20.76</td>
<td>15.19*</td>
</tr>
<tr>
<td>Interaction</td>
<td>20.55</td>
<td>2</td>
<td>10.28</td>
<td>7.52*</td>
</tr>
<tr>
<td>Error</td>
<td>109.32</td>
<td>80</td>
<td>1.37</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1510.24</td>
<td>165</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05.

Table 4.7: Summary of one between one within analysis of variance design.
As summarized in Table 4.8 there is a statistically significant difference between pretest and posttest scores. To get the maximum information from the data and to determine which student groups performed differently, post hoc analyses were performed. The Scheffe test was used due to its flexible nature in preserving the familywise error rate regardless the number of comparisons conducted (Keppel, 1993). The results indicate that on the basis of pretest scores there is a statistically significant difference between the student scores teacher 64 and those of teacher 41. Student scores for teacher 64 were also found to be statistically different compared to scores of students in the faculty-led workshops. In both cases the scores of students in the workshop facilitated by teacher 64 were lower. Considering the expected content knowledge level
of students in Teacher 64’s classroom, this is an expected outcome. No statistical
difference was found in student scores when comparing Teacher 41 groups and those in
the faculty-led workshops. Posttest results were also compared between workshop groups
using the Scheffe test. A statistically significant difference was found between student
groups of Teacher 41 and those of the faculty-led workshops. Students of teacher 41
scored higher on the posttest compared to students who took part in the faculty-led
workshops.

Discussion

There were several limitations faced consider during the analysis of student data.
The main limitation is the reduced number of student groups within the teacher-led
workshops. Only three teachers implemented the teacher-led version of the DNA
Fingerprinting workshop in their classrooms, and they each implemented the workshop
only once. Therefore, the number of student groups (N) for each teacher was very
limited. The second limitation was the inequality of N across teachers. Contrary to the
limited number of groups for the teachers who implemented the teacher-led workshops,
the faculty-led workshop was offered to a larger sample. All faculty-led workshops were
facilitated by the same university faculty member and were conducted within three
different school buildings. Therefore, the amount of student data collected from the
faculty-led workshops was significantly greater than the amount generated by teacher-led
workshops. The small number of groups for each teacher as well as the inequality of the
number of groups across workshop facilitators poses a threat to statistical power. The
third limitation was the reliability levels for the three subscales of the Attitudes Towards
Genetics Survey; normality of scientists, adoption of scientific attitudes, and leisure interest in science, and the Genetics Content Inventory. Due to the low Cronbach’s Alpha values we are less likely to find significance.

The first sets of analyses were conducted on the subscales of the Attitudes Towards Genetics Survey. The alpha level was set to .025 due to assumption violations. No statistically significant differences in attitude were detected among across workshop samples. The low statistical power must be taken into consideration for the possibility of a type II error.

With regard to content knowledge, a statistically significant difference was found among teacher samples based on the scores of the Genetics Content Inventory. Based on the descriptive analysis, the influence of the faculty-led workshops on student content knowledge was found to be minimal and statistically nonsignificant. There are two possible reasons for this outcome: Either the workshops did not contribute to the content knowledge of the students who participated in the faculty-led workshops, or variations in performance of student groups resulted in the scores of some groups cancelling out the effect of the DNA fingerprinting workshops on other groups. More analysis should be done to identify the nature of this outcome. However, given the low statistical power with the existing sample, no further analyses were conducted for this study. Increasing the number of additional analyses would require controlling for an inflated alpha. Such a decision would therefore further reduce statistical power. Due to these consequences, no further analyses were conducted. The analyses conducted using the data collected through the Genetics Content Inventory suggests a successful student outcome for both Teacher 41 and Teacher 64. The student scores for both teacher samples increased significantly.
between the pretest and the posttest. The students of Teacher 64 were able to close the performance gap that was present in pretest while students of Teacher 41 showed greater gains in posttest scores compared to the students in faculty-led workshops.
CHAPTER 5

CONCLUSION

The purpose of this study was to determine how successful teacher-led DNA fingerprinting workshops are in promoting desired student outcomes. This general purpose gave rise to three subsidiary research questions:

1. What are the motivations for teachers to attend a DNA Fingerprinting Professional Development Workshop?

2. What factors influence teachers’ decisions to implement the DNA Fingerprinting workshop in their own classrooms?

3. How effective are teacher-led workshops compared to faculty-led workshops in terms of student learning and positive attitudes among students?

