DIGITAL DIVIDE AND SCIENCE DIVIDE: COMPUTER ACTIVITY
DIFFERENTIATION AND TEACHER BELIEFS ABOUT TRACKED SECONDARY
SCIENCE STUDENTS

by

MAI YIN TSOI

(Under the Direction of Carolyn S. Wallace)

ABSTRACT

Several studies (Hoffman & Novak, 1998) have documented the “Digital Divide”, a phenomenon of at-risk student populations receiving fewer opportunities to use school computers than students from high-track classes. Low-track students use computers for low-level activities (such as drill-and-practice), while their counterparts engage in more creative and problem solving type computer tasks (Schofield, 1995). Underserved populations and females are also less likely to continue into science and math fields (Atwater, 1994), causing a “Science Divide”. In order to explore this intersection of computers, science education, and equity due to the legislated incorporation of computers into science curriculum, this mixed method study aimed: first, to describe the types of computer activities assigned in different track-levels in secondary science; second, to discover the ways teachers differentiated computer activities between classes of dissimilar track-levels and in relation to student demographics; and third, to interpret the salient teacher beliefs about students that affected teachers’ computer activity differentiation. At a large, suburban high school in southeastern United States during spring semester, 2002, a total of 29 science teacher interviews, one case study, and 1,070 Student Demographic Surveys informed this study. The results showed that the four main categories of computer activities assigned were: “internet searches”, “information dissemination”, “inquiry”, and “computer as tool”. Three methods of computer activity differentiation were used: “amount”, “change content”, and “change activity”. Fewer activities that covered less content, had lower student requirements, and were more teacher-centered were assigned to lower-track classes, which were comprised of predominantly African American and Hispanic students, males, and low-income students. Teachers cited low student math, science, and computer ability, diverse learning styles, low student motivation, atypical interests and life goals, and lack of student computer ownership as reasons for their activity differentiation. They differentiated to increase low-track students’ grades and to control behavior. Teachers’ own personal experiences as students, track levels taught, longevity in teaching, and “projected self-efficacy” influenced teacher’s choices and adjustment of computer tasks for different track levels. This research indicates that issues of race, class, gender, and teacher judgments about educational resource allocation impact both Digital and Science Divides.
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To God, Who showed me the path…

And to Trey Thigpen, who encouraged me to walk that path…

It is because of You both that I have made it this far.
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CHAPTER I
INTRODUCTION

Statement of the Problem

After the Russian success of Sputnik on October 4, 1958, Americans became increasingly interested in reforming the education of their youth. Ranked near the bottom on international tests in math and science achievement (Loveless, 1999), American students were not learning enough to be competitive against those of other countries like Russian and Japan; America’s failure to put the first artificial Earth satellite in space was a testament to this knowledge deficiency. Some of the instigated changes to the American educational system included high school graduation requirements, new tests and standards for teacher licensing, and curriculum restructuring (Persell, 1977).

The educational practice of tracking and placing students in groups by ability was also reexamined. Curriculum tracking, or “tracking”, is when educators separate students based on students’ ability, prior achievement, or future goals. Ability grouping places students in groups based on ability in a particular subject. Used in schools since the late 1800’s (Persell, 1977), student groupings became unpopular during the early 1900s due to the country’s need for a trained and able workforce for the factories. The changing U.S. foreign policy of the 1950s and 1960’s caused educators to reintroduce tracking practices into American classrooms.

The use of curriculum tracking and ability grouping in schools has been a topic of long-standing debate in educational arenas (Loveless, 1999, p. 14). The main rationale for tracking is that the act of separating students by needs, interests, and abilities allows teachers to better
accommodate the curriculum to each student’s particular strengths (Bellanca & Swartz, 1993; Oakes, 1986; Steinberg, 1992). However, some research has indicated that students might not necessarily learn better in homogeneous situations, due to differential perceptions and treatment (Oakes, 1985; Oakes, 1990; Darling-Hammond, 1985). It is not surprising that there is dissention on the use of tracking as an educational practice. (Alexander, Cook, & McDill, 1978)

One concern of educators and policymakers is the demographics of the students enrolled in differently tracked classes. There is a trend of high-level classes being filled with whites, males, and high socio-economic students (Braddock II, 1990). Low-level classes are often mostly comprised of minorities, females, low socio-economic, and ESOL students (Braddock II, 1990). For example, according to Oakes’ article (1986), “Poor and minority youngsters (principally black and Hispanic) are placed in tracks for low-ability or non-college bound students. By the same token, minority students are consistently underrepresented in programs for the gifted and talented.”

Findings like these have led some researchers to focus in on curriculum tracking within individual disciplines in an effort to explicate the effects of tracking. Challenging curriculum has been linked to academic achievement (Bellanca & Swartz, 1993; O'Neil, 1992). Indeed, within science education research, there may be some evidence that teachers’ behavior within the classroom is biased towards high-level science and math classes (Oakes, 1990b). The lack of minorities and females entering science and education careers has prompted a closer look at tracking in science education.

Besides different tracks and teacher behavior, there may be other ways in which science teachers differentiate between students of varying track levels. In 1996, the National Science Standards recommended the use of computers in science education for grades K-12 in a variety
of settings, such as modeling through computer simulations, data collection using computers, and inquiry investigations through computer databases (National Research Council, 1996). The government’s commitment to integrating technology into all schools can be seen in the “No Child Left Behind” Act of 2001, which requires that 25% of each state’s allocation of federal technology monies be used for staff development (Ansell & Park, 2003). The decreasing costs of technology implementation and increasing availability of computers in schools (G. Solomon, 2002) have created a singular situation where opportunities to use computers for science learning are being meted out by the teacher. The role of computers in the tracking debate needs to be investigated, as teachers increasingly incorporate the use of technology into science classrooms.

Another important reason to investigate the relationship between tracking and technology use in education was the increasing lack of computer access for certain populations, first recognized in the 1980’s (Roblyer, 2000). This phenomena of disparate access between the “haves” and “have nots” was referred to as the “Digital Divide”, a term conjured in the 1980’s (Clark & Gorski, 2001) to describe how low-income minorities, non-English speakers, and rural area dwellers were less likely than their counterparts to own a home computer, access the Internet, or have knowledge on how to use a computer (Roblyer, 2000).

However, as computers became more readily available and less cost-prohibitive in America, an alternative Digital Divide was becoming apparent—in schools. Students in high level courses like Honors and Advanced Placement (AP) classes were observed to be using computers in more authentic, meaningful ways; low-level students used computers for drill-and-practice and rote learning purposes (Schofield, 1995; Schofield, 1998). The Divide now seems to be appearing between track levels.
The problem focus in this study was to find out if the teachers were differentiating computer activities for dissimilar track levels in the same ways that science education seemed to be differentiated for dissimilar track levels. If there were substantial differences found between the computer activities for dissimilar track levels, then what factors might be involved in the process of differentiation? This is an important problem because similar patterns between computer and science resource appropriation may be the result of similar dynamics within the school culture. Thus, the results from studies like this one that investigate the deeper effects of curriculum tracking and ability grouping provide educators and legislators more insight into the secondary effects of this educational practice.

The research questions that drove this particular study are important also because they connected three areas of knowledge that have not been heretofore extensively integrated. There have been many studies that have investigated equity in science (Campbell Jr., 1999; Hilliard, 1998; Lee, 1997; Lynch, 2000; National Science Foundation, 1996; Okhee, 1997), equity in technology (Becker & Sterling, 1987; Chen, 1986; Clark & Gorski, 2001; Schofield & Davidson, 1998; Bromley, 1997), or technology in science learning (Chiappetta & Koballa Jr., 2002; Kahn, 1985; Wellington et al., 1994). Not much research has been done on the particular context of computer use in science classes, with a comparative lens on different ability track levels.

The results of this study add a unique set of data to the body of knowledge about equity issues in secondary schools and may further policymakers’ understanding of exactly what needs to be done to improve the science and computer skills of all of America’s future citizens. The ultimate objective of this research was to explicate how educators can help more non-Asian minority, female, and non-English speaking students to gain access to the tools that will increase their future success in society. These tools include: quality science teaching, computer activities
developed in productive and authentic ways for learning science, and supportive learning environments that pave the way for more students of marginalized populations to enter science and engineering fields.

As a researcher, it is important to situate myself within the context of this study. What was it about my past experiences led me to the formation and execution of this study? I believe my interest in equity issues and science education, as well as my love of computers, made the Digital Divide an inevitable area of research. As I researched the Digital Divide, I found myself thinking about how wrong it was that some people had no access to computers (among the other, more pressing injustices in the world). The computer was such a wealth of information for me. How different my life would have been without the computer and the Internet!

As I became increasingly interested in equity issues during my tenure in this doctoral program, I read about theories as to why certain populations are marginalized in the United States. I became sensitive to hegemony that seems to continually subjugate some and elevate others (Hilliard, 1998; Omi, 1994) and was able to relate to my readings through experiences in my life as a first-generation Chinese American. Therefore, when it came time to choose a research topic, I chose an area where my research efforts would perhaps contribute something of worth to the body of knowledge on equity issues. My hope was that these findings might spark the interest of other researchers and thus perpetuate the effort started here.

The Problem For Science Education

Science Equity: A Cousin to Computer Equity?

The term “equity” is defined as “the quality of being equal or fair; fairness, impartiality; evenhanded dealing” (Oxford University Press, 1989). A commonly interchanged term, “equality” means “the condition of being equal in quantity, quantity, value, intensity, etc.”
Although these two words have related connotations, they have very different meanings within the discourse of science education. It is possible to achieve equality in schools; all children can have equal access to books, computers, and school resources. Within this equality, however, it is also possible for inequity to exist—unfair, partial barriers that inhibit certain students (and enabling other students) from utilizing school resources to their fullest potential.

As we attempt to examine computer-based learning and its implications for science education, we must keep in mind that “equal” does not necessarily mean “fair”. Critical theorists have postulated that schools are social structures that perpetuate the hegemony that biases certain populations (Bowles & Gintis, 1976, p. 24). Through curriculum planning, tracking and ability grouping, and upholding the status quo, school environments are, in effect, microcosms of the outside world and serve to indoctrinate students into the belief systems of American society. Therefore, I believe that equality is not necessarily the same as fairness, but an equitable education means a fair education for all students because ideally there is no partiality.

The National Research Council (NRC) stated that educators in science must give every student the opportunity to have a quality science education "regardless of age, sex, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science" (National Research Council, 1996). Educators and parents in Georgia have chosen to offer differentiated curriculum to students of varying abilities in order to meet this “equality of education” mandate (Reed, 2003). Unfortunately, a comparison of the academic performances of various ethnicities in America suggests that science tracking may not be the ideal method for upholding the NRC dictates. "...In just about every age group and in every subject, the test-score gap between white
and African-American students has grown since 1986, reversing a trend in which the discrepancies decreased from the time the [tracking science] exams were first given [by the National Assessment of Educational Progress] in 1969, 1971, and 1973." (Hoff, 2000). And the science test scores of white students were higher than any other racial and ethnic group tested, both in 1996 and in 2000 tests, for students in grades 4, 8, and 12 (National Center of Education Statistics, 2001). These findings beg the question: is science tracking “fair”, or equitable, if there are disparities between different student populations on national science test scores?

Since the integration of computers into the classroom during the last two decades, the public has been led to believe the myth that the use of computers in schools will equalize all education and close this gap between privileged and underserved children (Clinton, 1996). Citing the wealth of information available through the World Wide Web, the Clinton Administration issued a charge for universal access for all schools and public libraries so that all students, regardless of race, background, or economic status, may finally learn from the same set of resources and identical bodies of knowledge (Clinton, 1996). The computer was to be the “silver bullet” for education.

Seemingly unrelated, researchers had started to notice inequities in student computer use, both inside and outside of schools. In spite of the government’s mission (through the Technology Literacy Challenge Fund’s $200 million budget) to supply every student and classroom with equal physical access to computers (Mack, 2001), there seemed to be differences among various groups of students in the ways computers are used for learning—this would indicate an inequitable access to or use of computers. For example, girls interacted with computers in ways that were quite dissimilar to those of boys; they tended to use computers for a specific task or objective, whereas males were more likely to “surf the net” and to adopt a “trial-
and-error” approach (Sutton, 1991). Minority students used computers mostly for “drill-and-practice” type activities that emphasized repetition and mastery of basic reading and math skills; white students, especially those of a higher socio-economic status (SES), usually engaged with computers for higher-level tasks such as programming and design (Sutton, 1991). These patterns lead us to ask: is the use of computer for education “fair”, or equitable, if there are disparities between student populations in the types of computer use?

Indeed, many continue to tout the power of computers to improve education in spite of these computer usage patterns. Software and education websites for science education have increased over the last ten years (Chiappetta & Koballa Jr., 2002). Proponents of computer use claim that access to the Internet will allow students to explore and learn without being inhibited by basic skills. “A child who has grown up with the freedom to explore provided by such machines will not sit quietly through the standard curriculum dished out in most schools today” (Papert, 1993). And for science, certain companies have developed software programs that are designed to be “intelligent tutors” so that students can learn how to think abstractly using problem-solving skills (Healy, 1998, p. 273). The benefits of using computers and computer-assisted tools for data collection in science laboratory exercises have been clearly communicated to teachers, as can be evidenced by the increasing number of teacher-preparation programs that require a technology course of their graduates, as well.

Implicit in this communal and legislative “stamp of approval” for computer-aided learning is the assumption that all students should and do have equal access to the Internet and computers. Even though many have touted the revolutionary potential that the computer possesses (Walker, 1984; Chiappetta, 2002; AAAS (American Association for the Advancement of Science), 1993), some educators have not paused in their global adoption of computers to
examine issues of equal access to the computers for all student populations. There has been increasing evidence that the computer access gap may be due to forces other than the affordability of purchasing a home computer. “New technologies are removing our excuses for not paying more attention to social, cultural, and linguistic differences and their importance to students. One size has never fit all in science education…” (Lemke, 2001).

The patterns of differences in computer use follow race, class, and gender divisions (Schofield & Davidson, 1998), indicating that there may be societal forces affecting the adoption and use of computers in education—in spite of the potential benefits to student learning for all students. “It is precisely those children who are disadvantaged in education, family income, and personal empowerment who will be least able and least motivated to embrace the new media” (Tapscott, 1998, p. 257). Children who have had negative experiences due to their race or class and who are aware of the opportunity structure in America have been shown to be less accommodating and accepting of school expectations (O'Connor, 1999). Teachers, as well, have been shown to have lower expectations of students from culturally diverse backgrounds and therefore allow these students less freedom and less interactions while strictly controlling the whole learning process (Solomon, Battistich, & Hom, 1996)

These students are also the same ones that are least able and least likely to embrace science as a school subject and as a future career, since success in the physical sciences is not usually in line with the major cultural beliefs held by minorities (Thomas, 1984). In examining the types of science classes in which these disadvantaged children are enrolled, researchers have noted that low income, non-Asian minority students usually populate low-track classes, while white and Asians are the ones who commonly make up the majority of the higher-level science classes (Bellanca & Swartz, 1993; Gamoran, 1989; Oakes, 1990). Since track-level has been
positively correlated to a student’s academic achievement in and attitude toward that subject (Oakes, 1990b), low-track science classes also serve to deter students from science careers. Along with school success in general, high-level science classes also lead to the knowledge and skill mastery that is necessary to enter science and math fields, which, in turn, is highly rewarded financially in our society (Atwater, 2000).

Since the ideas and views of teachers have been shown to have a direct influence on a science class’s day-to-day curriculum planning (Brickhouse, 1990) and therefore the incorporation methods of computers in science education, teacher beliefs about students became a central focus for this study.

Purpose and Rationale of Study

The purpose of this constructivist, interpretive, mixed method study was to explore the relationships among science tracking, computer assignments in secondary science classes, and teacher beliefs about students in different track-levels in a large public high school located in a suburban county in Southeastern United States. These domains were chosen based on past research in educational equity, in science education, and in the Digital Divide. The results of this study have the potential to increase understanding of the forces and cultural beliefs that could be perpetuating inequitable computer access between science classes of different tracks. This is of importance since inequitable computer access may be linked to other discrepancies in society such as access to knowledge, privilege, and power (Freire, 1970).
The research questions that guided this investigation were:

1. What types of computer activities are assigned to tracked secondary science classes?
2. What are the ways in which teachers differentiate these activities between classes of dissimilar track levels?
3. Which teachers’ salient beliefs about students in different track levels influence the teachers’ planning of computer activities?

As of today, the use of computers in science education is required by national and most state educational standards. Proponents of computer-based learning claim that students must develop competency in the use of technology in order to successfully participate in today’s information age (AAAS (American Association for the Advancement of Science), 1993; Swain, 2002), where the opportunities are only for those who are able to manipulate symbols and data. However, the use of computers to teach higher-level thinking and to expand children’s knowledge base is not a guaranteed success with just mere integration into the classroom. The computer could serve to help improve our educational system and place American students back in competition with foreign countries’ students only if it is a tool used within a comprehensive, well developed, purposeful manner (Healy, 1998).

The unique ethnic composition of our classrooms produces numerous issues to which many other countries are not subjected. Questions of equality and fairness can arise when precious school resources are scarce. In a country where race and class confound each other and are further complicated by the issue of resources, it is understandable why the arrival of the Information Age might incur a divide among populations of Americans. As technology continues to develop at an exponential rate, we would be doing a great disservice to our youth if
we uncritically pass over these divisions between groups and blindly subscribe the same or
generic computer-based learning to each and every child.

Theoretical Model of Study

I developed the following theoretical model as I was formulating the research questions
because a visual model helps me to better understand exactly how the study fit into the context of
science learning and technology. This “triad model” was how I saw science, technology, and
equity issues being related to each other, a visual depiction of the connections between three
dynamic and contextual school-based realms. In thinking about how these issues relate to
science education, I found myself, as I explored one area, returning to the other two areas. There
was no linearity to this debate; in fact, it seemed to me that these three topics intertwined and
reflected upon each other to form a triangle:

Figure 1. The three core areas of research inform and lead into each other, creating a “triad”, or
triangle, of theory. The relationships between each area are labeled with a letter. This
theoretical model helped develop this study.

Equity issues, as related to technology, are applicable to science education because of the
link connecting equity to science and the link connecting equity to technology. Although issues
of how certain groups of students learn with computers relate to all subjects taught in school, science must be considered separately for several reasons, one of which is that the distinct nature of the sciences in our society situates the subject at the center of equity debates. As discussed later in the Literature Review section, there has been a long-standing pattern of bias against minorities and females in America in science and through the use of science as a tool for oppression (Mack, 2001) (which, in science education, manifests itself as ability-tracking). In this study, I attempted to shed light on the similarities and differences between equity issues in science and equity issues in technology. The connections that make up the “sides” of this triad are described in the Literature Review section.

Definition of Terms

Due to the interdisciplinary nature of this study, it was necessary to explicate certain terminology that was used throughout the research process because various fields of study assign different definitions to common words or phrases.

Technology

The use of the word ‘technology’ was confined to how technology relates to learning, since this was the direction of the study. Commonly, the term technology is a synonym for "tool" or "instrument". Recently, with the arrival of the Information Age, many educators use the word technology as a substitute for computers. But, in a broad sense, technology “…means the systematic application of scientific or other organized knowledge to practical tasks" (Sleeman & Rockwell, 1976, p. 4). So, technology can refer to the process of applying knowledge to a task or an instrument that accomplishes the same goal; sometimes, the term can mean both.
Therefore, one can view the computer as a technology because inside the CPU (central processing unit) is a body of knowledge that was placed there by the creator of that computer. The computer can also be viewed as applying information to the task of, for example, teaching a student to read. Overhead projectors, VCRs (video cassette recorders), and microscopes all provide information to a learner for the express purpose of education.

What is important to keep in mind, however, is that the computer (or any technology) is not neutral in and of itself. Because the word technology includes the word "application", someone or something must be the subject of the verb "apply". Who is doing the application? What is applying the knowledge to the process? In the case of computers, the knowledge that is being applied to the computer user originated from a human being. Therefore, that knowledge is contextual, cultural, and biased.

Software is developed to reflect the values and ideals of the programmer through his/her worldviews. "Technology must be understood as a composite of social forces, cultural influence and values, as well as the technical mechanisms" (Buchanan, 1997). Student users are then exposed to these views and must make sense of it all, in light of their own understandings. The Internet is one example. "…More than 90% of its (the Internet's) contents are in the English language and a similarly high proportion is Euro-American-related content" (Buchanan, 1997). This comes as no surprise, since the majority of computer programmers and web designers are white males. So, in addition to the above definition of technology, it must be added that technology is also a transmitter of cultural information that "…incorporates the 'media' of communication" (Ely, Blair, Lichvar, Tykinski, & Martinez, 1996, p. 9). Buchanan warns that if we continue to blindly consider computer use in education as a neutral tool for equality, then we are continuing the practice of monoculturalistic curriculum.
In this study, the term “technology” referred to the computer as it is used for educational purposes. Thus, it was treated as interchangeable with the term “computer”, even though it was recognized that technology could encompass a myriad of tools that provide information to the learner.

**Computer use/assignments/activities**

These terms referred to the tasks, assignments, and activities assigned to the students in this study that incorporated a computer in some fashion. This included activities such as Internet searches, word processing, simulations, and CBL (calculator-based laboratories) activities that were not solely computational in nature. The tasks that were counted in this study were required to have a cognitive aspect besides calculation. As well, the activity must have involved a computer with a central processing unit (CPU) in order for the activity to be included in the data.

**Track Level, Track, Curriculum Tracking, Ability Grouping, Levels of Science Courses**

Curriculum Tracking is the practice of dividing students by needs, interests, or skills into different groups, or ‘tracks’, in high school. Sometimes the course objectives of the tracks are similar or even the same, but usually the curriculum, activities, and pacing of the different tracks vary. Ability Grouping is the same practice, but usually at the elementary and middle school levels. More about tracking is written in the Literature Review section. In this document, all these terms (except “ability grouping”) are used interchangeably. “Ability grouping” is used to refer to the grouping practices in elementary and middle schools and/or within the same classroom at all school levels.
CHAPTER II
LITERATURE REVIEW

The intent of this literature review is to locate the study within the present body of knowledge on equity issues, science education, computer-aided instruction, and teacher beliefs. Evaluating past research in these areas led me to posit the study’s research questions. Thus, an outline of the seminal works will help explain and further substantiate the importance of this study.

This chapter starts with a review of the history behind the concepts of race and class. Since these are two major themes in equity research, a brief presentation of the main equity issues in education is given and followed by a treatment of equity in the context of science education and of technology. The triad model, presented in the last section, will be used as the framework for reviewing the literature on science education and technology in education so that the interrelationships between the issues explored are clearly defined.

Finally, literature on the topic of teacher beliefs will be reviewed. This area was incorporated into the study during and after data analysis and was dictated by the nature of this study’s findings.

History of the Concept of Race

A review of the historical background on race and class are included in this study because of several reasons. Past research has shown that teacher beliefs about students are intimately connected to students’ racial and class backgrounds (Gomez, 1993; Lynch, 2000). Also, statistics on the student demographics of classes that are ability tracked follow divisions along
race and class lines (Oakes, 1985). By including the constructs of race and class in the Student Survey instrument, this study situated the investigation of computer activity differentiation within the context of race and class dynamics in American schooling. As a researcher, I needed to clarify my interpretation of race and class and how that interpretation played a role in the design, execution, and analysis of this study.

A historical analysis of literature provides no evidence that race had any real social significance before the sixteenth-century. Although physical variations among populations inhabiting unlike regions were noted by people as early as Egyptians, Hellenic Greeks, and Eastern civilizations, race as a concept did not play an important role in societal divisions until the dramatic world-exploration of Europeans (Cox, 2000; Smedley, 1999). The psychological need of humans to feel connected as a group promoted an increased awareness of skin color, hair texture, and facial features as the land-hungry Europeans encountered more and more regions and increasingly diverse populations during their world travels.

The Europeans noticed these outward variations and consequently developed a type of “ethnocentricism” that defined “we” from “them”, based on these physical attributes (Smedley, 1999). As Darwinism gained momentum in Europe, Europeans began to consider human physical characteristics in an alternative form (Smedley, 1999). They reasoned that since the plant and animal kingdoms apparently seemed to be arranged in a stratified, hierarchal system that propagated new plant and animal life, then perhaps humans as well are subject to similar schema of ranking. What ensued were heated political and scientific debates on phylogeny and the origin of mankind.

Immersed in a religious society, Europe was at a crossroads. They found it difficult to simultaneously maintain their deep-rooted beliefs of a genesis-based monotheistic world and the
apparent proof of evolution espoused by Darwin. They believed that God had created one man and one woman, but could not explain the wide variety of physical disparities they encountered in people of other continents. They reasoned that perhaps God had meant for humans to be classified in a particular order, applying the tenets of “natural law” to the inhabitants of the Earth (Smedley, 1999) and that some groups were more evolved than others. Variations in physical characteristics existed as a way to distinguish people’s membership in the different “categories” of the analogous stratified hierarchy of humans. Thus, humans with dark brown skin and wide noses belonged in a separate category than humans with fair skin and narrow noses.

Using this rationale, Johann Friedrich Blumenbach (1752-1840) presented the world’s first racial classification scheme as his doctoral dissertation in 1775 (Gould, 1994). He divided human beings into five groups using geography as well as physical traits, since European explorers noted that certain locales had a higher percentage of humans with particular physical traits than other areas.

…the Caucasian variety, for the light-skinned people of Europe and adjacent parts of Asia and Africa; the Mongolian variety, for most other inhabitants of Asia, including China and Japan; the Ethiopian variety, for the dark-skinned people of Africa; the American variety, for most native populations of the New World; and the Malay variety, for the Polynesians and Melanesians of the Pacific and for the aborigines of Australia. (Gould, 1994, p. 66)

Entrenched in this philosophical schema was the idea that the physical outer aspects of a human were also representations of inner attributes (Smedley, 1999). What ensued was a rush to corroborate these ideas through the use of the scientific method (Horsman, 1981). Craniology
became popular, as scientists believed that behavior and attitude could be predicted by examining a person’s brain. From these ideas, physical anthropologists have established divisions between groups of humans that are still used today.

In order to justify their appetite for world domination, Europeans were forced to view non-Europeans as people to be conquered and subjugated. They used Blumenbach’s racial classification system as their guide. “As a worldview, it [the racial classification system] was a cosmological ordering system structured out of the political, economic, and social experiences of peoples who had emerged as expansionist, conquering, dominating nations on a worldwide quest for wealth and power” (Smedley, 1999, p. 26-7). As a result, the concept of race had become one of several ordering systems (similar to religion) that were exploited as impetus and exoneration for Europe’s foreign policies during that period of history. Smedley continued:

…[The concept of] race originated as the imposition of an arbitrary value system on the facts of biological [phenotypic] variations in the human species. It was the cultural invention of arbitrary meanings applied to what appeared to be natural divisions within the human species. The meanings had social value but no intrinsic relationship to the biological diversity itself…” (p. 23).

The result of this value-laden system of classification was the imposition of “nontranscendable” (p. 22) social distances between groups, perfectly suited to the political and social needs of the European people at that time.

On the other hand, critics of this idea of biologically determined racial categories have argued that as a facet of science, race does not exist. Smedley’s 1999 book claimed that in terms of biology as a science, there is no genetic evidence to support the classification of humans through physical or behavioral traits. “[The concept of racial categories] originated, not as a
product of scientific investigations but as a folk concept; it initially had no basis, no point of origin, in science or the naturalistic studies of the times” (p. 27). His statement was a direct contradiction to Blumenbach’s work. According to Smedley’s book, variations of the human species are just that—genetic arrangements that occur naturally and that do not elevate one group’s worth over another’s. He stated that skin color and body structure should be considered as telling of a person’s value as the color and shape of a leaf on a tree. A comprehensive analysis of race literature traced the development of thought regarding race over the years (Littlefield, Lieberman, & Reynolds, 1982). The current trend of thought in anthropology embraces a “no-race” paradigm. These anthropologists claim that the concept of race as a biological ranking system is unfounded; the race concept was manufactured out of a historical and contextual need to understand diverse populations of humans.

Today, not everyone agrees with this more recent “no-race” paradigm. There still exist many proponents of the race paradigm. They countered the arguments of today’s anthropologists with the contention that, in actuality, the “race does not exist” line of thought was purposely conjured up as a way to avoid uncomfortable discussions on the topic of race. “…Americans, including many historians, tend to accord race a transhistorical, almost metaphysical, status that removes it from all possibility of analysis and understanding” (Fields, 1990).

In Tatum’s book (1997), one explanation for these uncomfortable feelings is offered: it is in the definition of race that Americans find discomfort. By using the concept of race as a tool to determine “otherness”, Americans inherently subsume the structures of domination and subordination as they divide up the peoples of this nation by appearances. This hierarchy can cause uneasiness among Americans because power is managed through these structures and “…a system of advantage based on race is antithetical to traditional notions of an American
meritocracy” (Tatum, 1997, p. 9). Uneasiness might then give way to denial and silence and “the system of advantage is perpetuated when we do not acknowledge its existence” (p. 9).

Many of the race-based, “nontranscendable” social distances created by the Europeans in the early to mid-20th century exist today in American society (albeit there are a number of other social distances within our complex society as well). These racial social distances have been manifested geographically in predominantly Black ghettos, Hispanic barrios, Chinese Chinatowns, and white Beverly Hills, for example. These social distances also affect young adults as they form collective cliques based on common experiences—usually being of the same race. The same social distances also cause conflict over interracial dating or marriage, when two people try to bridge these social distances. It is also important to note that for centuries other countries besides America (i.e. China, Japan) have subscribed to the ranking of human populations through physical characteristics and that America has not been alone in these judgments about people.

The educational arena is not without these social distances as well. Michael Levin wrote a book discussing the racial differences between students and relating these differences to disparities in student achievement. His book *Why Race Matters* (1997) is an example of a sociologist attempting to explain social and cultural differences between Black and white students using purportedly scientific data that attest to these innate physical differences. He supported his claims using IQ scores and states that innate ability to achieve academically is correlated to race. He stated in his book that because there are apparent differences in the IQ of Blacks and whites, then there must be something that is being measured. This characteristic may not be intelligence, Levin wrote, but it is similar to it.
When groups of students are compared, as in Levin’s book, the concept of race inevitably enters the educational domain because race has been used to categorize and rank people for so long. But there are several ways in which race can be used as a point of contrast because of the numerous connotations and definitions associated with the race concept. When race is used to identify and categorize groups of people, then the race concept adopts the biological form (as opposed to the cultural form) of the definition so that quick factions of people may be made. Researchers and educators who want to count the number of Asian students in a school, for example, are using the biological form of the race concept. They are looking at physical attributes in order to identify and categorize people into groups.

But race can take on the cultural form of the definition. Here is where value and rank become parts of that definition. Levin counted the number of Black and white students in the studies he reviewed, but then proceeded to explain IQ score disparities through cultural definitions of Black and white people. Blacks are not as intelligent as whites, Black students struggle with higher-order thinking tasks. In this context, being categorized as Black brings a set of assumptions about the characteristics of being Black that have a certain value judgment attached.

Thus, in this vein, if Hispanics have less access to computers than White students, then something about being of the Hispanic race must be to blame. In fact, a long history of connecting race with IQ has led to the use of race as justification and explanation for school segregation (Graves, 2001, p. 157). Subsumed in these discourses is the inherent assumption that
race is the only variable and that all other factors are held constant. This argument insinuates that all students, regardless of race, have equal access to educational resources, have equal opportunities to succeed in school, have equal support from family and community, and have equal experiences within the school community.

If the purpose is to compare individuals, then race can be used as a tool for grouping by physical attributes such as skin color. But if the goal is to provide explanations regarding certain social, political, or economic phenomena that pattern themselves along racial lines, then race is the lens through which one explains those phenomena (acknowledging that this lens is colored by years of historical context and human manipulations). Implicit in the use of the word race is the understanding that there is a positive-negative continuum along which Americans are placed (Hilliard, 1998) and the determinants of people's positions along that continuum are the objective physical characteristics with which they were born. The ways in which we use race in conversation unfortunately sometimes link biological associations with worth.

In this study, I have included the construct of race. Given the aforementioned politics that are entrenched in the term, it would seem that its inclusion would only bring confusion to the study. I believe that, in order to extricate and elucidate the bias and assumptions that lead to inequities in schools, it is imperative that race be brought to the forefront of the discussion. I will use the construct of race in this study because I wish to discover the value system(s) that these teachers, students, and administrators attach to this word. Race entered the conversation long before the genesis of this study. It would be detrimental to ignore its existence during this study.

Using race as a variable in this study did not confound my purpose. Because I am acknowledging the implications and assumptions that come with ideas of race, I am not adding to
the silence. In my opinion, avoiding the topic of race perpetuates its ideological use as a ranking scheme for the purposes segregation and division. Confronting race, especially with the intention of ascertaining its role in science learning, is perhaps just one way of moving against the flow of complacent acceptance of human divisions based on historical oppression and unmerited assessments.

Thus, in this study, I use the term race in a biological sense, for the purposes of categorizing the student participants. However, in the analysis of the data of this study, I use the term race in the cultural sense. I examined the ways in which teachers differentiated their computer activities and wanted to find out how their methods of differentiation correlated to various student populations based on race and class. These correlations were connected to value judgments and assumptions about student qualities besides physical attributes.

History of the Concept of Class

Unlike race, class is discussed as rooted in reality and based on economics, which is a lot more tangible and visible than race-based value systems. One can examine the institutional structures of a society and observe how class is expressed (Reissman, 1959, p. 169). Class structure in America is unlike that of other countries for several reasons. One cause is the stereotypical myth of the ‘American Dream’; it brings class to the forefront of the discussion.

Social classes are, "...groups of individuals and families occupying a common position in the economic system of production and distribution in industrial societies" (Rothman, 1993, p. 80). This position is determined by several factors. Since class is not an easy construct to measure (since it entails designating a specific position within the economic system), socioeconomic status (SES) is commonly used as an indicator of class. SES is comprised of three areas: occupation, education, and income (Conley, 1999).
The core of the “American Dream” is that the class structure in America is based on meritocracy. Meritocracy is the systemic rewarding of those societal members who deserve it, based on their character, efforts, and contributions. Those who are most able and worthy will accordingly gain the most. Socioeconomic attainment is possible for those who receive a good education, which then leads to prestigious employment and usually a healthy income. It is with this logic that many immigrants (for example, Asians) and minorities have placed a great emphasis on obtaining the best education for their children as a means of overcoming economic hardship (Lee, 1997).

However, occupation has been found to also have great bearing on people's lifestyles and perception of class position. Some jobs are not as permanent and stable as others and may continually threaten economic hardship (Kohn & Schooler, 1983). A job with less prestige but more pay may adversely affect an employee's self-confidence, in spite of the higher economic advantages. This lower self-confidence might manifest itself in a lower placement along the class continuum (Kohn & Schooler, 1983). So it seems that class is not an easy mathematical equation that can be solved using the three predictors of SES.

Omi and Winant (1994) wrote about using class as one of three paradigmatic approaches to race. The divisions in society that appear to be associated with race can be viewed through class (Omi & Winant, 1994). Classes exist because there is an unequal exchange of resources and materials in our society. Therefore, groups are ranked based on access and ownership of these resources; these groups form classes.

Conley also reiterated the same point. In his book, he argued that discourse on class issues must include the notion of wealth in order to adequately describe the class structure in America. Wealth, he wrote, are resources that obtained through inheritance or gifts. "Wealth is
much more stable within families and across generations than is income, occupation, or education" (p. 14). Not only can wealth help determine lifestyle, but it can also determine group alliances on an economic level. Thus, as Omi and Winant’s book claims, a privileged access to resources, such as wealth, leads to divisions within the population that we term “classes”.

The race-class debate arises from these definitions and from the race definitions stated earlier. In looking at the statistics, one would be tempted to claim that race and class are connected concepts in America. Conley’s book provided these facts: for every income level, Blacks have fewer assets than whites. As well, among the lowest income level, the median net worth of a white family is $10,000, while for a Black family it is close to zero.

To a considerable extent [lack of wealth] can be traced to a long history of deprivation in this country…this means that blacks have had much less opportunity than whites to earn, save or to inherit wealth. Because of this historical legacy, black families have had few opportunities to accumulate wealth and to pass it on to their descendants. (Brimmer, A. as quoted in Conley, 1999).

This connection between race and class does not seem to make economic sense. From a supply and demand standpoint, all humans desire resources and resources are not predisposed to a particular group. Herein lies the link: in actuality, resources are predisposed to the group towards which an unfair market advantage leans. Omi and Winant cited three reasons for this slant: prejudice, monopolistic practices, and disruptive state practices (such as unions, labor laws that keep minorities out of white jobs, and wage/employment privileges to certain groups) (p. 25). These three work separately and jointly to cause an unequal distribution of material and monetary wealth.
This link between race and class has caused some to put forth the idea that inequities in our society are really a matter of class, rather than race divisions (Conley, 1999). I do not believe that class can be considered without race within American society. Since the perpetuation of class concept rests on the socialization of each generation (Rothman, 1993, p. 85), race must be taken into account because of its ideological construct. Americans may judge each other on class using indicators such as automobiles, clothing, or possessions, but no indicator possesses more implicit meaning and connotations than race. Thus, as children are taught about the ways in which society functions, they inevitably also are indoctrinated on the common ways to compare and identify other members of their own social class.

Emphasizing membership is how social classes are perpetuated (Reissman, 1959). By continuing to determine one's worth in society through race, the systems of privilege and disadvantage are preserved. Along with an assumption about economics, the concept of class in America also holds many stereotypes.

The lower classes…are stereotyped as habitually lazy, inherently immoral, and socially impossible. Considered to be without ambition, they are doomed to remain at the bottom of the class structure. Some…are clean, honest, and try to lead decent, i.e., middle class approved, lives. These individuals, of course, are more socially worthy even though they probably will not rise either. (Reissman, 1959, p. 181)

Then, are these negative associations due to class or due to the roots of class: race? The image conjured up by Reissman sounds suspiciously like a description of the Negro race postulated by early anthropologists in the 1600s, not in the 1950s.

It also appears that movement from one class to another is qualified. Only those whose characteristics are "valued" enough may rise to a higher social class. Asian Americans are one
example of this phenomenon. Exhibiting a quiet work ethic and an unchallenging disposition, the stereotypical Asian student is considered the ideal learner in classrooms (Lee, 1997). These characteristics are valued in our “puritanically-based” American system. Thus, we see many Chinese and Japanese increasing their social status through business ownership, education, and income1 (Tatum, 1997).

Thus, class exists as an independent construct; but in America, class, at times, intersects with the ideas of race. Race (as in the act of placing value on human differences) can cause divisions among people—those in power separate themselves and effectively group and rank the remaining individuals according to physical traits. This stratified ranking is the template from which resource allocation is determined. The resultant divisions in economic wealth, occupation, income, and education are social classes. This is one of the ways in which classes are determined.

And in terms of education, schools are not always controlled, unbiased environments; rather, they actually can be communities of power stratification that effectively perpetuate societal oppression and privilege (Bowles & Gintis, 1976; Freire, 1970; Hilliard, 1998). "During the course of our history, a system of overt and covert education emerged to produce the social system desired by the groups in power. The system of education included specific inequitable features" (Hilliard, 1998). Thus, in previous studies of computer use in schools, race and class seem to be used as variables. But underlying the use of these terms are the deep-rooted constructs that espouse a power system that favors some and not others. Therefore, it was

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1 There are many Asian ethnicities that are predominantly lower-class in America, such as Cambodians, Laotians, and Vietnamese (Lee, 1997). These Southeastern Asians have not fared as well in America for a variety of reasons, one of which is the brevity of their existence in American history (in contrast to Chinese and Japanese, who have been immigrating to America since the 1800s).
paramount that class was included in this study. Students are multi-faceted products of their
culture, family, community, and society where race and class divisions exist.

The student participants were asked to provide the race category that they identified with
as well as their family's income. The students do not live in a race-less and class-less society.
To delete race and class from the study was to deny the existence of race and class—and that is
erroneous (Smedley, 1999). The students' identification with a race and class was used as a way
to better understand how issues of power, privilege, and resources may have impacted their use
of computers to learn science. Unlike other studies involving these concepts, I used race and
class as variables to determine the educational “rank” society had assigned to these students—
which ones were the “easy”, “good” students and which ones were the “difficult”, “low”
students? Their race and class were not used directly to explain patterns in science tracking and
computer use. Instead, race and class helped develop the results from this study into groups of
ideas and concepts that explicated prominent teacher beliefs that were influencing the
differentiation of curriculum for different track levels. In other words, race and class were not
viewed as the sole and direct causes of computer activity differentiation.