The data collection for the study took place between Spring of 2005 and April 2006, with results presented in Chapter 4. The interpretation of outcomes and the implications of the findings of the study are discussed in this chapter. Conclusions related to each subsidiary research question are presented in turn, followed by general implications for teaching and further research.
What are the motivations for teachers to attend a DNA Fingerprinting Professional Development Workshop?

The description of subjects in this study indicates that there was a mismatch between anticipated participants for whom the workshop providers targeted the DNA Fingerprinting Professional Development Workshops and those who actually attended the workshops. The DNA Fingerprinting workshop was designed to provide participating teachers with knowledge and skills that would enable them to implement the DNA Fingerprinting workshop in their own classrooms. The DNA Fingerprinting workshop was designed to addresses selected content within the grade 10 biology curriculum and is aligned with Ohio’s Academic Content Standards for science. Therefore, the targeted population was high school science teachers who are teaching biology courses. Contrary to the focus and the targeted audience of the workshop, the profiles of the participating teachers presented an interesting mismatch by grade levels and teaching areas. The grade level distribution of the participating teachers included 33 middle school teachers, 33 high school teachers and 7 teachers who identified themselves in administrative roles. The various grade levels and the range of content specialties represented among participating teachers raises questions as to whether the DNA Fingerprinting workshop was serving its intended purpose. Various reasons were identified as influencing teachers’ motivations to attend the DNA Fingerprinting professional development workshops. The majority of the teachers identified their need to improve their own science content knowledge and skills to be the main motivation to attend the workshop. Teachers’ lack of content knowledge and the need for professional development programs focusing on mathematics and science content have been noted in many studies (Garet et al., 2001,
The expressed need to improve the content knowledge as being one of the motivational influences for teachers to attend the workshop indicates awareness among teachers that they lack adequate content knowledge related to a key topic in biology, DNA.

The second most often expressed reason for attending the DNA Fingerprinting professional development workshop relate to policy requirements. Highly Qualified Teacher (HQT) requirements of the state and the approaching deadline for teachers to meet these requirements were identified as major motivations to attend the professional development workshops. The DNA Fingerprinting workshop enabled teachers to address the goals of HQT through their attendance. The high number of special education teachers participating in the workshop can be explained by the HQT requirements. Special education teachers are required to meet the HQT requirements for every content area they teach. Considering the fact that, in many cases, special education teachers teach three or more content courses, the pressure to meet the HQT requirements would be elevated for these teachers. Nearly any workshop constitutes an opportunity to meet the HQT goals for special education teachers. Although attendance by special education teachers to the workshop was a surprise, it makes sense in the light of policies related to HQT professional development requirements. Overall, then, the number of participating science teachers who actually had the potential to implement the workshop in their own classrooms was limited to 11. Based on the participant profiles, we can conclude that the DNA Fingerprinting workshop was not serving the goal intended at the beginning: to provide teachers with skills and knowledge necessary to allow them to implement the workshop in their own classrooms. The great majority of teachers attending the DNA
Fingerprinting workshop did not have a realistic opportunity to implement it in their own classrooms due to the grade levels or subject content areas they teach. However, the professional development workshop was serving two purposes: (1) giving teachers an opportunity to meet the policy requirements such as those of HQT status and 2) providing teachers with the knowledge and skills regardless of whether or not they have the potential to implement the workshop themselves. Teachers who did not have the potential to implement the workshop could at least gain experience with the content by attending the workshop. The extent to which this potential outcome was realized was not measured, but warrants further study.

What factors influence teachers’ decisions to implement the DNA Fingerprinting workshop in their own classrooms?