The Triad--Side A: Relationship Between Equity and Science Education

The number of Blacks, Hispanics, Native Americans, and females of all racial
backgrounds in the science, math, and technology-related fields is severely unrepresentative of
the general population (Brickhouse, Lowery, & Schultz, 2000; Campbell Jr., 1999; Kahle, 1982;
Moreno & Muller, 1999; NSF, 1996). Many are quick to attribute this disparity to a lack of
ability and educational preparation ( Elliot, Strenta, Adair, Matier, & Scott, 1996); to them, it
seems that because a lot of science and math content are mostly objective in nature, one should
be able to succeed in these areas regardless of his/her culture or background. Others believe it to
be a result of inequitable schooling and resource allocation (Hilliard, 1998; Lynch, 2000; Oakes, 1990b).

Thus, race, class, and gender issues have been closely linked to science education because of these perceptions. Science knowledge is sometimes seen as a valuable resource and is deemed necessary for contributing and functional citizens; competence in science and mathematics can lead to careers that yield great financial rewards, such as research scientists and medical doctors. Populations that have been historically underserved and considered low-ability, such as African-Americans and females, are not entering science and math related professions (Campbell Jr., 1999; Hanson, 1996). As a result, some researchers (Atwater, 2000; Wilburn, 1974) have claimed that these populations are not able to earn as much money or participate as fully in society as groups of people who typically do enter these fields—white males and increasingly, Asians, and Asian Americans² (Okhee, 1997).

Many researchers have stated that science knowledge is considered knowledge privileged to some populations (AAAS, 1998; Mack, 2001) (even though those populations have changed over the decades—see Tolley, 1996). This has resulted in varying access to this knowledge for different individuals, especially when mitigating factors existed to perpetuate these dissimilar patterns in access. These factors have been thought to be (a) access to resources, (b) economic status, (c) interest, (d) cultural barriers, and (e) lack of encouragement (Oakes, 1985, 1990a). These translate into, “…racial, class, and gendered social structures and cultural norms (that) restrict educational attainment for minority students” (Arnold, 1993).

Recent science education reform efforts have focused on increasing the number of minorities and other underprivileged populations that enter the science and math fields. There

² In this document, the term “Asian” refers to individuals who are of Asian descent but were not born in America. “Asian-American” describes those who were born in America with some Asian ancestry in the last one to three generations.
are two rationales behind this movement. One line of reasoning has been referred to as “enlightened self-interest” (Lynch, 2000), which says that if the science literacy for students increases, then the country as a whole benefits from a more technologically sophisticated workforce and greater prosperity for all (Secada, 1989). The justice model of science education reform (Lynch, 2000) states that we, as citizens in a postindustrial society, have a civil responsibility to ensure that our children have the tools and skills necessary to be contributing members of society “with an equal chance at attaining the accompanying social goods—rights, liberties, and access to power” (Lynch, 2000).

Lynch’s book also made the point that science knowledge includes social information that students need to access (called social knowledge). This is information about how to succeed in a certain society. Information such as where to go to school to best access science resources and how to communicate effectively with other scientists are vital to achieving power in a community that is based on cultural and social definitions of what is scientific knowledge. A person’s inclusion or exclusion in society depends on obtaining this social knowledge (Atwater, 1995).

Many science education researchers have investigated the science education of students in urban settings, since these populations tend to be at-risk for dropping out of school and not entering the science and math fields. For example, Angela Calabrese-Barton spent 3 years teaching urban homeless children at an after-school science program and using interactive ethnography investigated the ways in which these children learned science. She noted that the dictate “science for all” (Hurd, 1993), which was introduced back in 1847, has definitely not been met for students of low-income families and especially homeless children. The causes of this failure are many, such as inadequate school resources, insufficient knowledge base of
science teachers, and lack of interest and motivation of students (Calabrese-Barton, 1998). What her research indicated was that the act of teaching science involves the production of knowledge, culture and identities. This production is greatly affected by the persons involved, the beliefs they hold, and the societal context in which they live.

Therefore, science teachers communicate certain assumptions about power and privilege as they engage their students in learning. The interaction between teacher and learner “…is a historically, socially, and politically situated process that is inherently subjective” (Calabrese-Barton, 1998). This subjectivity can cause certain populations to be marginalized as teachers make judgments about children’s abilities and worth as students. When the issue of equity is examined, inevitable two models of arguments are usually presented: the deficit model and the inferior treatment model (Brickhouse, 1994). The deficit model arguments focus on what low-achieving students are lacking and how remediation efforts can increase their performance. They center on explanations for the underachievement. The inferior treatment model arguments look at hegemonic and institutional constraints that prevent underrepresented populations of students from succeeding in the science field. Brickhouse noted that this latter model is important to the area of science equity because it challenges the assumption that the academic failures of these students are not due to inherent qualities that are part of being a female, a minority, or a poor student.

Other researchers feel that science education reform is the way to helping these unsuccessful students. To make science accessible to all students, science content must be presented in ways that encourage students to build on their prior knowledge and they interact and develop newer and more useful scientific principles (Linn & Hsi, 2000, p. 44). Using computers, Linn et al was able to develop a curriculum program that scaffolded students with on-screen
prompts and inquiry-based problems that enacted the above suggestions. The authentic science
tasks asked students to consider alternative explanations, to communicate their rationales to
peers, and to document their line of reasoning as they navigated the computer program. Her
study showed that low-income minority students increased in science content knowledge and
performed as well as the control group of students on science process skills (Linn & Hsi, 2000).

There are other indications that science reform efforts can increase the science
achievements of marginalized student populations. Programs that implement standards-based
teaching and parallel researchers’ suggestions for inquiry-based learning have been shown to
help urban students attain significant content and inquiry gains (Songer, Lee, & Kam, 2002).

The case studies of the teachers involved in the study showed that the teachers felt that the
reform-based changes were conducive and supportive of an inquiry-based pedagogy. Other
studies have found similar results for urban students, when the teaching practices reflected a
more student-centered, problem-based focus (Kahle, Meece, & Scantlebury, 2000).

Some other suggested changes to science teaching that have been shown to increase
science achievement for urban students are co-teaching (Tobin, Roth, & Zimmermann, 2001),
exploring teacher epistemologies as they relate to classroom management issues (Yerrick,
Pedersen, & Arnason, 1998), and examining the effects of student-teacher discourse on power
relationships in the science classroom through assessments (Solano-Flores & Nelson-Barber,
2001). One of the most promising studies was conducted by White and Frederiksen (1998). The
authors examined an application of the software “ThinkerTools” in an inquiry-based curriculum.
The students used the program to predict the behavior of positive and negative electrical charges
as they learned about electrostatics in a physics course. The curriculum required the students to
document their trials and hypotheses and communicate their findings to others. The design of
the software allowed students the freedom to design their own paths for the charged particles, as well as adjust variables like speed and angle of motion. The authors found that using the “Reflective Assessment” method, along with the software, helped the 8 classes of urban children perform better on science content assessments and inquiry assessments (White & Frederiksen, 1998). The results indicated that the act of metacognition, reflecting on one’s thought processes, was the key to making the science activity meaningful to the students.

The connection between equity and science education was a critical portion of this study. There was indication that the five factors that limit access to science knowledge enumerated by Oakes (previously on p. 30) may also be present in the relationship between equity and technology. Since computers, like science, are thought of as an objective yet complex (Schofield & Davidson, 2001) area of education, teachers’ and students’ views about who should use computers and how they should be used may parallel those regarding science as well. As in the case of science knowledge, computer knowledge may be privileged to those who either “deserve” it or who will benefit the most from it (Schofield & Davidson, 2001). These stereotypes may influence how students do science (Steele & Aronson, 1998) as well as use computers to do science.

Curriculum Tracking in Science: A Major Area of Equity in Science Education

One of the areas of educational policy that has garnered a lot of attention is ability grouping and tracking practices in schools. Several hundred studies have been conducted on the effects of tracking in America, making it one of the most debated policies in education (George, 1988).

One of the first instances of ability grouping recorded was in 1867. The “W.T. Harris Plan” was implemented in St. Louis schools in order to separate and advance the more successful
students through school (Persell, 1977; Purdom, 1929). However, the Plan did not last long. As the United States moved from a predominantly agricultural-based country into the Industrial Age in the early twentieth century, a more specialized and trained workforce was needed to compete with other nations. Schools changed from being a place to put children when they were not needed during harvest time to a place where they were taught the skills necessary to work on the ‘assembly lines’ of factories: reading, writing, and arithmetic (Bellanca & Swartz, 1993). Tracking took a back seat to this push for a generalized, prepared workforce. Civics was included to ensure that the increasing number of immigrants joining the workforce would be educated on the beliefs and values of the American society (Bellanca & Swartz, 1993). Later, science, social studies, and business education were added to the subjects taught in schools (Bellanca & Swartz, 1993).

In the late 1950s, the educational scene shifted back to tracking. After Russia’s launch success with Sputnik, America’s political policy broadened into a global view. To promote and continue world competition against other countries, schools were now used to groom the best and the brightest to aid in this competition. Indeed, America’s political plans now included an emphasis on the academic and scientific excellence of upcoming generations (Donelan, Neal, & Jones, 1994). Sorting models were being experimented with to allow the more successful students to get the advanced education they needed. Some schools aggregated students with similar test scores, which resulted in three to four different “tracks” (Bellanca & Swartz, 1993). Other schools separated students depending on their scores for particular subjects. Thus, a student who scored high in reading was also placed in high courses for social studies, language arts, and other humanities (Bellanca & Swartz, 1993). The former type of separation was eventually referred to as ‘tracking’ and the latter type was called “ability grouping”.
Presently, there are two major ways of separating students based on ability, needs, and interests. Ability grouping is when students are put in groups based on ability in a particular area or subject. Thus, a student may be placed in an honors class for social studies, but then also registered in a low-level math class. By definition, schools that separate their students by curriculum are participating in ability grouping (Rosenbaum, 1976). Ability grouping is commonly done in elementary and junior high grades and sometimes occurs as early as third grade (Bellanca & Swartz, 1993) or even kindergarten (O'Neil, 1992). As well, proponents of ability grouping point out that if ability grouping is implemented properly, students are not “locked out” of classes that are appropriate for them. They are purportedly placed in suitable course levels “…for whatever length of time works best” (Fiedler, Lange, & Winebrenner, 2002). One form of ability grouping that has been developed for gifted students is “cluster grouping”. In this case, small groups of students are made within a heterogeneous class, so that the specific educational needs of these small groups may be addressed while tending to the needs of the whole class as well (Fiedler et al., 2002).

Curriculum tracking, or “tracking”, usually is done at the high school level. Based on teacher recommendations, advisor recommendations, test scores, and grades, students are placed in “tracks” of courses (Bellanca & Swartz, 1993). Tracking is when educators decide, “…to divide students into class-size groups based on a measure of the students’ perceived ability or prior achievement” (George, 1988, as quoted in Fiedler, 2002). That measure is usually some type of standardized test score. The number and levels of tracks vary from school to school and region to region; however, the most common tracks are Vocational/Technical, College Preparatory, and Gifted/Honors/Advanced Placement (Oakes, 1987). Students enrolled in the College Preparatory track take courses that prepare them for future entrance into college by
developing skills and content knowledge necessary for a college education. The Vocational/Technical courses aim to prepare students for immediate employment after high school and focus on skills necessary for jobs like office assistants, computer processors, and management.

Placement in tracks is based on two major areas (Oakes, 1990b). The first area is ability and that is determined through a variety of tools, including standardized test scores, grades, and teacher recommendations. The second area is post-secondary plans. A student who plans on going to college must be enrolled in the college-preparatory track in order to receive a diploma that has a “College Preparatory” endorsement. This informs prospective colleges that the student has received the adequate education necessary to succeed at a post-secondary institution. A diploma with a “Vocational/Technical” endorsement sends the student towards the labor force (Oakes, 1990b). Parents, teachers, and students theoretically work together to assess the student’s abilities and future goals; this assessment should then lead to a choice of track for the student’s educational tenure at that school (Oakes, 1987).

Often, both practices of tracking and ability grouping are referred to collectively as “ability grouping” in research literature. In this document, both these terms will be used to refer to the practice of grouping together students with seemingly similar academic skills and abilities for the purpose of achieving the best learning possible.

Proponents of ability grouping and tracking have put forth four major reasons in support of this educational practice. In theory, separating students by ability, needs, and goals appears logical. Provide those students who learn best with the necessary resources to maximize their potential, while aiding those who are lacking with appropriate remediation; all students are therefore enabled to be successful. This “catering” to the students’ individual needs should yield
a beneficial and profitable result for all students (Bellanca & Swartz, 1993). Detractors of tracking have answered these four claims as well. Both sides of each argument are presented here. Afterwards is a brief summary of the relevant legal aspects of tracking.

One argument in support of tracking is that students learn best when they are in a class with others of like ability (Kulik & Kulik, 1982; Scott, 1993). “In the absence of ability extremes, each pupil can receive more teacher time and attention” (Bryson & Bentley, 1980, p. 16). In view of the fact that schooling has always been treated as a systemic tool for transferring information and values, it makes sense that tracking fits into this ideology. Place students into categories that help them succeed the most.

Those who perform poorest get a separate curriculum, slowed and lightened, so they can have an equal chance to succeed. Because the best students often have a greater capacity to memorize the curricular information as measured by standardized tests, it is believed that they ought not be inhibited in their learning by those with less capacity to store and recall (Bellanca & Swartz, 1993).

As well, there is research that supports the claim that achievement scores of gifted students do increase somewhat when they are grouped homogeneously (Feldhusen, 1989; Kulik, 1984; Oakes, 1986) and that historically disadvantaged students (African Americans and Latinos) do not necessarily learn better in untracked settings (Loveless, 1998).

A flurry of research has shown, however, that the benefits of tracking are not universal. In fact, there has been compelling evidence that shows harm and ineffective learning for students in average and low-level classes (Slavin, 1986; Rosenbaum, 1980; Good, 1984; Esposito, 1973; Findlay, 1970; Noland, 1985; Oakes, 1987; Persell, 1977). Behavior problems and dropout rates are higher in low-level classes (Berryman, 1980). Job prospects for graduates of
Vocational/Technical levels are comparable to that of students who drop out of high school (Rubens, 1975; Berryman, 1980). Indeed, even though research by Oakes’ (1986) and others (Alexander, Cook, & McDill, 1978; Gamoran, 1989) have documented some academic gains by high-level students in homogeneous classes, she also noted (Oakes & Lipton, 1990) that others have found evidence that these high-level students do just as well in mixed-ability classes (Esposito, 1973; Noland, 1985).

So, does tracking increase student achievement for all students? It seems that perhaps “detracking”, the practice of changing a school system from tracked classes to heterogeneous classes, benefits some and marginalizes others. Grouping versus non-grouping studies seem to indicate that there has been no strong consensus on whether tracking has a definite positive or negative impact on academic achievement overall, at all ages of schooling (Borg, 1965; Slavin, 1986). Indeed, Slavin’s 1986 meta-analysis of 29 studies yielded a finding that

…the effects of ability grouping on student achievement are essentially zero…in nine of these thirteen studies (the thirteen from which effect sizes could be estimated, including all five of the randomized studies) results favored the heterogeneous groups, but these effects are mostly very small…Taken together, research comparing ability-grouped to heterogeneous placements provides little support for the proposition that high achievers gain from grouping while low-achievers lose (Slavin, 1986).

It must be noted that the findings in Slavin’s meta-analysis only applied to cases of between-class grouping within the same courses (e.g., high, average or low sections of Geometry) (Slavin, 1986). These results, Slavin noted, “…should not be read as indicating a lack of differential effects of tracking as it affects course selection and course requirements.” In other words, tracking practices (as opposed to ability grouping) might place a Vocational/Technical track
ninth-grade student in Physical Science and a Honors/Gifted ninth-grade student in Biology—and the studies included in Slavin’s paper did not investigate the effects of tracking on these scenarios. This would be difficult, considering the dissimilar science content covered.

Oakes (1990) provided an explanation for the findings that high achievers do increase in achievement when ability grouped.

That tracking can and often does work well for the top students should be obvious. Certainly it is possible to create excellent classes in the midst of mediocre ones: Start by providing the best teachers, the most successful students, and, often, the smallest class size. Add special resources, a sense of superior academic “mission,” perhaps a parent support group, and these top students will get the best education in town…when advantages to students in high-ability tracks do accrue, they do not seem to be primarily related to the fact that the students are similar, but to the special curricular and instructional advantages high-ability groups are given (Oakes & Lipton, 1990).

Thus, inherent in the separation of students by ability is an unequal allocation of educational resources to the different tracks. Indeed, researchers have noted that low tracked classes are often taught by the least experienced teachers, sometimes with very low levels of preparation in their subject fields (O'Neil, 1992; Bellanca, 1993). High ability classes are usually supported, in part, by involved and usually higher educated parents—this ensures that these classes get the lion’s share of the school’s resources and attention.

When it comes to the tracking issue, politically active parents have the edge. They can ensure that the school starts a gifted program and that their child gets placement in the right sections taught by the best teachers with the best resources….at the other end of the spectrum are the parents who stay away from the school…those parents who do not get
involved are the least likely to voice opinions about curriculum, apply pressure for class placement, complain about poor teaching, or make waves about schedules, book assignments, or bullies on the playground (Bellanca & Swartz, 1993).

Oakes added that these involved parents are usually white and of a higher socioeconomic status (O’Neil, 1992).

Perhaps the answer to this debate is neither option. It seems that tracking may be harmful to low-level classes, while detracking may not help high-level classes achieve as much. The quality and type of instruction in the classroom may be of greater importance than the track level of the students.

Ability grouping is inherently neither good nor bad. It is neutral. Its value depends upon the way in which it is used. Where it is used without close examination of the specific learning needs of various pupils and without the recognition that it must follow the demands of carefully planned variations in curriculum, grouping can be, at best, ineffective, at worst, harmful. It can become harmful when it lulls teachers and parents into believing that because there is grouping the school is providing differentiated education for pupils of varying degrees of ability, when in reality that is not the case—when it leads teachers to underestimate the learning capacities of pupils at lower ability levels—when it is inflexible and does not provide channels for moving children from lower to higher groups (Goldberg, Passow, & Justman, 1966 as quoted in Bryson & Bentley, 1980).

The second argument proposed in favor of tracking in schools is that slower students must be protected from “emotional and educational damage” from being in the same classes as smarter peers (Oakes & Lipton, 1990). Constantly being compared to higher achieving students
may lower the self-esteem and confidence of less achieving students. By separating students into
groups where they are competing and being challenged by others of the same ability level,
educators are enabling all students to feel good about themselves and their particular gifts and
talents.

There is research evidence that the opposite is true, however. The stigma of being
labeled as a ‘low-level’ student seems to erode self-confidence and motivation.

The findings regarding the impact of ability grouping on the affective development of
children are essentially unfavorable. Whatever the practice does to build or inflate the
egos of children in the high groups is over-balanced by evidence of unfavorable effects of
stigmatizing average and low groups as inferior and incapable of learning (Bryan &
Findley, 1971).

As the low-track students continue through tracked and ability grouped educational systems,
morale suffers; the achievement gap grows between the high and low levels (Yates, 1966).

The third reason given for tracking is that it can free the teacher from the strenuous task
of trying to teach to such a wide spectrum of abilities in a heterogeneous classroom. Teachers
have the unique and thorny task of teaching to an audience whose background, cultures, abilities,
and understandings are as varied and individual as the students themselves. A great diversity of
instructional strategies, tasks, materials, criteria, and assessments are necessary to meet the needs
of any group of children; tracking might delimit the extremes of the range and help with class

Still, anti-tracking proponents believe that this separation of students by ability actually
permits an inequitable division of school resources and enables a focusing of teachers’ attentions
in an alternative way. “(T)racking serves to exclude many children from ever being in classes
where…’high-status’ subjects are taught” (Oakes & Lipton, 1990). In order to separate students into tracks and groups, the teacher and school administration must make a judgment about a student’s ability and capacity to succeed. Unfortunately, these judgments do seem to follow racial and class-related trends.

At schools with large concentrations of low-income and non-Asian minority students, disproportionate percentages of teachers judge their science and mathematics students to have low ability. At schools with racially mixed student bodies, the proportion of classes judged to be high-ability diminishes as minority enrollment increases, and minority students are more likely than their white peers to be placed in low-track classes (Oakes, 1990b, p. vi-vii).

Educational judgments are usually based on standardized test scores (Bryson & Bentley, 1980), which, because of the way the tests are authored and developed, usually marginalize groups of students who do not fall within the narrow range of the normalized standard distribution. These groups tend to be children from low socio-economic homes and/or from homes with non-mainstream cultures (i.e. Hispanic households, non-English speaking households) (Bryson & Bentley, 1980).

Oakes added to her previous comments that because of these unequal judgments and subsequent track placements, minority students usually end up learning under the numerous disadvantages accrued in low-track classes and these disadvantages appear rather stark. Low-track classes were found to usually involve a lot more worksheets, directed learning, and remediation. Teachers were mostly concerned with developing students’ skills in following directions and rote memorization. Classroom tasks tended to be highly structured and directed, leaving very little room for student exploration and independence. Teachers seemed to be
focused primarily on class management, behavior issues, and controlling socialization (Oakes, 1990b, p. 7). “Teachers in low-track classes emphasized matters of discipline and behavior, and they often listed such things as “following directions,” “respecting my position,” “punctuality,” and “learning to take a direct order” as among the five most important things they wanted their class to learn during the year” (Oakes, 1986).

On the other hand, high-track teachers seemed to ask more questions and to support more independent and critical thinking (Oakes & Lipton, 1990). Class time usually centered more around learning and less on discipline and class routines. Teachers appeared to have higher expectations of students in high-track courses; the teachers also had more motivation and enthusiasm for their teaching. As well, curriculum was better organized and tended to be more inquiry based (Oakes & Lipton, 1990; Oakes, 1990). “In these data, we found once again a pattern of classroom experience that seems to enhance the possibilities of learning for those students already disposed to do well—that is, those in high-track classes” (Oakes, 1986).

Oakes referred to these disparities between low and high track classes as a dilemma of inequitable “access to valued knowledge” (Oakes & Lipton, 1990). “…Students in low-track classes simply have less exposure to the teaching goals and strategies that are most likely to generate interest and promote learning among students at all achievement levels” (Oakes, 1990b). The apparent disparities between the learning experiences of students in high and low track classes situate students at different distances from the ‘starting line’. Critical thinking and problem solving based curriculum enables high track students to develop the necessary skills that will prepare them for college and successful employment afterwards; they start the race at the starting line. Workbooks and rote memorization type activities that seem to dominate low-track curricula inhibit low track children from gaining the same necessary skills that can aid in life
success; these students are placed far behind the starting line. And unfortunately, once these judgments and track placements are made, it is very difficult for the student to break out of that placement. Movement between tracks is rare and usually fraught with bureaucratic requirements that few parents and students are willing to navigate (Bellanca & Swartz, 1993; Slavin, 1986).

The fourth contention in favor of tracking states that the practice is fair and equal. Since track designation is based solely on student performance, ability grouping is truly a just and impartial way of meeting all students’ educational needs (Bellanca & Swartz, 1993). However, detractors of tracking note that indeed, mobility between tracks has been shown to be quite difficult and tenuous (Bellanca & Swartz, 1993; Gamoran, 1992; Oakes, 1985). “Students placed in low-ability classes are usually denied the knowledge that would allow them to move into higher classes” (Oakes & Lipton, 1990).

It is this idea of equality that connects tracking and ability grouping with the law. Several landmark cases in the 1960s and 1970s set the tone and context in which tracking is practiced today. I now will briefly review some of the more pertinent legal aspects of tracking.

The Fourteenth Amendment to the Constitution of the United States ensures that all individuals are guaranteed the right to life, liberty, and the pursuit of happiness without due process of law. As well, states must protect all people who come under the protection of the Constitution (Bryson & Bentley, 1980, p. 59). Unfortunately, these constitutional rights became entangled with ability grouping, an issue that the courts had to address during the Civil Rights movement when schools were using grouping practices as a way to circumvent government mandated school desegregation policies (Bryson & Bentley, 1980, p. 65).

School boards and administrators claimed that ability grouping was a practice that was necessary to meet the needs of both low and high achieving students. However, when these
same boards and administrators were questioned in court, some admitted that grouping was a way to placate white parents and dissuade them from moving their children to private schools, in reaction to school integration in the 1960’s (McCarthy, 1976). Racial issues were of concern.

The courts have maintained consistently that policies regarding tracking, grouping, and classification are up to the prerogative of school officials; several case decisions (e.g. Moses v. Washington case, 1971; Hobson v. Hansen case, 1979) have stated clearly that the courts are very reluctant to get involved with the day-to-day administration of school policies. However, when the practice of grouping infringes upon the rights of individual students, then the courts have not hesitated to step in and intervene. For example, in the landmark case of Hobson versus Hansen (1979), the Federal District Court for the District of Columbia decided that the school system in question was using grouping techniques in ways that were depriving low track students of access to equal educational opportunities. “Evidence in the case indicated that the track assignments were not directly related to the ability to learn; that vocational choices were significantly limited by the track assignments; that no remedial instruction was provided for students in the lower tracks, a factor which resulted in very few students crossover from their initial assignment; and that the limited curriculum available to students in low tracks offered them very little educational enrichment.

The Hobson versus Hansen case is a prime example that illustrates what the law requires of school systems. First, grouping and classification programs must be directly related to the instructional objectives and must clearly be necessary in order to meet the students’ particular educational needs. The school system has the burden of proof to show that tracking is the best option for meeting those educational needs. As well, they must show that tracking in no way marginalizes or stigmatizes a child. Indeed, by the Fourteenth Amendment, each student is
entitled to due process before placement in a low track due to the potential of stigmatization (Bryson & Bentley, 1980, p. 59). This means that the school must document and detail the procedures by which they determined the track placement, as well as the circumstances that led the school to pursue that course of action. Random, unjustified placement of students into tracked courses violates the student’s right to due process (Bryson & Bentley, 1980, p. 60).

Students can be classified and grouped by ability, so long as the process was not racially biased (Moore v. Tangipahoa Parish School Board, 1969). In this legal case, the school board could not prove that the tests used for track placement were bias-free; thus, the court decided that their tracking program was unconstitutional. Many of the tests used for track placement in the 1960s were normalized on middle-class white students. One of the more famous instances of this was in the state of California. In 1979, Chief Judge Robert F. Peckham wrote that the use of intelligence tests to place Black students in mentally retarded classes was “…an unlawful discriminatory intent…the intent was not necessarily to hurt black children, but it was an intent to assign a grossly disproportionate number of black children to the special, inferior and deadend E.M.R. (educationally mentally retarded) classes” (Larry P. v. Riles, 1979, as quoted in Bryson & Bentley, 1980). Thus, schools had to eventually turn to other measures of academic ability besides the Stanford-Binet test and IQ (intelligence quotient) tests (Bryson & Bentley, 1980).

Indeed, in light of the conflicting research data reviewed earlier on student achievement in grouped versus non-grouped classes (Slavin, 1986; Steinberg, 1992), it is no wonder that educators are hard-pressed to show how tracking directly benefits student learning. It is noted here, however, that the lack of strong trends in increasing or decreasing test scores and grades have not been documented for grouped or non-grouped students is not an indication that students are not learning, altogether. What the law seems to insinuate is that school officials must be able
to demonstrate that the students’ learning and academic needs are best met through the tracking practices in question, and biased test scores are not adequate for this burden of proof.

So, is the presence of a disproportionate number of a certain race in a particular track level (called “suspect classification”) grounds for a judicial investigation into the legality of ability grouping? Not necessarily. The school administration must show that the tracking program provides clear benefits to those students in the low track (Bryson & Bentley, 1980, p. 185). As well, these benefits must far outweigh any negative impact on the child’s psyche from being placed in the low track. Being grouped into that track ought to be the optimum method of meeting that student’s educational needs. Otherwise, the tracking would be deemed as based on “suspect criteria” and may be ordered as unconstitutional (Bryson & Bentley, 1980).

In conclusion, ability tracking is a common school practice (George, 1988) that clusters students based on ability, but it is also a practice that is mired in politics and entrenched beliefs about merit and ability. Due to glaring disparities in ethnic representation in certain ability levels, critics of tracking have claimed that students of the dominant group are seemingly “tracked” into high-level classes (Bellanca & Swartz, 1993; Bryson, 1980; Donelan, 1994), especially in the subject of science and math (Oakes, 1990b). Minority students, sometimes automatically perceived as low-level students (Lavoie & Adams, 1974), are disproportionately placed in low-level science classes (Bryson & Bentley, 1980; Esposito, 1973). These critics of tracking believe that the groupings have no correlation to students’ true academic abilities and are actually rooted in racial discrimination. What is at the heart of the debate, however, is exactly how educators determine a student’s ability to perform in certain subjects. “…the practice helps no one and hurts many…it sorts students into immutable destinations correlated with race and social class and is therefore inherently undemocratic” (Loveless, 1999, p. 2).
Because there is no objective, unbiased method of determining a student’s true academic ability, the fallibility of human judgment allows for predetermined beliefs about race and social class to enter into the process of track placement.

Given the earlier discussion of how race and class are used as measures of human value, I am of the opinion that tracking is strongly connected to how educators view race and class. Historically, Black, Hispanic, and Native American students have been stereotyped as poor and lacking ability (Oakes, 1985). These views, formed by years of racial bias and discrimination throughout American history, may be playing a large role in how schools track students in science and how teachers respond to the students in these tracked classes. Indeed, this would be an integral aspect to examine in a study (like this one) that attempts to document disparities in computer use among students in a tracked curriculum.

Mired in policy issues and local governments, tracking regulations have spawned much controversy. Nevertheless, it is clear that there is an inequitable access to high-level classes by minorities. The debate revolves around merit, rewards, privilege, and oppression. Who deserves to have the best teachers, the good science equipment, and the small classes? Who has the academic abilities to make the best use of the school’s scarce resources? Who does and does not deserve access to scientific and technological knowledge? The tracking policies of a school community bespeak to the beliefs and attitudes of those who make the policies; when resources are divvied into pie-pieces, it is clear who is favored and who is not when one looks at the sizes of the pie-pieces.

In summary, equity in science education is a vital component to the increased science literacy in America. As researchers attempt to explicate the causes behind the lack of minorities and low-income students in science and engineering careers, they must also consider the ways in
which tracking and ability grouping play a role in those causes. Although there may be a lack of strong evidence to directly connect tracking to academic achievement as measured by test scores and grades, there remain the findings of disparities in student distribution by race and SES in different tracks. The research documenting widely dissimilar educational experiences between high and low track classes is also cause for concern, as other studies portray the affective implications of tracking on students.

A parallel can be drawn to computers in education. A school resource, computers are sometimes “doled” out to those classes who deserve them. High-level classes have more access to computers because some teachers believe that those students can benefit more from them (Schofield & Davidson, 2001). Computer-use is denied to those students who misbehave and granted to students who exhibit model behavior, thus “earning” computer time (Schofield & Davidson, 2001). Just as in ability tracking, a valuable resource (in this case, computers, as opposed to quality teaching practices) is meted out on a merit-based system that privileges some and oppresses others.

Both computers and science education can be effective tools towards developing future economic success. Both can be considered scarce resources. Both are economically dependent and are controlled by those in power positions (i.e., superintendents, policy makers, and taxpayers. In this line of logic, it is quite feasible to consider the ties between equity and technology to be duplicates of the ties between equity and science.

The Triad--Side B: Relationship Between Equity and Technology

Of the five factors that Oakes refers to above, the access to resources is echoed in the original definition of the digital divide. If we claim that computers are an educational resource, then minorities and low-income families have less access to computers than their counterparts.
(Hoffman & Novak, 1998). However, the second factor, economic status, is also very relevant to equity in technology use. Poor neighborhoods rarely can afford new software and gadgets, or technical support for those items (Becker & Ravitz, 1998; Healy, 1998; Schofield, 1995; Schofield & Davidson, 1998). School systems running on meager budgets do not have extra resources for the things that are integral to quality education. Funds are necessary for curriculum development that incorporates new research on the learning potential of computers, for teacher development that helps train educators how to teach more effectively, and for the hiring of more staff to decrease class size, increase teacher enthusiasm, and promote more teacher-student interactions. Indeed, low-income households typically have parents who are unable to get involved with their children’s use of the computer because of their lack of education, expertise (Tapscott, 1998), or value placed in the computer (Mack, 2001, p. 27), as compared to other items perceived to be of more importance.

Clearly, equity issues relate to the use of computers in classrooms. The digital divide was originally about hardware access, but as computers become more affordable, this concern becomes less salient. What is of more concern now is access to the Internet and access to knowledge on how to use the computer and the Internet. Society is now in an Information Age and computer skills can aid a person in accessing and manipulating information (Healy, 1998); this privileges a person in an environment where knowledge is the valued commodity.

…information technology is inevitably driving the shift from an industrial society to an information society. The raw material or basic commodity of this society’s knowledge-based economy is information. In the knowledge-based economy only the marketplace should determine which goods and services are produced and how they are generated; there are no public goods. (Birdsall, 2000, as quoted in Mack, 2001)
Therefore, knowledge of computers could result in greater control of that marketplace.

However, the marketplace is not an equitable forum as this quotation supposes, for those who do not have the skills to access information cannot participate in the power transaction. Social norms, resource (time, teacher, and computer) shortages and stereotypes keep computer usage as a “privilege” to be granted to only certain groups of students. This is an inequity—biased access.

Schofield and Davidson (2001) found this to be true in their study. Students who were advanced academically or had more knowledge about computers tended to have more access to computers, while those students in lower-track courses and with limited to no knowledge about computers used computers less. They believed that this was because

…social processes within schools may direct such resources in non-random ways. Thus, it is important to understand what happens within schools that shapes the use of the computer resources they have and that potentially channels access to those resources toward certain groups of students.

However, there is evidence that SES and race do not always determine computer use in a school. A study of the 152 schools in the National School Network (NSN, a group of schools that were among the first to obtain high-speed Internet access for all their computers) found no significant difference in type of computer use and quantity of computer use between schools that served students from varying socio-economic families and ethnic backgrounds (Becker & Ravitz, 1998). “…Overall, NSN schools that serve lower socioeconomic and historically disadvantaged groups are doing as well in innovating instructionally useful Internet- and network-based learning experiences for their student bodies as are NSN schools serving more advantaged
populations.” Indeed, they found that low-income schools participated in more types of network learning activities than the high-income schools.

On the other hand, when the study looked for patterns within schools, it found that “above-average” classes were five or more times more likely to use the Internet than “average” and “below-average” classes, as defined by the teacher of the class. But this finding was not as strong of a pattern as the one mentioned above regarding types of network learning activities being linked to low-income schools. What this would suggest is perhaps that the issue of equity and technology is not exactly clear-cut. For example, the same study also noted that when two factors (substantial ability differences among classes and substantial socio-economic/racial differences) were present, “…the lower-ability classes were almost never favored with more Internet use.”

In comparing different schools of this network, the study may have overlooked the ways in which a school might compensate low quantities of computer access for certain student populations with high quantities of access for other populations. Since there was evidence that computer use did vary for classes within certain schools, it appears that the equity issues surrounding technology need further examination and clarification.

I refer back to Healy for support of my proposition. She noted that an engaged, active, innovative teacher is a considerable factor as to whether computers are used effectively as learning tools, or more importantly, whether students will learn or not. She wrote:

In 1987, Diane Ravitch warned about the danger of letting the ‘glamour and gimmickry of educational technology’ erode the humanistic side of the curriculum, the search for meaning, and the ability to analyze materials that do not produce instant gratification. She quoted a comment by the editor of the technology section of Forbes magazine: ‘In
the end it is the poor who will be chained to the computer; the rich will get teachers.’ (p. 47)

This quotation was used to prompt responses from the teachers in this study (see Appendix A).

The last part of the quotation is quite summative (Ravitch, 1987). Perhaps the results found in the aforementioned study were due to teacher differences. Our future research, then, must take into account the context of the study. What forces help some students and not others gain access to quality teaching and resources? What beliefs about students influence teacher decisions on not only who gets access to the computers but also how certain students should use those computers? As Healy believes that real, purposeful learning depends on the type of teaching and not necessarily on computer use, perhaps equity in technology may center on beliefs about worth and merit and not on the quantity of computer exposure.

In what ways do teacher attitudes play a role in the quality of computer use? In Schofield and Davidson’s 2001 study, it was found that because computers were scarce, computer access was turned into a reward for the students. Opportunities to use the computers were used as “carrots” to motivate students and elicit their compliance with the teacher’s requests. “Teachers frequently used access as a reward for good behavior, especially strong academic performance.” This should raise a red flag: the students who exhibit strong academic performance probably need as much access to computers as the students who are struggling academically. Schofield and Davidson continue:

This tendency was exacerbated by teachers’ concerns about students’ inappropriate use of the Internet and by their concerns regarding the possibility that students might intentionally or unintentionally damage the computers to which they had access. Taken together, these factors tended to increase usage by students who were academically
strong and to decrease use by those who were either weaker academically or less attuned to the schools’ behavioral norms.

Seemingly, this study bespoke of the major role that the teacher beliefs play in determining access to computers, as well as the quality of that access.

Taking into account Healy’s comments about the prohibitive cost in maintaining computers, it makes sense that teachers would be concerned about damaging these costly tools. However, it is curious that these teachers could determine beforehand which students were more likely to inappropriately use and/or damage the computers. Would this not call their personal judgments on the students’ characters into question? Could we assume that these judgments are truly unbiased and equitable?

Students themselves also propagate these societal views of educational merit. When asked to explain why a certain class used the computer lab more than another, a student stated that the high-level language classes in his school always got to use the computers, and since his class was not high-level, he and his classmates did not have access to the computers (Schofield & Davidson, 2001). Schools and society model views on who should be allowed into the computer labs and students adopt these attitudes as the norm of the community. Thus, these “low-level” students probably never expected to go to the computer lab!

In addition to teacher effects and student attitudes, the subject being taught may also play a significant role in technology equity as well. For example, in addition to the above findings, Becker and Ravitz’s study noted a difference between classes of several subject-areas.

…this [results] was particularly true for classes in computer or media studies, even when controlling on socioeconomic factors, and may be true for other subjects, like science and social studies, where Internet use is greater than average. It was not true, though, for
other subjects, which, however, are less likely to use the Internet than the three subjects named...And at the middle-school level, the most technically knowledgeable and reform-innovating teachers—science teachers in particular—may be assigned students of higher academic ability, and this practice may unwittingly contribute to inequalities of opportunity within the school building.

The authors add that these tendencies “…are not widespread”. I note that there was a very small sample size of science teachers in this study and that prevented the authors from drawing their conclusions across science classes. Had there been enough science teachers in the study, would a distinct pattern arise? Thus, it is vitally imperative that studies like this one (that focus on equity patterns in science classes) are conducted. This leads into the last side of the triad, the relationship between science education and technology.

The Triad--Side C: The Relationship Between Science Education and Technology

There are four major ways in which computers can be used in the classroom: a) as computerized “tools”, or application software, b) as ways to teach basic skills, c) as links to communication and information via the Internet, and d) as instruments to develop problem-solving and thinking skills (Healy, 1998). In spite of an educator’s acceptance of technology in teaching, Healy states that there is not much research describing how well learning is enhanced by computers, if at all (p. 61). Software research tends to be short-term, not well controlled, and unreliable in terms of measurement. They frequently fail to factor in “teacher effects”, so Healy feels that “…published statistics don’t always tell the whole story” (p. 62).

Computers are related to science education because of America’s legislators, school administrators, and general public opinion. The National Science Education Standards clearly states that computers should be incorporated into the teaching and learning of science. “A
variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. The use of computers for the collection, analysis, and display of data is also part of this standard” (National Research Council, 1996, p. 175). In Georgia, the A-Plus Education Reform Act of 2000 specifically requires that teachers in Georgia be trained to use technology in their classrooms (Georgia Educational Technology Training Centers, 2001). Even the National Curriculum states that students need to know how to use a computer early on in their educational career: It is clear that on all fronts, the use of computers in education is strongly advised and promoted.