The outcome expectation of the workshop designers was that participating teachers would implement the DNA Fingerprinting workshop within their own classrooms. The major finding of this study is that the desired outcome is not likely to happen in most cases. A total of 73 teachers participated in the professional development workshops associated with this study, with 31 of these teachers attending the DNA Fingerprinting workshop during the period of this study. Of these 31 teachers, only 11 teachers had a realistic potential to implement the workshop in their own classrooms based on the grade level and the subject area content of their teaching assignments. For those having the potential to implement the workshop within their classrooms, the influences on implementation decision can be grouped into four categories.
Teachers identified the university offering as both a positive and a negative influence on their implementation decisions. Encouragement and support from the university were positive elements influencing implementation behavior. These elements appear to become more influential over time. The level and the intensity of the connection between participating teachers and the university team (workshop provider) seem to be the primary variable. After teachers complete the workshop, in most cases they minimize their contact with the university. Although the data collected throughout this study was short-term and limited to two partial school years, the findings imply that it would be more difficult for teachers to implement the workshop after a lapse of time since they have to refresh their knowledge and skills related to the content and the procedures. It is, therefore, not surprising to find teachers increasingly reluctant to implement the workshop as time passes. Two possible approaches are proposed to address this need. One strategy would be to offer refresher workshops for teachers for the purpose of reinforcing the content knowledge and skills presented in the initial professional development workshop. However, this approach might be limited by the time constraints of both the teachers and the university faculty members. A second option may be to provide teachers with resources that they can refer to before implementation. The difficult areas of the workshop can be identified as the content knowledge and the laboratory procedures. Developing a short video focusing on the content and the procedures, as well as providing lecture materials to teachers, may provide the needed support and encouragement. This approach would also addresses the ongoing content knowledge difficulties of teachers by allowing repeated examination of resources as needed. The workshops were offered to a diverse group of teachers, and the majority of
the participating teachers did not have the means or the potential to implement the workshop in their classrooms. Providing content materials addressing different grade levels would give these teachers resources suitable for integrating workshop content into other grade levels as well.

How effective are teacher-led workshops compared to faculty-led workshops in terms of student learning and positive attitudes among students?

Student data from two instruments were analyzed to respond to this research question. While there were no statistically significant differences found among students’ attitudes toward genetics by teacher sample, the limitations of low statistical power and low reliability of the Genetic Content Inventory and three subscales of the Attitudes Towards Genetics Survey should be taken into consideration. The Genetic Content Inventory results suggest that the two teachers who implemented the workshop in their classrooms were successful in their implementation process and student scores increased on the posttest outcomes. This can be taken as evidence of what is possible, even though the results of their efforts cannot be generalized broadly.

The number of teachers who implemented the workshop in their classroom may seem quite low in comparison to the number of teachers that attended the DNA Fingerprinting professional development workshops. But we should take into account that there were only 11 teachers with a realistic potential of implementing the workshop within their classrooms. The outcomes of this study were substantially impacted by the mismatch in personal profiles between expected workshop participants and the majority who actually attended, so the obtained results based on the implementation behaviors of three participating teachers cannot be broadly generalized. But the findings do provide us
with some insights as to the influences on motivations to attend the DNA professional
development workshops and to consequently implement the DNA Fingerprinting
workshop in one’s own classrooms.

The outcomes of the study suggest that the DNA Fingerprinting workshop can be
successfully implemented by experienced teachers as a component of the science
curriculum. Although the results are not generalizable to every professional development
program or teacher, the approach of packaging content intensive topics such as DNA
Fingerprinting into workshop format was successful. Teachers were enabled to gain
valuable content knowledge and laboratory skills, and some participating teachers were
able to implement the workshop successfully in their own classroom environments. There
are other areas that can be identified as content intensive, such as the topic of
transformation which is also part of the molecular genetics content. The professional
development approach applied to DNA Fingerprinting may also be applicable to
transformation and other content intensive areas.