At key stage (KS) 3 pupils should begin to “use information and data accessed from a computer”…at KS 4, pupils will need to use IT (information technology) for “pattern searching in complex data” and to gather, record and present data in a “full range of forms”. IT also has a role in accessing and organizing data “relevant to their study of science”…(Wellington, 1994)

Why this fervor to incorporate computers into science curriculum? One reason is that science is one of the few subjects where data-collection is an integral part to learning the subject. Since experimentation and data-analysis is closely tied to scientific thinking and literacy, the use of a computer to facilitate time-consuming lab projects can be beneficial to engender learning. Lengthy computations are reduced to a few keystrokes with the use of spreadsheets. Setbacks such as faulty thermometers and lacking graphing skills are overcome by calibrated temperature probes and graphing software. Students who used to struggle with timing the journey of a moving toy car can now utilize the power of infrared scanners that measure real-time distances and time periods and obtain that data within seconds. Taking away the technical barriers to data-collection helps the lab activity become “authentic” (Wellington et al., 1994) for the students.
They, theoretically, are able to grasp the major concepts illustrated by the exercise because they are not encumbered by the small details of executing the task (termed “inauthentic labour in the learning process” (Wellington et al., 1994)).

Another reason for the eager adoption of computers into classrooms is the possibility of computer simulations. Since computers can offer students digitized representations of reality without regard to space or time, scientific phenomena not perceptible to the human senses can be portrayed through computer simulations. “…They operate outside the viscous flow of time in which humans perform tasks” (Kahn, 1985). Supposedly, students are better able to construct understandings about the world around them when the relationships are presented in a high-fidelity program. The graphic abilities of computers also help teachers to present these relationships using models and pictures of concepts, such as genetics, that would otherwise be confusing or difficult to explain on a chalkboard (Chiappetta & Koballa Jr., 2002).

As well, computers can save resources as well as money for the school. Costly dissections and numerous samples of chemicals can be things of the past with a computer-simulated experiment whereby the student manipulates representations of objects on the screen. By “virtually” conducting the lab activity through the computer, the students obtain results that help them learn the scientific concept and waste nothing but electricity in the process (Wellington et al., 1994).

With these virtual experiments, safety concerns are also minimized (Wellington et al., 1994). Students are not exposed to harmful substances (although Healy points out that radiation and “screen-staring” are quite real physical implications of extended computer use) and are not subjected to broken glassware, sharp instruments, or erroneous combinations of incompatible chemicals. As well, experiments that are very dangerous to conduct and demonstrations that are
beyond the budget of the school may become part of the science curriculum as the computer simulates these otherwise impossible assignments.

Two of the more important reasons why technology is increasingly used in science education are motivation and science literacy. The “novel factor” (Healy, 1998) of the computer can help. Children are sometimes more motivated to participate in class when computers are used for teaching (Collins, 1991). “Most students enjoyed using the Internet, often vociferously asking to be allowed to work on it” (Schofield & Davidson, 2001). As science test scores of American students continue to fall behind those of other countries, using the computer to promote student engagement in science seems like an obvious choice.

Science literacy can be promoted through the use of the Internet as a way to discover facts and information pertaining to science topics. As students “surf the Web”, they are exposed to “the ultimate interactive learning environment…” (Tapscott, 1998). He explains that the Internet is an incredible source of human knowledge and is equipped with tools to tap into this knowledge, ways to access people around the world who also have access to the same knowledge, and a growing number of services one can utilize just using the computer. Through these activities, it is assumed that the student will gain critical skills necessary for success in today’s society. “When used advantageously, the Internet also enables teachers to help students develop the important skills of organizing, analyzing, composing, and problem-solving needed for an information-based society” (Chiappetta & Koballa Jr., 2002).

The Internet is beneficial “…when used advantageously”. It is not the Internet itself that brings about problem-solving skills, a primary proficiency that is a cornerstone of science educational practice. “Problem-solving, therefore, is the set of mental and physical strategies used to reach the goal or aim or to complete the project” (Lally, 1994, p. 219). Is it necessarily
true that the act of accessing the Internet inherently trains students to develop these skills? Healy noticed that students in her studies employed a “guess-and-test” methodology (p. 46) whereby the mouse-controlling student randomly clicked on objects on the screen until something happens. Trial-and-error leads them to the next level of the program, not any type of mental or physical strategy. “Thus, they eventually build up a seemingly impressive repertoire of the right moves to make without having had to reason about anything…I am vividly reminded of the legions of experienced teachers who have plaintively told me, ‘I can’t get these kids to concentrate on anything for more than a few seconds. If the answer doesn’t come right away they have no patience and no strategies for problem-solving.’” (p. 46).

There are many reasons to include computers into science education. Nevertheless, curriculum developers and legislators alike must be cognizant of exactly why computers should be made a part of the science classroom. If, indeed, children are engaging with the computer as an overpriced toy, then should school districts sacrifice scarce resources and funds to obtain computers? This question must be considered in light of the fact that many schools are not using the computers they do have because of lack of teacher training, technical support, and funds to repair dysfunctional equipment (Schofield, 1995).

Teacher Beliefs

This final area of relevant literature has been studied for several decades and has resulted in a large number of studies (see Clark & Peterson, 1986 and Pajares, 1992). Educational researchers started studying beliefs when they realized that beliefs were a stronger indicator of action than attitude, which dominated educational psychology research during the behaviorist era until the 1970s. Rooted in the behaviorism groundwork from the 1960s, teacher expectations came to the forefront of research with Rosenthal and Jacobson’s never duplicated study
In their book *Pygmalion in the Classroom*, teachers who were
told that they had high-level students exhibited different, more favorable teaching behaviors than
those teachers who believed they had low-achieving students (even though the classes were
heterogeneous in ability). Indeed, some have proposed that teachers develop higher expectations
for students who exhibit “middle class-like behaviors” (Gouldner, 1978). Thus, the connection
between what teachers believe and what students accomplish in the classroom were researched
further.

Beliefs can be defined as “…part of a group of constructs that describe the structure and
content of a person’s thinking that are presumed to drive his/her actions” (Bryan & Atwater,
2002). Several researchers have written that beliefs are the strongest predictors of human
behavior (Bandura, 1986; Dewey, 1933; Rokeach, 1968). Thus, beliefs are of interest to
educators and teacher education programs because they have direct influence on what content
teachers cover and the practices teacher choose, including lesson planning, assessment, and
evaluation (Clark, 1988; Eisenhart, Shrum, Harding, & Cuthbert, 1988; Nespor, 1987; Pajares,
1992; Richardson, 1996). Also, teachers’ beliefs about teaching and students in general can
impact that teacher’s expectations of his/her own students’ success in the classroom (Winfield,
1986). Research has shown that teachers’ expectations of students can ultimately affect student
learning. “Differences in expectations lead to differences in what is taught, which in turn lead to
differences in what is ultimately learned [by the student] (Brophy, 1983).

Beliefs differ from knowledge in that there does not need to be verification (Nespor,
1987) in order to determine their validity and appropriateness. Knowledge is based on some fact
that has had consensus from others. Beliefs do not require consensus. “As such, they [beliefs]
are deeply personal, rather than universal, and unaffected by persuasion. They can be formed by
chance, an intense experience, or a succession of events, and they include beliefs about what oneself and others are like” (Pajares, 1992).

Because beliefs do not require validation by others, they tend to be “disputable, more inflexible, and less dynamic” than knowledge (Pajares, 1992). Because beliefs can differ in conviction (Pajares, 1992), there must be a way to describe the range of beliefs held by a person. Rokeach (1968) wrote that beliefs have a “centrality” component about them; the more central the belief, the more inflexible and entrenched the belief. Beliefs can form “clusters” (Pajares called these “attitudes”) that vary in centrality and these clusters, when object or situation specific, can lead to action (Pajares, 1992). Beliefs in one attitude can be connected to other beliefs that are located in other attitudes.

The idea of centrality comes from the belief model proposed by Rokeach. He defined a belief system as the group of individual beliefs that a person holds about the world. The belief system is structured like an atom, in that there are core beliefs (represented by the nucleus) and subsequent, less “central” beliefs are arranged in a system around those core beliefs. How central a belief is depends on what the belief is about. If the belief deals with a person’s identity or self, then they are part of the core beliefs. Also, beliefs that are corroborated by others are located here as well. Beliefs formed from experience are more central than beliefs that have not been substantiated by previous encounters. Beliefs about personal preference tend to be arbitrary and therefore less central.

Rokeach also wrote about the three parts of a belief. Beliefs have three components. The cognitive portion represents knowledge. The affective component of beliefs is connected to a person’s emotions. Finally, the behavioral part of beliefs can be strong enough to drive a person to take action. Nespor (1987) on the other hand, described four characteristics of beliefs:
existential presumptions, alternativity, affective and evaluative loading, and episodic nature. According to Nespor, these four add up to make beliefs strong or weak. When all four are present, then it is difficult to change the belief.

Existential presumptions are the beliefs about the nature of the world, “propositions or assumptions about the existence or nonexistence of entities” (Nespor, 1987). Thus, if a belief is about the existence of a higher power, for example, then it will be hard to modify. Alternativity describes how grounded in reality is a belief. If a person has created an “alternative” reality (Abelson, 1979), then reconciling those beliefs with reality can be difficult. “Such beliefs are not amenable to falsification—or even challenge—and failures to translate them into reality in no way diminish their value” (Nespor, 1987). The example that Nespor’s article provides is one of a teacher who believes that the classroom should be friendly and fun. Even though her own childhood classes were not friendly and fun and her present classroom was not either, she continually strove to attain these qualities through her teaching practices. Affective and evaluative loading is the feelings and judgments associated with a belief. And the episodic nature of a belief is how connected the belief is to a particular incident or experience. The stronger the association is, then the stronger the belief.

Beliefs that are formed earlier in life have the potential to bias the gathering of later information. Since this bias could predispose the person to only take in data in support of the earlier belief, this can render the original belief unmovable and thus rarely changed (Pajares, 1992).

Beliefs are also context specific (Pajares, 1992). They are formed about a certain object, incident, or subject. Thus, in order to best elicit detailed and specific statements from teachers about their beliefs, they must be asked about their beliefs on a particular context: educational
beliefs about (blank). “Teachers have beliefs about matters beyond their profession, and, though these certainly influence their practice, they should not be confused with the beliefs they hold that are more specific to the educational process” (Pajares, 1992).

Beliefs cannot be directly measured; they must be inferred (Rokeach, 1968). People are not always accurate or forthcoming in representing their beliefs to others. Therefore, several methods must be employed in interpreting a person’s beliefs about something. The best way is to look at what a person says, what a person intends to do, and what a person actually does. It is unavoidable that beliefs must be inferred (Pajares, 1992). Some researchers have developed instruments to develop beliefs, such as the Minnesota Teacher Attitude Inventory (MTAI), the Kelly Repertory Grid (KRG), and the Heuristic Elicitation methodology (HEM) (Richardson, 1996).

But, if these instruments are not specific enough or do not touch on exact nodes of beliefs, then the researcher might miss out on a large set of beliefs. The best ways to try and get at someone’s beliefs is through interview and observation (Brophy, 1983). But even then, sometimes the interviewee will not know exactly what their beliefs really are or may misrepresent them. That is why it is important to observe their actions as well, to see if those stated beliefs are prominent in their actions.

There is evidence to show that teacher beliefs are related to student achievement. Several researchers (Darley & Fazio, 1980; Peterson & Barger, 1984) have stated that teachers’ attributions for the successes and failures of students are instrumental in understanding how teacher beliefs correlate to student performance. One study found that a student’s success, rather than perceived ability, resulted in increased positive feedback from the teacher (Weiner & Kukla, 1970). Thus, what a teacher believes about why students do well (or poorly) is highly predictive
of how the teacher responds to the students (Cooper & Burger 1980; Covington, Spratt, & Omelich 1980; Medway, 1979; Meyer 1979; Silverstein 1978). The study by Brophy and Rohrkemper (1981) documented a relationship between teacher attributions and choice of educational practices. Thus, teacher beliefs about student abilities have impact on curricular choices and teaching strategies. These choices and strategies may help or inhibit student learning. “Teacher’s beliefs have an impact on the quality of science learning occurring in classrooms” (Bryan & Atwater, 2002).

Another area of teacher beliefs is teacher expectations. It has been proposed that teacher attributions explicate how teacher expectations relate to student achievement; attributions are the descriptions of the process (Cooper & Tom, 1984; Peterson & Barger 1985). These beliefs are related to teacher attributions in that they are also judgments made about students. Teacher expectations are complex to investigate because although the evidence of these studies point to a causal relationship, it might very well be that students’ achievement (or lack thereof) in the classroom might be causing teachers’ expectations. As well, when teachers are given misleading information in order to examine how their expectations develop and relate to student performance (“Self-fulfilling Prophecy Theory”, or SFP) constant information from the students is being read by the teacher and quickly assimilated into ever-developing beliefs about those students (“prediction”) (Brophy, 1983). In these cases, the misleading information is disregarded and thus fails to be a variable in the study. In order for teacher beliefs to be truly studied, it has been proposed that naturalistic classrooms provide the most authentic context (Brophy, 1983).

Because the learning environment is a contractual and symbiotic relationship, the teacher’s beliefs may affect student achievement in the fact that those beliefs may have bearing on how the student feels about him/herself. As young children develop their identities, they take
in outside information about themselves and work that into how they see themselves. So, if teachers believe that low-level students are incapable, it may be that the kids start to believe it themselves and then fulfill that prediction and actually become incapable. This is the Self-Fulfilling Prophecy—which a situation was not present before, until the introduction of a belief that then made it a possibility. In order for the SFP to be present, that condition cannot be there beforehand.

It is thought that teacher beliefs about students are related to how the instructor views teaching as a practice and learning as a process. “The nature and degree of teacher expectation effects in a particular classroom are likely to vary as a function of beliefs about teaching and learning and specific teacher and student characteristics” (Winfield, 1986). There is much research showing that teachers’ beliefs about students are based on student characteristics (Carr & Klassen, 1997; Gomes, 1993; Kozol, 1991, Marshall, 1996; Winfield 1986). These beliefs are formed from a student’s race, class, gender, culture, and language.

Teachers have higher expectations for students who exhibit middle-class-like behaviors, such as verbal proficiency, classroom social skills, and academic effort (Gouldner, 1978). However, lower-class and minority students are not exposed to life experiences that would help them develop these behaviors that are favored by teachers (Winfield, 1986). This results in teachers putting in more effort to help these students achieve in the classroom (Winfield, 1986).

Studies have shown that academic climate and teacher expectations are the two main factors that can contribute to the success of schools with high populations of low-income and minority students (Purkey and Smith, 1983). Thus, it is imperative that teacher beliefs be included in research that attempts to address equity issues in science education. Teachers are the ones who make the ‘front-line’ decisions as to what content is taught, how that content is taught,
and to whom that content is taught. With previous research results pointing to a strong relationship between teacher beliefs and teacher practices, it is not surprising that the area of teacher beliefs became an important element to this study as the results were analyzed.
CHAPTER III
METHODOLOGY

Crotty’s writings (Crotty, 1998) delineated the four elements of a study as methods, methodology, theoretical perspective, and epistemology. In a sequential order, each section should logically follow from the previous and have bearing on the arrangement of the next section. According to Crotty’s book, the methods are the techniques and procedures used to gather data in a study. The methodology is the strategy or plan that dictates the choosing of those particular techniques and procedures for the study. The theoretical perspective describes the way in which the researcher views the world—the philosophical stance on what data will be collected and for what purpose. Finally, the epistemology of a study is the philosophical grounding for decisions regarding knowledge in the study (What is knowledge and from where does it come?). These are the definitions of the four terms on which this section is based and will be treated in reverse order.

In this chapter, the epistemology and theoretical perspective of this study are described first. Then, the research design is discussed and the rationale behind using mixed methods for the study is given. The sample for the study is described afterwards, with details about the school’s county and the science teachers in the school. The next section is focused on how the study data was collected and analyzed, both the statistical and the qualitative data. The last part of the chapter deals with validity and reliability issues.
Epistemology

One of the core concepts that formed this study was the existentialist concept of humans as entities in the world (Crotty, 1998). I believe that objects exist in the world and as people interact with these objects, knowledge is constructed. ‘Knowledge’ is defined by the Oxford English Dictionary (O.E.D.) as “…intellectual acquaintance with, or perception of, fact or truth…familiarity gained by experience…” (Oxford University Press, 1989). There needs to be something that is making this “intellectual acquaintance” and having the “experience” that gains the “familiarity”. That something is the human being.

Constructivism is the epistemology of this study. I was interested in understanding how teachers differentiated computer activities for different track levels and the reasons teachers gave for their choices. Because teachers’ practices are a reflection of their beliefs (Cabello & Burstein, 1995; Pajares, 1992), an investigation into teachers’ practices with computer assignments necessitated a look at teacher beliefs. And a study of beliefs would best be completed with an epistemology that purports knowledge accumulation through “vicarious experience”—and that epistemology is constructivism (Denzin and Lincoln, p. 166).

Theoretical Perspective

Humans are cognitive beings that react to their surroundings based on prior experiences and knowledge. “When the mind becomes conscious of something, when it ‘knows’ something, it reaches out to, and into, that object” (Crotty, 1998 p. 44). This active relationship is referred to as “intentionality”. The result of this interaction between subject and object is meaning (Crotty, p. 45). This is one of the cornerstones that separate positivist and constructivist epistemologies.

Likewise, as researchers interact with the context and subject of their study, they approach the investigation with a particular socialized worldview. This worldview then leads the
researcher to use particular methods and even choose research topics that follow in that vein. Crotty also noted that this worldview, or theoretical perspective, gives the researcher a context in which to conduct the study and a basis for the study’s logic and criteria (Crotty, p. 6). This perspective on the world drives all aspects of the inquiry and is the driving force behind research design. “We conduct inquiry via a particular paradigm because it embodies assumptions about the world that we believe and values that we hold, and because we hold those assumptions and values we conduct inquiry according to the precepts of that paradigm” (Schwandt, 1989, as quoted in Glesne, 1999).

I believe that a certain reality exists outside of human consciousness. As humans, we strive to understand and depict this reality through our senses and experiential information. Our approximations of reality are inhibited only by our human fallacies and unique set of prior knowledge that colors our future interpretations. This is accordant to my past experiences as a chemist.

Although my prior education has been in the positivist area of Organic Chemistry, my current interests lie in the more humanities-oriented area of science education. And the study of human experience hardly lends itself to the positivistic tools of science. So, by making a distinction between the study of people and the study of the environment, I can utilize a wider range of research tools that better approximates human behavior.

In fact, some theorists believe that reality can take one of two forms: the social reality and the natural reality (Dilthey, 1976). Social reality deals with happenings and situations between and involving humans. A victim of a crime feels anger; the emotion is part of that person’s social reality. The existence of that emotion is due to the interaction of perpetrator and victim—the emotion does not exist without humans. However, natural reality involves the
naturally occurring world that lends itself to objective testing and observation, unlike social reality aspects. A scientist can test for the presence of an amino acid, but cannot necessarily test for the presence of anger. According to some philosophers (Dilthey, 1976), these two realities can co-exist together in the universe as separate entities.

Thus, I chose a mixed methodology for my research because I believe that there are some social data that are consensually agreed on and that can be measured using quantitative tools (e.g. the number of students who are Asian American). But I also recognize that teachers’ actions are based on their own perceptions of what is reality, thus supporting the idea of a socially constructed reality. These social facts cannot be measured using positivist methods; rather, they can only be described and interpreted.

The major thrust of this study, then, had an interpretivist theoretical perspective. The goal of the study was to interact with the teachers and from those interactions “interpret” what teachers viewed as what was truly happening in their classrooms. However, the study’s methodology also incorporated some positivist methods and tools to help with the contextualization of the interpretation of the teachers’ views; this resulted in a mixed methods study. According to Glesne’s book (p. 6), an interpretivist study may result in theory. It can also be naturalistic, descriptive and inductive in nature, while searching for patterns and seeking pluralism and complexity. These definitions aligned well with the intent of this research study.

Interpretivism is rooted in the writings of Max Weber (1864-1920). He believed that social science is centered on “Verstehen”, or understanding, while the natural sciences focus on “Erklären”, or explaining. While ensuing debate discussed whether Verstehen and Erklären were really separate purposes or one in the same, most philosophers after Weber have agreed that,
“…studies of the natural world and the social world have come closer together” (Crotty, 1998, p. 71).

The focus of an interpretivist perspective is looking for, “…culturally derived and historically situated interpretations of the social life-world” (Crotty, 1998, p. 67). Because the study of humans does not easily lend itself to ‘empiricist methodology’ (Crotty, 1998, p. 67), interpretivism came about as an alternative to imposing positivist methods on social science. The goals of interpretivism are to understand why people do the things they do and to explain their actions through their social reality. The act of exploring how others see their world enables researchers to make better sense of the motivations behind human action.

This study clearly necessitated an interpretivist perspective. Teachers are the ones who plan the curriculum for students and are in direct control of assignment choice and adjustments. To investigate these choices of activities and adjustments, I had to probe and interpret the teachers’ understandings of students and of computer use in science education. These “probings” enabled me to offer an explanation of the human and social reality of science classrooms at this particular school in Geoffrey County.

Research Design

One of the main intents of this study was exploration. Since there has not been much research conducted on tracking with a focus on science and computers, it was important to design the investigation so that there was a description and characterization of how computers were being used, if at all, in tracked science classes. An in-depth portrayal of the computer’s role in secondary science education would then set the foundation for further research into why certain social patterns exist in tracked classrooms. The expectation was that these results would
enrich current understandings about racial and social equity in schools; as well, this study would inform the hypothesis that similar forces are causing the Digital Divide and the Science Divide.

For the aforementioned reasons, the research questions were as follows:

1. What types of computer activities are assigned to tracked secondary science classes?
2. What are the ways in which teachers differentiate these activities between classes of dissimilar track levels?
3. Which teachers’ salient beliefs about students in different track levels influence the teachers’ planning of computer activities?

A mix of qualitative and quantitative methods were used to address the first two research questions, due to the questions’ objective focus. Although a mixed methodology combines tools from two different genres of social research, it is very possible to set up the research framework so that the strengths of both areas can be maximized. Proponents of mixed methodology believe that quantitative and qualitative methods are very compatible to blending. “The main differences…between the two approaches lie in the nature of their data, and in methods for collecting and analyzing data. However, these differences should not obscure the similarities in logic, which makes combining the approaches possible.” (Punch, 1998, p. 240). There are several reasons why this is feasible.

Research is designed with validity and reliability in mind: which methods will answer the research questions with the least amount of error and yield the greatest amount of useful, dependable information? Instead of taking the stance that methods must necessarily evolve from paradigmatic or philosophical roots, researchers can take a more pragmatic position and locate themselves along a continuum of choices. “…What is involved is not a simple contrast between
two opposed standpoints, but a range of positions sometimes located on more than one
dimension…Selection among these positions ought often to depend on the purposes and
circumstances of the research.” (Hammersley, 1992).

Certain questions will align better with a particular set of methods than others. In spite of
the historical correlation between quantitative methods and theory-validation (and qualitative
methods and theory-generation), it is important to reconsider the usual pattern of using one type
of methodology for only one type of question. How this is accomplished is dictated by how the
methods are implemented and how the data is treated. Therefore, it was quite feasible to utilize
open-ended questionnaires, interviews, classroom observations, and quantitative surveys and
statistics in addressing the first two research questions of this study.

The third research question dealt with characterizing teachers’ subjective social reality.
Its qualitative objective is best met with qualitative methods. Of the wide variety of methods
used in interpretivist research, several were chosen to best “get at” teachers’ beliefs about
students in different tracks. All 21 teachers were interviewed using a semi-structured protocol.
As well, 4 teachers were purposefully chosen for second round interviews; 1 teacher was
purposefully chosen for a qualitative case study and his classes were observed on several
occasions. The rationale for these methodological choices is given in the section “Data
Analysis”.

The semi-structured interview method was chosen because there was uncertainty as to
what were these teachers’ beliefs about students in tracked classes. Although the interview script
was written with certain assumptions that were rooted in past research, the interview process has
to allow for unexpected directions. Researchers ask questions in the context of purposes
generally known fully only to themselves. Respondents, the possessors of information, answer
questions in the context of dispositions (motives, values, concerns, needs) that researchers need to unravel in order to make sense out of the words that their questions generate. Questions may emerge in the course of interviewing and may be added to or replace the pre-established ones; this process of question formation is the more likely and the more ideal one in qualitative inquiry (Glesne, 1999, p. 68).

The methods chosen above also address the relationships in the theoretical model developed for this study. The first question attempts to describe the side of the Triad theoretical model that connects “Science” and “Technology”; a depiction of computer practices in science classes helps delineate how technology plays a role in science education. The second side of the Triad, “Technology” and “Equity”, flows directly into the research question of how teachers differentiate computer activities between track levels. And the side between “Science” and “Equity” is addressed by the third research question; teachers’ beliefs about students’ characteristics have ramifications on how equity is maintained in classrooms.

Sample

The sample for this study was one of convenience and of purpose. The study was conducted at a suburban high school in Georgia (pseudonym “Bayley High School”). The school was chosen purposefully in order to obtain a sample that was representative of the student demographics of the state in order to increase the generalizability of this study’s results. The 2000-2001 Department of Education Report Cards for the state (Georgia Department of Education (GADOE), 2001) were used as references on school and state population data. Since race, socioeconomic status (SES), gender, and tracking have been indicated to have effects on science achievement and computer use in schools, these were the factors used to choose the high school for this study. These demographics are detailed in Chapter 4.
At the time of this study, Geoffrey County was a leading county in Georgia in professional development in technology training. The teachers involved in this study are employees of a school board that has been extremely proactive in encouraging the use of technology in education. One of the goals of the Geoffrey County K-12 Science Program is that “…the scientific and technologically literate individual uses science and technology to make informed decisions” ("Geoffrey" County Public Schools (GCPS), 1998). It was hoped that choosing a Geoffrey County school as the study’s site might yield a greater number of teachers in the study that were actively using technology in their classes. This was, of course, not a guarantee that the policies and goals set by the school district were reflected in the individual beliefs and practices of the teachers working in that school district.

The area of Geoffrey County where the research site is located is comprised of metropolitan and suburban areas. Many of Geoffrey County’s residents are of middle to high socio-economic status and are white. In one portion of the county, especially the area that borders a neighboring county, minority populations have been steadily increasing. Many immigrants new to the state locate themselves in this area and are gradually populating more of both adjoining counties.

“School clusters” determine school populations in the county that the research site is located. The county is partitioned into these clusters of geographical areas whereby students residing within each area attend the school assigned to that cluster. This high school was purposefully chosen as the research site because of its reputation for having a diverse mix of student ethnicities and cultures. As well, the science faculty at this school expressed great interest in participating in this study.
The current system of tracking in Geoffrey County is fairly new and has had very few changes. Before 1995, there were three track levels (termed “Honors”, “Academic”, and “General”) for biology and physical science, and only one track (“Academic”) for Chemistry and Physics (Reed, 2003). The Academic track was designed for college-bound students. Only two years of science was required for graduation, but students who wanted to attend four-year colleges elected to take three years of science. This was comprised of about 60-70% of the students in the county (Reed, 2003). In 1995, when the state elected to require three years of science for graduation, Geoffrey County eliminated the Physical Science course and required all students to take one year each of biology, chemistry, and physics. It was at this time that the present four-track system was also implemented. Students could enroll in the “Gifted” (assuming the student was designated as a Gifted student), the “Honors”, the “College Preparatory”, or the “Technical” level course of each science content area. Presently, about 30% of the county’s students are in the Gifted or Honors courses (which are designed for students who are planning to major in the math, science, or technology fields), while 50% of the students are enrolled in College Preparatory science courses, and 20% are in Technical classes (Reed, 2003).

The 21 science teachers at the research site taught Biology, Chemistry, Physics, and Anatomy/Physiology during the time period that the study was conducted. Science was one of the subjects that were “ability tracked” at this school; students could take science courses in one of four tracks: Technical track (Tech), College Preparatory (CP) track, Gifted track, and Honors/AP track. Certain prerequisites are necessary before a student may take a CP or G/H/AP science course, with prerequisites for Gifted courses being the most rigorous since they require special testing. For this study, the Gifted and Honors tracks were considered as one track level because there were several instances where the Gifted students were enrolled in the same class as
Honors students; the teacher was responsible for differentiating curriculum and activities to meet the needs of both groups of students. This combined track is referred to in this study as “G/H/AP”. School recommendations for a student’s science track-level enrollment can be overrode by the parent’s request. Of the 21 science teachers in this study, 19 of them taught classes in more than one track-level. The other 2 teachers were first-year teachers. All teachers had current teacher certifications by the state.

In examining the 19 teachers with teaching loads of two track levels (none taught more than two track levels), 13 of them taught classes in two track-levels where both levels were in the same science content area (i.e. CP Chemistry and Honors Chemistry). These 13 teachers made up a ‘subgroup’ that was analyzed for the second research question and are referred to as the “13 Teacher Sub-Group”. This subgroup was comprised of five males and eight females. One female teacher was Asian/Indian and another female teacher was African American. The other teachers were white.

All students enrolled in any science class during spring semester, 2002 and who were present to complete the Student Survey (see below) were included in this study as well (the number of returned student surveys was 1,070). Not all students who attended Bayley High School at this time were necessarily enrolled in a science class, due to scheduling issues such as failures, transfers, and fulfilled science requirements. Each student’s track-level was classified based on the current science class he/she was enrolled in at the time of the study. Therefore, if a student was taking Technical Biology during the time of data collection, then that student was considered a “Technical track” student, for the purposes of this study’s data analysis.
Data Collection

Each of the 21 teachers were asked, during a first round of interviews, about the computer activities they assigned in their classes during the spring semester of 2002 and the factors they considered when choosing computer activities; these first-round interviews were of a semi-structured design (see Appendix A). Interviewing is a research tool used to elucidate the understandings of a participant. “…It [interviewing] is not a discussion where mutual information is shared, but one where the interviewee’s experience is placed at the centre” (Davies, p. 584, as quoted in Glesne p. 86). The interviews were tape-recorded and transcribed and filed by teacher. All teacher descriptions of computer activities were also tape-recorded and transcribed. These activities were then separated by teacher and by course in which they were assigned.

To provide additional information regarding the student context in which these teachers were teaching, data was collected from the students. A Student Survey was developed for this purpose (Appendix C). The Student Survey asked students to report their demographical information.

In order to ascertain the effectiveness of the Student Survey for data collection, the Survey was piloted at a nearby high school within Geoffrey County. The results were tabulated and analyzed for misleading or confusing items. For the revised version of the Student Survey, the following changes were made:

- The phrase “educated guess” was replaced with “GUESS”
- Item 8 had blanks added for students to indicate the number and types of computers to which they had access (instead of just the number)
It was necessary to determine whether the student populations in different tracks differed in other ways besides science ability and/or career goals (the main justifications for separating students into track levels). It was hypothesized that if, in fact, teachers were found to be changing computer assignments for different track levels, then perhaps the teachers’ choices were somehow associated with certain dissimilarities between the tracked classes (and/or with variances in student science ability and career goals). The four areas of demographics collected from the students were: race, average family income, and gender. For this purpose, the numerical data from the Student Survey were entered into a statistical analysis program and analyzed. These statistical results were used to buttress findings for the second and third objectives of this study.

To increase the reliability of the teachers’ reports of the computer activities assigned in their classes, the student responses to the short answer question of the Student Survey were also typed into a spreadsheet and used to corroborate the science teachers’ reports.

Data Analysis

The first research question was “What types of computer activities are assigned to tracked secondary science classes?” To answer this question, the common types of assignments reported by the teachers were grouped into “clusters” based on several factors: the learning objectives intended by activity, the requirements made of student, and the type of technology employed in activity. These clusters were used to make generalizations about the types of computer activities assigned to science students at this school. The clusters were called “Types of Computer Activities”.

The second research objective inquired about the ways in which teachers differentiated these activities between classes of dissimilar track-levels. It was deemed necessary to describe
the student populations for which these computer activities were intended. The sample size was limited to self-reported data. No causal relationships were insinuated or explicitly implied by these analyses; rather, the student demographics served only to bring a context to the analyses.

The statistical data collected from the 1,070 Student Surveys were analyzed using a z-test of proportions (Moore, 2000) with the software SPSS for Windows, version 10.0. The focus of this part of the analysis was to see if the proportions of different student populations differed between track levels in science. This statistical test provided a comparison of student demographics between each track level in order to determine whether the proportions of students with particular attributes differed significantly from one track level to another. For each track level, a spreadsheet was used to calculate the percent of students with the following attributes:

- White
- African-American
- Hispanic
- Asian/Pacific Islander
- Native American
- Mixed Racial Heritage
- Other
- Male
- Female

As well, the percent of students with the following characteristics were calculated:

- family income from $0-20,000
- family income from $25,001-50,000
- family income from $50,001-70,000
In addition, the students were asked to choose from five descriptors that best approximated the number of times computers were used for learning during their science class. The descriptors were:

- never
- rarely (1-2 times a semester)
- sometimes (1 time a month)
- often (2-3 times a month)
- always (1-2 times a week)

Of the 21 teachers in the study, 13 were put together in a “sub-group” for analysis for the research question on ways of computer activity differentiation. As stated earlier, this “13 Teacher Sub-Group” consisted of teachers who taught two track levels of the same science content area. The non-subgroup teachers were not analyzed for this research question because they either taught only one track-level or only classes of unlike content areas (i.e. biology and chemistry). Analyzing their methods of activity differentiation would have introduced a confounding variable.

From the interview data of the “13 Teacher Sub-Group”, memos were written about the computer activities assigned by each of the 13 teachers. The memos were then tabulated into a chart, divided by teacher, and compared for commonalities and trends. In short, this qualitative data was reduced to crudely quantifiable data (Glaser & Strauss, p. 101) in order to determine the number and types of ways in which teachers were changing and/or adjusting computer activities for different track-levels. For example, the memo for Teacher DK was “Different requirements
for lower level” (see Appendix F for all memos). The memos clustered around three major methods of differentiating computer activities; these resulting three “Method of Differentiation” groups were labeled with a descriptive name to answer the second research question of this study.

To ensure that I had coded these computer activity differentiations without bias, the memos of the computer activities were given to a member of my research committee. He was asked to code the activities based on differences that he saw in the assignments; his codes validated my codes and were in agreement with my categorizations of the computer activity differentiations.

When the results indicated that every teacher in this study differentiated their computer assignments in some way, the study developed another focus. The 21 teacher interviews were then analyzed using a constant comparative method (Glaser & Strauss p. 101) in an effort to generate a theory that would give insight as to why computer activities were adjusted by all the teachers for different track levels.

The intent of the constant comparative method is not to test a hypothesis; rather, it is “…concerned with generating and plausibly suggesting [but not provisionally testing] many categories, properties, and hypotheses about general problems…[and] should result in an integrated theory” (Glaser p.104). This method only requires a saturating of data and does not necessitate that all data possible be collected.

There are four stages to this method: (a) Comparing cases that apply to each category, (b) connecting categories and their properties, (c) setting the boundaries of the theory, and (d) stating the theory (Glaser, p. 105). Initially, the transcripts of the 21 teacher interviews were analyzed
for teacher explanations as to why computer activities were adjusted or changed for classes of
different track levels. As suggested by Glaser and Strauss’ 1967 book, the interviews were
coded for categories relating to tracking, computers, students, and assignments. These categories
were written along the margins of the interview transcripts, with elaboration written on a
separate sheet of paper (titled “Notes Page”) (p. 106). The interview transcripts were printed
with line numbers so that exact quotations could be referenced on the Notes Page. As additional
categories were found, they were compared to previously designated categories for similarities
and differences (p. 106).

One of the more obvious properties that emerged from the categories coded was that the
teachers’ explanations were embedded with salient beliefs about student characteristics in
different track levels. Recorded as a memo (p. 107), this property surfaced repeatedly among the
21 teacher interviews. This result was discussed with the researcher’s major advisor, who
concurred with the researcher’s suggestion that the teachers’ beliefs about student characteristics
were related to their decisions about computer activities. This unforeseen result led to the
addition of the third research question of this study.

The second stage of the constant comparative method was to integrate the computer
activity differentiation with these teachers’ beliefs about students. The 21 teacher interviews
were then analyzed a second time—this time with a focus on teacher comments regarding
students. These comments were coded for major themes and also noted in the transcripts’
margins, as well as on the Notes Page. The original interview (see Appendix A) protocol was
not intended to probe these themes; this led to an expansion of the methods for this study. In
order to address this the objective of the study, 4 of the 13 analyzed teachers were purposefully
chosen for further investigation based on their differentiation methods and their reasons for
differentiation. These teachers were: Teacher DA, Teacher RMI, Teacher RMY, Teacher GSH, and Teacher PB. The intent of these second-round interviews was to “fill in gaps and to extend the theory” (p. 109). The interview protocol for these second-round interviews is given in Appendix B.

Teacher DA was chosen for a second-round interview because of her belief that students of all track levels had the same cognitive abilities. Teacher RMI had the widest academic gap between her two track-levels and used all three methods of differentiation. The beliefs about students expressed by Teacher RMY were the most defined and stereotypical. And Teacher GSH was chosen because she was 1 of 2 teachers who differentiated activities in favor of lower-track students. The second round of semi-structured interviews were conducted with these four teachers to further explicate the reasons for their differentiation and the beliefs they held about their students.

As well, these second interviews were used as member-checks of the data gathered from the first interview in order to check the “trustworthiness” of the data. This sharing of the interview transcripts with the teachers was treated as “have-I-understood-you” sessions (Young & Tardif, 1988, as quoted in Glesne p. 86) and allowed the teachers to correct, clarify or make additions to any topic they had commented on previously. This member-check format also encouraged the teachers to reflect deeper on their ideas and explain further their beliefs about students and teaching with computers. As an additional prompt to elicit the teachers’ perceptions of student characteristics, a sheet of paper with the words “Technical Students” was given to the teachers. The teachers were asked to use the sheet to draw a concept map of what they believed to be the major characteristics of Technical level students. While the teachers drew on the sheet, they were asked to discuss and comment on their concept map in an open-structured interview.
that was tape-recorded and later transcribed. Then the teachers were handed two other similar sheets of paper that had the words “College Prep Students” and “Gifted/Honors/AP Students”, respectively. They were asked to do the same with these sheets as they did with the first one (only Teacher RMI used this technique—the other teachers chose to just talk about their beliefs). These discussions were also tape-recorded and later transcribed.

The data collected during the second-round interviews were then coded for teacher beliefs about students and qualitatively compared to the categories found in the 21 first-round interviews. An initial theory was formed regarding computer activity differentiation and teacher beliefs. To help with the third phase of the constant comparative method (delimiting this initial theory), a case study was conducted on one of the 21 teachers (Teacher PB). The purpose of this case study was to better understand the other of the two teachers (Teacher GSH was the first teacher) whose beliefs did not coincide with those expressed by the other 19 teachers of the study. In this way, by looking at an outlier, the categories of teacher beliefs might be “theoretically saturated” (p. 111). Because Teacher PB’s beliefs were unlike those of his peers, examining those beliefs provided a counter-example to the themes found in the beliefs of the other teachers. This counter-example, or “negative case analysis” (Lincoln & Guba, 1985), helped to test and expand the emerging theory formed from the other teacher’s interviews.

This study focused on the beliefs and pedagogy of Teacher PB in an effort to add depth to the third research question’s results. This case study developed not because of a methods criterion, but rather because of the results of the teacher interviews. The beliefs about students that were found in this participant’s first interview were distinctly unique and unlike those of his colleagues. Indeed, “…a case study is not a methodological choice, but a choice of object to be studied” (Stake, 1994, p. 236). A case study is “…an intensive, holistic description and analysis
of a single instance, phenomenon, or social unit” (Merriam, 1998). This fit with the intent and spirit of this study’s objectives. Therefore, this was chosen for part of the methodology.

Validity and Reliability

The validity and reliability of a study lend to its “trustworthiness”. A work that proposes new or divergent ideas (or even confirming ones) will be better received in the academic community when it is clear that the researcher established the credibility of the findings. Lincoln and Guba’s book (Lincoln & Guba, 1985) provided eight techniques for increasing the validity of a study. I was able to incorporate a few of these techniques.

1. Prolonged engagement and persistent observation—I returned several times to the study site to observe and take field notes on Teacher PB, the case study. As well, I had long conversations with him outside of class time and on the phone, since a professional friendship developed between us during this study. Moreover, I had serendipitously become good friends with Teacher DA since the conclusion of the data collection and still meet with her socially on a regular basis. During these social meetings, I have come to know and understand Teacher DA very well.

2. Triangulation—the data gathered from the Student Surveys were used to corroborate teacher reports of computer activities. Also, I observed several classes while they were doing computer activities and took field notes on student interactions, teacher interactions, and all actions.

3. Peer review and debriefing—my major professor was consulted on emerging themes and theories. Her input helped shape and refine the whole research process.
4. Negative case analysis—I purposely chose Teacher PB as the subject of the case study because his beliefs about students in different tracks were unlike those of his colleagues. This helped test, strengthen, and enlighten certain parts of my hypotheses because he provided a counter-example to the belief trends found in the other teachers’ interviews.

5. Member checking—transcripts of the teacher interviews were shown to four teachers for their input and clarification. As well, preliminary themes I found in the transcripts were shared with the four teachers and their comments were recorded during the second interview.

6. Rich, thick description—all field notes and memos were written with as much detail as possible.

7. External audit—the coding of the computer activities and computer activity differentiation was reviewed and confirmed by Dr. David Jackson, a member of my doctoral committee. As well, the coding of teacher beliefs in the teacher interview transcripts was reviewed and confirmed by Deniz Peker, a colleague of mine in the Science Education Department at The University of Georgia.

The only technique not used was the “clarification of researcher bias”. This is one of the limitations of this study. At the time the study was developed, I did not think that this technique would have increased the validity of this study.

Limitations to the Study

At the onset of this study, the teachers were told repeatedly that they were not being judged on the amount of computer integration in their curriculum. Due to the strong emphasis by Geoffrey County on using computers in all classes at all levels, teachers have slowly been making efforts to take their students to their school’s computer labs, as well as to enroll in
teacher technology development workshops. However, it was apparent to me by their comments that the teachers in this study were nervous about how I would view their computer activities. “I don’t use computers at all in my class, so I guess there’s no use in you interviewing me.” (Teacher DT) “I know I should use computers more in my class. I promise I will next year, when I have more time!” (Teacher ST).

This could be considered a limitation to this study in that the teachers’ nervousness might have led the teachers to censor their comments about computers and/or students’ use of computers. Even though I observed several teachers’ classes during computer activities and found them to be concurrent to what the teachers reported to me, it is possible that there were teachers not observed who incorrectly characterized the computer activities assigned (or the reactions of their students during the activity). A subsequent study could overcome this limitation by videotaping instances of science classes using computers and viewing the videotape with the teacher, recording his/her comments on the class.

Another limitation to this study was the statistical data gleaned from the Student Surveys. The information analyzed from the Surveys is all self-reported. Adolescents may not accurately know their home income or remember the exact number of computer activities assigned in their class that semester. Geoffrey County’s policies did not grant me access to students’ personal school records to verify the demographical information reported by the students on the Surveys.

Finally, the third limitation lies with me, the researcher. The interview data was analyzed and interpreted by a researcher who views the world with a certain lens. This lens may alter and
block a more “true” interpretation of what the teachers were saying in their interviews. Although measures were taken to help prevent researcher bias, it is inevitable that the researcher’s interactions with her subjects will be somewhat colored by the researcher’s past experiences and knowledge.
CHAPTER IV
RESULTS

The purpose of this chapter is to describe the types of computer activities assigned in the science classes at the research site and how those activities differed between track levels. As well, this chapter attempts to portray the salient teacher beliefs that came up during teacher interviews and teachers’ explanations for how those beliefs impacted their choices and adjustments of computer-based activities.

This chapter is divided into two parts. The first part is dedicated to characterizing the ways in which computers were used to teach science at the research site. First, I describe the general statistics about the student population. These statistics were gathered from county published information and from self-reported data from the 1,070 student surveys collected during this study. In the second part of this chapter, teachers’ salient beliefs about students in different track levels and the ways they differentiate computer activities are summarized from interviews conducted with the teachers in this study. The ways in which the beliefs relate to computer activity differentiation are also described.
The research questions that guided this research study were:

1. What types of computer activities are assigned to tracked secondary science classes?
2. What are the ways in which teachers differentiate these activities between classes of dissimilar track levels?
3. Which teachers’ salient beliefs about students in different track levels influence the teachers’ planning of computer activities?

The results that addressed these questions were analyzed using statistics and interpretive grounded methods, in keeping with the study’s interpretivist theoretical perspective.

Part I: Characterization of Science Computer Use in Bayley High School

School Demographics

All the following statistics were current at the time of data collection. At the time of this study, Bayley High School had a total population of 2598 and is one of the largest high schools in Geoffrey County. Bayley was comprised of 28.8% Black students, lower than the state’s percentage (37.9%) of Black students. Bayley had over three times the percentage of Hispanic students than the state (which is at 4.7%). The school also was 13.0% Asian, which was higher compared to the state’s percentage (2.2%) of Asian students. This high school was a bit more diverse, percentage-wise, than the state as a whole.

In terms of gender, Bayley High School had about 1% less males than the state and, correspondingly, 1% more females. Because families’ SES are not documented and recorded by the state, educators sometimes use enrollment in the “free/reduced-price lunch” program as an indicator of a family’s SES. For the state, 43.2% of the students were enrolled to receive free/reduced-price lunches during the academic year 2000-2001. At Bayley, 26.3% of the
students were eligible. Thus, Bayley High School had a lower percentage of low SES students than the state.

For tracking, 12.0% of the Bayley student population were enrolled in the Gifted program, 38.2% were in Vocational Labs (specialized courses for entrance into specific vocations immediately after graduation, such as cosmetology and auto mechanics), and 6.4% were in the English to Speakers of Other Languages (ESOL) program. The state percentages are provided in Tables 1 and 2. Based on these statistics, Bayley had proportionately more students in Gifted and in ESOL classes than the state average. The percentage of students enrolled in Vocational labs was used as an indication of the number of students in Technical track classes. Although not all Technical students take Vocational labs, it was assumed that more Technical students would take Vocational courses than students from any other track level.

Results from Student Surveys

The Student Survey was given to all students enrolled in a science class during Spring Semester of 2002. Of the 1,070 Student Surveys returned, 207 were from Technical level (Tech) students, 700 were from College Preparatory level (CP) students, and 163 were from Gifted/Honors/AP level (G/H/AP) students (note: the track-level of student’s science class at the time of the Student Survey completion was considered to be the student’s science track-level). The Tech responses accounted for 19.3% of the total number returned, while the CP and G/H/AP students were 65.4% and 15.2% of the total, respectively.

Because there was an unequal number of student responses from the three track levels and because the demographics being analyzed were non-parametric scales, I chose to use the z-test of proportions (Moore, 2000) to analyze the Student Survey results for demographic differences between track levels. This method of statistical analysis was ideal because it does
Table 1

Summary of Student Race Demographics Percentages in Georgia (GADOE, 2001)

<table>
<thead>
<tr>
<th></th>
<th>Black</th>
<th>White</th>
<th>Hispanic</th>
<th>Asian</th>
<th>American Indian</th>
<th>Multi-Racial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bayley HS</td>
<td>28.8</td>
<td>40.8</td>
<td>15.2</td>
<td>13.0</td>
<td>0.2</td>
<td>2.0</td>
</tr>
<tr>
<td>State of Georgia</td>
<td>37.9</td>
<td>53.7</td>
<td>4.7</td>
<td>2.2</td>
<td>0.2</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Table 2

Summary of Other Student Demographics in Georgia (GADOE, 2001)

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Gifted</th>
<th>Vocational Labs</th>
<th>ESOL</th>
<th>Free/Reduced Lunch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bayley HS</td>
<td>50.4</td>
<td>49.6</td>
<td>12.0</td>
<td>38.2</td>
<td>6.4</td>
<td>26.3</td>
</tr>
<tr>
<td>State of Georgia</td>
<td>51.1</td>
<td>48.9</td>
<td>7.4</td>
<td>53.7</td>
<td>2.2</td>
<td>43.2</td>
</tr>
</tbody>
</table>

not require that the data be normally distributed and enables the researcher to compare various groups of different sample sizes. In addition, the research questions of this study called for a comparison of the proportions of students with certain demographics in different track levels. If race, gender, and class were not significant student characteristics, then the proportions of students of different races, genders, and SES levels would be equal among the three track levels.

The following reported statistical results refer to the percentages of students with a particular characteristic within a track level (e.g. 27.9% of students in CP science courses were Black means that of the 700 CP students that responded, 195 were Black). The percentages of students in each track with certain characteristics are summarized in Table 3 and Table 4. The obtained statistical results of each student characteristic are discussed individually afterwards.
Table 3

Percentages of Students in Each Track Level, According to Self-Reported Race, Gender, and Family Income

<table>
<thead>
<tr>
<th></th>
<th>TECH</th>
<th>CP</th>
<th>G/H/AP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RACE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>33.3</td>
<td>28.6</td>
<td>12.3</td>
</tr>
<tr>
<td>Asian</td>
<td>7.6</td>
<td>13.9</td>
<td>26.4</td>
</tr>
<tr>
<td>White</td>
<td>25.8</td>
<td>35.9</td>
<td>47.9</td>
</tr>
<tr>
<td>Hispanic</td>
<td>24.2</td>
<td>13.9</td>
<td>3.1</td>
</tr>
<tr>
<td>Multiracial</td>
<td>5.1</td>
<td>5.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Other</td>
<td>4.0</td>
<td>1.9</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>GENDER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>48.3</td>
<td>39.5</td>
<td>48.5</td>
</tr>
<tr>
<td>Females</td>
<td>51.7</td>
<td>60.5</td>
<td>51.5</td>
</tr>
<tr>
<td><strong>INCOME</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$0-25k</td>
<td>14.3</td>
<td>10.8</td>
<td>7.7</td>
</tr>
<tr>
<td>$25-50k</td>
<td>39.6</td>
<td>31.5</td>
<td>26.5</td>
</tr>
<tr>
<td>$50-75k</td>
<td>29.7</td>
<td>30</td>
<td>32.9</td>
</tr>
<tr>
<td>$75-90k</td>
<td>9.9</td>
<td>15.6</td>
<td>14.8</td>
</tr>
<tr>
<td>$90k+</td>
<td>6.6</td>
<td>12.1</td>
<td>18.1</td>
</tr>
</tbody>
</table>
Table 4

Percentages of Student Responses on Amount of Computer Use in Their Science Class

<table>
<thead>
<tr>
<th></th>
<th>TECH</th>
<th>CP</th>
<th>G/H/AP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>20.7</td>
<td>37.7</td>
<td>3.7</td>
</tr>
<tr>
<td>1-2 x</td>
<td>70.4</td>
<td>42.8</td>
<td>54</td>
</tr>
<tr>
<td>1x a month</td>
<td>5.4</td>
<td>9.1</td>
<td>27</td>
</tr>
<tr>
<td>2-3x month</td>
<td>3</td>
<td>8.9</td>
<td>14.7</td>
</tr>
<tr>
<td>1-2x week</td>
<td>0.5</td>
<td>1.4</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Race

There was a significantly lower percentage of Black students in G/H/AP science courses than in CP science courses, \( z (700) = 5.06, p = 0 \). As well, there were proportionately more Black students in the Tech classes than in G/H/AP, \( z (207) = 4.74, p = 0 \). The same findings were found for Hispanic students, but in addition there was also a significantly higher percentage of Hispanics in Tech than in CP, \( z (207), p < .05 \).

The pattern for Asians was the same as for whites. Proportionately, the G/H/AP classes had the most Asian and white students of all the track levels, while CP was second highest and Tech was the lowest. There were no significant differences in the percentages of multiracial students and students of other racial groups (groups not listed by the state as one of the major groups counted statistically). However, there was a significant difference between CP and G/H/AP for the racial group “Other”: there was a higher percentage of “Other” students in G/H/AP than in CP, \( z (163) = 1.97, p < .05 \). Table 5 and Figure 2 summarizes of these statistical results.
### Table 5

**Summary of Significant z-Test of Proportions from Student Survey Data on Race**

<table>
<thead>
<tr>
<th>Race</th>
<th>Tech versus CP</th>
<th>CP vs. G/H/AP</th>
<th>Tech vs. G/H/AP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AFRICAN AMERICAN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in proportion</td>
<td>0.04</td>
<td>0.16**</td>
<td>0.20**</td>
</tr>
<tr>
<td>z-statistic</td>
<td>1.10</td>
<td>5.06</td>
<td>4.74</td>
</tr>
<tr>
<td><strong>ASIAN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in proportion</td>
<td>-0.06**</td>
<td>-0.13**</td>
<td>-0.19**</td>
</tr>
<tr>
<td>z-statistic</td>
<td>-2.85</td>
<td>-3.47</td>
<td>-4.91</td>
</tr>
<tr>
<td><strong>WHITE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in proportion</td>
<td>-0.10**</td>
<td>-0.13**</td>
<td>-0.23**</td>
</tr>
<tr>
<td>z-statistic</td>
<td>-2.96</td>
<td>-2.98</td>
<td>-4.71</td>
</tr>
<tr>
<td><strong>HISPANIC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in proportion</td>
<td>0.10**</td>
<td>0.11**</td>
<td>0.20**</td>
</tr>
<tr>
<td>z-statistic</td>
<td>3.00</td>
<td>5.62</td>
<td>6.23</td>
</tr>
<tr>
<td><strong>OTHER RACES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in proportion</td>
<td>0.02</td>
<td>-0.04*</td>
<td>-0.02</td>
</tr>
<tr>
<td>z-statistic</td>
<td>1.40</td>
<td>-1.97</td>
<td>-0.74</td>
</tr>
</tbody>
</table>

*Note.* *p < .05, **p < .01
Figure 2. Comparison by track level ($n_{\text{Tech}} = 207$; $n_{\text{CP}} = 700$; $n_{\text{G/H/AP}} = 163$) of the percentages of students of different races ($n_{\text{Af-Am}} = 281$; $n_{\text{Asian}} = 153$; $n_{\text{Cauc}} = 374$; $n_{\text{Hisp}} = 58$; $n_{\text{Multi}} = 0$; $n_{\text{Other}} = 30$). Percentages differ significantly on all track levels for all racial groups except “Multiracial”. 

Gender

For gender, the significant differences found were between the Tech track and CP track, $Z(207) = 2.26$, $p < .05$, as well as between CP and G/H/AP, $Z(700) = -2.09$, $p < .05$. There were no significant differences between Tech and G/H/AP on gender. Thus, there were proportionately more males in Tech than in CP and proportionately more males in G/H/AP than CP. The percentages of males in Tech and G/H/AP were statistically equal. Table 6 and Figure 3 summarize these findings.
Table 6
Summary of Significant z-Test of Proportions from Student Survey Data on Gender

<table>
<thead>
<tr>
<th>Males Versus Females</th>
<th>Tech versus CP</th>
<th>CP vs. G/H/AP</th>
<th>Tech vs. G/H/AP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in proportion</td>
<td>0.09*</td>
<td>-0.09*</td>
<td>-0.001</td>
</tr>
<tr>
<td>z-statistic</td>
<td>2.26</td>
<td>-2.09</td>
<td>-0.03</td>
</tr>
</tbody>
</table>

*Note. *p < .05, **p < .01* These results indicate a trend towards males in higher level classes.

Income

There were five levels of income in which the students could identify themselves. The lowest income bracket and the middle-income bracket had no significant differences between tracks.

For the $25-50,000 yearly income bracket, the percentage of Tech students who marked this category was higher than that of G/H/AP, \( z \ (207) = 2.03, p < .05 \). For the second highest income bracket, the significant difference was between Tech and CP: proportionately less Tech students marked this category than CP, \( z \ (207) = -2.66, p < .05 \). The highest income bracket had significant differences between all three tracks, however. Again, there were proportionately less
Figure 3. Comparison by track levels ($n_{Tech} = 207; \ n_{CP} = 700; \ n_{G/H/AP} = 163$) of percentages of male and female students ($n_{Male} = 455; \ n_{Female} = 614$). The percentage of males in Tech differed significantly than that in CP. The percentage of males in G/H/AP also differed significantly than that in CP. The percentage of males in Tech was not significantly different that that in G/H/AP.

Tech students in this income bracket than CP students, $z (207) = -2.66, p < .05$, and less percentage of CP students than G/H/AP, $z (700) = -1.89, p < .06$. As well, there was a lower percentage of Tech students than G/H/AP in this category, $z (207) = -3.38, p < .05$. In summary, G/H/AP students were the most likely and Tech students were the least likely to be at this highest income level. This is summarized in Table 7 and Figure 4.
### Table 7
Summary of Significant z-Test of Proportions from Student Survey Data on Income

<table>
<thead>
<tr>
<th></th>
<th>Tech versus CP</th>
<th>CP vs. G/H/AP</th>
<th>Tech vs. G/H/AP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>$0-25,000</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in proportion</td>
<td>0.03</td>
<td>0.03</td>
<td>0.05</td>
</tr>
<tr>
<td>z-statistic</td>
<td>1.00</td>
<td>1.13</td>
<td>1.69</td>
</tr>
<tr>
<td><strong>$25-50,000</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in proportion</td>
<td>0.06</td>
<td>0.04</td>
<td>0.10*</td>
</tr>
<tr>
<td>z-statistic</td>
<td>1.51</td>
<td>1.05</td>
<td>2.03</td>
</tr>
<tr>
<td><strong>$50-75,000</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in proportion</td>
<td>-0.02</td>
<td>-0.04</td>
<td>0.10</td>
</tr>
<tr>
<td>z-statistic</td>
<td>-0.47</td>
<td>-0.89</td>
<td>-1.10</td>
</tr>
<tr>
<td><strong>$75-90,000</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in proportion</td>
<td>-0.06*</td>
<td>0.003</td>
<td>-0.05</td>
</tr>
<tr>
<td>z-statistic</td>
<td>-2.42</td>
<td>0.11</td>
<td>-1.61</td>
</tr>
<tr>
<td><strong>$90,000+</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in proportion</td>
<td>-0.05**</td>
<td>-0.06</td>
<td>-0.11**</td>
</tr>
<tr>
<td>z-statistic</td>
<td>-2.66</td>
<td>-1.89</td>
<td>-3.38</td>
</tr>
</tbody>
</table>

**Note.** *p < .05, **p < .01*
Figure 4. Comparison by track level (n_{Tech} = 207; n_{CP} = 700; n_{G/H/AP} = 163) of percentages of students from different levels of family income (n_{$0-25k} = 108; n_{$35-50k} = 317; n_{$50-75k} = 299; n_{$75-90k} = 142; n_{$90k+} = 118), as reported by students on Student Survey. Tech and G/H/AP were significantly different at the $25-50,000 income level. Tech and CP were significantly different at the $75-90,000 income level. All three levels differed significantly from each other at the highest income level.

How often computers used in science class

The students were asked to mark one of five categories that best described how often they used computers in their science class. The lowest category was “never”, while the highest category was “1-2 times a week”. The students’ responses were compared between track levels.
There were significant differences found between every category except the “1-2 times a week” category. At the “never” level of use, a greater percentage of CP students chose this category than Tech or G/H/AP students. The least likely to choose this category were G/H/AP students. For the “1-2 times a semester” level, the most likely to choose this was Tech, then G/H/AP students, then CP students. For the “1 time a month” and “2-3 times a month” groups, there was the same pattern found. G/H/AP chose this category proportionately more times than CP students, who in turn chose it more often than Tech students.

Thus, it can be seen that Tech students perceived that the use of computers in their classes ranged from “never” to 1-2 times a semester, while G/H/AP students perceived using computers “1-2 times a semester” to 1-3 times a month. CP students chose “never” the most, but were least likely to choose “1-2 times a semester”. They perceived to use the computer more often than Tech students. These results are summarized in Table 8 and Figure 5.

It is noted that although these results are from self-reported data, these trends do indicate the students’ perceptions of how often they used computers in their science classes. Although the effects of student beliefs on science learning are not addressed in this study and are beyond the scope of this study, future studies should investigate this area of science equity, since it is possible that teacher beliefs have some relationship to the beliefs held by their students in their classes.
### Table 8

**Summary of Significant z-Test of Proportions from Student Survey Data on Amount of Computer Use in Class**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Tech versus CP</th>
<th>CP vs. G/H/AP</th>
<th>Tech vs. G/H/AP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Never</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in</td>
<td>-0.17**</td>
<td>0.34**</td>
<td>0.17**</td>
</tr>
<tr>
<td>proportion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>z-statistic</td>
<td>-5.13</td>
<td>14.36</td>
<td>5.26</td>
</tr>
<tr>
<td><strong>1-2 times a semester</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in</td>
<td>0.27**</td>
<td>-0.11**</td>
<td>0.15**</td>
</tr>
<tr>
<td>proportion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>z-statistic</td>
<td>7.13</td>
<td>-2.64</td>
<td>2.99</td>
</tr>
<tr>
<td><strong>Once a month</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in</td>
<td>-0.04</td>
<td>-0.18**</td>
<td>-0.22**</td>
</tr>
<tr>
<td>proportion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>z-statistic</td>
<td>-1.94</td>
<td>-4.94</td>
<td>-5.69</td>
</tr>
<tr>
<td><strong>2-3 times a month</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in</td>
<td>-0.06**</td>
<td>-0.06*</td>
<td>-0.12**</td>
</tr>
<tr>
<td>proportion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>z-statistic</td>
<td>-3.76</td>
<td>-1.97</td>
<td>-3.93</td>
</tr>
<tr>
<td><strong>1-2 times a week</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference in</td>
<td>-0.01</td>
<td>0.01</td>
<td>-0.001</td>
</tr>
<tr>
<td>proportion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>z-statistic</td>
<td>-1.44</td>
<td>1.08</td>
<td>-0.17</td>
</tr>
</tbody>
</table>

*Note. *p < .05, **p < .01*
Figure 5. Comparison by track level ($n_{Tech} = 207$; $n_{CP} = 700$; $n_{G/H/AP} = 163$) of percentages of students’ reports of computer use in science class ($n_{Never} = 310$; $n_{1-2x} = 529$; $n_{1x a month} = 118$; $n_{2-3x a month} = 92$; $n_{1-2x a week} = 12$).
Summary of Student Data

Based on the analysis of data, Bayley High School’s science students were comprised of predominantly white and African American students, with Asian and Hispanic student proportions about comparable. The G/H/AP level classes, in comparison to the lower level classes, had proportionately:

- more whites
- more Asians
- more students of “other” races (as compared to CP classes)
- more males than CP, but equal number of males to Tech
- more students of middle to high SES
- more self-reported science class computer use (except for the category “1-2 times a semester”, where a higher percentage of CP students chose this category than the percentage of students in G/H/AP)

Types of Computer Activities Assigned by Teachers in Science Classes

There were 15 distinct types of computer activities assigned to science students in Spring, 2002. The teachers assigned, on average, 2 to 3 activities during the school semester that the study was conducted. Based on the objectives and requirements of the assignments, the 15 types were grouped into four main categories. The four categories are described below.

The first category of computer activity centered on information delivery. It was named “Information Dissemination”. The purpose of assigning these activities was to transmit information about science content to the learner via technology. The objectives usually were “to get students to learn more about (blank)” or “to help students become more aware about (blank)”. This category included the following activities: computer-based tutorials (type D),
computer-based simulations found on the Internet or a CD Rom (type E), teacher lectures utilizing PowerPoint presentations authored by the teacher to deliver content during a class lecture (type N), and teacher lectures using Internet images from the computer projected through an overhead projector (type O). Many teachers stated that the main objective of these activities was to expose students to technology because “…they will need it in the future. They’re in the information age” (Teacher KF). Since the science learning involved with these activities was heavily dependent on the teacher’s choice of context, Internet sites, and/or content depth, this category of computer activities was also labeled as “teacher-centered”.

The “Internet Searches” category was comprised of four types of assignments, all of which required some student-generated product. Type A activities were Internet searches that were unguided in class. Teacher assigned class time for students to find information about a certain topic, with no directed guidance. If student was required to finish the activity at home, then the activity was included in this Type. The second type, labelled “B activities”, were unguided Internet searches, but meant to be completed outside of class time. The third type, Type C, were guided Internet searches in class. The teacher would provide or suggest certain websites to be used by the students. Finally, Type CA Internet searches were also guided, but the websites designated by the teacher were to be visited by the student at home or outside of class time. Some type of written product resulted from all four of these kinds of activities.

“Computer as Tool” is the third category of computer activities. These assignments entailed the use of a computer as a basic science tool. Usually these activities had skill-based objectives, such as “…exposure to word processing” (Teacher DK) or “…learn how to organize their lab report information in a way that makes sense” (Teacher SC). There were four kinds of assignments included in this category. Type H was “report writing/word processing/document
formatting”. The student was required to produce a product using a word processing software, such as Microsoft Word. Type I activities required the student to use a graphing program, such as Microsoft Excel, to graph data collected by the student or the student’s lab group. The objective of these types of activities was to solely generate a graph and/or correlation line. Type F activities were called “student searches”; these assignments did not specifically require the students to use a computer to find the necessary information to complete the assignment. The student was free to choose any media to obtain data to complete the written product. Type F activities were deemed distinct from the “Internet Searches” category because there was no emphasis on the World Wide Web for the assignment. However, some teachers (Teachers BI, PB, and ST) did note that students commonly used the Internet for these assignments. Finally, Type P activities, “student-produced PowerPoint” were assignments where students were to create a PowerPoint demonstration on a teacher-designated topic or concept. Again, “Computer as Tool” assignments were meant for student-generated products as the final result of the activity.

In contrast, activities in the “Inquiry” category involved the student utilizing the computer as a tool, but instead, to accomplish a goal. For example, a very common activity would be students using a graphing program to discover the relationship between two variables. The focus of these activities was on the learner; the student constructed their own understandings of the science content through inquiry and exploration. Although the teacher chose the experiment to be conducted and the variables to be investigated, the students had to collect data, manipulate that data, and critically analyze that data in order to achieve the intended objective of the computer activity. Successful completion of the activities in the aforementioned three categories were not necessarily predicated on critical thinking by the student. In Type G
activities, the teacher assigned a problem to the student and it was left up to the student to decide on a plan of action. The objective of the activity was not just finding information, as in Type F assignments, but rather organizing and purposefully choosing methods that will solve the problem. The second type of activity was Type K, using spreadsheets for problem-solving. These assignments required the students to use a spreadsheet program to find a scientific relationship, derive a chemical or physical equation, or discover connections represented by laboratory generated data. The one teacher that gave these types of assignments (Teacher BI) emphasized in his interview that the use of spreadsheets was intended to help students ascertain science concepts that resulted from the assignment, rather than to reinforce concepts presented in class lecture previously. Finally, Type L activities entailed students discovering scientific concepts, like Type K activities, except through the use of a graphing program. The program utilized by Teachers BI, PB, and SW was “Graphical Analysis”, a software package manufactured by Vernier Software (Vernier, 2003). Similar to Microsoft Excel, Graphical Analysis has a user-friendly interface that allows students to enter lab-generated data into the spreadsheet and, using the program’s drop-down menus, manipulate the data until a linear correlation line is produced. The resulting manipulations then are discussed by the teacher and through the data, the student recognizes how the variables examined during the activity mathematically relate to each other.

There were three teachers (Teachers BI, SW, and PB) whose computer activities fell into this category. Their assigned computer activities were meant for more than just mere exposure to technology. These teachers taught physics using the “Modeling Method”, whereby students used Graphical Analysis to input data from an investigation and developed theoretical models to describe their observations. Although these 3 teachers did have students use the computer as a
tool, the computer was a tool for a purpose besides a student-generated product. The goal was that the students would develop science skills—and not just a computer literacy skill. The objective of these assignments was that students would develop graphing skills, critical thinking skills, modeling skills, and scientific inquiry skills; these assignments were highly centered on the student, not the teacher. Thus, “Inquiry” category activities were also labeled “student-centered” activities, whereas “Information Dissemination”, “Internet Searches”, and “Computer as Tool” activities were all designated “teacher-centered”. A summary of the different types and categories of activities is presented in Table 9.

**Types of Computer Activity Differentiation by Teachers in Science Classes**

Of the 21 teachers interviewed in this study, only 13 of them did not teach classes in multiple science discipline areas. It was assumed that the curriculum for each science discipline area was unique and therefore would naturally warrant a content differentiated curriculum for each area. This potentially could have included differentiated computer activities for the four science areas at Bayley High School: biology, chemistry, physics, and anatomy and
Table 9

**Types of Computer Activities Assigned**

<table>
<thead>
<tr>
<th>Type of Activity Label</th>
<th>Computer Activity</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Student search for information</td>
<td>Computer as Tool</td>
<td>These activities do not specifically require the students to use a computer to find the necessary information to complete the assignment. The student is free to choose any media to obtain data to complete the written product.</td>
</tr>
<tr>
<td>H</td>
<td>Report writing, word processing/formatting</td>
<td>Computer as Tool</td>
<td>Activity entails using computer as a basic science tool. Low level objective, such as exposure to word processing or organizing lab report information.</td>
</tr>
<tr>
<td>I</td>
<td>Data graphing</td>
<td>Computer as Tool</td>
<td>Computer is used to graph data collected by students. Objective is solely to generate a graph and/or correlation line.</td>
</tr>
<tr>
<td>P</td>
<td>Students make a PowerPoint</td>
<td>Computer as Tool</td>
<td>Assignment is to create a PowerPoint demonstration on a certain topic or concept. Similar to Activities H and I—using the computer as a basic tool.</td>
</tr>
<tr>
<td>D</td>
<td>Internet-based tutorial</td>
<td>Information Dissemination</td>
<td>Teacher directs students to a set of websites that helps instruct students on a new concept or skill. Students navigate the activities on the website(s) as an exercise. No student product.</td>
</tr>
<tr>
<td>E</td>
<td>Internet/CD-Rom based simulation with activity</td>
<td>Information Dissemination</td>
<td>Teacher directs students to a set of websites (or projects simulations from a CD-Rom in class) that simulates a laboratory experience or provides a virtual tour. The objective is introduction of content—not a practice or exercise. No student product.</td>
</tr>
<tr>
<td>N</td>
<td>Lecture with PowerPoint</td>
<td>Information Dissemination</td>
<td>Teacher uses PowerPoint program as a visual aid for lecture. No student product.</td>
</tr>
<tr>
<td>O</td>
<td>Computer or Internet for lecture</td>
<td>Information Dissemination</td>
<td>Teacher projects images from computer (or from Internet through computer) onto screen as a visual aid for lecture. No student product.</td>
</tr>
<tr>
<td></td>
<td>Activity</td>
<td>Category</td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>G</td>
<td>Student problem-solving</td>
<td>Inquiry</td>
<td>Teacher assigns a problem to student and it is left up to the student to decide a plan of action. The objective of activity is not just finding information, like Activity F, but rather organizing and purposefully choosing methods that will solve the problem.</td>
</tr>
<tr>
<td>K</td>
<td>Spreadsheets for problem-solving</td>
<td>Inquiry</td>
<td>Activity requires students to use a spreadsheet program to solve a problem, derive an equation, or discover unknown relationships. Teacher emphasizes the objective of using the spreadsheet as a tool to discover science concepts that result from the spreadsheet, rather than reinforcing concepts presented in class.</td>
</tr>
<tr>
<td>L</td>
<td>Graphing for problem-solving</td>
<td>Inquiry</td>
<td>Similar to Activity K, whereby students discover scientific concepts and relationships through the use of a graphing program.</td>
</tr>
<tr>
<td>A</td>
<td>Internet search (unguided) in class</td>
<td>Internet Searches</td>
<td>Teacher assigns class time for students to find information about a certain topic, with no directed guidance. Student navigates Internet independently. If student must finish at home, the activity is still in this category. Some type of written product results from this activity.</td>
</tr>
<tr>
<td>B</td>
<td>Internet search (unguided) at home.</td>
<td>Internet Searches</td>
<td>Similar to Activity A. However, activity is to be completed outside of class time. Some type of written product results from this activity.</td>
</tr>
<tr>
<td>C</td>
<td>Internet search (guided) in class</td>
<td>Internet Searches</td>
<td>Similar to Activity A. However, teacher provides/suggests certain websites to be used by the students. Some type of written product results from this activity.</td>
</tr>
<tr>
<td>CA</td>
<td>Internet search (guided) at home.</td>
<td>Internet Searches</td>
<td>Teacher provides/suggests certain websites to be used by the students outside of class time. Some type of written product results from this activity.</td>
</tr>
</tbody>
</table>

physiology. This assumption prevented me from analyzing the differentiation methods utilized by all 21 teachers; differentiation of computer activities was not a valid comparison for these other teachers. Rather, the 13 teachers who taught in only one science discipline area were put
together into a sub-group for this part of the data analysis. The following were the interview findings of this 13 teacher sub-group.

The sub-group teachers taught two track levels of the same content area. In examining the computer assignments for these 13 teachers, I labeled the teachers’ classes as “high” or “low” track, in relation to each teacher’s teaching load. So, for example, Teacher BI taught AP Physics B and AP Physics C. For him, the latter class was his “high” track. But for Teacher DA, her “high” track was CP Biology and her “low” track was Tech Biology.

It was found that there were three major methods of differentiation of computer activities between track levels. The first method (called “Amount”) entailed assigning a different number of computer activities to two track levels. With the exception of one teacher (Teacher ST), all teachers assigned more computer activities to their higher-track students. A total of 77 computer assignments were given to low-track classes during Spring Semester 2002, as opposed to 122 assignments to the high-track classes. This was a difference of 22.6% more activities in favor of the high-track classes.

Teacher ST had 31 incidents of computer assignments for her low-track class and 29 for her high-track class. For both levels, she incorporated computer activities heavily in the Petroleum Unit, which was covered during the spring semester (see Appendix D for a complete list of computer activities assigned by the 13 Teacher Sub-Group). This resulted in 26 assignments for both levels and three additional assignments for CP Chemistry. However, in addition to these extensive computer plans, she also brought her Tech Chemistry class to the Media Center once a week for 5 weeks to look up websites in order to fill in a question sheet she had produced (Internet Search activity).
There was a marked, significant difference in the total number of computer assignments given to high and low track classes (see Table 10). However, at the 95% confidence level, there was no significance to the distribution of types of computer activities between the track-levels. In looking at the distribution percentages, it could be argued that there is an indication of a trend towards low-level students using the computers for obtaining information (“Information Dissemination” and “Internet Searches”) and high-level students using the computer for other objectives (“Computer as Tool”). The lack of significance could be due to the low number of computer activities in total. For the purposes of this study, nevertheless, no clear conclusion can be drawn regarding the distribution of types of computer activities between the track-levels. These percentages are summarized in Table 10.

The second method of differentiation (called “Change Content”) was to either increase or decrease the information covered in the activity, usually by adding or deleting content or skills mastered in the activity. Many of the teachers (Teachers DA, DK, DT, HS, MRO, RMY, SC, PB) reported that they “dumbed down” the assignments by “taking out the math” or simplifying the science concepts covered in the assignment. The criteria for labeling a particular differentiation under this title was that the teacher’s adjustment centered on the content or skills objectives of the assignment.
Table 10

<table>
<thead>
<tr>
<th>Category of Assignment</th>
<th>Low Track Classes</th>
<th>Percent of Total</th>
<th>High Track Classes</th>
<th>Percent of Total</th>
<th>Significance of Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer as Tool</td>
<td>3</td>
<td>3.90%</td>
<td>11</td>
<td>9.01%</td>
<td>Not significant</td>
</tr>
<tr>
<td>Information Dissemination</td>
<td>30</td>
<td>39.0%</td>
<td>36</td>
<td>29.5%</td>
<td>Not significant</td>
</tr>
<tr>
<td>Internet Searches</td>
<td>23</td>
<td>29.9%</td>
<td>44</td>
<td>26.1%</td>
<td>Not significant</td>
</tr>
<tr>
<td>Inquiry</td>
<td>21</td>
<td>27.3%*</td>
<td>31</td>
<td>25.4%</td>
<td>Not significant</td>
</tr>
<tr>
<td>TOTAL</td>
<td>77</td>
<td></td>
<td>122</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: * This result is high, due to Teacher PB’s unusually high number of Inquiry assignments.

For example, Teacher RMY said, “I might do the same activity in CP [as in Tech], but not as much of the algebra that’s in the calculations. That’s completely different. I even have to rewrite the activity, a lot of the times, so they [Tech] can do it.” She also changed the skill requirements of her computer activities for different tracks. For the culminating project in the Air Unit, Teacher RMY had her CP Chemistry class do a report on the chemistry of air and how it applies to legislation. “With the [CP] Air Project, they had to go into just a lot more detail. They had to look at cause and effect relationships…it’s like, ‘How does this…what is it, how does it affect you, what are the sources, what are we going to do about it—solutions?’” On the other hand, her Tech Chemistry class made children’s books on the chemistry of air as a review for the final exam. They were not required to “process” the information. “I led the [Tech] kids to two websites that could give them simplistic enough information so they wouldn’t have to do too much of that [processing]. And the goal was ‘Report to me what you find.’”
The third method of differentiation was not as commonly found as Change Content. Teachers changed computer assignments for lower-track students by altering the requirements or the method of how the activity was completed (called “Change Activity”). Teachers DK, DA, RMI, ST, and SC employed this method of differentiation. For example, teachers deleted requirements from the student product (i.e. Teacher DK substituted a brochure for his Technical Biology students in lieu of a full written report for his CP students) or had students do the activity in a different way (i.e. Teacher DA had her Tech Biology students working on their Bacteria project completely during class time instead of doing it for homework; her CP students completed their Photo Essay assignment outside of class time). The content and skills covered by both levels was intended to be identical. So, on another assignment, Teacher DA simplified for her Technical Biology students the worksheet that accompanied the Sight and Sound computer activity, “…but the activity itself is going to be the same.”

Teacher RMI, for example, assigned a lot more projects in her Tech Chemistry class than her Gifted/Honors Chemistry class. Although she felt that Gifted/Honors students need more opportunities to express their creativity, she assigned more in-class projects to Tech students because it was a way to help their grades.

RMI: The baking soda [assignment] was a lot like the Benzene thing [project]. With the Tech, we spent a day, the whole class day going to the library and stuff. And with the Gifted, it was one question at the end of their lab that they were expected to look up [on the Internet] for homework.

MT: And so you consciously…

RMI: plan that way. Yeah.

MT: OK. Because of…
RMI: Because of the, they [the Tech students] won’t do it…the failure rate is very high in the Tech level. Not turning stuff in is the biggest problem. Like how I went through and showed them one day—I said, ‘Let’s do a graph of everybody’s grade in here.’ We counted the number of zeros that people had and their grade. And then I said, ‘What do you notice here?’ And somebody said, ‘Well, the person that turned everything in has the highest grade!’ If you turn everything in, on time, you can pass.

When asked about how she chose computer activities for her students, Teacher ST detailed several ways in which she altered the presentation of the material and the student requirements.

ST: [I change] the level of difficulty. Tech [students] prefers more hands-on, visual. Whereas CP [students], they can take just sitting there, listening. Versus Tech, you need to have more activities where they can actually touch stuff, break the concept up into parts. Whereas CP, since they’re higher level than Tech kids, they can do more. [I change] how fast you’re moving with the concepts. You have to be slower with Tech. You have to break the concepts up in parts and give them plenty of practice—different ways—drawing, coloring, cutting out, pasting, just activities like that.

If computer use is assumed to be a desirable educational resource for students, then all three methods of differentiation (Amount, Change Content, and Change Activity) were employed in ways that favored the high-level students (except for Teacher GSH, which will be explicated later in Part II of this chapter). That is, high-track students had more computer assignments, covered more in-depth content in those assignments, and were required to produce more, independently, and with more difficult requirements. The teachers justified their choices in curriculum differentiation with explanations involving negative beliefs about low-track
students’ abilities, interests, and educational needs. These negative beliefs are explained later in this chapter.

Summary of Computer Use in Science Classes at Bayley High School

The teacher interview data indicated that there were four main categories of computer activities assigned to students during spring semester, 2002. These were:

- information dissemination
- computer as tool
- inquiry
- internet searches

The teachers differentiated computer activities between track levels in three methods:

- amount
- changed content
- changed activity

All methods were employed with the viewpoint of compensation for the low track students and enhancement for the high track students. Therefore, the teachers in this study assigned more activities that covered more content and had more requirements to the classes that were predominantly white and Asian (as compared to CP and Tech) and other races (as compared to CP), that had a higher male contingency (than CP classes), and that were of middle to high SES. The student reported data on how often student felt they used the computers in class corroborated the teacher interview data on computer assignments; that is, more computer assignments were given to high track classes than low track classes during spring semester, 2002.
Part II: Description of Teachers’ Salient Beliefs about Students in Different Track Levels
As They Relate to Computer Activity Differentiation

Section A: General Trends and Patterns in Teachers’ Beliefs

The first portion of this section describes five major themes found across all 21 teachers’ first interview data. Section B of this section details the results from the second round of interviews of four teachers and the results from a case-study of one teacher. Both sections attempt to portray the major beliefs teachers held about their students in different track levels and how those beliefs related to their choices of computer activities for both tracks. These beliefs resulted from the interpretation of the teachers’ comments during discussions about their computer assignments and their explanations for their choices of curriculum and teaching practices. Five major themes emerged in the teachers’ answers to the question of why they differentiated computer activities between track-levels. These themes were: (a) student ability (science, math, language, and/or computer), (b) student learning styles, (c) student motivation, (d) student interests and life goals, and (e) ownership of a home computer. Each of these themes will be discussed in turn.