Implications for Further Research

The results of this study are not generalizable beyond the students and teachers
who participated in this study. However, the results would likely to be applicable to other
workshop settings focusing on intensive content knowledge similar to the DNA
Fingerprinting professional development workshop.

Further research is necessary to address limitations faced throughout this study.
Clearly, the long-term results of professional development workshops such as those
represented by the DNA Fingerprinting Workshop should be studied. Many university
faculty members collaborate with school districts to provide enrichment workshops and
to increase student exposure to cutting edge knowledge and procedures, and the efficacy and long-term impacts of such arrangements warrant greater study. This study identifies several variables influencing teachers’ motivations to attend a DNA Fingerprinting professional development workshop, and their motivations to implement the workshop into their teaching practices. Some of the motivational factors uncovered were not anticipated, and their prevalence across schools is unknown. The strength of these variables should be measured through time to identify long-term outcomes and to guide professional development practices.

Program developers should take into account that the teachers participating in workshops will not always be the group targeted as the potential audience. This was observed to be the case during the DNA Fingerprinting professional development workshops of this study and is likely to be a widespread occurrence. The audience targeted by the workshop providers in this study, with the consideration of the workshop content, was high school science teachers, particularly biology teachers. The expected outcome was to have teachers implementing the DNA Fingerprinting workshop within their own classrooms. However, teacher profiles and the associated teacher data indicate the strong influence of educational policies on motivations to attend the workshop. Program developers and educators should take notice of the observed shift between the targeted audience and the attending teachers into consideration. There may be modifications to the structure of the workshop that could be made to address the needs of teachers representing diverse grade levels and content areas taught. This can perhaps be accomplished by providing teachers with instructional materials that are suitable for
lower grades as well as using a more integrated approach that would allow teachers from other content areas, such as mathematics, to take a more productive role in the teaching practices of this workshop.

The majority of teachers who attended the DNA Fingerprinting professional development workshop were identified as either middle school teachers or special education teachers. Most of these teachers did not provide any data to this study. Therefore it is unknown to the researcher if these teachers were able to acquire any knowledge or the skills that significantly influenced their teaching or if they were able integrate any of it into their own teaching. Follow-up studies are needed to further examine teacher understanding of DNA and its applications to daily life, and how the content is being used to engage students in learning. A long-term study should be utilized to determine whether the variables identified here as motivating factors for professional development and implementation behaviors among science teachers are consistently found. Addressing complications resulting from non-equivalent groups in regard to the number of participating students and their levels of content knowledge would overcome the limitations faced in interpreting the results of this study. Also, long-term observations of teachers’ instructional practices could complement the findings of this study, as would increasing sample size by involving teachers from more than one school district. Though the findings of this study are severely constrained in terms of generalizability, they do identify potentially significant factors related to the impact of professional development activities that are worthy of further explication and additional study.
LIST OF REFERENCES


APPENDICES
APPENDIX A

ATTITUDES TOWARD GENETICS SURVEY
## Attitudes Towards Genetics Survey

For each statement please choose the response best corresponds to what you think

**SA: strongly agree**

**A: Agree**

**N: Not Sure**

**D: Disagree**

**SD: Strongly Disagree**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Too many laboratories are being built at the expense of the rest of education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>A scientist can have a normal family life</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>I would rather find out about things by asking an expert than by doing an experiment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>I enjoy reading about things which disagree with my previous ideas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Genetics lessons are waste of time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Talking to friends about genetics outside of school would be boring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>I would like a career teaching genetics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Genetics makes life better</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Scientists do not care about their working conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>I would rather solve problems by doing an experiment than be told the answer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>I dislike repeating experiments to check that I got the same results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>I enjoy doing genetics lessons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>I would enjoy having a job in genetics during my break</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>I job as a scientist would be boring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>This country is spending too much money on genetics research</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Scientists are just as interested in art and music as other people are</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>It is better to ask teachers the answer than to find it out by doing experiments</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>I am curious about the world in which we live</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>The material covered in genetics lessons is uninteresting</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Listening to genetics report on the radio is boring</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>A job as a scientist would be interesting</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Genetics can help to make the world a better place in the future</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Few scientists are happily married</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>I would rather do an experiment on a topic than read about it in science magazines</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Finding out about new things is unimportant</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>I look forward to genetics lessons</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>I enjoy watching forensic science shows during my leisure time</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>I would dislike being a scientist because it requires too much education</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Money used on genetics projects is wasted</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>If you met a scientist, he/she would look like anyone else you might meet</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>It is better to be told genetic facts than to find them out from experiments</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>I like to listen to people whose opinions are different from mine</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>I would enjoy school more if there were no genetics lessons</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>I dislike reading newspaper articles about genetics</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>I would like a career as scientist</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>I don’t see a positive impact of genetics research in my life</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B