Student ability

Many teachers said that lower-track students, especially Technical students, had less science skills, math skills, language skills, and computer skills. As Teacher RMI said, “Well, there’s a great difference in mental ability in these three [ability] groups. Which is why they’re in those groups, primarily. That’s their [the Technical students] starting, their basis for being in the Technical group.” Indeed, every one of the 21 teachers in the study had commented on the lack of educational skills of Technical students, even those who did not teach Technical students during the study like Teachers SW and BI. Teacher RMY stated that a lot of her Technical
students were not capable of abstract thinking, which was necessary to understand chemistry concepts. Teacher PB noted that the algebra skills of all of his students were lacking, but they were especially deficient in Technical Physics students.

MT: Do you require the same things [of both track levels] in terms of the Graphical Analysis and the lab report?

PB: Yes. Yes. The lab report is a little bit, a little bit more mellow [for the Technical level classes]. I have to usually help them [the Technical students] a little bit more with the mathematics, with the equations, with identifying inverse relationships and quadratic relationships and things like that. Just because they’re, the Technical level math [classes] is a joke. It’s EXTREMELY poor. I still have students, juniors and seniors of the PT [Technical Physics] class, that if I asked them to rearrange that equation for resistance, they wouldn’t be able to do it. It’s seventh grade Algebra, and they still, they’re that bad.

There were 4 teachers (Teachers DK, DA, KF, and RMY) who claimed that these students did not have adequate language/writing skills as well.

MT: Will you require them [the Technical students] to type up the paper?

Teacher DK: I can’t, no I don’t do that…I don’t force them to do it. Um, I strongly, strongly urge it, though, because some of them can’t write [laugh]. They can’t use a pencil! I’ll almost require it, but I can’t, I won’t feel, I don’t feel too comfortable, forcing, counting off for not doing that.

Some of these teachers believed that this lack of ability was innate and some stated that the lack was due to circumstances; some, like, Teacher DK, attributed the lack to both.

MT: Why do you think the Tech kids can’t, aren’t performing, as well as the upper levels, in your opinion?
DK: One would be language barriers. Um, two may be, I’m finding out that more and more students living in single [parent] households and I’ve not actually correlated it, grades versus single [parent] households, but um, I’m thinking that when kids have a single parent that they are probably, and if they have siblings or something that they probably have to take care of them, although whether the fact [they are] helping to finance the needs of the family. So, that can be a problem and I imagine that is why a lot of, some of them are doing poorly in class. And then, of course, the third would be just, they are genetically or biologically just not as intelligent. That would be why. You know, it’s kind of a social implication, maybe some genetic, biological nature—versus nurture, sort of deal.

Teacher DV claimed that her Tech students have less experience with computers and was not sure if they really knew how to use computers as well as her CP students. “I think it’s because they don’t have exposure to it [the computer]. They haven’t been forced to do that [work with a computer], I guess.”

Teachers stated that because lower-track students had less ability in science, math, and computer literacy, they had to “dumb down” their activities to meet their needs. They were not able to handle the rigor of activities done by higher-track students. “And the Technical kids, I don’t think that most of them have the ability to perform at a high of a level as some of the College Prep kids…it’s like they can give you a lot of facts but they have trouble putting it all together and using it for an argument. So there’s a little bit different comprehension level, I think, between College Prep and Technical, as far as just their general science ability,” said Teacher HS. Teacher MRO stated, “They [College Prep students] have a better inherent native ability to do the work.” Teacher DA had the same belief. “And when you’ve got kids who are
really struggling and REALLY need it simplified, you end up—I really hate this term, but there’s nothing better—you end up ‘dumbing it down’. And when you do that, you lower the expectations. But how can you not when there are kids who need it, need it done that way…in order to meet their needs!”

Student learning styles

The second theme found in the teacher interviews was student learning styles. Several teachers noted that low-ability students usually had atypical learning styles. More ‘hands-on’, ‘visual’, and ‘artistic’, these students do not learn well from lecture and note-taking, as higher-level students could. In these classes, there had to be more activities in general (not necessarily computer-based) in which students used their senses to learn the content being presented. Labs, coloring worksheets, cutting/pasting activities—these were some of the ways teachers catered to what these teachers believed as students’ diverse learning styles.

DT: The Tech students are much less focused. Their attention span is just not as great as the College Prep students. You have to design the best approach with them in a lot of different things, you know, instead of eating all your lunch at one time—eat more times during the day, basically! They actually require a lot more hands-on and attention…because all their life they’ve…these kids, a lot of them come to high school without the basic skills they need to be successful…

However, Teacher GSH made it a point to state that she did not believe that Tech students’ atypical learning styles was indicative of their mental capabilities. She believed that certain students are “geared towards” lecture and other students need more stimulation in order to learn successfully.
GSH: I think that the College Prep kids can take an idea that you tell them and they can visualize it in their own minds. And a lot of the Technical students have to see it, and actually manipulate something in order to see that happening. Physically see something, hands-on do it. They have a very hard time reading a paragraph out of a book or listening to somebody say something and understanding the concept.

MT: And you think it’s because of…

GSH: learning styles…I mean, I don’t think that there’s any—I really don’t see an intellectual difference very much, but I do see a bit “I just don’t want to sit here and listen to you! [in the Technical students]” [laugh] So it’s just what they’re [the Technical students] interested in.

Teacher GSH herself was placed in the Technical track in high school after failing Algebra. These personal experiences have influenced her beliefs about Technical students. Her beliefs will be explained further in Section B of this review.

Two teachers of interest in this belief were Teacher DT and Teacher RMI. During the interview, while describing the disparate skills between Technical and College Prep students, both teachers reflected on the use of computers for their Technical students and came to the realization that, in describing the non-traditional learning styles of Technical students, computers might be of greater benefit to these students than CP students. Teacher DT said, “But I think the Tech…actually as I’m thinking about it [pause], you know, computer activities might do a better job with the Tech kids because of the hands-on, because they’re more visual [pause]. Hm [pause].” Teacher RMI echoed his sentiments; she too came to a realization about the applicability of computers to Technical students’ learning styles.
Student motivation

The third reason teachers gave for differentiating computer activities was student motivation. Teachers stated that Technical students have problems with motivation for academics. The most common examples given for this characteristic were the students’ inability to complete and turn in homework or behave in class.

DA: I guess Technical students are typically less interested, in general, in school period…I find that very few Technical students are interested at all in anything academic…They don’t want to do the work, they don’t want to have to think. They don’t think they’re ever going to use it, so why bother? “I’m not gonna need to work with negative numbers when I’m working on a job. So what difference does it make?”

MT: Do you think that is the root of their lack of motivation?

DA: I think that probably a large part of it, I don’t think you can pinpoint one thing that makes a Technical student a Technical student…They don’t want to, um, answer a question correctly because they don’t want their friends to think that they’re some smart, goody-two-shoes, you know? So they’ll make some smart-aleck little comment instead of giving you a correct answer even though you know they know the answer…I don’t see that as much in CP. And I don’t know why that is.

And Technical students’ lack of wanting to “do school”, or lack of academic motivation, influenced Teacher DA to modify computer assignments for her Technical classes. She adjusted the curriculum schedule so that all Technical level projects would be completed during class, under her supervision. This was to ensure that the project would be completed—otherwise, she feared that none of the Technical students would complete the project. Indeed, Teacher DA had a difficult time relating to this aspect of her Technical students. “I don’t remember [when I was
in high school] EVER, ANY of my friends, NOT turning in an assignment. It just, you didn’t do it. You didn’t NOT turn in an assignment…Oh, it drives me absolutely batty [that my Technical students do not turn in assignments]! But, you know, there’s nothing I can do.”

Teacher BI believed that the lack of motivation might be because Technical students have needs that are not being met.

BI: I think the lower level students have been turned off to education; it doesn’t do anything for them. The needs that the kids have in the lower level classes are so different AND they’re not being met. And those needs could be the fundamental Maslov type needs of comfort and love and security. If those aren’t met, then they don’t care about school. Or it could be that their need is more relationship based, where they always feel like an outcast in a class and so they have a rebellious attitude towards anything that tired to make them conform to the environment.

Student interests and life goals

The fourth justification provided by teachers for their curricular choices was that students in low-ability tracks had different interests and life goals than their counterparts. “These kids are not going to a 4-year college” was a common statement given by the teachers. They believed that these students were headed for industry, blue-collar jobs that allowed them to utilize their kinesthetic abilities, rather than their intellectual skills. For example, Teacher PB had the same educational goals for his CP students as his Tech students (to recognize Physics patterns in nature), but modified the depth at which these patterns were investigated in light of his students’ future career plans.

PB: …I don’t worry as much about those [Physics] patterns [in nature] with the Technical level kids, because these are the kids who are going to go off to maybe [a technical
college in Geoffrey County] and um, learn how to be, you know, auto repair technicians or electricians or maybe cosmetologists—that kind of thing. And so they don’t necessarily need to, basically learn about all the grand patterns of nature. But I try to make them familiar with as many that seem to fall out of the kind of labs that we do, OK? …With the Tech students, I go from application to, you know, “Hey, here’s the background info that we won’t get too far into.” And with the College Prep folks, I’ll go, “OK—let’s figure out how the system works. Let’s establish this theory, or these principles, and then see how they are immediately applicable in the world around us.”

MT: So it seems like their future goals kind of draws your decision on how to…

PB: Sure, sure. Which, I guess, would come down ultimately to track-level…I try to keep a “I’m going to give you what you need—these are basic skills that you’re going to need”. But I also try to put it in as meaningful and as entertaining of a context as possible.

Student ownership of a home computer

Finally, the fifth student characteristic cited for justification of activity differentiation was the students’ access to a home computer. This was the most common student characteristic cited in the teacher interviews. Out of the 21 teachers, 17 of them noted that student computer ownership was a factor in their planning of computer activities (Teachers AK, BI, DK, DT, DA, GSH, HT, HS, NM, RMI, RMY, PB, ST, SW, SC, WJ, and DV, who asked students as a class if any did not have access and made assignment accommodations accordingly). All these teachers believed that Technical students, as a group, did not have as much access to a home computer as CP students. Only one teacher, Teacher PB, had attempted to actually ascertain and document the number of students who had access to a home computer. At the beginning of the school year,
he gave the students a personal data sheet to fill out and on that sheet, he asked students to note whether they had a computer at home. “So that I can determine, so it doesn’t have to be, ‘Oh, Bobby doesn’t have a computer. Bad Bobby!’ and you don’t make it an embarrassing situation,” he said. Some teachers, like Teacher WJ and Teacher GSH, said that they would give an extension on assignments for students with no home computer. Others stated that they refrained from assigning too many computer-based activities to Technical level classes.

Teacher DT stated that if he knew more about computers, he would purposefully differentiate his computer activities because of student home computer ownership. “If I was computer literate I would see myself doing different activities with one group versus the other. More advanced [activities] with the College Preps…because, you know, particularly the kids that have computers at home, you know, there is a relationship between College Prep, family income possibly, and computer ownage.” Teacher HT noted that he would be more likely to assign activities that take longer than a class period if he knew that all students had access at home “…so we could do half a lesson here [at school] and they could finish it a home…So that requires them to go home, get BACK on the Internet, on their own, get back through the website to where they already were, and keep going. So that’s a big one for me now.”

Student computer ownership was a barrier to some teachers’ computer application in the classroom because of their concern for the students’ feelings. Like Teacher PB, Teacher DA was aware of the shame that might accompany a lack of computer ownership. “I wouldn’t do that [ask kids to look up a website at home] because you don’t know what kids have computers and which ones don’t and I wouldn’t want to put that kind of stigma on them because most kids are going to be very uncomfortable saying that they don’t have a computer, because that implies that they’re poor and can’t afford it.”
In contrast, Teacher MRO said specifically that home computer ownership has no impact on his planning of computer activities. “Well, as far as I’m concerned, all the students have access to the computers in the Media Center. Even if I knew that they all had computers at home or if I knew that 80% had computers at home, that wouldn’t be a factor [in my planning of computer activities]. Because I would assume that the 20% that don’t [have home computers], they can just go to the Media Center.” He was the only teacher out of the 21 who expressed this opinion.

These were the five main themes in student characteristics cited by the teachers. However, there were also additional justifications for the differentiation besides student characteristics. Indeed, teachers explained how student characteristics related to their activity differentiation. These additional reasons fell into two main areas: (1) to increase lower-track students’ grades (and/or to ensure completion of assignment) and (2) to control behavior (increase time-on-task).

To Increase Lower-Track Students’ Grades.

The first area was cited the most often. It was important to teachers that students understood the ‘main points’ of the activity and would usually take out the higher-level thinking portions of an activity to make sure that the lower-level parts were mastered adequately. Teachers oftentimes claimed that Technical students never do homework, due to lack of motivation, organizational skills, and parent influence. So, all assignments (computer and otherwise) had to be completed during class hours or else “…we would never see them again once they walked out the door!” (Teacher RMI). These additional ‘secondary’ explanations connected the method of differentiation with the teacher beliefs about students.
For example, Teacher DA stated that she was “dumbing it [curriculum] down” for Technical students “in order to meet their needs”. She repeatedly noted that if she did not design the class assignments to be completed during class time, then her Technical students would never turn it in. “And Tech kids are a lot less grade driven because most of them don’t care whether they pass or not,” she added. In her interview, Teacher DA described a situation in the fall when she assigned a cell project to both her CP and Tech Biology classes. For the CP class, the project was to be completed at home. However, she blocked off 5 instructional days for the Technical students to complete the project in class.

DA: And even then, maybe 50% of the kids won’t turn it in. And they’ve had FIVE days in class to work on them.

MT: Wait. But the students did the project in class…

DA: Yeah!

MT: Where did the projects go?

DA: It would be incomplete at the end of the week. It would be a blank piece of cardboard. Even if I’m over their shoulders saying “What are you doing? Why is there nothing on here?” “Oh, well, so and so left something at home.” “Well, you could be working on another part of it. Well, why do they have it at home? This is an in-class thing.” Well, they always have an excuse. There’s always some LAME excuse for why it’s not done. And it amazes me. They don’t do it. They DON’T do it. So, if they can’t even do a POSTER that’s done IN-CLASS, I KNOW they’re not going to do a project that’s as big as this photo essay project that requires as much work as a photo essay.

And so, she only assigned the photo essay computer assignment to her CP class that spring.
Teacher DK specifically changed his computer assignments to prevent Technical students from failing. “If they [Technical students] tried to write a paper [like CP students], it would hurt them too much on the grade, I think. I couldn’t grade them any easier on a paper, really. I’d, the grammar, the syntax, everything would be so poor that I wouldn’t be able to grade it very well, so I do make it a little bit simpler for them to write.”

To Control Behavior.

The other secondary explanation stated by teachers for their curricular choices was that differentiation helped control lower-track students’ behavior. Teachers hoped to increase students’ time-on-task by making assignments more visual and ‘hands-on’. The computer activities oftentimes included ‘fill-in-the-blank’ type worksheets and severely limited Internet searches so that students would stay focused on the assignment’s objectives. Teacher HS said, “Yeah, going behind them, walking—if they’re at the computers, we’ll walk behind them, make sure they’re ON the right site, they’re not goofing off—being off-task.”

In his computer lab activity on waves, Teacher PB had his CP Physics students use “slinkies” (a child’s toy comprised of a large, floppy metal coil) in the halls to collect data on wavelength and frequency and then input that data into a graphing program. However, for the Tech students’ lab, he purposefully substituted the slinkies with a machine called a “wave driver” so that he could monitor and control student behavior within the confines of his classroom.

PB: We [the Technical class] did all of these [CP] labs [capacitance and wave mechanics] in a slightly different format because the Technical kids, they have a hard time with slinkies in the hallways. It’s just a little too much for them to handle! It’s just a behavior thing, and I don’t want…you can imagine, you know. Four kids in the hall,
and then you’ve got six groups of these folks up and down the hallway: “WHOO HOO!” And calling out to other people walking down the hall, “Hey, homey! What’s up!” It’s just, the kids just get out of hand.

MT: Why is their [Tech students’] behavior different than CP students’ [behavior]?
PB: Um, I think, at this point, you have to understand, they’re [Tech students] juniors and seniors. And by this point, to a degree, they [Tech students] have been conditioned to almost, potentially, behave a little bit differently and a little bit more rambunctious than a College Prep class.

MT: Because of their [Tech students’] track?
PB: Um, yes. Yes. And I think, to a degree, they’re treated a little bit differently [because they are in the Technical track].

In summary, the 21 teachers gave five major reasons why they differentiated computer activities for their classes: (a) student ability (science, math, language, and/or computer), (b) student learning styles, (c) student motivation, (d) student interests and life goals, and (e) student ownership of a home computer. These teachers also explained how student characteristics related to their activity differentiation. These justifications fell into two main areas: (1) to increase lower-track students’ grades (and/or to ensure completion of assignment) and (2) to control behavior (increase time-on-task).

Section B: In-Depth Examination of Four Teachers and A Case Study of One Teacher On Their Beliefs about Students in Tracks: Effects on Computer Activity Differentiation

This section of the Results is divided into two parts. The first portion is an in-depth description of the salient beliefs found in the interview transcripts of four, purposefully chosen, teachers in this study. These four individuals were asked to participate in a second, follow-up
interview in order to better explicate and describe their beliefs about students and the relationship between these beliefs and their choices for computer activities. As the analysis progressed, it became apparent that the connection between teacher beliefs and computer activities was not always linear. Many factors appeared to play a role in how these teachers chose activities and modified them for different track levels. As well, their beliefs about students had direct implications for their planning of other activities and the class’ curriculum as a whole. Therefore, many of these interviews sometimes centered on activities in general and were not always exclusively about computer use in the science classroom.

Teacher DA was chosen because of her belief that the cognitive abilities of all her students, regardless of track, were comparable. Because this was inconsistent with other teachers’ claims that Tech students were not able to think abstractly or handle complex problem-solving tasks, I wanted to further explore which of her beliefs did play a role in her development of computer assignments. She had assigned the independent, integrative Photo Essay assignment to her CP Biology students and the Bacterial/Viral Report project to her Technical Biology students.

The largest “gap” between tracks was found in Teacher RMI’s classes. She taught Gifted/Honors Chemistry and Technical Chemistry. She was chosen for the second round interviews because of this large disparity between her classes. I was curious as to what beliefs about students predicated her choice of two computer simulations for the Gifted/Honors class, versus a “balancing chemical equations” tutorial and the Benzene report for her Tech class.

By far, the beliefs about students expressed by Teacher RMY were the most defined and stereotypical. She was chosen for another interview because her beliefs echoes those reported in past research on teacher beliefs about disadvantaged students. Also, she was eager to participate
in the study and volunteered for a second interview so she could further explain her views and
statements about students in different tracks.

And Teacher GSH was also a good choice for a second interview because she was one of
two teachers (Teacher PB was the other) who expressed that they made efforts to emphasize and
to raise the standards to which they held Technical students. Unlike her peers, she had positive
things to say about Technical students. Her own experiences in high school directly affected the
way she viewed the abilities of her Technical students and were worth exploring further.

Finally, Teacher PB was chosen for the case study portion of this study for two reasons.
First, he too was an outlier in terms of his beliefs about low-track students and therefore his
beliefs were used as a negative case analysis to further develop my interpretation of the teachers’
beliefs. Second, he was one of three teachers who had his students use the computer for inquiry-
based activities on a regular basis. This unusual emphasis on student-centered learning using
technology interested me and I wanted to know more about how he came to use computers in his
teaching practices.

Teacher DA

Teacher DA is a white female in her mid-20s who taught Technical Biology and CP
Biology. As a child, Teacher DA grew up around computers. Her parents owned a computer
business in Arkansas. She stated that she felt rather confident working with computers and
running them for particular tasks. At home, she owns three desktops and one laptop; she and her
husband have separate, personal computers. As a second year teacher, she was still in the early
stages of her teaching career and was not clear as to the role computers played in science
learning. She stated that computers are “science-based, in terms of technology”, but did not
clarify as to what science on which computers were based.
Growing up, Teacher DA was in the Gifted program at her school. She found school to be rather easy and always enjoyed math-based classes, such as Algebra and Chemistry. Her Bachelor’s degree was in Biology and she took only one computer course in her educational career: a course on programming in Basic. She said that she enjoyed teaching because students can get involved and respond to her teaching. She strove to get the “Aha!” from students; she felt successful when she could “see the light bulb come on” when kids understood a concept.

During her interview, Teacher DA frequently compared her students to herself when she was a high school student. This happened often when she spoke about student motivation. She noted that her students were not in the Gifted program and wondered aloud if perhaps the discrepancies she found between her past experiences as a student and the behavior observed in her students was due to this difference in track. To her, if a student is motivated and has parent involvement, then he/she has a good chance of being successful in science. She stated that when she started teaching, it came to her as a “shock” that students in general (unlike herself in high school) had little intrinsic motivation for school tasks. CP students were grade driven, but not inspired to put effort into learning for the sake of learning, according to Teacher DA.

As she spoke about student behavior and characteristics, she commonly used a mocking tone when describing unfavorable attributes and mimicked typical student comments with an exaggerated whiny or “dumb” tone. When asked to describe the “typical” Technical student, she stated that these students are mostly ESOL, have a lack of access to computers (because of their immigrant status), have equal computer abilities to CP, have less attention span, do not do homework, have low motivation, have no parent involvement in their education, and have low science skills. As well, she said that some Tech students are poor, which translated to no computer access at home. This then results in underdeveloped Internet searching skills. In the
classroom, she has noticed that Technical students are very unresponsive, unengaged, and difficult to motivate. The exception to this was ESOL students who are newly immigrated to the United States. These are her hardest working students and make teaching Technical classes bearable. Unlike their Technical peers, they strove for A’s and B’s. In her opinion, most Technical students are happy to be just barely passing the class. Their low grades are due to absences and failure to turn in assignments. She became very heated when discussing this student attribute. “It drove me absolutely batty!” It was difficult for her to understand why Tech students would not turn in homework. As a student, she and her peers made great efforts to ensure that homework was always turned it. It was unheard of, to not turn in homework. Tech students also typically do not see the applicability or relevance between science and their every day lives, even though she admitted that the emphasis of the Technical Biology course was life connections and applications. The official name of the course was listed as “Applied Biology” in the county course guide.

Teacher DA also described Tech students as highly influenced by peer pressure. Oftentimes, these students will give a “smart-aleck little comment instead of giving you a correct answer even though you know they know the answer.” In terms of learning style, she felt that Tech kids are not as concerned with finding the right answer and will be more willing to try things to see the outcome. “When kids get interested in the activity, I think, you typically see the Technical kids doing it more for the sake of doing the activity and getting what they can out of it.” She expressed confusion when asked whether low-track placement makes students have the aforementioned qualities or whether the fact that they have these qualities got them placed in the low track. However, she also said, “I don’t think you can pinpoint one thing that makes a Technical student a Technical student.”
In describing their appearances, she said, “More of my ‘sagging-pants boys’ are Technical, you know—the ones that have the crotch at the knees, kind of thing. Where they’re having to hold their pants up while they’re walking down the hall!” Technical female students are more risqué with their dress than CP female students. She stated that she does see the same types of dress in CP classes, but not to the extent in Tech classes. The difference is not so stark that she would be able to identify the track levels based on dress alone, however. More students in Tech classes tend to slouch in their seats. “Just laziness again, maybe! Slouch, head on the desk…”

When asked to describe some strengths of Technical students, Teacher DA replied, “It’s hard to pinpoint a strength because so much of Technical is PULLING everything out of them. They don’t give a whole lot. So it’s hard to see a strength.” In trying to explain this lack of motivation, she stated that it was not an intentional act on the part of the student. It was because of their past experiences of being tracked in low-ability classes. “Teachers have identified them as being slow learners or um, not as bright, or whatever, and…so they’ve (Technical students) have learned to NOT respond because they get the answer wrong and they get ridiculed…So they stop trying somewhere along the point. And it just continues. They never get out of that rut. ‘I’m not smart, so I can’t learn’.”

She claimed that CP students were usually lazy (but not as lazy as Tech students), not willing to put forth more effort than required to earn a satisfactory grade. The majority of CP students are grade-driven and this is the source of their efforts in class. “Your CP kids, I always hear kids talking about ‘Well, if I get an A, I get $10’ or whatever.” In her experience, these students tend to be more responsive and interactive with her in class; she noticed more “give-and-take” with her CP students. This was the biggest difference between CP and Tech classes,
she said. They have better science skills in that they are able to use metric rulers, do conversions, and understand more complex science concepts. CP parents are more involved with their children’s education and will emphasize education with their kids. CP students want to get the right answer. She even noted that when Tech students are engaged with a hands-on activity, they often get more out of the activity than CP students because Tech students are not as focused on grades and are able to experience the activity for the sake of the activity. CP students do better with lecture and hands-on activities as supplement, versus just hands-on like Tech students.

The choices that Teacher DA made for computer assignments did not fit with these expressed beliefs. Many times during her interviews, she commented on how student response drove her curricular choices. In describing her process of choosing lessons and activities to teach Biology, she stated that she focuses on getting students’ interest at the educational level appropriate to the learner. Her ideal computer activity would be a virtual fly lab that she had encountered before somewhere. It was ideal because she thought it was “cool”. As a student, she herself enjoyed the drosophilae fly lab in college and envisioned that her students would feel the same way about a simulation of the same lab activity. The ideal student that would respond best to her computer activities would be one who “typically gets excited about doing non-lecture type stuff. Kids who typically get excited about labs, get excited about doing hands-on stuff...those are the kids that you KNOW are going to really get something out of the computer activity.”

There were two computer activities assigned to the Technical classes and two computer activities to the CP classes. Teacher DA assigned an Internet Search activity (Bacterial/Virus Disease report), which entailed students looking up facts on a bacteria or virus and writing up
their findings, and a Sight versus Sound simulation (Information Dissemination), which had students testing their reflexes to sound stimuli on the website. The worksheet for this simulation was simplified for the Technical students. The CP Biology students were assigned the Photo Essay project (Inquiry), where the student had to locate and interview a professional in a career dealing with Biology and construct a photo essay depicting that person’s job. Also, they had the same Sight versus Sound simulation, but with a longer, more in-depth worksheet to fill out. The differentiation between the Bacteria/Virus project and the Photo Essay project was deemed a “Change Content” method of differentiation (because the Tech students were expected to report information and the CP students were expected to discover applicability to real life—differentiation of intended objectives). On the other hand, the differentiation of worksheets for the Sight versus Sound simulation was a “Change Activity” method. The reasoning for this coding was because the intended objectives were the same for both tracks, but Tech students had less work required of them. Therefore, the activity, rather than the goals, was the focus of the differentiation.

It was found that there was some congruence between Teacher DA’s beliefs about students in the Technical track and the ways she differentiated computers activities. Although she did note that Tech students do better with hands-on activities, she did not assign more computer activities to her Tech students. She does consider the computer a hands-on tool, so there is indication that her beliefs about Tech students keep her from assigning more computer activities to those students.

What was very apparent in her interview data was her emphasis on student motivation. She repeatedly commented on how, as a teacher, she struggled with the low motivation of her Tech students. She disliked how CP students were only motivated by grades. She defined a
good student as one who was motivated to learn for the sake of learning; however, none of her students fit this description. Given her background in the Gifted program as a teenager and her peer group in high school, it appears that her definition of appropriate student academic motivation was formed through her own experiences as a student. She herself was interested in learning and worked hard to master the material. Therefore, she assumed that her students would be of the same agenda—they too would naturally have intrinsic motivation for academic success.

Because she found her Technical students to be unlike her in this regard, she attributed this disparity to their lack of effort, or “laziness”. She believed that all students, in general, make the conscious choice to be motivated or not. However, Tech students have the additional influence of parents and peers; their choice to be passive in class stems from peer pressure to look “cool” and from parents who fail to model the value of education. “Parents are less involved, who don’t care about their kids’ education,” she said.

Interestingly, she noticed how one of her CP students became interested in the veterinary field because of the Photo Essay assignment (and ended up securing a summer job at the veterinary office he had interviewed), yet it never occurred to her that a Technical student might benefit from the same activity. What prevents her from seeing the potential of independent, creative activities like the Photo Essay assignment in Tech classes is her frustration with unreturned homework and tasks. To her, if Technical students can not be trusted to walk out of the classroom with a simple worksheet and to return it completed the next day, then how was she going to trust Tech students to locate a camera, make arrangements to interview a person, develop the photos, and take the time to put together the required portfolio—all outside of class time?
However, she did assign the Bacterial/Viral report (a “Computer as Tool” activity) and the Sight vs. Sound Reflex activity (an “Information Dissemination” activity) to the Tech students because she felt that engaging their interest was worthwhile. She measured her teaching efficacy by the amount of interest and affective responses of her students. This explains her incredible frustration with students who “sit like a bump on a log” and who give monosyllabic answers to her questions in class. These students are not effectively learning, by her standards, and therefore must not be motivated.

In summary, student motivation (and thus, student affective response to her teaching) was her measure of successful learning. Teacher DA withheld “cool” activities (and she defined “cool” as something that she would have enjoyed herself as a student) as a response to lack of motivation. Therefore, she uses her prior identity as a student as a way to understand and explain student behavior. Her reasons for differentiation are not based on student ability necessarily, but on student behavior. She believes that that behavior is mediated by parental influences, peer influences, and past educational experiences (although she is unclear as to how Technical students end up in the Technical track). Her attribution for student success is the student’s intrinsic motivation to be engaged and responsive, which in turn, is affected by home and environment.

Her extreme frustration with her Technical level students is manifested by the conflict between her expectations of how motivated her students should be and the level of motivation she observes in her students. This conflict is very confusing to her and she has not resolved it. This prevents her from assigning independent, creative projects to her Tech students because giving student-driven, exploratory activities to students who exhibit no motivation would serve to only exacerbate the situation. She does not see the computer as a way to motivate students,
but as a consequence for demonstrated student motivation. This is why she used the “Change Activity” and the “Change Content” methods of differentiation—because she believed that the Technical students could not handle the independent, inquiry nature of the Photo Essay assignment and would not finish the longer worksheet assigned to the CP level Sight versus Sound activity. These are also the reasons why she did not assign more computer activities to her Technical classes, in spite of her belief that Technical students do better with hands-on activities and that the computer is a hands-on tool. Student motivation is Teacher DA’s paramount reason for differentiation of computer activities for different track levels.

Teacher RMI stated in both interviews that the mental abilities of Tech students were comparable to those of Gifted students. However, Technical students work better with notes, worksheets, and creative, hands-on projects. She has noticed that they learn best from labs and other hands-on activities; she thinks it is because they need a manipulative aspect in order to comprehend the scientific concepts. She emphasized several times that Tech students need a lot of guidance and additional help, especially outside of class time (although they were not
consistent about showing up when scheduled). One example was with Internet searches; she said that some Tech students ask for her help outside of class. “I don’t know if that’s because they just didn’t want to do it themselves, if it was an apathy thing, or if it was that they needed help.” She was unable to just “let them [the Technical students] go” during class activities; she had to constantly walk around the room to help students during lab activities. She said that the science content taught to Tech students had to be more on lower levels of Bloom’s taxonomy.

So, why was there a difference in science content if the mental capabilities of both populations are equal? To Teacher RMI, Tech students were in the track that they were “not because of ability but because of apathy and a lot of College Prep students are where they are because, not because of ability but because of parent influence! [laugh]” Therefore, in general, she believed that science ability (not mental ability) and track-level were the same, unless outside circumstances had a greater influence on track placement. For example, if parents pressured the school enough, then their child would be placed in a higher track level.

Teacher RMI characterized Gifted students as more independent, not needing her assistance as much as Tech students. They were able to have more class discussions and do more math-related, abstract-type tasks. She felt that Gifted students could “soak up” information and were able to see, by themselves, the applications for the science content they learned. In class, they asked more questions than Tech students. She attributed these characteristics to the fact that many Gifted students have been in the Gifted track since elementary or middle school and therefore have been “well trained” to do well in academic settings. Also, having had the same academic peers for so many years as a result of being in the Gifted track allowed them to be more comfortable in taking risks and attempting problems. To her, these higher-track students seem to initiate themselves more and have no problems with searching the Internet.
Her main reason for differentiating computer activities was because “they [Gifted students] can handle it more without me having to walk them through every single thing.” Teacher RMI defined student learning as student independence. If students did not need her help, then that was indication that they were learning. For example, when asked to describe a particularly successful computer activity, she noted that the lab simulation with the Gifted students and the balancing equations tutorial for the Tech students were notable. “It furthered their understanding…we were able to do a lot more in a smaller amount of time.” Her definition of the ideal student for computer use was, “Self-motivated. I think self-motivated is just the most helpful because then, and just, frees me up a lot so I can make it around to every student that’s a needy student, then I’d be spending all my time with one kid and neglecting the others.” Thus, motivation results in successful learning, which then allows her to focus on unsuccessful students. This saves time, which seems to be very important to her, as she mentioned time efficiency several times in her two interviews.

So, time efficiency is a main focus for Teacher RMI. But there was another rationale to her activity differentiation than just concern for time. During the second interview, she admitted that she assigned computer activities to her Tech classes in order to “pad their grades”. When asked to explain her comment, she began to describe some more characteristics of Tech students. These attributes contributed to Tech students needing more attention and time from the teacher. During her second interview, Teacher RMI drew concept maps as a way to express her beliefs about these student attributes. These concept maps are depicted in Figure 6 and Figure 7.
Figure 6.
Teacher RMI’s concept map of Technical students’ characteristics. She drew connecting lines between several concepts to show that they related to one another and caused a “cycle” of effects for these students.

Through the lines drawn on her concept map, Teacher RMI showed that she believes that there is a cyclical situation with Tech students’ science learning. Technical students will not do homework or make-up work. This causes a situation where Teacher RMI must make accommodations for these students so they will not fail the class, due to these missing assignments. She stated that the reason behind their non-commitment to homework is lack of
Figure 7.
Teacher RMI’s concept map of G/H/AP students’ characteristics. In this case, she did not have any connecting lines depicting relationships between the concepts.

parent involvement. She feels that parents, due to their class and lack of education, do not encourage and teach their children to value education. This, in turn, leads students also to devalue education. She thinks that Tech students instead choose to focus on other life aspects, such as working to make money, drawing, and the arts. In her experience, she has noted that they are not involved with school-based extracurricular activities, unlike Gifted students. Therefore, according to her, they do not develop the skills to succeed with traditional tests, but instead put their energies into areas where they do feel successful, such as drawing and creating. That is why they do better with hands-on activities and projects.
Teacher RMI’s explanation for the Gifted students’ attributes were also based on parent involvement. She stated that because Gifted students’ parents tend to be of a higher SES and more educated, they pressure their children to do well in school. Thus, Gifted students develop the skills needed to be successful at education and find success in traditional tests and tasks. She noted that they ask many questions in class. When asked to do a creative project, she said that they tend to balk and are very uncomfortable. According to her, Gifted students’ success at school leads them to become involved with activities surrounding school, such as school government and sports teams. This involvement with school increases the students’ investment in education, which adds to their motivation. To her, they seem to “like” school and are very conscientious of grades. This concern, she stated, drives them to take extra measures to make sure they are rarely absent, thus rarely missing homework or assignments. This is in contrast to Technical students.

She seemed to contradict herself when trying to relate ability to tracking. Although she stated that the mental ability of Tech students was comparable to that of Gifted students, she did note a distinction between their science abilities. This difference in the students’ needs, she believes, is because of unequal ability and motivation, which is predicated on student choices on what to emphasize in their life. These choices are affected by parents and past successes. Parental support and a long history of quality teaching from Gifted teachers help high track students “soak up” lectures and succeed on traditional-type tests. Low track students lack parental support at home; as well, many of them work outside of school to support their families. Their choice to not emphasize education resulted in apathy in class and an inability to complete school assignments. This, in turn, affected their grades in class.
She also said that she would tend to do higher-level thinking activities with her Gifted students. “I look at the difficulty of it [the activity]. If it’s something that’s pretty easy, it’s just fun and engaging, then both [levels] can do it. If it’s something that requires that they have to think while they do it [laughs], I know that’s horrible! Yeah, I tend to [assign it to Gifted students].” This comment shows that she believes Gifted students are capable of thinking and succeeding at challenging tasks, but Technical students are not. But then during this reflection, Teacher RMI made a significant realization about the needs of her Tech students. “Actually [pause], it’d probably be better to do it the other way around because the Tech students really get into the computer, using the computers. So…hm…I’m just thinking while I’m talking! [laughs] Maybe I should do that! [nervous laugh].” This portion of her interview shows that she is unclear on how to best plan computer activities to suit the needs and skills of her students in both track levels. Although her first instinct is to challenge her Gifted students, she also believes that Technical students need more motivation and hands-on activities. The computer, in her mind, can provide educational challenges as well as entertain students.

Teacher RMI’s beliefs about student characteristics played a large role in her choice of activities for her classes. The students’ choices about what to emphasize in their lives and what to be motivated about set up a situation where Teacher RMI had to tailor the computer activities to fit those choices. Because she believed that Technical students chose not to be academically motivated, Teacher RMI thought that Technical students needed activities that were hands-on and completed solely at school. If these prerequisites were satisfied, then she was able to help “pad” their science grade. Therefore, she turned her attention to finding fun and engaging computer activities for this track level.
On the other hand, Teacher RMI believed that Gifted students did choose to emphasize education and therefore were motivated to put effort into school and school-related activities; as a by-product of this emphasis on performance, they disregarded the importance of creativity in academics. So for these students, Teacher RMI felt able to assign computer tasks to be completed outside of class and focused more of her energies on finding activities that bring out the students’ creative side.

Her disparate emphases for the two track levels are apparent in her computer activity planning. For her Gifted students, she had five computer activities. Two computer activities were laboratory experiment simulations projected in class and completed as a class (Information Dissemination). The two simulations were intended to get the Gifted students to think about different ways to solve the proposed problem and explore the virtual “laboratory” for solutions. As a class, they brainstormed about why certain solutes were used commercially for cold packs and why the freezing point of a solution drops after adding a solute. Through these “Bridging to Lab” modules, Teacher RMI tried to engage their curiosity and creativity in problem solving through these simulations. The other three computer activities assigned were homework assignments where the student had to look up concepts or phrases that pertained to the lab activity being done in class (Computer As Tool). These assignments show how Teacher RMI trusted her Gifted students to complete work independently, outside of class, and without her direct guidance.

For her Technical students, she gave four computer activities. One activity was using the projector and the computer to show an Internet site to the class (Information Dissemination). The second activity was for practice on balancing chemical equations; Teacher RMI projected a website that acted as a virtual tutor and had the students repeatedly attempt balancing problems
until they all were successful (Information Dissemination). The third activity was an Internet Search assignment, where the students had to look for information on benzene and write two paragraphs about their findings (Internet Search). Finally, Teacher RMI showed a PowerPoint presentation on nuclear energy that was authored by another teacher (Information Dissemination). This PowerPoint augmented her lecture and was coded an Information Dissemination activity. All four of these assignments were intended to get science content to the student and to interest the student through the medium of technology. All of the objectives for these activities could have been met without the use of a computer. Even for the balancing chemical equation tutorial, Teacher RMI admitted that the sole purpose of projecting it in class was to speed up the process of doling out practice problems to the students. It saved her the time of thinking up problems, writing and erasing, and repeating the process. The four activities were highly structured and controlled, allowing for very little student independence and exploration. Also, they were all completed during class time, with guidance from her. These activities show how Teacher RMI focused on making science more fun for her Technical students and on helping them raise their achievement in science.

Teacher RMI had the largest gap between track levels. However, she had the same definition of student success for both tracks, which was kids completing assigned work. She expected her Gifted students to be able to “run with it” and be more independent in their learning. Technical kids need more “hand-holding”. She differentiated assignments primarily because of this difference in teacher support. Freeing her up is a sign that the student is learning. If a student did not require her individualized attention, then that indicated that the student was successful in finishing the task independently. She could then move on to needy students.
Her concern about student independence might be indicative of how she views teaching. To her, there is a certain amount of content to be covered. There is only one of her to meet the educational needs of the whole class. The more needy the students are, the more time she must spend helping certain individuals. This takes away from the class’s learning. Therefore, she must choose activities that meet the capability and independence levels of her students.

But, when asked to create the ideal computer activity, barring any limitations, she was unable to describe a computer activity that was not teacher-centered—none were inquiry-based or involved independent critical thinking on the part of the student. So, meeting the needs of her students does not mean relinquishing control of the learning process. Her response to the interview question was to let students take digital photos of themselves during the tie-dye activity and make a PowerPoint presentation of the photos, or have the students work on a “Web Quest” (a preset number of websites purposefully chosen by the teacher for the students to explore in order to accomplish a certain objective). She noted that the PowerPoint presentation she was currently preparing at that time for use during the next school year would lead students through a series of websites to educate them on lab safety. Again, this was another “Information Dissemination” activity centered on the teacher. The computer, for Teacher RMI, was a teaching tool, not a learning tool. Therefore, the computer was not a necessary component to the learning of science in her classroom.

In summary, Teacher RMI’s beliefs about Technical and Gifted students affect her planning of activities. She believes that Technical students’ life choices creates a situation where they are unable to complete work outside of class and require a lot of guidance. Therefore, she plans highly structured, teacher-centered computer activities to be done completely during class time. They are meant to deliver content to the student. As well, she uses the computer as a way
to counteract their apathy towards academics and to engage their interest. The at-school assignments help their grades because they have so few completed grades, due to their absences. However, she believes that her Gifted students choose to focus on school and education, which results in a higher level of motivation and a lower emphasis on creativity. Thus, she attempts to assign activities that generate problem solving and creative thinking. Also, she trusts these students to complete computer assignments at home. These assignments are not as teacher-centered as the Technical level assignments. For both levels, student completion of assignments without support is her ultimate goal.

Teacher RMY

A mother of two, Teacher RMY is a white female who was in her 14th year of teaching. At the time of the study, she was teaching part-time in order to spend more time at home with her 7-year old daughter and 10-year old son. She has a Bachelor’s degree in Animal Science and in Agricultural Education. At home, she has access to three computers: a desktop, a laptop with a docking station, and her son’s personal desktop computer. She has taken several courses in technology, including a training course for the Apple IIe computer, for using databases, and for Microsoft Word and Works. As well, she has had experience creating online courses and teaching them through the high school.

The beliefs that Teacher RMY had about her students were quite defined. She was able to list student characteristics quickly and with authority. She stated that Technical students were of a lower SES than CP students. They come from single parent homes and have a hard time seeing the value of school. To her, they do not seem motivated about education and are not involved in extracurricular activities or clubs. The few Tech students that are motivated do have higher grades. She said that a lot of these students work outside of school or go home and “veg
out”. They are mostly interested in their paycheck to pay for needs, like car insurance. Her explanation for this was that parents of Tech students do not impose limits on work hours, so these students work a lot—sometimes too much. She noted that Technical students are of a different ethnic background, usually Hispanic or Middle Eastern (she made no mention of African Americans). This is of note, since Teacher RMY was the only teacher in this study who made any reference to the racial backgrounds of her students.

According to Teacher RMY, the parents of Technical students are usually blue-collar workers, mostly involved with construction. The future goals of Tech students are vocational occupations, such as using a specific piece of equipment or machinery. She complained that these students never do school work outside of class time, which is a sign of their low motivation. As well, she claimed that their mental abilities are lower than that of CP students, which is why they are in the Technical track. She said that they are not able to do math as well, think abstractly as well, and think comprehensively as well, especially upper level thinking skills. They cannot take what they have learned and see how it applies to them in their lives.

However, Teacher RMY’s description of CP students was in complete contradiction to her description of Technical students in every way. She said that CP students were of a higher SES, coming from two-parent homes. She believed that they value education, at least for the sake of grades. They are involved with school-related activities and teams. Usually, the motivation to get good grades is what drives them to do their homework. In her teaching experience, she has noticed that there are fewer minorities in CP classes and the parents of CP students are usually white-collar workers who have gone to college. Either a 4-year college or technical school is in the future of these students. She is of the belief that CP students are more easily “molded” than Tech students.
She stated in her interview that all of these student characteristics have two origins: home and student choice. Teacher RMY believed that a student’s identity and a student’s attitude towards school both are artifacts of parental values and actions. As well, Tech students did not fulfill their whole potential because of their own choice. According to her, Technical students choose to not do the work or emphasize education. These choices are driven by parental influences. She added that there is a subset of Tech students who are as capable of mastering the content as Gifted students and who even started out in elementary school in the Gifted program, but have “burnt out” along the way. She did not elaborate further on their burn out and their loss of interest in school.

She called the Tech classes “non-achieving classes” and noted that the educational system makes an effort to divide the students according to ability.

RMY: They try not to schedule a very capable person for a non-achieving class. We refuse, we don’t put an upper-level kid, who’s capable of doing great work, we don’t put him in Technical levels unless the child who basically messes up because if they’re in Technical, they become a behavior problem more than anything else. At least if they’re in College Prep or Honors/Gifted, then it’s kind of like it’s on their own head. They won’t act up as bad.

Because of this division of ability levels, she stated that she has different expectations for her students. She expects more engagement and more effort from her CP students. She also expects them to be more proficient with computers. “If you don’t know how to do it [work with a computer], you need to learn now.” Because of the future goals of CP students, she wants them to be able to see the applications of chemistry in every day life. They need to know Chemistry for college. However, she said that she has a hard time seeing a purpose to teaching Chemistry
to Technical students. She feels that she does not understand how learning Chemistry will help them find a job. Chemistry could make them more aware of their environment and their surroundings, but she thinks that there is no further benefit to the Technical level student from learning Chemistry.

The conflict for Teacher RMY was that she was bound to teach county designated science curriculum. Although this curriculum fit the needs of her CP students, it was irrelevant to her Tech kids. So the science learning goals she had for the two tracks of students were different. CP students needed to learn critical thinking skills and content. If they showed motivation and had a learner’s attitude, that signified that they were thinking, which was successful student learning. Tech students, on the other hand, needed to do well in the class so they could move to the next grade level. Their lower mental abilities was the reason why they were in the Technical track in the first place, so she did not deem it necessary to teach them how to think abstractly or to apply learned knowledge to their everyday lives. They would not be able to accomplish these objectives.

The computer activities assigned to the different tracks bespeak of these disparate expectations Teacher RMY had for her students. For her CP Chemistry class, she assigned three computer activities. The first was the Polymer Project, where the students had to look up information on chemical tests on polymers, using websites provided by Teacher RMY. The second activity was for extra credit; students looked up topics relevant to content being taught in class for 20 extra points. The third activity was the Air Report, where the students put together a presentation and display conveying the importance of the chemistry of air and how it relates to everyday life. For these three computer activities, the students were expected to complete most of the work at home.
On the other hand, her Technical students also had three computer activities, but two of them were different than the ones assigned in the CP class. The Tech students also completed the same Polymer Project as the CP students without modifications. The extra credit activity was offered to the students, but Teacher RMY stated that she did not actively promote the activity. For the Air Project, the Technical students were asked to design and construct a children’s book on the chemistry of air as a review of the topics to be covered on the final exam. She planned the activity so that the whole project could be completed during class time, but some students chose to complete portions at home.

Her disparate expectations for her two track levels are exhibited in her computer activity differentiation. The CP level Air Report required some independence and transfer thinking on the student’s part. The CP Air Project was student-centered in that the student was responsible for discovering the scientific applications of the material. He/she had to find out the significance of air and how it applied to them. This involved some higher-order thinking skills and reflection on the part of the CP students. On the other hand, for the Air Project Teacher RMY expected the Tech students to report what they found on the website she had designated for them to explore. There was no intention of giving the student any independence or input into the science learning. Teacher RMY controlled what the student learned by limiting the content of the children’s book to concepts that were to be reviewed for the final exam. The only aspect that was unique to the student was the artwork and book creativity, which was not a science-based objective.

Because Teacher RMY expects her CP students to more academically capable, more engaged, and more independent, she planned the Air Report to be more reflective and “real life” based. The activity required more student motivation and effort. However, the Technical level children’s book on air was not reflective or “real life” based. It was a simple “regurgitation” of
disseminated information and the activity was meant as a “fun” project to help keep the Technical students’ interest during the stressful, distracting, end of the year. She did not plan the activity so that the Technical students would discover the life applications of air chemistry or realize the relationships between the science they were learning and their future goals. This, however, was the intent of the Air Report for the CP students.

In summary, Teacher RMY planned her computer assignments in ways that represented her beliefs about students’ academic abilities and future plans. Strongly influenced by parents and their own perceptions of the world, student’s choices about what to emphasize and focus on in their life were the main influences on Teacher RMY’s intended objectives of her computer activities. Her expectations of student science achievement were affected by the students’ track level and by her beliefs about their characteristics (such as home life, outside school activities, and cognitive abilities). Of the five teachers who participated in second-round interviews, Teacher RMY had the most salient and dichotomous beliefs about the students in the two track levels she taught.

Teacher GSH

In her third year teaching, Teacher GSH was a white female in her late 20s. She had a Bachelor’s degree in Science Education and specialized in Chemistry. At home, she had one desktop computer and has had extensive coursework with computers. Among them were workshops on Microsoft Word, Windows, Microsoft Excel, and PageMaker, all 2-3 day sessions taken at a local computer-training center. She also took programming courses in college (Fortran, Cobal, and ADA—a computer language used by the military).

Early in her first interview, Teacher GSH expressed strong favoritism for her Technical students, which was unusual for the teachers of this study. She believes that Tech students have
the same mental capabilities as all other students and are able to accomplish the same goals. The factor that separated Tech students from their peers was the fact that they have diverse learning styles unlike those of average students. She thinks they learn in a different way and approach their surroundings with an atypical outlook. Sometimes, they are deficient in one area (such as math), but are quite capable in all other educational arenas. Teacher GSH said several times that Tech students learn best with hands-on experiences and do not take well to traditional, lecture-based instruction.

Although most Tech students are lacking in one area, she feels that they have many strengths. They are very dedicated and have purpose to their lives. “They’re not wish-washy, usually.” She laughed when she stated that sometimes the direction of their dedication is with the teacher and sometimes it is against the teacher; either way, Tech students have strong personalities and are motivated about things that matter to them. To her, they seem incredibly social and enjoy interacting with peers and others. She admits that this gets them into trouble sometimes, but said vehemently, “And again, it’s not a bad thing! It’s a good character trait. It’s just that it doesn’t always [laugh] fit with what you’re trying to do! [laugh]”

Teacher GSH noted that Tech students have less exposure and knowledge about computers. They lose interest quickly during lecture-type classes. These students are more successful with active, “get out of their seats”-type classes. She feels that they need to “manipulate things” in order to understand scientific concepts and need more “stimulation” to stay interested in class. If they lose interest, they tend to drop out of school—and she tries to prevent this from happening. She commented that there are a wide variety of ability levels in Tech classes, but for the most part, they all are talented in some area. They usually are lacking
math skills and reading skills, due to falling behind over the years of being in the Technical track.

When asked to describe the demographics of her Tech students, she was conflicted in her beliefs on this topic. “I’ve got not only a variety of nationalities, but a variety of socio-economic levels [in Tech]. Um, I hate to say this—some of them may be of lower economic background, because I really don’t think that, I don’t know if that’s true or not! [laugh] But that’s what—I think that’s what people try and make you believe.” She seemed uncomfortable making that statement. She added that many Technical students work outside of school to support their family, whereas CP students work to spend money at the mall. She said that the average Tech student tends not to value education as much as CP students, which she thinks is due to a lack of role models and parents accepting mediocrity. “Kids say, ‘My parents didn’t pass math and they said it was OK for me to fail math.’ But math is NOT genetic!”

Teacher GSH expressed concern about the tracking system. She said that she would do away with tracking if she could. She does not see any benefit to tracking for students. In fact, she feels that the negative experiences that Technical students have in school are the main reason why they end up in that track level. They misbehave when they are treated as “lacking” in some area and this behavior gets them placed in the Technical track. “It just crushes their egos.” Several times in both interviews, she expressed concern for the self-images of her Tech students. She noted that the confidence levels of her Technical students increased when she trusted them enough to allow them to use Bunsen Burners for the first time in lab. “Other teachers told me not to, that they [the Technical students] would burn the school down.” She added that she had the best behavior from her Tech classes on days when she used more “advanced” chemical equipment with them in lab.
Teacher GSH stated that CP students are “geared towards lecture. They can take an idea and simply visualize it in their minds”. They do not require kinesthetic activities, unlike Technical students. She said that the Internet search skills of CP students are more developed because they have been exposed to the computer more. This may be because their parents have used computers. Even if CP students are bored with school, dropping out of high school is not an option for them. According to her, parents of CP students have invested much energy and interest in their child’s education and started to motivate their child towards college early. This is the main reason why CP students make it into that track. “If they [students] don’t have the pressure to graduate and go to college, they’re not going to [graduate and go to college].”

For Teacher GSH, the purpose of computers in science education was for entertainment. The computer keeps students interested in the class. She wanted to help them develop search skills and be able to find websites that offer tutorials and individualized aid for learning, especially for non-English speaking students. She stated that she incorporated computers into her curriculum so that students would be exposed to technology and then the students would realize its potential for learning. Gaining students’ interest and making the class “fun” for students were her main goals in teaching.

However, because of the particular learning needs of Tech students, she felt that computers also had the potential to capture the interest of Tech students more than that of CP students, which was an important aspect for her. When there was student excitement, she believed that students were learning. In fact, her own exhilaration at student excitement was apparent when she recounted an incident of a Tech student finally being successful with calculating moles of a substance.
GSH: When they [the Tech students] get to some of the mole problems and the harder math levels, they will work for hours. And I’ll just work with them after school and they’ll come in at lunch—they’re VERY dedicated, once they try and get it. And once they get it…I’ve had different students jump up, out of their seats, in the middle of class, and run, physically! Around the room screaming “I got it! I got it!” And then start trying to teach everybody else! So, when they get it, that’s just the best feeling [for a teacher]! ‘Cause that makes everything else, “This kid’s been giving a headache for three weeks straight!” But, it’s worth it…So, but they get so excited once they’ve figured out, and then I think that builds them, ‘cause you just see their grades go up.

The concern Teacher GSH had for her Tech students had its origins in her own experiences as a high school student. Growing up, she had always been a good student who was successful in all her classes. However, in algebra class, she was unable to grasp the concept of variables. She recounted how her math teacher did not stop long enough during class to help Teacher GSH clear up the misconception. Thus, the problem worsened as the course progressed and later math topics built upon the misconception. She ended up failing algebra and had to retake the course the next year.

As a result of her course failure, she was placed in the Technical math level. She remembered how other students made her feel stupid because of her class placement. Throughout the rest of her high school career, she was enrolled in the Technical track for math. However, she was allowed to enroll in higher tracks for other academic subjects. As an example of how capable she was, she said that during her senior year, she was enrolled concurrently in AP Psychology and Technical Senior Math (an applied math course geared towards non-science, non-math majors). She also pointed out that she became a Chemistry teacher, which is further
proof that she was not “dumb”. Sometime in her educational career, she finally was able to grasp the concept of the algebraic variable and has had no other problems with math since.

She stated that she understood what it was like to be in the Technical track. She believed that those teachers who have never taken a Technical course as a student are unaware of the social stigma that is associated with that track level. Because she is able to empathize with her Tech students on their experiences as students, she said she makes it a point in her teaching to look out for their individual needs and cater to them. Even though she has noticed that Technical level students might need more concrete teaching practices, she thinks their retention of science concepts is a lot deeper than that of CP level students. She said that she teaches the same science concepts to both tracks at the same pace, but utilizes different techniques and methods with the Tech kids. As well, she takes out the complicated math and reading to adjust for their lack of ability in these areas. She smiled when she said that likes teaching to students who “goof off and play”. They are the ones who respond to her with the most passion and enthusiasm, and that makes her feel good about her teaching.

The computer activities assigned by Teacher GSH reflect her concern for her Technical level students’ affect and motivation. Although she only had one computer activity for that track level, she devoted much class time and personal effort on the one Bacteria Project. The Technical students were given one day in the Media Center to search the Internet on information about an assigned bacterium. Then the classes spent two days in the computer lab learning how to use and designing their presentation on PowerPoint, in groups of two. Teacher GSH spent a week collaborating with the school’s technology staff, trying to work out ways to upload her students’ presentations onto the school’s server so her Technical students could display their work in class to their peers through Teacher GSH’s classroom computer. She said it was
important to her that the students could share their projects with each other to increase student motivation and pride. Due to the extensive class time devoted to the project, she counted the assignment as five daily assignment grades.

For her CP Chemistry classes, Teacher GSH had three computer activities. Twice during spring semester, she used the computer and an overhead projector to display examples of certain chemistry concepts from a CD Rom. And she showed her class a PowerPoint presentation that she had authored on the chemistry of nuclear power as part of a lecture. For both track levels, she also maintained a personal website that listed homework assignments, photos of her students during lab activities, links to helpful websites, and class notes that could be printed out in lieu of students copying them by hand during class.

Although she had more computer activities in her CP level classes than her Technical level classes (differentiation method “Amount”), she had more personal investment in the Technical level computer assignment. She had similar beliefs about Technical students as other teachers, but because of past experiences, couched those beliefs in an alternate light. These characteristics were viewed as teaching challenges to be surmounted, not student excuses for failure. Teacher GSH believed that, in general, Tech students have been dealt with unfairly by the educational system because of their inability to fit the “ideal student” mold. She understood that the student characteristics unique to the Technical track level were to be appreciated, not critiqued. Therefore, she purposely emphasized computer use for her Tech students as a way to compensate them for the shortcomings they have been subjected to through their placement in the Technical track. She said, “I try to push them a lot further.”

Her definition of successful student learning is increased student interest. Student interest is affected by student self-confidence, which in turn is impacted by student learning
styles and behavior (inherent in the student). These factors determine the educational experiences they receive at school. She caters to student interests, because of student learning styles. Some home and environment beliefs also affect student learning style and life choices.

This concern for students’ interest was manifested in the ways she incorporated computers into her science teaching. For her CP classes, the computer was used to project examples of science concepts in class in order to increase interest in the lecture. The PowerPoint she developed on nuclear power had many images and sound effects, which her students enjoyed. However, the main objective of these computer activities was information dissemination. They were not intended as opportunities for independent student exploration or creativity. As well, the CP class website had digital photos of the students themselves during lab activities; these photos increased the number of students who accessed the website.

For the Tech classes, however, Teacher GSH spent a lot of class and personal time making sure the students learned how to use PowerPoint and were successful in displaying their Internet researched facts about bacteria. When asked why she spent so much time on the Technical level Bacteria project, Teacher GSH stated that the Tech students needed the exposure to technology, which would otherwise not have happened in other classes. She stated that the Technical track rarely integrates computer use into the school curriculum. She intended the Bacteria project to help keep the Technical kids interested and focused on learning about science. She said that she wanted the students to develop search skills, while expressing their creativity through the PowerPoint presentations. This was an important teaching objective for her.

A look into her experiences as a student herself affords some indication as to why she is so concerned about student interest. She was put into the Tech track in high school because she did not do well as a student in algebra. The ignominy of being in Tech impacted her beliefs
about Tech students, which in turn affects how she teaches Tech students today. Having been labeled as Technical herself, she probably identified with her Technical students. Thus, she took it upon herself to add to the educational experiences of these students by incorporating computers and thus compensating for the lack of engaging activities in other, traditionally taught Technical classes.

What is of note, however, is that Teacher GSH described some of the same Technical level student characteristics as the other teachers. So, at first, it was confusing how she could have similar negative beliefs about Tech students but have a positive attitude (beliefs with an affective component) towards these same students. Her comments on Tech students’ SES provided some insight into this paradox. She stated that Tech students were of a lower socio-economic background, but kept deferring the statement as her own belief. She said, “I think that’s what people try and make you believe.” It seems that she has formed ideas about Tech students that are stereotypically negative. However, in her understandings of students, she has changed these beliefs into student aspects that are positive, thus maintaining the same belief but giving them a less disparaging effect.

In summary, Teacher GSH uses the computer as a way to increase student interest in science, which leads to greater student confidence in academics. Like her colleagues, she holds the same beliefs about Technical student characteristics, but couches these beliefs in a different light. Her own experiences in the Technical track as a student adds a unique affective component to her beliefs about Technical students, so she plans computer activities in ways that compensates for the lack of computer use in the Technical track curriculum. She does have a greater number of computer activities for her CP level students, but they were used primarily as ways to transmit science content to students while also increasing student interest through the
unique medium. The way in which she planned the Technical level computer activity bespeaks to her overall concern for the affective and educational needs of those students.

Teacher PB

Personal History.

A 29-year old white male, Teacher PB has taught high school Physics for 5 years. He earned his Bachelor’s degree in Geology and his Master’s degrees in Science Education and in Earth Science from Vanderbilt University. At home, he owns one desktop computer. He has obtained his technology certification from Geoffrey County (a course that trains teachers to use technology in their classroom) and had taken two technology classes during his undergraduate career. The use of technology was promoted and emphasized at Vanderbilt and students used computers extensively in all courses. As well, he has taken the requisite technology classes necessary for teacher licensure in the state.

Teacher PB grew up in a family that was very supportive but demanding. Education was a paramount value to his parents and was instilled in him at an early age. Indeed, his mother had only received one final grade of ‘B’ her whole life. “I knew that there was a ‘bar’ that needed to be, to be jumped over, a standard that kind of needed to be met, from what my parents’ expected. And they KNEW that I was capable of it, so the weren’t going to accept anything less.” These parental expectations impacted his beliefs about students; these will be explained later in this chapter.

Educational History.

Teacher PB found elementary school to be relatively easy. In high school, he took AP and Honors courses. He admitted that he was not particularly math gifted; he never took Calculus in high school. He remembered vividly certain late nights during his teen years when
he would stay up and ask his father for more practice math problems. Because of his struggles with math, he now takes extra time during his teaching to understand the Physics calculations before presenting them to his students. He played soccer in high school and in college. He became involved with activities, such as rock climbing, in college.

He said that as a high school student, his behavior in class was a challenge to his teachers. “I wasn’t a saint in the classroom, which I think sometimes helps me deal with some of the riff-raff that goes on [in my classroom].” He had authority issues as a student in that if the teacher did not earn his respect with their knowledge and skill as a teacher, then he “wrote them off”. He would disrupt classmates and challenge the teacher during lectures. One example he gave was his junior year of Algebra II. The teacher had always previously taught Pre-Algebra but that particular year was forced to teach this course instead. While the teacher was reprimanding him for his unacceptable behavior, he “basically told her to get out of [his] face, with a few extra words kind of tossed in there. And that gave me a couple day holiday and I had a little bit of a lesson there!” Even as a teacher, he finds it hard to respect fellow educators unless they are able to “show that they know what they’re doing”. His only concern with this viewpoint was that he needed to work on using more tact when expressing this view of others.

The two best teachers of his educational career were Mrs. Warren (who taught him AP English during senior year) and Mr. Freeman (who taught him English honors during junior year). He could tell they were good because they were extremely excited about what they were teaching. They were able to convince him that English was important to learn and to think about through their presentation of the content. Both teachers were open to alternative views and held high expectations of all their students. They were willing to help students along the way towards these expectations, as well. In their comments about student writing, they were honest because
they knew that students would learn better from that honesty. Being in their classes helped Teacher PB become a better writer than 90% of his peers in high school, which aided him during his college career.

Of note is the fact that Teacher PB said that his worst teacher was his Chemistry teacher. Science learning was comprised of only four lab experiments over the whole year, with students standing around confused and attempting to fill out a “meaningless worksheet full of blanks”. He said that he frequently relates his experiences with this teacher to his present students with the hope that they may appreciate how much better their science experience is in his class.

During his third interview, while describing these three teachers, he realized that his teaching style and philosophy mimics those of Mrs. Warren and Mr. Freeman. He stated that he does not consciously think of them when he teaches, but he unconsciously models his teaching towards theirs because to him, they were good teachers.

PB: They weren’t incredible classroom managers and I’m not the best either, in terms of my classroom management. Um, but things flowed really well in their classrooms. And Physics is one of those things that usually where I tend to teach it, it’s real important to have one idea build on the next very, very logically. I spend a lot of time making and planning and tweaking and thinking, “OK, in what order do I want to ask these questions so that we undo all the misconceptions in the right way and don’t introduce any new ones?” And I actually remember that their classes and their sequencing of ideas always made a lot of sense and was very natural, very logical, very easy to come to conclusions. They built things up very, very well.

In his free time, Teacher PB runs, rock climbs, hikes, reads non-fiction (he never reads any fiction), and plays with his dog, Higgs (named after the subatomic particles), who is a
constant companion on his outdoor trips. He enjoys challenging himself with practicing mathematical derivatives and reading material that helps add context to the topics he teaches in class. It is very important to him that he makes it to the gym 2 to 3 times a week and that he stays in good physical shape. It is important to him, he said, to keep a well-rounded life. However, his extracurricular activities come after planning for his classes. He noted that he is expected to show up at work prepared to teach students every day and that is his most imperative responsibility, even more so than his own needs sometimes. Only for lesson planning would he skip a session at the gym or forego a climbing trip.

He entered Vanderbilt University with the intent of majoring in English and Classics. However, during his freshman year, he received his first C+ grade in a writing class, his lowest ever during his stay at Vanderbilt. That grade hurt his confidence in his writing abilities, so he enrolled in a Comparative Literature class the next semester to test his writing abilities. He received an ‘A’ this time, restoring his faith in his talents. But the C+ incident forced him to consider other areas of interest. Serendipitously, he enrolled in a Geology class because he always had enjoyed spending time outside. And then he knew, “This is it! This is me.” Because the Geology Department was small, he was able to get more individualized attention and was active in independent Geology research by his junior year in college. He was awarded one of 30 Vanderbilt Summer Undergraduate Research Program scholarships to travel to Nevada for one week of fieldwork and for a work experience at a geochemistry facility at USGS in California for two weeks. The required national convention at the end of the summer afforded him the opportunity to share his findings with other students and faculty, “surrounded by really brilliant people”. He ended that amazing summer with a month trip traveling all over the western United
States, climbing and observing incredible geology all over. “I realized, yeah, I’d picked the right thing to do. And so then my senior year was just, ah! Just blossomed! Just took off.”

**Teaching Career.**

His career change from Geology to teaching was also opportune. He was not interested in working as a technician, so when he graduated, he took a job framing houses for a few months. During this time, his plans to attend graduate school to study glaciology were foiled, due to funding cuts and he was financially unable to continue his education. He said that at this time he spent some time reflecting on his life. “OK, why do you like Geology and Geophysics and rocks and glaciers so much?” He then got a job teaching classes at his climbing gym. He took on the responsibility of designing the curriculum for the introductory classes. Realizing that teaching was “fun and cool”, he said that he came up with the idea of combining his passion of being outside with Physics and Geology and teaching.

An opportunity came up to return to Vanderbilt for their Master’s/Teacher Certification program in Science Education. He got a partial scholarship for the program and completed the program in 13 months. What brought him to teaching, then, was his “enjoyment of knowing how things work”. During his student teaching, he was paired with a teacher who was one of the authors of the National Science Standards. She, along with his other Teacher Education instructors at Vanderbilt introduced him to the ideas of inquiry, problem-based learning, and constructivist thought. Because these concepts made sense to him and aligned with the teaching practices of what a good teacher should be, he adopted them into his own teaching style.

MT: So what drives you to do so well at teaching?

PB: It’s because of the folks that I dealt with at Vanderbilt. I mean, like I said, they threw down the gauntlet and said, “THIS is what is supposed to be going on!” If you’re
going to make a difference, I mean, if you’re really going to really turn these kids into folks who can think for themselves and you can throw out the ‘lifelong learner’ [educational term] and all the snazzy language, but there’s a lot of truth to that. And if you’re going to make that happen, there ARE some very specific ways and things that you should try to do to make that happen. And so, what I try to do is that I try to look at what I’m expected to teach and um, come up with the most clever and meaningful way to be able to get that out there.

**Introduction to Graphical Analysis program.**

During his work with his cooperating teacher, she had received a $65,000 grant to open up a new computer lab associated with her Physics class. It was one of Teacher PB’s responsibilities to open up all these boxes from Vernier Software and Pasco and to put the hardware and software together. One of the items he ran across was a program called Graphical Analysis (Vernier, 2003). He said that when he later came to work at Bayley High School, he recognized the same program being used by the other three Physics teachers. He was curious as to how the software was being implemented in Physics education and started reading research literature on the program. He observed how it was implemented in different classes and eventually developed his own way of using the program. It was incredibly important to him that he not “copy other teachers”, but that rather he develop his own activities and methods of using Graphical Analysis. He said that he finds it irritating when new teachers are unable to create their own teaching material and are solely dependent on their peers for that.

PB: I would poke my head in [to Teacher SW’s classroom] and say, “Can you use Graphical Analysis for this?” He’d say, “YEAH! Let me show you how!” or he would say, “Yes, certainly you can.” And so, I took both [responses] and was willing to go and
figure it out. I would take as much as he would tell me, but I wasn’t going to let him just, “Here, here’s how to do it”…So, my first year, I didn’t get any help—I made up all the stuff on my own and I was completely motivated to do that, not a problem. So whenever I would go to Teacher SW for help, or anyone for help, I’d always come in saying, “Here’s what I’ve done. Here’s what I want to do. What do you have?”…But I see a lot of folks walking around [this school] without much to offer. And I don’t want to be in that case.

During his second year teaching at Bayley High School, he was committed to using the “Modeling Method” of teaching Physics that was the basis for the Graphical Analysis program. This method entails using student-collected data on physical phenomena to create equations and models that approximate the phenomena. Those models then are used to teach relationships between components in nature. The Modeling Method incorporates inquiry, problem-based learning, and constructivist student thinking, which were integral to Teacher PB’s beliefs about what constitutes good teaching and learning. However, this second year was also his first year teaching the “Principles of Technology” course (“PT” course), the Tech level for Physics. He said that he did not feel confident with the behavior of those students. “I don’t want these kids playing with the computers!”

So, he “cooked up a lab” on torque, which happened to be his first original lab using Graphical Analysis. However, he had the students use a graphing calculator to find the hyperbolic graph of the best-fit line instead of using the computers. “Well, it basically turned my 3-day lab with College Prep [students]…into a 5-day, graphing-by-hand nightmare [for the Technical classes].” This early experience with Graphical Analysis helped him realize that if he truly believed that Modeling Method of teaching science was a worthy teaching technique, then
it was worthy enough for him to overcome his hesitancy of letting the Technical students use computers, for the sake of convenience and time constraints.

About this time in his teaching career, an announcement came out in the school that there was a number of old Apple computers being discarded, due to the age. Any teacher willing to move them was allowed to claim them for their classroom use. Teachers BI, SW, and PB went and took every computer back to their classrooms and set them up for use with the Graphical Analysis program, exclusively. Teacher PB obtained six computers and two printers for his room. There were no Internet connections in their rooms at that time. Thus, these teachers were able to put a computer into the hands of every two to three students on a daily basis, if needed, without the hassle of scheduling the Media Center and of wasting time traveling back and forth to the Media Center.

**Development of Graphical Analysis-Based Labs.**

Teacher PB stated that he derives great joy in using Graphical Analysis to teach his students about Physics. He thinks that the program lends itself well to physical patterns that can be modeled with a three-variable equation and the interface of the program is very user-friendly for the students, regardless of their computer ability. As well, the program allows students to manipulate the data in a variety of ways, thus enabling them to explore how the data relate to each other.

As Teacher PB examines the content to be covered in his classes, he said that he looks for relationships that fit a three-variable equation. He then develops a lab activity for the students to collect data on two of those variables. “If you’re thoughtful enough, you can look in a book and find a system and say, ‘OK. I can design an activity so students will come to this point.’ And so, in other words, my way is to figure out [out to develop a Graphical Analysis lab activity] is,
‘OK, how are my students going to come up with torque is force times lever arm?’ And that makes teaching fun.” He enjoys the challenge and creativity of producing these activities, using what he knows about Physics.

**Beliefs about Science and Teaching.**

Teacher PB repeatedly expressed his excitement about recognizing and understanding natural phenomena and patterns in the environment around him. To him, the purpose of science is to discover “neat” things in the world and appreciate them for their “neatness”. Developing an understanding about these events leads to that appreciation for their existence. That appreciation serves as motivation for further exploration and discovery.

Another benefit to looking at the world, he said, is the ability to apply recognizable situations to new ones. This promotes independent thinking. And he takes pleasure in being able to help others develop this thinking.

PB: I think that momentary pause of ‘That’s why that happens…hey that’s kind of nifty! I was able to figure that out on my own, based on things that I’ve seen elsewhere’ is worthwhile, for me. And certainly people will disagree with that and have different reasons for why science is important, but, um, that’s one of the reasons why I went into teaching. That’s why I’m not a scientist right now…I enjoy the very academic side of it and understanding, you know, why things look the way that they do. And I realize that I also really enjoy being able to, you know, kind of help folks figure that out, or using a case to explain why that happens…I like helping people, I like learning more about the way the world works and I like to be able to structure my classroom in a way that will help the kids do that as well.
According to him, what he gains, as a teacher, from helping students learn about the world is enjoyment and even new knowledge for him. As he works with more Tech students, he develops new techniques for motivating the unmotivated and for disciplining the behavior problems. “OK, this worked with Bubba from 2 years ago. Maybe it’ll work with Bubbette this year! That keeps me fresh.” He believes that good teachers are learning from their classes every day, just as their classes are learning from them. He recognizes that many teachers refrain from teaching Technical level students, but for him, it is worth the effort because of what he gains from the experience and because of the students themselves. “It’s worth doing because THEY’RE [the Tech students] important, as ALL students are important. And I like the fact that, by working with them, I PROGRESS as well.”

By enabling his students to observe and appreciate these scientific patterns, Teacher PB feels like he is instilling a degree of “value” on science, an additional value on the world. This is why, he explained, he only reads non-fiction in his free time. Any new area of knowledge or thought can aid him in conveying to his students the sense that science is important, whether it be philosophy, astronomy, or math. This act of increasing the value of the scientific world is what makes teaching a noble profession. To him, teaching is valuable because of the value it imparts on other things.

PB: I mean, this sounds very cheesy, but teaching, I think, really IS a very noble, and almost aesthetic profession, if it’s done the way that it needs to be…It’s [teaching] important and if you don’t think it’s important, then you know, you need to get out. To use something that the principal said, that I think is significant. If you find yourself at a cocktail party, “Hey what do you do? What do you do?” “Oh, I’m a doctor. I’m a
scientist. Or I’m a lawyer.” “Oh, I’m just a teacher.” See you! We don’t need you in education! Teaching is SIGNIFICANT.

He stated that he finds himself fascinated when watching science unfold in front of his students. He described a situation of a student who, through trial and error, discovered the direction of a bar magnet that would cause a certain pattern in some iron filings. “To WATCH that process happen, whether it’s incredibly quick with a bright kid or slow and arduous with a, you know, a kids who’s having a hard time with it—it’s still neat to watch that happen.”

Because of this enjoyment of the learning process, he said that he tries to teach all content using inquiry and problem-based activities.

Teacher PB noted that it is important to him that his students understand the layout of the science content being taught. Logical sequencing of topics is what encompasses good teaching. If the teacher lays out two to three ideas, “when you have laid out A, B, C, and D” that relate to each other in a certain way, then it is likely that students will be able to “turn around and tell you [the teacher] E and F” through their own discoveries. This focus on centering the learning process on the students then helps him evaluate students’ comprehension of the material. He constantly monitors student conversations during lab activities and pays attention to the explanations given by students to their peers about the activity. And if the activity is structured in the right way (in that a logical sequence of topics precedes the activity), then the scientific patterns “fall out of the data”. He added, “I felt that there was even an intuitive sense [by the students] of what was going to happen, that they were able to express graphically, that was not confirmed with some real data, and then some real conclusions. Students seemed to ‘get it’.”
Therefore, his class discussions are interactive. He encourages students to provide the answers and constantly asks them probing questions. When students resist his efforts, he counters with encouraging and motivating comments.

PB: OK, somebody tell me the purpose of this lab we just did.

Student A: I don’t know.

PB: I don’t believe you. Come on. Think harder. Why did we do this lab? [Several students offer answers. He nods vigorously after each, pointing to the next student for additional comments.] Even Matt, who has been absent for seven days, knows what’s going on. Good. Now, what did that graph look like? Show me with your hands. [All students make a diagonal line in the air with their hands.] Thank you. What’s the name of that curve? [Class shouts, “Inverse!”] And where have we seen that before, ladies and gentlemen? And how do we straighten out curves? [Class goes on to discuss taking the inverse of a best-fit line to obtain a linear relationship.]

In terms of tracking, Teacher PB is against the idea of one failed class affecting a student’s track placement. He stated that tracking happens too early in the child’s educational career and has large implications on later opportunities for learning. When asked what he would do as the principal of the fictional “Teacher PB Academy” (a school designed and directed by him), he laughed and said that he would definitely program some type of ability grouping for students of high ability. He is a big proponent of heterogeneous ability classes because there is an inherent benefit to students learning from others dissimilar to them in ability and talent. It also breaks through that degree of intimidation of high versus low ability. But he said that he also values the learning that occurs when “a group of particularly talented folks who can analyze poetry or who think abstractly about, you know, bizarre mathematical things, or crazy themes in
drama or English or whatever” meets together to learn from each other. Placing a Technical student “with an attitude problem in the midst of that kind of student group” would not be beneficial, in his opinion. “I think some of those ideas might end up being a bit too high-browed [for the Technical student].” On the other hand, he felt that high ability students have a lot to gain by exploring the equipment and concepts covered in the systems-based curriculum of the Technical level.

Beliefs about Students.

Many of Teacher PB’s comments about student characteristics centered on his Tech students. He has noticed that Tech students have a difficult time with involved mathematical calculations. Complex derivations and algebraic equations are confusing to them and they need a lot of guidance when completing these types of lab calculations. Teacher PB tries to include only the math that is integral to the completion of the activity or that is illustrative of a “neat” phenomenon and deserves some attention. In fact, he stated that in the past he has not shied away from requiring his Tech students to do certain calculations if those calculations led students into the next physics concept to be discovered in class.

According to Teacher PB, Technical level students have been “trained” through their years in the Technical track to behave more rambunctiously. They have problems disciplining themselves when working in an environment other than the classroom and “rising to the occasion”. Teacher PB purposely conducts the wave-motion lab activity in the classroom with his Tech classes and in the hallways with his CP classes. He feels that his students are representing him as a teacher and therefore unruly behavior in a public place like the school hallways would reflect poorly on his class management skills.
He noted that Tech students have a difficult time thinking independently because “they are used to having stuff handed to them all the time”, such as worksheets and fill-in-the-blank activities. Therefore, he finds that he must “poke and prod them more and lead them further along the process of problem-solving”. Tech students, at first, balk at this unusual treatment and sometimes harbor some resentment at being forced to think deeply about physics problems.

The topic of student motivation figured heavily in all three of Teacher PB’s interviews. For Teacher PB, successful learning occurs when the student has a good attitude for learning and is motivated to put in effort. He stated several times that student ability is not necessarily a prerequisite for a student to learn in his class. He has great confidence in his own abilities as a teacher to “deal with a student” with low ambition. He thinks that his style of teaching lends itself to motivating that type of student. He finds that he has some difficulty with students of low math ability and low motivation, which is rare. Usually, he has students with low math ability and some motivation or high math ability and no motivation. The latter type of student is the kind he is “more psyched to work with”. According to him, it is easier to engage this type of learner through intellectual challenges, which are easy for him to develop. He finds both types of students in all track levels, but more commonly finds them in his Technical level classes.

In his third interview, Teacher PB recounted an incident during the fall semester of a student who fit the description of high ability and low motivation. Teacher PB spoke to the student’s parents and to his other teachers, but to no avail. The student would come to class every day, but would do no work. He received zeros on all his assignments in Technical level Physics (called the “PT” class).

PB: But one time, it was just killing him [the high ability, low motivation student] to watch some folks flail back in the corner with a pulley set-up. They went
through a couple of very specific sequences and I said, “OK, based on number 1, 2, 3, and 4, then you should be able to build 5 on your own.” And um, it was killing him. He was just sitting there going, “Grrr. God! Ugh...OK!” [mimics student looking frustrated, turning head to look at peers, pretending to be disinterested, and then finally marching over to help the group]. And then he had to get up and he had to go and get involved. And he was helpful. He didn’t get it perfectly right, but he definitely kind of helped them make progress.