GENETICS CONTENT INVENTORY
Genetics Content Inventory

Student name: 
Teacher name: 
Period: 

Please answer the following 15 multiple choice items. Only select one choice.

1- “CGTATTGA”
What would be the complementary DNA strand?
   A. GGATAACT
   B. GCUTUUCT
   C. GCATAACT
   D. CGTATTGA

2- Which one of these is not part of a DNA molecule?
   A. carboxylic acid
   B. sugar molecule
   C. nitrogen base
   D. phosphate group

3- DNA is
   A. insoluble in 90% ethanol
   B. a complex protein
   C. a lipid that is destroyed by detergent
   D. typically linear in prokaryotes and circular in eukaryotes

4- Which of the following statements BEST explains the relationship between genes, DNA and chromosomes?
   A. Each DNA molecule contains genes.
   B. Each gene contains many DNA molecules.
   C. Each DNA molecule contains many chromosomes.
   D. Each chromosome contains many DNA molecules.
5- Which of the following best describes the order of events that leads to genetic expression?
   A. DNA __ RNA __ amino acid __ protein __ genetic expression
   B. RNA __ amino acid __ DNA __ protein __ genetic expression
   C. DNA __ amino acid __ protein __ RNA __ genetic expression
   D. RNA __ protein __ DNA__ amino acid __ genetic expression

6- A 10kb long, linear DNA fragment has one HIND III recognition site, located approximately three quarters of the way along the molecule. After using the HINDIII enzyme to restrict (cut) the DNA and separating the resulting fragments on a gel, an observer would see
   A. two bands indicating approximate lengths of 7.5 and 2.5 kb respectively
   B. one 10kb band
   C. two bands indicating approximate lengths of 5 kb each
   D. a smear of many different sized bands

7- Gel electrophoresis is used to separate DNA molecules based on
   A. genetic relatedness
   B. size
   C. percentage of protein by mass
   D. solubility

8 – In gel electrophoresis DNA migrates from one end to other because of
   A. gravity
   B. buffer solution
   C. restriction enzymes
   D. charge of the molecule

9- The size of human genome is ________
   A. 3,000bp
   B. 30,000bp
   C. 3,000,000bp
   D. 3,000,000,000bp

10- 1kilobase equals to _____________
    A.10 base pairs
    B.100 base pairs
    C.1000 base pairs
    D.10000 base pairs
11-Restriction enzymes are
   A. proteins
   B. genes
   C. lipids
   D. sugars

12- The primary function of DNA is to
   A. code for protein synthesis
   B. keep the nuclear structure intact
   C. make nucleotides
   D. work as a biological clock

13. Which of the following best describes the hierarchical order starting from the smallest
   A. Nucleotide - DNA – chromosome - gene
   B. Nucleotide - Gene – DNA – chromosome
   C. chromosome – nucleotide - DNA- gene
   D. DNA – gene – chromosome

14- The nucleotide bases are bonded with __________ bonds
   A. Ionic
   B. Covalent
   C. sugar
   D. Hydrogen

15- Which DNA sequence below includes a “typo”
   A. AGATCCGA
      TCTACGCT
   B. GACTAACC
      CTGATTGG
   C. CCTAGCAT
      GGATCGTA
   D. ATCGGCCA
      TAGCCGCT
APPENDIX C

INTERVIEW PROTOCOL
Interview Protocol

The following questions were used to guide the interview process as necessary.