So, Teacher PB manages his low motivation students by engaging them in problems that provoke thought. These students, he believes, are willing to “think with the teacher” on occasion because they are genuinely interested in the problem; or they may be intrigued by their peers’ problem-solving process and want to join in. “Then all of a sudden they want to stand in and say, ‘Hey! Here’s what I think!’ So, that happens more often than, you know, slugs with low motivation, low ability.”

There were other student characteristics noted by Teacher PB in his interviews. According to him, Technical level students are usually of a lower income and therefore are not as likely as CP students to own a home computer. This results in sporadic access to technology. Technical students tend to be more social and interact with others in class more often than higher-level students. Their future plans usually include a vocational or technical field, where prior exposure to sophisticated equipment would help them in their work. He noted that this is a major reason why he tries to use vocational type equipment, like oscilloscopes and ammeters with his Tech students. His rationale was that these students would probably need to use them in auto mechanics or machinery-type jobs.
Teacher PB also said that CP students are better equipped to handle mathematical
calculations because of their past educational experiences. He feels that both CP and Tech math
classes are severely lacking in being able to teach content for transfer purposes. CP students
develop more computational savvy because they have been exposed to computers more, at home
and at school. He noted that CP students come from higher SES families, with more involved
parents. He finds that he is able to joke around with these students more and they tend to ask
him more involved questions about the content being learned.

However, he also believes that both levels of students are equally capable of learning
physics, regardless of math or science ability level. With certain curricular adjustments, both
track levels can find educational success if they have the right attitude and are motivated to “buy
in” to his teaching (trust him enough as their teacher to listen to his ideas and entertain these new
concepts as potential new knowledge). He said that this “buy in” is integral to making the
learning process work. He believes that it is his responsibility, as the teacher, to structure the
learning environment so that this “buy in” will happen. As well, it is the students’ responsibility
to trust him and to be open-minded enough to give him the chance to convince them that what
they are learning is worthy of note. For this reason, he surrounds his classroom with
inspirational quotations taken from literature and past scientists. Also, he said that he spends the
first two days of the semester composing with the students a set of “expectations”. The “Student
Expectations of Mr. PB” and the “Mr. PB’s Expectations of Students” hang on large, blue sheets
at the front of the room. These two documents bespeak of the respect he has for his students and
his emphasis that the learning is a dual effort between teacher and student.

In examining the computer activities assigned by Teacher PB to his two track levels of
Physics students, I noticed that there was a distinct difference in the number of assignments
given. For his CP Physics class, he had six Graphical Analysis based lab assignments, a Physics Presentation project, and 12 instances of computer with overhead projector use for displaying “clever animations or simulations” off the Internet for lecture purposes. The Physics Presentation project required the students to develop a 20-minute activity (with a visual display) that educated their peers on a subject related to physics.

PB: The whole point was they pick something that they’re very interested in and they investigate the physics of it…and then be able to put that in a presentation format so that they could then share it in a meaningful and engaging matter with the rest of the class, which is why I asked them to have an activity.

Over the course of several weeks, he guided the students on how to design their activity and allotted two days of class time for the students to do background research in the Media Center. He noted that he did not require the use of technology for the presentation, but did encourage them to explore the use of multimedia for their demonstration. As a result, many of the students had a PowerPoint presentation for their visual component requirement. Like the other teachers, Teacher PB used the computer with overhead projector as a way to better illustrate certain science concepts during lecture and these twelve instances were meant for information dissemination purposes.

On the other hand, his Technical level students completed only four Graphical Analysis based lab assignments. Teacher PB noted that the Technical level physics course is taught in a systemic format (topics are presented to students as they relate to a “system”, such as “machines”). Therefore, in the spring semester when this study was conducted, the Technical students had a lower number of Graphical Analysis based labs, but over the whole year, had completed about the same number of this type of computer lab activity.
Therefore, since the intent of Teacher PB was not to decrease the number of computer opportunities for his Technical students, I did not consider “Amount” as a method of computer activity differentiation for Teacher PB.

Unlike his colleagues, Teacher PB had the same educational goals for both track levels: to recognize patterns in the world and make sense out of them, to apply the patterns to alternate situations, and to appreciate the occurrences of these patterns in their everyday lives. For him, successful learning requires only that students trust him enough to “buy in” to the ideas he is trying to convey and effort. No advanced math or science skills necessarily required; in his classes, learning is an equal opportunity event.

Teacher PB sets up his labs where there are only three variables with which the student works. He structures these computer activities so that they are “fail-safe”—the physics pattern can be found with relative ease, sometimes with a bit of manipulation. The students are scaffolded and indirectly situated so they eventually discover the pattern of interest. For example, students measured distance and time to determine speed; there were no other variables to measure and therefore their results ultimately were of speed data.

For Teacher PB, he believes that his Tech students have never actively “done science” before, where they set up an investigation and actively discover patterns in nature. In Biology, they learn about animals and plants and observe details and characteristics about them. In Chemistry, students usually work on mastering equations and formulas that describe certain patterns. But here, in his classroom, he said that the students use the computer as a tool for actual discovery of a majority of the topics covered. They find the patterns and then come up with equations and formulas that describe their observations. The student thinking is typically deduction, versus the induction of traditional science classes.
Teacher PB appears to project his beliefs about his own abilities onto his students by assuming that they have the same abilities as he. Thus, failures are attributed to lack of effort; successes are due to them “buying into” what he is teaching. Neither of these occurrences was due to a lack of math skills or reading skills. The students’ “buying into” his teaching was another way of saying that the students adopt and accommodate Teacher PB’s projected efficacy into their own self-efficacy as scientific thinkers.

However, although Teacher PB believed that students of all levels have the innate ability to think and reason, he also stated that they have not been in the right situation to utilize that ability. The kids are not motivated because they have not had the opportunity to or have not been encouraged to do so through the Technical track system. But in his judgment of them, he feels that they can use their abilities to become successful; they just do not know how to do so, due to inexperience in this area.

So, it is Teacher PB’s method of teaching that makes the computer activity authentic and meaningful, not the computer itself. Rather, his belief in the students’ ability is what makes his teaching effective. His beliefs drive his planning—the computer is just part of his planning. What drew me to focus on this teacher’s computer activities was the reason why he incorporated the use of computers into the lab activities, not necessarily how he had students use the computer itself. He incorporated computers into his lab activities because it saved computational time. As well, the computer program allowed for more student flexibility in seeing patterns. Students could adjust variables with a click of a mouse and immediately see the consequences.

During the results analysis, Teacher PB’s differentiation of activities between track levels seemed to stand out from that of other teachers. Like his colleagues, he too “took out” the math computations and he too decreased the amount of science content for his Technical students. But
Unlike his colleagues, he made sure that both track levels “did” science and were a part of the scientific inquiry process. Although he limited the boundaries of this inquiry in order to somewhat ensure student success (limiting data collection to two variables), he allowed his students more freedom of discovery and independent thought than any of the other teachers I spoke with in this study. So, his confidence in both Tech and CP allows him to “trust” his students to venture out and discover, knowing that he will always be able to reel them in with his motivational method of teaching and his earnest interest in students’ educational success. “I fight them [unmotivated students]. Every day,” he said. Teacher PB expects the students to “do” science. In his class, there is no other option because he expects no less from his students, regardless of track level.

**Summary of Teacher PB.**

In summary, the ways in which Teacher PB differentiated computer activities in his two track levels show that he takes student math ability, student behavior, and student past educational experiences into consideration when planning. Like his colleagues, he used the “Change Content” (decreasing the amount and difficulty of math calculations for Technical students) and the “Change Activity” (substituted the wave-driver machine for “slinkies” in the hallway for his Technical students) methods of differentiation because of his beliefs about Technical students’ math ability and behavior. He assigned the Physics Presentation project to his CP Physics students as a way to help students see the applicability of physics concepts in everyday life, especially in the students’ areas of interest. He believed that their past experiences in the CP track level have “conditioned” them to know how to independently carry out a research project successfully outside of class time. Because of his belief that Technical students are not as comfortable and familiar with (but not necessarily incapable of) independent thinking as CP
students and because of class time constraints, he did not give the Physics Presentation project to his Technical classes. The Technical level physics curriculum was taught in a systemic pattern, which in general took up more class time than the way in which CP Physics was taught. Also, Teacher PB found that his Technical students needed more time to think and understand physics concepts than his CP students; this was due to the lack of practice with deductive and challenging thinking during their tenure within in the Technical track level.

However, the science objectives and goals he set for his two track levels were identical and testify to his belief of the innate cognitive ability of all students to learn science when problem-based experiences are presented in an authentic and student-centered format. He believed that all students were equally able to see physics patterns within the data collected during the Graphical Analysis based lab activities, although the time required doing so varied between the two track levels. In spite of the fact that Teacher PB did utilize the same methods in differentiating his computer activities for his two different track levels, he believed in structured his computer activities so that all students from both track levels would accomplish the same science objectives and goals. Therefore, in terms of science learning, neither of his track levels was at a substantial disadvantage to the other track level in the area of computer activities.
CHAPTER V
DISCUSSION AND IMPLICATIONS

My suggestion [on how to conclude a study] is to work toward a conservative closing statement that reviews succinctly what has been attempted, what has been learned, and what new questions have been raised” (Wolcott, 2001, p. 122)

The purposes of this mixed method study were to determine the ways in which teachers were differentiating computer activities for students of different science track levels and to describe the salient teacher beliefs that related to the teachers’ methods of differentiation. Every science teacher (21 teachers in all) that taught at Bayley High School in Georgia was interviewed. All students enrolled in a science class during spring semester 2002 were given a demographical Student Survey (1,070 students returned surveys). Of those twenty-one teachers, four were chosen for second round interviews and one was chosen for a case study to further explicate teachers’ beliefs of students of different track levels. The results were analyzed using an interpretive and grounded approach. The research questions that guided this study were:

1. What types of computer activities are assigned to tracked secondary science classes?
2. What are the ways in which teachers differentiate these activities between classes of dissimilar track levels?
3. Which teachers’ salient beliefs about students in different track levels influence the teachers’ planning of computer activities?
First is a summary of the quantitative results of this study. Then, for the section on the teacher beliefs findings, summative belief statements are given for all twenty-one teachers. Also detailed is the discussion of the four teachers who participated in second-round interviews, as well as the case study of Teacher PB. Inferences are detailed at the end of each section. Finally, this chapter concludes with research implications for further studies.

Types of Computer Activities Assigned

Based on the analysis of data, Bayley High School’s science students were comprised of predominantly white and African American students, with Asian and Hispanic student proportions about comparable. The G/H/AP level classes, in comparison to the lower level classes, had proportionately:

- more whites
- more Asians
- more students of “other” races (as compared to CP classes)
- more males than CP, but equal number of males to Tech
- more students of middle to high SES

In general, all the teachers incorporated the computer into their science teaching in some way. It was a common teacher belief that mere exposure to technology was a worthy objective for the activity. The strong pressure on teachers by Geoffrey County to integrate computers seemed to have a large impact on these teachers’ decision to use computers in science education. Consequently, all twenty-one teachers had assigned some type of computer activity during the 2001-2002 school year.

In answer to the first research question, teacher interview data indicated that there were four main categories of science computer activities assigned to students during spring semester,
2002. These were: information dissemination, computer as tool, inquiry, and Internet searches (both at school and at home). The three categories besides inquiry activities were teacher-centered in nature. The science learning was wholly dependent on the teacher’s actions and choices. The activities were not structured for students to express their opinions or to have the freedom to communicate their understandings to others, two important aspects of student-centered learning (Layman, Ochoa, & Heikkinen, 1996). The teacher decided what content was to be mastered and in what way the content was to be mastered. Even for the Internet searches, some of the assigned activities were based on websites chosen by the teacher; students exploring any other websites were construed as “off-task”.

With the exception of Teachers PB, SW, and BI, all the teachers did not incorporate a student-centered focus into their computer activities on a normal basis. Teacher DA did assign one computer activity (the Photo Essay project) to her higher track students that gave students the freedom to explore careers in science, which was deemed a form of student-led inquiry. However, in general, the students were assigned computer activities that were highly directed by teachers and seemed incidental to the process of science learning—almost a “secondary” level of curriculum planning for teachers. The teachers planned for the computer in science teaching in the same ways they planned for science instruments, projects, and labs—citing time, resources, and student ability as the main driving forces in their decisions to include these types of activities in their science teaching. In fact, during the teacher interviews, none of the teachers offered any suggestions or ideas for student-centered, explorative uses of the computer.

The analysis of the assigned computer activities in this study indicated a tendency of the teachers to favor information dissemination activities for the lower track classes and more Internet searches for the higher track classes. Although the differences were not significant, the
fact that almost all of the activities assigned were low level (i.e. teacher-centered, task-oriented, non-generative “recall” objectives) indicate that students at all levels primarily did not participate in thoughtful computer activities. A trend also towards Information Dissemination activities in the lower tracks compounds this finding. For example, during the interviews, several teachers had noted that Tech students lacked math, science, and language abilities and that they were incapable of higher-order and abstract thinking.

The teacher interviews also indicated that teachers gave their higher track students more independence in completing computer assignments. These students were asked to do most of the Internet searches and other computer assignments at home, whereas lower track students were required to complete most of their assignments during class time. One of the most often cited reasons for this differentiation decision was home computer ownership. Although only Teacher PB had actually tried to determine the number of students who did not have access to a home computer, many other teachers believed that lower track students were poor and therefore did not have the financial resources to own a computer. This belief apparently led the teachers to give, for the lower track students, less home conducted Internet searchers, as evidenced by the 10 at-home Internet search assignments versus the 13 at-school. In contrast, the higher track students were assigned 34 at-home Internet search assignments and 10 at-school assignments. These results support previous findings of teacher differentiation of curriculum for students of unlike science track level: many teachers of low track classes focus on controlling and keeping students busy because of the belief that they are less capable than higher track students (Bryan & Atwater, 2002; Oakes, 1990).

The use of the computer was not an integral component to the science learning in the assigned activities. Almost all of the main objectives intended with the assignments were not
predicated on computer use. With some minor modifications, students probably could have mastered the same science content and skills without a computer in all of the activities. Granted, there were a few teachers who had secondary objectives of increasing student computer ability, but only two teachers (Teachers ST and GSH) specifically instructed students on how to use a particular piece of software. For example, Teacher DA’s Sight and Sound simulation has been done in other science classes with a meter stick, stopwatch, and a falling object or bell. All Internet search activities could have been completed with the books in the Media Center (note: all twenty-one teachers had at least one assignment in this category). And the sole objective of the teacher lecture with PowerPoint/Internet projected through overhead projector was to add more visuals and excitement to an otherwise typical class. The majority of computer use for science education at this school was for enhancement purposes in that the computer was just “another way of teaching the same thing” (Teacher WJ).

The ways in which computers were used to teach science did not seem to accomplish the teachers’ intended goal: to motivate students to deeper or more authentic science learning. The novel factor of using computers (Healy, 1998; Schofield, 1995) was not enough to prompt students to invest energy into complex problem-solving tasks or into deep reflection on the science content. Constructivist researchers claim that teachers should facilitate students’ reconstruction of science understandings by setting up situations that allow students to interact with objects in their environment and to engage in higher-level thinking (Driver, Asoko, Leach, Mortimer, & Scott, 1994). Although the students did “interact” with the computers a few times during the semester, the interaction with the technology usually was not structured to be deeply
meaningful or authentic for learning science ideas. The majority of the computer assignments analyzed in this study did not ask students to synthesize new ideas, to extrapolate or apply concepts to alternative situations, and/or to communicate their rationales to peers.

Methods of Differentiating Computer Activities and Student Demographics

For the second research question, the results indicated that the science teachers differentiated computer activities between track levels with three methods. The teachers either altered the number of computer activities assigned (“Amount”), changed the content or skills covered by the activity (“Change Content”), and/or changed how the activity was completed or what was required of the student product (“Change Activity”). The teachers did not implement the method “Change Activity” as commonly as they did with the other two methods. One possible explanation for this finding can be found in the teachers’ beliefs about low-level students. They described these students as incapable of grasping complex science concepts. This belief would lead to a differentiation of learning objectives. If the teachers believed low-level students capable of mastering the same science content and skills as high-level students, then perhaps they would have used the method Change Activity more often (which does not entail a differentiation of learning content and skills).

All three methods were executed in ways that focused on the perceived educational needs of each track level. The teachers in this study assigned more activities that covered more content and had more requirements to the classes that were predominantly white and Asian (as compared to CP and Tech) and other races (as compared to CP), that had a higher male contingency (than CP classes), and that were of middle to high SES. The Technical track classes consisted of more
African American, Hispanic, and white males, who were of low to middle SES. These students received less computer assignments that covered less content and were less stringent and demanding, in terms of student products.

This is of concern because these student demographic patterns are similar to those found for populations that tend to succeed in the science and engineering fields. Many past studies have documented the lack of minorities, females, and low-income students entering the “science pipeline” (Atwater, 2000; Hall & Post-Kammer, 1987; Lynch, 1994). “Scientific research, education, and capitalism serve each other so intimately that it is hard to think of one without the other. No where is this more dangerous than in economically and politically oppressed communities” (Secada, 1994, p. 22). Researchers and theorists have claimed that one of the predictors of future success is access to educational resources, such as quality teaching (Boyer & Radzik-Marsh, 1994; Darling-Hammond, 1995; Freire, 1970).

Since the demographic trends of this study mimic those found in the American workforce (i.e. population characteristics of low track classes mimic population characteristics low-income jobs), this supports the theory that schools are microcosms of society where the beliefs and rules of society are propagated in younger generations (Freire, 1970; Hilliard, 1998; McLaren, 1994). Therefore, the results of this study indicate and support previous findings that race, gender, and class have direct impact on who receives more challenging and engaging curriculum. This, in turn, results in disparities as to which students are granted access to educational resources and which ones are enabled to succeed in school.

Computer Activity Differentiation and Teacher Beliefs About Students

In answer to the third research question on salient teacher beliefs about students in different tracks and how those beliefs affect computer use planning, the results showed that the
teachers gave five major reasons why they differentiated computer activities for their classes: (a) student ability (science, math, language, and/or computer), (b) student learning styles, (b) student motivation, (c) student interests and life goals, and (d) ownership of a home computer. In their interviews, the teachers also explained how student characteristics related to their activity differentiation. These justifications fell into two main areas: (1) to increase lower-track students’ grades (and/or to ensure completion of assignment) and (2) to control behavior (increase time-on-task).

The fact that these themes were apparent regardless of the particular track level taught by the teacher bespeaks to the impact of teacher beliefs on curricular decisions. For example, Teacher BI taught AP Physics B and AP Physics C, while Teacher HS taught College Prep Biology and Technical-Special Education Biology, but both these teachers assigned more computer assignments to their classes of higher track, respectively. Therefore, the practice of tracking students in this particular high school engendered a system whereby a “value” was placed on higher track levels and that value was very contextual. It was not of consequence the actual track level, but the fact that a certain track level was the lower of the two levels taught that made the level less valuable. This valuation was not necessarily based on actual evaluations of the students’ abilities.

This valuation corresponded to certain teacher beliefs about the students in that level. Students in lower track levels were seen as less capable than those of the higher track level. Teacher WJ, for example, noted that his CP Physics students were not able to engage in higher-order thinking activities. In contrast, Teacher RMY felt that her CP Chemistry students were very good at understanding how several concepts could relate to each other. Of note was the fact that when the teachers were asked to describe how tracking influenced their decision on
computer activity planning, they all replied that tracking did not play a role in their choices. Rather, they said that the students’ needs, abilities, and/or interests and choices in life were the main determinants of how they incorporated computers into their science teaching.

Perhaps the teachers were uncomfortable talking about the practices of tracking, as teachers are when the topics of race, class, and white privilege enter a conversation (Henze, Lucas, & Scott, 1998). “The introduction of these issues of oppression [racism, classism, and sexism] often generates powerful emotional responses in [participants in discussions] that range from guilt and shame to anger and despair” (Tatum, 1992). Having been told ahead of time that the study involved examining differences in track levels, teachers might have been reluctant to discuss their true beliefs and feelings about students in their classes for fear of censure or negative repercussions. And another possibility is that the teachers did not discuss tracking very much because they themselves were unconscious of the issues of power and opportunity that are inherent in tracking practices. For example, a study, conducted on a group of pre-service teachers that investigated their recognition of racism in the classroom, found that white teachers are hesitant, and sometimes even resistant, to recognizing and acknowledging the racial identities of their students—and themselves. Termed “dysconscious racism” (King, 1991), the act of denying or failing to recognize the existence of race is to accept the systemic and continuous subjugation of certain populations based on unexamined beliefs and assumptions about those populations.

However, the fact that the teachers in this study quickly attributed student attributes as their justification for computer activity differentiation between track levels bespeaks to their “dysconscious” racism, classism, and sexism. The first interview protocol never asked teachers to describe their students’ demographics or motivational levels (Appendix A). Indeed, the
question asked of the teachers was in regard to only tracking and their computer assignments. The teachers themselves made the connection between tracking and race and class (only one teacher, Teacher BI, discussed gender). Therefore, the interview results imply that these teachers believed students’ track placement was connected to (and perhaps even a consequence of) the students’ particular characteristics and demographics. Thus, the differentiation of science curriculum (and as a result, computer activities) was a consequence of teaching a particular track level of students.

The implications of these results corroborate previous research on teacher beliefs of low track students. Teachers base their beliefs about students on characteristics such as race, culture, ethnicity, language, and class (Bryan & Atwater, 2002). For instance, teachers believe that students of color and students of low-income families are less motivated and less interested in education (Ogbu, 1987; Olmedo, 1997). African American males are described as underachievers, poor communicators, and negatively disposed to authority (Ford & Harris III, 1996). Teachers also have stated that there is a lack of parental support in low-income families because the parents themselves do not see the value of education and/or are not knowledge equipped to support their child’s studies (Calabrese Barton et al., 2001). All these perceived factors make it difficult for teachers to believe that they can help these at-risk students succeed academically.

Problems with teaching these students would logically force teachers to be concerned with grades and class performance. Rather than opting to fail a whole class of underachieving students, teachers chose to adjust the learning assessments to fit the perceived performance capabilities of their students; these perceptions resulted from socially constructed ideas about certain social classes and ethnicities (Page, 1991). Thus, adjusting curriculum pacing so that a
computer assignment is completed entirely during class time was one way these teachers ensured that these apparently unmotivated students would actually turn something in to the teacher and get a grade besides a zero. Additionally, these teachers purposely assigned teacher-centered, highly structured activities in an attempt to curb misbehavior. Implicit in these decisions was the assumption that student exploration and independence in their science learning would increase the chances of off-task behavior and socialization. For example, Teacher PB’s decision to use a wave driver machine instead of slinkies in the hallways with his Tech students was primarily based on his fear that the students would be distracted by their surroundings. He admitted that the fear was unfounded and that he had no prior evidence on which to base his fear.

Therefore, these teachers adjusted the computer requirements (“Change Activity”). In order to further address their concerns about student grades, they altered the content covered by the activity (“Change Content”). These practices that were found in this study parallel those found in the study by Hayes and Deyhle (2001). The authors examined the science curriculum of two elementary schools, one (Jefferson Elementary) in a working-class/poor and ethnically diverse area and the other (Lake Elementary) located in a professional class and white neighborhood. They found that the curriculum at Jefferson Elementary focused on organization and control (in an effort to raise declining test scores), while the curriculum at Lake Elementary was centered around an informal and conversational format with a focus on engaging students (Hayes & Deyhle, 2001).

Curriculum differentiation has been a topic of study and attention (Connell, Ashendon, Kessler, & Dowset, 1982; Oakes, 1992; Page, 1990). Many past researchers have noted that this practice serves to perpetuate educational, social and economic inequality (Hayes & Deyhle, 2001). Because many times this differentiation is rooted in student characteristics like race and
class, schools become mechanisms by which the patterns of social inequality are propagated in future generations (Apple, 1981). It has been shown that minority students and students of poor backgrounds usually are subjected to school curricula that is inferior to that of students of the dominant groups (Page, 1991). As well, the negative teacher attitudes that sometimes lead to these differentiated curricula can also serve to alienate minority and low-income students (Gilbert & Yerrick, 1999).

Some researchers have found that differentiated curricula can be beneficial, however (Lesko, 1991). This has caused the research on curriculum differentiation to be complex and confusing. Several studies have focused on special programs designed to facilitate the science engagement and learning of students of different ethnic and socioeconomic backgrounds. One study examined the student achievement of a program spanning five years and found that African American students performed increasingly better on a science standardized test (Mulkey & Ellis, 1990). Another study looked at the enhanced learning of students of Southeast Asian background whose families were recent immigrants to the United States (Hammond, 1999). These elementary school students also did well in the community-centered garden project. For both programs, curriculum was differentiated to reflect and incorporate their unique and individual cultural identities and experiences into the learning of science. The differentiation was intentional and core to the development of these programs.

In light of these apparently contradictory research studies, the advantages and disadvantages of curriculum differentiation are not always clearly defined. Although the expressed intent behind differentiated curricula is centered on the welfare and needs of a child, teachers are sometimes unaware of the deep implications of this practice. In addition, the confounding effect of negative teacher beliefs of at-risk students results in this educational
practice becoming a tool that can create inequitable opportunities for educational success. I believe that when curriculum differentiation is based on unconstructive and negative teacher (or program developer) beliefs about at-risk students, then the practice of differentiation does not adequately serve the learning needs of those students. On the other hand, if the differentiation centers on authentic and affirmative beliefs about at-risk students, where students’ differences are instead celebrated, valued and incorporated into the curriculum, then results like the ones found in Mulkey and Ellis’ and Hammond’s studies would be the norm.

Therefore, a necessary area of further research would be to examine the science achievement differences of the students receiving differentiated curriculum that is based on debilitating teacher beliefs about students. Although the scope of this study extended to only documenting and describing the differentiation and interpreting the differentiation through student demographic data and teacher interviews, more information about the students’ science learning under these conditions would add to this study’s findings. Past research on the effects of negative teacher expectations on minority and low-income students’ achievement (Brophy, 1983; Bryan, 2002; Gouldner, 1978) suggests that these students’ science learning would also probably suffer from differentiated curriculum formed from those same negative teacher expectations.

Another important influence on how computers are incorporated is the teacher’s belief about the abilities of the students. These beliefs dictated adjustments to the actual activity and activity product. All of the teachers, except Teacher PB, believed that student academic ability was an innate and static characteristic. Some believed it to be genetic (for example Teachers DK, RMY) and some believed it to be environmental (for example Teacher RMI, DA). Teachers’ beliefs of student math, science, and reading ability had great impact on how
computers were incorporated into the curriculum. Also, these beliefs affected teachers’ choice of adjustments to the activities for different track levels, especially for those teachers who believed that student ability could not be drastically improved.

The exception to this finding was Teacher PB’s beliefs. He noted repeatedly in his interviews that in order for a student to succeed, he/she need only to have a positive attitude about learning and be motivated to think about different ideas and “give it a try”. He stated that the student does not need to be good at math or science to learn in his class. Teacher PB believes that student ability is not static and can be increased through repeated opportunities for critical thinking and discovery. To him, any student is capable of wondering about their world, of questioning patterns that exist, and of probing relationships between variables. All it takes is an open mind and some effort.

Because of his unique beliefs about student abilities, Teacher PB utilized the computer in his classroom in an atypical way than his colleagues. He used the computer as a way to save time in the learning process and to help students explore alternate methods of treating scientific data. A minority of his assignments were information dissemination activities, which was conversely true for the other teachers. Students used the program Graphical Analysis to plot data collected during the lab and to figure out ways to obtain linear correlation lines in the graph. The program chosen by Teacher PB allowed students the freedom to input their own data, manipulate their own data, and draw their own conclusions about the relationships between the two variables tested. These repeated exercises in using the computer to navigate an inquiry-based problem were meant to help students increase their critical thinking skills, graphing skills, and recognition of math functions. And Teacher PB assigned them as regularly scheduled activities because he believed they would change student abilities.
Past research has indicated that teacher beliefs about students do impact teacher planning of assignments and curriculum. Thus, the results of this study add to this knowledge; the results indicate that teacher planning of computer activities are also impacted by teacher beliefs in the same ways as curriculum planning is affected. More about Teacher PB’s methods of computer activity differentiation and beliefs about students is discussed later on in this chapter.

This section of the chapter focuses on the five teachers who were chosen for second round interviews for a more in-depth investigation into their beliefs about students and their choices for computer activities. The objective of these second interviews was to gather more information about what those beliefs entailed and how they related to methods of differentiation. For each teacher, a summary of his/her beliefs is given, followed by a discussion about the implications of those beliefs.

Teacher DA

Although Teacher DA believed that the cognitive capabilities of her two levels of tracked classes were equal, she had very defined ideas about what Tech kids were like, as students. The majority of her answers to interview questions focused on Tech students’ attributes; they were, by far, extensive in comparison to her descriptions of CP students. Her ideas about successful learning were affected and deeply intertwined with these beliefs about student characteristics.

As well, her beliefs about what students’ educational motivation should be and what they appeared to be were in conflict. Her own experiences as a student in the Gifted program helped her form the idea that all students should be intrinsically motivated to learn for the sake of learning. She noted that Technical level students do not respond to her teaching and “sit like a bump on a log”, which she insinuated as a lack of motivation and a lack of learning. She blamed
the lack of parental support and laziness for this behavior. Planned computer activities were a response to observed student behavior.

Her beliefs about low-track students are similar to those found by other researchers. Researchers have found that teachers of low-ability students characterized those students by motivation, effort, interests, clothing, and parental support (Lynch, 2000; Winfield, 1986). However, Teacher DA did not comment on the race of her students and the gender. Income played a part only in her discussion of home computer ownership.

Teacher DA is an example of a teacher who believed in the innate cognitive abilities of all her students, yet harbored negative views about her low-track students. She based her curricular decisions on student response and motivation, rather than an assessment of their needs, abilities, and interests. She was unlike her colleagues in that she stated that all students are able to learn science. She was similar to her colleagues in that her negative beliefs about Technical students’ characteristics affected her planning of computer activities.

Her understandings about student abilities may be rooted in her own experiences as a student. Being in the Gifted program throughout her educational career, she was used to learning and working with peers who found schooling easy and fun (Davis & Rimm, 1998). Gifted students enjoy mental challenges and usually are either very successful in school or react to school structure through underachievement (Davis & Rimm, 1998). Therefore, Teacher DA grew up with children who liked school and probably exhibited a lot of intrinsic motivation. Research has shown that teachers’ prior experiences have incredible impact on their views and understandings of teaching and learning (Pajares, 1992; Richardson, 1996).

Thus, she is confused as to why her students do not exhibit the same love of learning. She tries to do “cool” activities with them, but they do not respond in the ways she expects them
to respond (i.e. how she would have responded if she were a student herself). So, when her Technical students fail to turn in homework and projects and seem unbothered by their falling grades, Teacher DA becomes very conflicted and frustrated, which results in her withholding “cool” activities from these students and using the “Change Content” method of differentiation. In her mind, the students have the mental capabilities to do well in school. Hence, she attributes her Tech students’ failure at succeeding in education to lack of parental support, peer pressure, laziness, and personal choice. In order to keep these attributes from causing her Tech students to fail Biology, she used the “Change Activity” method of differentiation and made the Sight and Sound worksheet shorter so they would be more likely to complete the activity.

The use of the computer as a “carrot”, or reward for favorable behavior is a common phenomenon documented by research in educational technology (Healy, 1998; Schofield, 1995). The high cost of computers, as well as the time-intensive, steep learning curve associated with introducing technology into a teacher’s regular “bag of tricks”, has turned technology into a resource that must be doled out to certain worthy recipients. Teacher DA is an example of a teacher who has formed a clear “rating” system to determine how she integrates computer activities into her teaching. If students show her that they are motivated to learn, and they show this interest by responding to her teaching and following her directions, then she rewards them with “cool” activities (“cool” as defined by her own interest in the activity) and hopes they will get as much out of the computer activity as she would have if she were a student. On the other hand, students who do not show any motivation to learn and who do not respond favorably to her teaching efforts are allowed to use the computers as well, but the rationale behind this allowance
is that these students need hands-on activities in order to learn science. The intent is preventing
more failure, versus the intent of engaging and further motivating the learner, as it is with her CP
Biology students.

Given the demographic results obtained for the students, these results are of concern.
Teacher DA rewarded more white and Asian females (CP level had less males than Technical
level), of a higher SES, with the independent, student-centered Photo Essay assignment that
aimed to help students see the applicability of biology to real-life. They also were assigned a
longer Sight and Sound worksheet. More of her African American and Hispanic male students
received the more structured, teacher-controlled Bacteria/Virus project and a shorter Sight and
Sound worksheet. It is not clear whether Teacher DA consciously factored the issues of race,
gender, and class into her choices for computer activities for each track, but it is apparent that her
computer activity differentiations affected unlike student populations of race, gender, and class.
This can definitely be construed as inequitable treatment of students of unlike tracks and unlike
characteristics.

These findings from Teacher DA’s interviews have implications for teacher development
programs. This teacher’s own vicarious experiences as a student have strongly impacted her
understandings of her students. As new teachers are being prepared to enter the profession,
teacher educators must encourage and promote self-reflection for teachers on their ideas and
views on what constitutes successful learning and teaching. By explicating these beliefs, perhaps
future teachers can better understand the ways in which they decide how to allot teaching time,
attention, and curriculum to certain students. This understanding may lead to a more critical and
honest evaluation of their teaching beliefs and practices. Also, teachers might better see the implications of their actions and how those actions affect different populations of students, if the class track levels are comprised of students with disparate characteristics like race, gender, and SES.

**Teacher RMI**

Teacher RMI had very clear explanations for why her Technical students needed more hands-on activities and why they were not as successful in school as her Gifted students (parents do not value school, student adopts negative academic attitude, student does not attend school and chooses to emphasize other areas in life, grades go down). Teaching students from both ends of the tracking “spectrum”, she was afforded a unique view of the dissimilarities of students who are tracked in science. Like Teacher DA, she too believed that all students had the innate mental ability to do well in science. Also, she felt that Technical students were apathetic about education and were not intrinsically motivated to do well in school, unlike their Gifted counterparts.

What is of note is that Teacher RMI’s views about her students were similar to those documented in other studies of teachers of tracked students (Bryan, 2002; Lynch, 1994; Oakes, 1990b). She had a very detailed explanation for the disparities in work completion of her students and this explanation was deeply connected to issues of class. As noted in the literature (Calabrese Barton et al., 2001; Solomon, 1996), it is a common teacher perception that low-income parents do not see the value education; they also are unable to grasp the importance of schooling, due to their own lack of education.

Conversely, Teacher RMI attributed the educational success of her Gifted students to parent influence as well. According to her, because these parents are of a higher SES and
usually very educated, they promote the value of education with their children. This, in turn, influences these students to make life choices that help them succeed in school (i.e. participating in school-related extracurricular activities). Again, these beliefs have also been documented by past research.

Her understandings of the reasons behind the differences in Tech and Gifted academic motivation were the most detailed and complete of all the teachers in this study. She was able to clearly map out the social causes of her students’ science performance. This may be related to the fact that she taught students from the extreme ends of the tracking spectrum. The juxtaposition of the “highest” students against the “lowest” students perhaps afforded her a distinct view into tracking practices that enabled a more elaborate explanation for student science ability disparities.

Teacher RMI’s beliefs about students are of concern because they are so well formulated. The schema she developed to explain the observed differences in science achievement are deeply involved with issues of class. Somehow, in her teaching experiences, she came to understand that people of different classes value different things in life. These disparate choices have direct consequences on other aspects, one of which is academic achievement. And as long as she notices a difference in learning styles and learning success between her two track levels, she has no reason but to continue to support her ideas about class and education. As well, if these beliefs are highly central to her teaching belief system (Pajares, 1992), then even new observations of her students that directly contradict her beliefs would most likely result in Teacher RMI adjusting her beliefs so that her original ideas about Tech and Gifted students are still maintained.
Her differentiated learning objectives for each track levels’ computer activities give some indication to the centrality of her beliefs about students. Because she thinks that Gifted students can handle higher-level thinking activities, she assigned them more computer activities (“Amount”) and covered higher-order skills (“Change Content”). Tech students, on the other hand, received less computer activities and information dissemination type activities. This is because she believes that Tech students need more “fun” and engaging activities in order to increase motivation and thus “pad their grade”. Researchers have stated that beliefs do not always directly correlate to action and that beliefs can support a range of practices (Richardson, 1996). For Teacher RMI, it seems that her beliefs do inform her computer activity differentiations, based on her interview data and analysis of her assignments.

Like Teacher DA, these differentiations have implications for various populations of students. Teacher RMI assigned activities that focused on application and transference of learned material to her Gifted students, who were mostly white and Asian and of a higher SES than her Technical students. Rote skill practice and information dissemination activities were assigned to more African American and Hispanic students of a lower SES (gender was not significantly different between Gifted and Technical track levels). Like Teacher DA, it is not clear if issues of race and class figured into the curricular decision-making process, but the choices she made do favor students of certain races and economic backgrounds.

Further research into how she developed these beliefs would be of great value to administrators and policy makers who make decisions about teaching loads and curriculum. If juxtaposing students from the extreme ends of tracking plays a role in developing teachers’ thoughts on student motivation, then it would be useful to find out what aspects about that juxtaposition are integral to that process and if all teachers would develop those same ideas. My
opinion is that for Teacher RMI, it is a combination of the ideas with which she already came to
the profession and her experiences teaching Technical and Gifted students. Some research has
shown that the beliefs held by beginning secondary teachers (versus elementary teachers) about
differences in achievement are usually more commonly rooted in ethnic and gender issues and
are frequently situated in a broader societal context, like class (Avery & Walker, 1993). If this is
indeed widespread, then the implications of Teacher RMI’s findings are also directly related to
teacher preparation programs, which can focus on explicating these preconceived ideas and
helping new teachers re-examine them.

Teacher RMY

Teacher RMY was chosen for a second interview because her comments about Tech level
students were so blatantly laden with stereotypes and perceptions. It was difficult for me to
remain objective and unbiased when conducting the interview with her because her comments
were disparaging, but spoken with a calm, “matter-of-fact” demeanor. I felt sorry for her Tech
students after I listened to her descriptions and explanations of student qualities.

Like her colleagues, teaching was a teacher-controlled relationship for Teacher RMY.
She believed that it was the responsibility of the teacher to cater the curriculum to best meet what
students needed, based on their future goals. Therefore, school was preparation for life after high
school. If the student was going to attend a 4-year college, then she needed to teach him/her the
skills and content that was prerequisite to a higher education. However, if the student was
headed to a mechanic shop, then the science she taught should relate to that area of employment.

Her views about student characteristics are similar to those found in other studies on
teacher beliefs (Gomez, 1993; Kozol, 1991). She attributed student academic and mental
characteristics to home influences and choices made by the student. With her extensive
experience in teaching (14 years), it makes sense that her beliefs about students were deeply entrenched. What is of concern is that these beliefs then “blind” her to Tech students’ true abilities and make it difficult for Teacher RMY to meet the needs of these students. If her beliefs about Tech students’ attributes are so sweeping and entrenched, then the chances are slim that she would notice any student characteristics unlike those in her understanding of reality.

Teacher RMY’s longevity in the teaching profession has made these beliefs about Tech students a part of her central belief system about students and teaching.

The computer activities assigned to her CP and Technical Chemistry classes illustrate these entrenched beliefs. Although both levels were given the Polymer Project, they had extremely contrasting Air Projects. Teacher RMY stated that she wanted her CP students to see the relevance of air chemistry to everyday life and intended for them to develop critical thinking skills about the applicability of chemistry in order to prepare them for similar tasks in college. Therefore, their Air Project entailed a written report whereby the students had to synthesize the gathered information and apply it. On the other hand, the Technical students were asked to gather information on air chemistry in order to review for the final exam. They had to design and construct a children’s book that reinforced taught concepts. She expected these students to enter blue-collar or construction based jobs upon leaving high school; the intent of the assignment was to engage their interest enough so they would pass the course.

Besides assigning one more computer assignment to her CP students (“Amount”), Teacher RMY used the Change Content and the Change Activity methods of differentiation in the Air Project. She altered the skills and content to be covered by each track level, as well as changing the actual student product to be turned in. Given the demographics of these two track levels, these differentiation methods resulted in giving a more rigorous, higher-level thinking
activity to students who were predominantly white and Asian females and of a higher SES. More African American and Hispanic males received the children’s book activity. In light of how disparaging her beliefs are about Technical students, there is some indication that race and class were recognized factors in her process of activity planning. She was the only teacher who remarked on the racial and SES backgrounds of her students.