1- What was your motivation to attending the workshop?

2- Can you describe your workshop experience? Was there anything that really stands out for you?

3- Have you get a chance to implement the DNA Fingerprinting workshop in your own classroom?

4- How comfortable are you implementing the DNA Fingerprinting workshop?

5- How important is it for you to receive support from the university?

6- What kind of circumstances is necessary for you to implement the workshop in your classroom?
APPENDIX D

DNA PRE-WORKSHOP QUESTIONNAIRE
DNA Pre-Workshop Questionnaire

1 What is your purpose of attending this workshop? Explain

Please select all that apply

2- I teach:   AP Biology
             10th grade biology
             Middle School
             Other________

3- How many years of teaching experience do you have? ____________

4- What is your educational background:
   Bachelors____________________________
   M.Ed______________________________
   PhD______________________________
   Professional development courses _________

5- Do you have any experience with technological aspects of molecular biology? Explain

6- Do you include DNA technologies in your teaching? Explain

7- Are you considering implementing DNA Fingerprinting activity in your classroom?
APPENDIX E

DNA FINGERPRINTING FOLLOW-UP TEACHER QUESTIONNAIRE
DNA Fingerprinting Follow-up Teacher Questionnaire

Please select the best response to the following questions:
1- Gender  M □  F □

2- Which best describes you? (Check one box only).
□ White (not Hispanic)  □ Black (not Hispanic)
□ American Indian or Alaskan Native  □ Asian or Pacific Islander  □ Hispanic
□ Other (specify) ______________

3- At the end of this school year, how many total years will you have taught?
Number of years I have taught full time___________________
Number of years I have taught part time___________________

4- At the end of this school year, how many years will you have taught in your current school district?
Number of years I have taught full time___________________
Number of years I have taught part time___________________

5- Which grade level/s are you teaching?
_________________

6- How long have you been teaching at your current grade level?
_________________

7- Which content area(s) are you teaching? __________

8- What is the highest level of formal education you have completed? (Check one box only).
□ Completed a Bachelor’s degree
□ Completed an academic Master’s degree, postgraduate certificate program (e.g., teaching) or first professional degree (e.g., law, medicine, dentistry)
□ Completed a doctorate (Ph.D. or Ed.D)

9- Do you currently hold a certificate or license to teach?
Yes □  No □

10- While studying to obtain your bachelor’s degree or equivalent, what was your major area of study?
□ Mathematics
□ Biology
□ Physics
□ Chemistry
□ Education
□ Mathematics Education
□ Science Education
□ Other ____________________
11- If you have a master’s degree, what was your major or main area of study?
- I do not have a master’s degree (If checked skip to the next question)
- Mathematics
- Biology
- Physics
- Chemistry
- Education
- Mathematics Education
- Science Education
- Other ______________________

12- How many hours of professional development in the following areas have you accumulated?
   a) Science content --------------------------------------------
   b) Science pedagogy/instruction -----------------------------
   c) Science curriculum ----------------------------------------
   d) Integrating information technology into science ---
   e) Improving students’ critical thinking or inquiry ski
   f) Science assessment ---------------------------------------

13- In the past two years, have you participated in any professional development activities?
- Yes ☐  No ☐  If yes, please describe:

14- Did you have any previous experience with molecular genetics or DNA fingerprinting?
- Yes ☐  No ☐  If yes, please describe:

15- What motivated you to attend the workshop?
16- Since participating in the DNA Fingerprinting workshop, have you implemented DNA fingerprinting in your classroom? (Complete implementation or implementation of basic principles)

☐ Yes. Please explain factors affected your decision making.

☐ No. Please explain factors affected your decision making.

17- Would you like to be interviewed by the researcher? It will approximately take 20-30 minutes and the time and location will be determined based on your convenience.

☐ Yes. Please provide contact information.

☐ No