Research on teacher beliefs have indicated that a change in beliefs are rare and require a lot of effort on the part of the teacher (Pajares, 1992; Rokeach, 1968). A discrepant event or situation is not enough to cause enough of a crisis in the belief system, if the beliefs are located close in to the “center” of the belief system. In other words, if her beliefs about student characteristics are fundamental to her methods and views of teaching, then it will be difficult for her to extinguish or adjust those beliefs about students. Because of her long tenure in the profession, it is likely that these disparaging beliefs about low-income, non-Asian minorities have been deeply embedded into her views of schooling.

A subsequent study to this one could interview Teacher RMY further and perhaps interview her students from different track levels. It would be informative to explore how she had formed her current beliefs about student characteristics and what past experiences helped her shape those ideas. As well, a more objective observer (than Teacher RMY) could possibly juxtapose her beliefs about students and the actual characteristics of her present students to see if, in fact, her beliefs are or are not accurate portrayals of student attributes. Due to the rigidity of her beliefs and the concordance of her beliefs with prior research on teacher bias and stereotypes, I hypothesize that Teacher RMY has created an understanding of her classes that does not correlate to how they truly are.
Another potential area of exploration would be to test the rigidity of her beliefs about student characteristics. Perhaps participating in in-service workshops on diversity and culture may give her the opportunity to critically examine her deep beliefs about students. However, past studies have stated that the mere exposure to new theories about students is not enough to engender long-lasting or substantial shifts in beliefs (Bryan & Atwater, 2002; Lynch, 2000). And of course, changes in beliefs are not necessarily going to result in changes in teaching pedagogy and curricular decisions (Richardson, 1996).

Nevertheless, it is her reality that dictates her choices of teaching practices to use in her classes. Therefore, by examining how those personal beliefs came about, we may be able to better explicate how disparaging beliefs about students are formed and use that information in designing better teacher preparation programs. There are certainly numerous teachers besides Teacher RMY who attribute student academic success to the personal life choices that students make for their life goals; these teachers probably also believe that these choices are affected by home and environment. Talking to other teachers who hold similar beliefs about student characteristics to Teacher RMY’s beliefs could help determine the common teaching experiences these teachers used as the basis for developing those beliefs.

Teacher GSH

One of the most interesting aspects of Teacher GSH’s comments about students was her concern for the affective and motivational needs of her Technical students. Her past experiences as a student herself placed in Technical level math classes strongly impacts her views about this track level, which is common in teachers, as research has noted (Richardson, 1996). The same disparaging characteristics described by her colleagues were seen as strengths and positive qualities. For example, when describing Technical students’ motivation, she noted that they are
not always interested in school. This belief has been shown to be common in many teachers of low-income, minority students (Kozol, 1991; Lynch, 2000). However, she then stated that Tech students are motivated about other things, which is a testament to their strong personalities. She incorporates commonly held teacher beliefs about low-level students, but accommodates for her own positive feelings about the Technical track level into those beliefs. She seems to have adjusted her belief system so that the same negative student characteristics are acknowledged, but the attributions and explanations for those characteristics are favorable.

Of all the teachers interviewed, she was the only one who expressed concern about tracking. She does not agree with its use as an educational practice because she believes there are no benefits to tracking students in high school, only negative ramifications. This is the main reason why she differentiated her computer activities in ways that focused on the needs and interests of her Technical students, rather than her CP students. The years of being in the Technical track has caused these students to be lacking in math and science skills and to need more hands-on, stimulating activities in order to learn.

Based on these beliefs, assigned the Bacteria Project to her Technical students and not her CP students. She spent a lot of class time and personal energy on making the project work for her students. She felt that the Technical students needed the exposure to technology and if she did not take the time to teach them how to use PowerPoint, then the likelihood that they would ever learn elsewhere was slim. This was deemed a Change Content method of differentiation, with an emphasis on the Technical level’s needs. However, she did have more computer opportunities to her CP students (“Amount”), with two incidents of projecting CD Rom images during lecture and one incident of showing a teacher-generated PowerPoint on nuclear power for another lecture.
Her positive feelings about the Technical track directly impacted her choices for computer activities. However, the fact that she had more computer opportunities for her higher-level students contradicts this hypothesis. This can be understood in a second look at her beliefs about CP students. In her interviews, she stated that CP students are able to better conceptualize concepts than their counterparts. They have more invested interest in succeeding at school and are more motivated to try in school. Perhaps Teacher GSH felt that these characteristics warranted more times of exposure to computers and that Technical students needed more “quality time” with computers, at the cost of less incidents of exposure.

The idea that minorities and low-income students are lacking in basic skills and knowledge is a commonly held teacher belief (Grant & Secada, 1990), attributed to a dearth of parental support and school resources. Since Teacher GSH’s Technical classes were comprised of predominantly African American and Hispanic males of low-income backgrounds, her efforts to “compensate” for the injustices of past Technical teachers are related to issues of race and class. She blames the tracking system and social injustices for the disparities in skills and abilities. From her interview data, it seems that Teacher GSH is very aware of how class impacts the science education of students from low SES families (it is not clear if she is aware of racial impacts).

Further exploration of Teacher GSH’s beliefs would serve to be an informative future study. Studying the ways in which she accommodates seemingly contradictory beliefs about students could give insight into how teacher belief systems are formed and maintained in teaching science. Although she has positive feelings towards her low-level students, her choices for computer activities were not predicated on science academic needs. They were based on increasing student interest and excitement and not on developing scientific inquiry skills.
Therefore, Teacher GSH is an example of a teacher whose beliefs about the purpose of computers prevent her from utilizing the computer to its full potential. Although it is important to meet the affective needs of students, it is also important for teachers to help students learn about science and how to “do” science. It would be useful to research Teacher GSH’s other non-computer based activities and assignments to see if perhaps she does adjust them based on student academic needs, as well as student affective needs.

Teacher PB

Watching Teacher PB teach inspired me. His energy and enthusiasm for learning and science was unusual and refreshing. From his motivational quotations around the room to the ways he interacts with his students, it was clear to me that he takes science teaching seriously. This emphasis on his craft as a teacher was evident in how he planned computer activities for his CP and Technical level physics students.

His strong confidence in all his students’ potential in science was very unique to this study. No other teacher had expressed such favorable views about their students. Although Teacher PB still held some common belief about low-level students (Tech students have not been cognitively challenged in school, Tech students are of lower income backgrounds, Tech students tend to misbehave, Tech students have lower math skills), he adjusted his computer activities in ways that accommodated for these supposed deficiencies, but never changed the intended learning objectives for the activities. He assigned more computer activities to his CP class (“Amount”), he deleted some of the complex calculations in the lab report for his Technical class (“Change Content”), and he shortened the lab write-up for his Technical class (“Change
Activity”). But for both levels, the main objectives of the computer activities were the same: to discover and develop a mathematical equation that best describes the observed physical phenomena in the lab activity.

His peers had unlike goals for their students of different tracks. He had enough confidence in all his students’ cognitive abilities to confidently expect both tracks to attain the same learning goals. Also, he did not allow his beliefs about student characteristics to impact his expectations of students, in terms of science learning. Whereas Teacher DA withheld “cool” activities based on motivation and behavior, Teacher RMI had higher-order learning objectives for her Gifted students based on student life choices, Teacher RMY had higher-order learning objectives for her CP students based on student future plans, and Teacher GSH personally invested more time and energy into her Tech students’ computer activity to compensate for their lack of computer experience—all these teachers adjusted the main objectives of the computer activities based on their beliefs of student characteristics. Teacher PB did not. And there is little indication that any collaboration or sharing of teaching ideas occurs between the teachers at Bayley High School.

So, in order to promote and maintain student motivation, he designs the students’ first experiences with “doing” science through modeling so that there is guaranteed success. This results in positive performance attainments; these continue to build on themselves with every new lab the students complete. They see their peers also succeeding, so they start to have positive vicarious experiences as well. Teacher PB heaps on the verbal persuasion and through these computer activities, three of the four forces that shape student self-efficacy are in place (Bandura, 1986), as explained below.
Perceived self-efficacy is defined as “…people’s judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with judgments of what one can do with whatever skills one possesses” (Bandura, 1986, p. 390). Self-efficacy is formed by four main sources of information (Bandura, 1986). The first is performance attainments. Performance attainments are past successes in executing the action. This is the strongest predictor of self-efficacy because it is rooted in authentic mastery experiences (Bandura, Adams, & Beyer, 1977). If a student has been previously successful in using a complicated graphing calculator, then his/her judgments about future use of the tool will be positive. If using the calculator in the past has been a string of failures, then it is likely that the student has a low self-efficacy about future use of the tool. After a pattern of positive experiences, even periodic failures will not adversely affect the positive self-efficacy of the student (Bandura, 1986, p. 399).

The second area of self-efficacy is vicarious experiences. When people see others performing successfully, then they sometimes can convince themselves that the same possibility is open to them as well. They are able to transpose the experience onto their own personal judgments about their abilities. As well, if one notices that others have failed in a particular task, then their own self-efficacy for that action is lowered (Bandura, 1986, p. 399).

Another source of information for self-efficacy is verbal persuasion. This area has been shown to be less effective than the aforementioned two, but can influence self-efficacy to some degree. “People who are persuaded verbally that they possess the capabilities to master given tasks are likely to mobilize greater sustained effort than if they harbor self-doubts and dwell on personal deficiencies when difficulties arise” (Bandura, 1986, p. 400). This has been shown in several studies (Chambliss & Murray, 1979).
Finally, physiological information can influence a person’s self-efficacy about a task. If a person begins to sweat, shake, and feel afraid when attempting a behavior, then it is likely that those feelings and reactions can cause him/her to believe that they are inept at the task. Anxiety (or conversely, excitement) is a major somatic reflex that can play a role in determining motivation or sustained effort for an action. “Treatments that eliminate emotional arousal to subjective threats heighten perceived self-efficacy with corresponding improvements in performance” (Bandura & Adams, 1977, as quoted in Bandura, 1986).

So, assuming that Teacher PB’s students gain a positive feeling about being successful with Graphical Analysis and these activities do not cause fear or anxiety, it can be concluded that Teacher PB’s scaffolded computer activities probably increase the students’ self-efficacy of doing scientific investigations. However, in terms of teacher expectations, Teacher PB may have projected his own self-efficacy onto his students. As a child, it was not an option in his parents’ eyes for Teacher PB to fail at school. So failure became a non-option for himself as well. Now, as a teacher, he projects this “denial of failure” onto his students, with the rationale that if he could do it, anyone can. This transference of retrospective reasoning-turned-projective reasoning might be called “projected efficacy”.

The students do not view “doing science” as an inherent ability because they actually increase in their ability as the year goes on in Teacher PB’s class. So, once they start to believe that ability is not static, they may begin to increase their self-efficacy. “The same person may view ability differently in different domains of functioning” (p. 119, Bandura’s book). Preexisting conceptions of ability are changeable through social influence. When the students automatically sat down after collecting data and started using the Graphical Analysis program without any direction from Teacher PB, it seemed that they felt confident about their skills with
the program. Actually, one group of students rushed to finish collecting their data and split up the team’s responsibilities so the data could be inputted into the computer before the end of class. They said they wanted to see what kind of correlation line they got. This particular group had just been sent out into the hallway the day before for bad behavior and often joked that they were not good at science.

Teacher PB’s “projected self-efficacy” and confidence in his students’ abilities to do science led him to plan computer activities that were inquiry-based. There are five essential features of a classroom activity conducted via inquiry (Layman et al., 1996).

- Learners are engaged by scientifically oriented questions.
- Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
- Learners formulate explanations from evidence to address scientifically oriented questions.
- Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
- Learners communicate and justify their proposed explanations.

Through the use of Graphical Analysis in his planning of lab activities, Teacher PB incorporated all of the five features of inquiry into student learning. The students were engaged by the investigations, to the point of barely noticing my presence in the room. Teacher PB never gave them more information than needed to complete the activity, so that the students had to come up with their own explanations from the data they collected themselves. This emphasis on the importance of data leading to model relationships then enabled students to critically think about the data and compare their models to other student group’s models. Finally, through the
rigorous, structured lab report, students were asked to put their ideas on paper and communicate their thinking about the unknown. It is this effort-laden process that students build knowledge about physics relationships in Teacher PB’s class. Critical thinking is defined as nonalgorithmic; complex; amenable to multiple solutions; involving nuanced judgment; employing multiple criteria; uncertain; self-regulating; imposing meaning; and effortful (Resnick, 1987, as quoted in Layman, 1996). I believe Teacher PB’s Graphical Analysis labs emphasized many of these criteria.

Similarly to Teacher PB, Teacher DA may be projecting her own self-efficacy on her students as well. However, she believes that the students’ inability to self-regulate and self-motivate is a stable, inherent quality, just like how her giftedness was an inborn characteristic for her when she was growing up. She believes that these low-track students are unable to use their abilities to succeed in school. As a result, her “projected self-efficacy” does not result in confidence in her students’ ability to learn science. This lack of confidence is apparent in the ways she planned computer activities for her Tech Biology class.

**Summary of Five Teachers**

In summary of this in-depth examination of five teachers’ beliefs about students and effects of those beliefs on computer activity differentiation, it is clear that past experiences and teaching experiences play a role in forming teachers’ views about student abilities, background, and characteristics. Teacher DA planned uses of the computer as a response to student behavior. Their behavior was mediated by student characteristics, such as home life and personal choices. Teacher RMI based her choices of computer activities on the “neediness” of the students, a result of student background and personal choices as well. Teaching the two extreme levels in the tracking spectrum enabled her to see student differences more clearly, resulting in a more
elaborate theoretical explanation of those student differences. Teacher RMY had the most stereotypical views of her tracked students and from these views she developed understandings about their future goals and directions. She tailored her computer activities to meet those future goals and directions. Teacher GSH believed some of the same ideas about Tech students as the other teachers, but adjusted her attitude positively towards those beliefs because of her past experiences of being a Tech student herself. She planned activities for the affective needs of her students. Finally, Teacher PB believed in the innate abilities of all his students. Because of this belief and of his distinctly unique views about teaching science, he planned inquiry-based, independent, student-centered computer activities that mimicked true scientific investigation in order to increase the science abilities of all his students. He practiced “transformational” versus “transmissional” forms of teaching (Jackson, 1986).

Past researchers have found that even though teachers are aware of science education reforms, they do not always change their teaching habits (Yerrick, Parke, & Nugent, 1997). In-service summer institutes and guest lectures by renowned theorists in science education were not enough to alter teachers’ entry level fundamental beliefs about the nature of scientific content knowledge, teaching, and assessment practices. Teachers were found to assimilate only portions of reform ideas into their belief systems, and even then only in ways that supported and affirmed their previous beliefs about teaching and learning (Yerrick et al., 1997; Hollon, 1987).

A parallel of the previous results can be made to the findings of this study. Just as teachers are resistant to adopting reform ideas about teaching, the teachers in this study may be reluctant to critically examine their beliefs about female, minority and low-income students. These beliefs about student characteristics are so entrenched that some teachers noted that these characteristics were “facts” and will not change (Teacher RMY, DK). Teacher DA even
commented on the effects of teacher expectations on student motivation, but did not have the insight to notice her own low expectations of her Technical students. Teacher PB was the only teacher who took the time to determine whether the use of computers was the best way to teach science to their students (and he discovered this serendipitously through his distrust of Technical students’ behavior).

The ways in which these teachers planned and developed their computer-based curriculum do not reflect a belief that low-track students can achieve more, change their attitude, or control their own education. The “transmission”, teacher-centered format of teaching exhibited by the majority of these assigned computer activities communicates to marginalized students that their teacher does not expect them to be able to master the material without the teacher’s help.

Implications

The results of this study indicated that teacher beliefs about student characteristics have a direct impact on how teachers differentiate computer activities for different track levels. The student demographics of the different track levels examined in this study were significantly different by race, gender, and total family income. Therefore, race, gender, and total family income had some influence on teacher beliefs about students, which in turn impacts curriculum planning of computer use in science education. Non-Asian minority students and poorer students receive less computer opportunities, lower-level objectives, and more structured, teacher-centered computer activities. White and Asian students and richer students are assigned more computer opportunities, asked to use higher-order thinking skills more often, and trusted to complete independent, student-centered computer activities. Gender plays a role in that when CP classes are the higher of the two levels being compared, females receive computer activities
similar to those of the privileged group. When CP is the lower of the two levels, then males receive computer activities similar to those of the privileged group.

These results also imply that the Triad theoretical model proposed for this study is a good representation of the relationship between science education, equity, and technology use in schools. They all follow from each other and they lead into each other. The student demographic data and the teacher differentiation methods indicate that the issues of equity in science education parallel those in equity in school computer use. The complexity and interdependence of teacher beliefs, student characteristics, and student use of computers necessitated a mixed methodology because there was no linearity to their relationships. It is possible that there are other “corners” to the Triad that would add to the development of sides A, B, and C. Future researchers need to examine more closely the social and political factors that influence these three sides and perhaps discover if there are other theoretical areas that would help explicate these connections.

What can be concluded from these findings is that the connection between teacher beliefs and teacher choices in curriculum planning is complex and contextual. No two teachers differentiated computer activities for the same reasons, but many of them differentiated activities in similar ways and had similar beliefs about students. The fact that the methods and beliefs were more alike than the rationales behind the methods and beliefs indicated that perhaps teachers employ a set number of techniques for altering curriculum for students of different tracks.

Therefore, in studying teacher beliefs, researchers must not reduce the study data to mere surveys and questionnaires. The richness of repeated interviews and observations help shape the researcher’s understanding of how beliefs transform and direct action. Even the 31 interviews
conducted for this study seem to be barely enough to draw the conclusions in this chapter. Going deeper into the schooling experiences of these teachers and their students would have made the interpretive process more valid and authentic.

As well, research in the area of equity affords certain cautions and concerns. For example, although none of the teachers spoke about gender issues in their classes, the statistical portion of the results indicated a significant difference in the percentages of females in the Technical and G/H/AP track levels, as compared to the CP level. Since teacher beliefs must be inferred and cannot be directly measured, researchers must sometimes “read between the lines” to get at their true beliefs when those beliefs are not stated forthright. It is certainly possible that there is a number of other beliefs not mentioned during this study’s interviews and were missed throughout the analysis process. Therefore, equity research benefits from a mixed methods approach (using quantitative and qualitative methods) in order to glean as much information about beliefs and context as possible, especially when some teachers may feel embarrassed or uncomfortable expressing certain non-politically correct ideas about Tech students.

Future Research

The study of equity issues in education is important if we are to move away from a monocultural educational system that enables students of the dominant groups to succeed in science and math. “Equity in education refers to the scrutiny of social arrangements that undergird schooling to judge whether or not those arrangements are consistent with standards of justice” (Secada, 1994). Because “equal” does not necessarily mean “fair”, it was important to critically examine the ways in which the mandated use of computers for science education differed for students of unlike track levels.
This study hopefully will initiate further equity research into the use of computers in science education and how the issues of tracking impact that use. Tracking has been shown to affect teacher expectations, beliefs, and planning in the classroom. This study adds to this knowledge by confirming that computer planning is also affected by tracking practices and teacher beliefs as well.

More studies need to be conducted on ways to promote in service teachers to reflect on their beliefs about students, as well as motivating them to challenge and perhaps change some of those beliefs. Helping teachers better understand the relationship between their assumptions about students and their teaching practices may give them pause to consider the ramifications of their assignments, as well as the implicit messages sent to students through their curriculum choices.

Also, this study’s results are confined to the participants at the research site. Additional studies like this one are needed at other schools from other parts of the country. More data from the actual classes (i.e. year-long classroom observations) and the dynamics between teacher and students would greatly enrich and substantiate the findings of this study. Extrapolating this study to the other academic subjects in high school might determine whether the patterns discovered in this study are science specific. It is possible that teachers are differentiating computer activities in similar ways for English, math, or social studies, for example.

Another limitation to this study is that only tracked science classes were examined. Although all schools in Georgia practice curriculum tracking, it is important for other researchers to investigate how teacher beliefs affect curriculum differentiation for students of different abilities in heterogeneous classes. If similar results are found for non-tracked science classes, then those results would further substantiate the claims made in this study, that is, teacher beliefs
about students influence teacher judgments about how to mete out science educational opportunities to students of disparate races, SES, and genders.

Finally, there is a need for more research on the relationship between race, class, gender, and teacher beliefs. As well, it is also imperative that researchers investigate how these factors impact student learning, individually and in concert. Although the assignments studied in this study were clearly changed for different track levels, it is not necessarily true that the students of all tracks have learned unequal amounts of science content and skills; it also is not an obvious conclusion that they would perform differently on a standardized test in science. Further research on how these disparate teacher practices impact student achievement and the conditions under which they affect it. Ultimately, we are all concerned about providing students with the best opportunities to maximize their potential. The ultimate implication to studies like this one is whether or not students are harmed, helped, or changed by teachers assigning different activities to different track levels. Future equity research needs to explore this other end of the question.
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APPENDIX A

PROTOCOL FOR FIRST ROUND OF TEACHER INTERVIEWS

1. In your opinion, what are the purposes of using computers in science classes?

2. How can computers transform science learning for different students?

3. What are some barriers to computer use in science classes?

4. Describe your process of choosing activities (computer-based and non-computer based) to incorporate in your teaching for each different class?

5. How does class track-level influence your decisions about computer use in your science classes?

6. What are the science and computer capabilities of your different classes?

7. What are the necessary aspects for good learning in your different classes?

8. The editor of the technology section of Forbes magazine once wrote: ‘In the end it is the poor who will be chained to the computer; the rich will get teachers.’ What are your opinions of this comment?

9. As teachers make up their lesson plans, many factors influence their choices on which activities to assign to their students. For the following items, check the boxes next to the factors that influence your decision on which computer activities to do (and when to do them) in each of your classes:
   - Student age
   - Student gender
   - Student ethnic background
   - Language spoken by student
   - Student family income
   - Student owns a computer at home
   - Student past experience with computers
   - Student ability in science
   - Student ability with computers
   - Student discipline record
   - Student appearance
   - Student past behavior in class
- Class physical arrangement
- Track-level of the science class
- Number of computers accessible
- Software/hardware available
- Class management issues
- Time needed for computer activity
- Resources needed for computer activity (i.e. worksheets, probes)
- Your own familiarity with the software/hardware
- Your own comfort-level with software/hardware
- Your mastery of the content
- Content being covered
- Skills outlined in AKS

OTHER—Please list any and all that you think of:
APPENDIX B

PROTOCOL FOR SECOND ROUND OF TEACHER INTERVIEWS

1. Tell me about a typical day using technology in your classes.

2. Tell me of an instance when the computer activity went well. What were the circumstances? What made it go so well?

3. What would be an ideal computer activity for your students, barring any barriers (suppose you had a million dollars, no time constraints, and could teach whatever you wanted)?

4. Describe the ideal student that you plan your computer activities for.

5. Give a general description of a typical Technical student, a typical CP student, and a typical G/H/AP student. What are his/her likes, dislikes, strengths, weaknesses, appearances, family life, academics, race, gender, friends, etc.?

6. Why do you have different computer activities for your different track levels?

7. What other information would you like for me to include in the interview?

8. Please read over your first interview transcript and feel free to comment, edit, or elaborate.
APPENDIX C

STUDENT SURVEY

Remember, ALL information on this survey is confidential and will not be seen by anyone except Ms. Tsoi and her advisor. Your teacher, your friends, and your parents will NEVER see this survey.

1. CODE NUMBER (from Consent Form): ______________

2. Age: ______________

3. ☐ Male   ☐ Female

4. Race/Ethnicity: ________________________________

5. Yearly gross family income level (If not sure, make an educated guess and write "not sure" under the number)
   ☐ $0-25,000   ☐ $25,001-50,000   ☐ $50,001-70,000   ☐ $70,001-90,000   ☐ $90,001 +

6. Present grade level: ☐ 9th   ☐ 10th   ☐ 11th   ☐ 12th other: ____________

7. Does your family own or have easy access to a home computer? ☐ Yes   ☐ No

8. How many computers (desktop and laptop) are there in your home? ___________

9. How often does your science class use computers (check one)?
   ☐ never   ☐ rarely (1-2 times a semester)   ☐ sometimes (once a month)
   ☐ often (2-3 times a month)   ☐ always (1-2 times a week or more)
   ☐ other______________________________________

10. Describe the computer activities that are assigned in your science class. What are they like? How helpful are they? What would you like to change?
    ____________________________________________________________________
    ____________________________________________________________________
    ____________________________________________________________________
APPENDIX D

LIST OF ASSIGNED COMPUTER ACTIVITIES BY TEACHER AND TRACK LEVEL FOR 13 TEACHER SUB-GROUP (TAUGHT TWO TRACK LEVELS, SAME SCIENCE CONTENT AREA)

TEACHER BI

AP PHYSICS B--5 computers plus personal laptop in room

1) Problem of the week. 18 a semester. Can use internet or not. One problem, for example, asked them to use a spreadsheet to figure out if they would rather have a lump sum now or a penny a day for a certain period of time. Problem objectives varied, from developing search skills to exploring new computer applications.

2) Formal lab reports. 3 times a year, 1 during 2nd semester. Format on webpage. Done on computer. Requires data/graphs to be displayed. 1/3 of students draw with computers.

3) Web site of class. Has answer keys, how to do labs and reports, and syllabus.

4) 6 or more labs—graph data using Graphical Analysis. First 3 labs are a linked motion lab=35 points. Other labs = 20-25 points.

5) Use video camera to film projectile path of launched water balloon. Step film frame-by-frame to graph path.

6) Collect data for labs on calculator.

7) Quote assignment. They must find author and source (it’s by W. Heisenberg). Quotation not found in Bartlett’s. Assignment developed before Internet to help students hone research skills.

8) 1 of 50 Questions assignment. List of 50 science questions. Student chooses one and uses whatever means necessary to find answer. Purposes were to allow student to explore area of interest and to help student relate things to science.

AP PHYSICS C

1) 4-5 labs—graph data using Graphical Analysis.

2) Use video camera to determine terminal velocity of ping-pong ball falling along a marked rope. Project images on screen in classroom. Students practice unit conversion and velocity calculations.

3) Use spreadsheets to solve problems. 5-6 problems and 3-4 lab experiences. Problems come from section of book designed for technology-based problem solving.

4) Students make answer keys. They scan them and post on website. Helps students practice web authoring.

TEACHER DK

TECH BIOLOGY

1) Research project on Infectious Disease. 2 days in Media Center. Same as CP. But, students make a brochure.

CP BIOLOGY

1) Lectured with PowerPoint. 2 times this semester. New thing he’s just tried this semester. “New thing—to add variety to lecture”.
2) Infectious diseases project. 2 days in Media Center to research assigned disease. Students must write a paper and create a booklet/visual aid/PowerPoint presentation. Strongly encourages use of computer. Gives students websites and search engines they can use.

TEACHER DT

TECH BIOLOGY

1) Infectious Disease project. Look up websites chosen by TD and fill out an information sheet. 1 day in Media Center. 20 points.
2) Microorganisms Project. Make a field guide with drawings. Look up websites chosen by TD. 2 days in Media Center. 50 points.

CP BIOLOGY

1) only one project during Fall semester. None during Spring 2002.

TEACHER DA

TECH BIOLOGY

1) Bacterial or Viral Disease project. Required 1 Internet source and 1 book source. 1st day walk students through useful links and basic search skills. 2nd day students had free time to finish project. Write up findings.
2) Sight vs. Sound Reflex activity. At www.explorescience.com, there is an activity where the student can time their sight and sound reflexes to stimuli. Pick shape/color and click with mouse for reflex measurement. Did this in Math Computer lab and in classroom when Computer lab was booked. Easier worksheet than CP.

CP BIOLOGY
1) Photo Essay on a Biology Professional. Independent project on any topic about Biology. Interview a professional in the field and make photo essay, actual photos preferred—but do have Internet option. Idea found on www.accessexcellence.com, a site for shared teacher ideas. Objectives are to develop writing skills, research skills, take responsibility with an interview, and show students careers in science (broadens their views on uses of Biology). 200 points over a 2-month period with intermediate checkpoints.

2) Same Sight vs. Sound activity, but later in the semester (see above for description).

TEACHER GSH

TECH CHEMISTRY

1) Has class website with homework assignments, pictures of students during lab, links to help sites, class notes so they don’t have to write them.

2) Bacteria Project. 1 day in Media Center to do Internet search for bacteria information. Then 2 days in Computer lab to make a PowerPoint presentation, in groups of 2. Then use computer and projector in class to present PowerPoints to class. Counted 5 daily assignment grades, each 10 points.

CP CHEMISTRY

1) Has class website with homework assignments, pictures of students during lab, links to help sites, class notes so they don’t have to write them

2) Used computer with projection to show examples in class from a CD Rom—2 times this semester.

3) PowerPoint that SG made on Nuclear Power. Showed during class.

TEACHER HS

TECH BIOLOGY (COLLABORATIVE—means teacher had a Special Education teacher assisting)

1) Infectious Disease project. Any disease of their choice. Answer a given list of questions and do a class presentation. 2 class periods in Media Center.

2) Suggested websites for homework. To help complete a lab or get more information on a topic.

CP BIOLOGY

1) Weekly extra credit. Write a bibliography of a person SH chooses. Advised to use the Internet. 1 point.

2) Animal Book for 1st grader. Gives list of requirements and webpages to start from. Test grade

3) Infectious Disease project. Any disease of their choice. Answer a given list of questions and do a class presentation. 2 class periods in Media Center.
4) Suggested websites for homework. 5-6 times this semester. To help complete a lab or get more information on a topic.

TEACHER KF

TECH BIOLOGY

1) Storybook on a Phylum. Internet search for 1 day in Media Center, FK gives students the websites to use. Gives students required format and required information. Students must find and put book together, computer required. Suggested computer for drawings, and most did. 100 points, 10% of grade.
2) Extra credit. Student looks up answers to questions that come up in class. Write answers for 10 points.

CP BIOLOGY

1) Bacterial Disease project. Internet search for 1 day in Media Center. Write a paper on findings. 100 points, 10% of grade.
2) Storybook on a Phylum. Internet search for 1 day in Media Center, FK gives students the websites to use. Gives students required format and required information. Students must find and put book together, computer required. Suggested computer for drawings, and most did. 100 points, 10% of grade.
3) Extra credit. Student looks up answers to questions that come up in class. Write answers for 10 points.

TEACHER MRO

TECH PHYSICS

1) Pendulum Period lab. 6 portable computers—students used Graphical Analysis to input data given by RM, to obtain a graph, linearized version of graph, and equation of the line. Answer questions about lab. 30 points.
2) Internet search on article on waves and vibration. Summarize article, generate questions, and answer questions. All did search, but assignment was turned in for extra credit 10 points.

CP PHYSICS

1) Internet search on article on waves and vibration. Summarize article, generate questions, and answer questions. All did search, but assignment was turned in for extra credit 10 points.
2) Internet site on waves. Simulation and learning site. Read information and take online quiz on 5 different topics to expose students to stuff out there.

TEACHER RMI
TECH CHEMISTRY—computers used for illustration of concepts or practice

1) Computer with projector—an example from Internet onto screen for class. 1 time.
2) Internet exercise for balancing equations. Projected website onto screen for class to practice with. Faster than MR writing examples on board and erasing each time.
3) Internet search for benzene. 2 paragraphs on characteristics and hazards of benzene for 20 points. Objective was to practice writing for Gateway test.
4) PowerPoint on Nuclear Energy, produced by another teacher. Showed it as lecture during class.

GIFTED CHEMISTRY—computers used for illustration of concepts

1) CD Rom based lab. Calorimetry lab, from a CD Rom obtained from a local teacher conference—“Bridging to Lab” module. Done as a class, the lab was projected from computer onto screen and as a class, students direct choices during this virtual lab. Heat of solution was calculated after adding a solute. Results compared to commercial cold pack and students reasoned why other solute was used commercially.
2) CD Rom based lab. Freezing point depression. Done as a class.
3) Look things up that pertain to lab. Asks them to “look up”, but all the students end up on the Internet. For 3-4 labs this semester. Example: Look up what Na₂CO₃ is for lab.
4) Does not require typing.

TEACHER RMY

TECH CHEMISTRY—takes out math requirement in assignments

1) Polymer Project. Collecting samples of polymers to recycle. Students look up information on chemical tests on polymers. MR gives students websites to use. At least one person per group must look up information.
2) Encourages students to look stuff up on Internet outside of class—for extra credit.
3) Students made a children’s book as a review of the air unit. Could have been done all at school, very little home time required. Objective: reinforcement, fun, just synthesize information.

CP CHEMISTRY

1) Polymer Project. Collecting samples of polymers to recycle. Students look up information on chemical tests on polymers. MR gives students websites to use. At least one person per group must look up information.
2) Extra credit. Look up topics related to what they were learning. For example, in petroleum unit—look up cars, hybrids. Up to 20 points. 10 out of 14 groups did it.
3) Air report. Students were to use report to teach themselves about topic. Go to Media Center and look up information for presentation, display, graphs, and charts. Require 1 internet source. 100 points. Done at home and at school—required some home time. Objective: to synthesize information and apply, “try to understand a topic”—how does air chemistry affect environment and legislation?
TEACHER ST

TECH CHEMISTRY

1) Note taking in Media Center. Once a week for first 5 weeks of unit, students look up sites for notes on unit. Students fill in answers to questions in notes. Notebook quiz checks these notes, 20 points.

2) Benzene project. Students given 2 sites to navigate through and answer questions at end of activity. Also, students write 2 paragraphs that include information that they learned in activity. 50 points.

3) Excel to graph data. Air unit on Boyle’s and Charles’ law. Graphs made in computer lab. Instruction sheet on how to use Excel, what to click on.

4) Computer with projector for petroleum unit. 3–4 times a week during the 6 week unit.

CP CHEMISTRY

1) Petroleum PowerPoint lecture. For organic chemistry chapter.

2) Fractionated Tower Project. Gave students a couple of internet sites. Students get information so they could draw a fractionated tower and label its parts. The site broke down a tower and showed how it worked.

3) Tutorial for Graduation Exam—juniors only. 2 days in Media Center. Only 8 students went.

4) Vitamin/Mineral project. Students had to use certain sites to get information (sites were given during 1st semester and reused repeatedly for different activities). Students then gave a presentation and needed a creative visual aid. Computers not required.

5) Sometimes a bonus point for typing an assignment.

6) Excel to graph data. Air unit on Boyle’s and Charles’ law. Graphs made in computer lab. Instruction sheet on how to use Excel, what to click on.

7) Computer with projector for petroleum unit. 3–4 times a week during the 6 week unit.

TEACHER SC

TECH BIOLOGY

1) Famous Black American Scientist project. Internet Scavenger Hunt—find the names of people based on what they did and write a short report on one of them. 1 day in Media Center. 100 points = small. Class work total is 35% of total grade. So lots of class work.

2) Bacteria and Viruses Unit. Self-made PowerPoint for lecture, projected in class. Different PowerPoint in that there were more pictures and examples to illustrate concept, less text.

CP BIOLOGY
1) Famous Black American Scientist project. Internet Scavenger Hunt--find the names of people based on what they did and write a short report on one of them. 1 day in Media Center. 100 points = small. Class work total is 35% of total grade. So lots of class work.

2) Bacteria and Viruses Unit. Self-made PowerPoint for lecture, projected in class.

3) Assigned students to look various things up on Internet for 5-10 minutes. Students write up what they find for a grade. 3 times this semester.

TEACHER PB

TECH PHYSICS

1) Graphical Analysis to analyze lab data through graphs. Discover physical relationships from graph. Complete lab report write up on graph paper (but most use computer). More lenient on grading of math and calculations.
   a. Hooke’s Law lab.
   b. Energy Efficiencies Lab. Used bar graph instead of typical data plot to compare efficiencies of dart guns.
   d. Capacitance and Wave Mechanics labs done in Fall, with different equipment (no slinkies in hallway).

CP PHYSICS—6 computers, 1 broken monitor

1) Using the software ‘Graphical Analysis’ to analyze lab data through graphs. Discover physical relationships from graph. Complete lab report write up on graph paper (but most use computer).
   a. Ohms Law Lab
   b. Circuits Lab
   c. Capacitance Labs
      i. Plate Separation Distance Lab
      ii. Plate Area
      iii. Plate Discharging
   d. Wave Mechanics with slinky

2) Physics Presentation. Students must develop a 20 minute Physics activity and a visual component on a subject related to physics. “The whole point was they pick something that they’re very interested in and they investigate the physics of it…And then be able to put that in a presentation format so that they could then share it in a meaningful and engaging manner with the rest of the class, which is why I asked them to have an activity.” Guided students over weeks on how to design an activity. 2 days in library for background research, but technology not required. Suggested technology and most have used it in some form for presentation. 8% of semester grade.

3) Computer with projector to show during class discussions of clever animations or simulations (electric field waves) off Internet. Objective: to present information. About 12 times.
4) Chooses not to do too many simulations because students don’t get the full impact of doing it themselves.
5) Had students look up website of NASA at home—for extra credit.
APPENDIX E

SPREADSHEET OF TYPES OF ASSIGNED COMPUTER ACTIVITIES ARRANGED BY TEACHER, TRACK LEVEL, AND ACTIVITY TYPE

<table>
<thead>
<tr>
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## APPENDIX F

MEMOS ON TEACHERS’ METHODS OF COMPUTER ACTIVITY DIFFERENTIATION

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<thead>
<tr>
<th>Teacher</th>
<th>How they differentiate</th>
<th>Memo</th>
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<tbody>
<tr>
<td>BI</td>
<td>Less class time spent on computer activities with AP B because their competency is lower (2:16). Less activities, but more meaningful ones with AP C because they have more “student science ability” (2:53, 2:54, 2:55). Computers can cause the gap between techies and non-techies to increase (2:25, 2:45, 2:46), so it’s OK to use more computers with C. All internet research is with AP B. No reports, projects, creative assignments with AP C.</td>
<td>Less with higher level, but more in depth</td>
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<tr>
<td>DK</td>
<td>Lectured with Powerpoint with CP, but not with Tech, to add variety to lecture. Same internet research project, but Tech has different product. Grades Tech easier because of language and writing issues, can’t do homework, less attention, biologically not as intelligent. He does not know how to use technology. He does not see a need to differentiate the activity.</td>
<td>Different requirements for lower level.</td>
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<tr>
<td>DA</td>
<td>Activity is doable by both levels. Did more “problem solving”, creative internet research project (photo essay) with CP because Tech will not turn in HW (lots of explanations). So the internet research project for Tech was designed so that all of it could be done at school, with supervision (4:6). Made product easier for Tech. Refrains from doing “cool” activities with Tech because they aren’t motivated (4:31).</td>
<td>In depth activity with higher level; assignment adjustment and different requirement for lower level.</td>
</tr>
<tr>
<td>CS</td>
<td>More internet searching for CP because some of Tech has low computer ability, which is “confusing or frustrating” (6:3). If students need a lot of individual attention, then she does not assign activity (6:8, 6:9). CP is more independent. Powerpoint for Tech had more pictures and examples because “they do better with the visual, rather than having the slides on Powerpoint where they have to read it…”</td>
<td>Assignment adjustment; more activities with higher level.</td>
</tr>
<tr>
<td>DT</td>
<td>2 internet research projects with Tech, none with CP. All done at school. Tech has less attention span, less motivation, no basic skills, more visual.</td>
<td>Assignment adjustment; more activities with lower level.</td>
</tr>
<tr>
<td>GSH</td>
<td>More interesting, “get out of their seats” activity with Tech. Purposely pulls more technology into Tech because less familiar with it, have less math skills. Tech loses interest in</td>
<td>More activities with lower level.</td>
</tr>
</tbody>
</table>
lectures due to different learning style—need hands on. Tech need more stimulation, don’t have computers at home.

<table>
<thead>
<tr>
<th>HS</th>
<th>More activities with CP because Tech students lose HW. CP can keep up with assignments—more mature, can handle freedom, will turn them in. Stays on task. Did not make Powerpoint an option for Tech in the Infectious Disease project.</th>
<th>More activities with higher level; assignment adjustment for lower level.</th>
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<tbody>
<tr>
<td>KF</td>
<td>More internet project with CP because Tech could not handle writing a formal paper, have no access, and less of them turn projects in.</td>
<td>More activities with higher level.</td>
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<tr>
<td>MRO</td>
<td>More in depth activity internet simulation activity with CP. Only basic graphing with Tech. Orchestrates activities to be challenging to students at their level. CP has more ability to do science work, more computer ability. Differentiation due to student ability in science and math skills.</td>
<td>More in depth activity with higher level.</td>
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<tr>
<td>RMI</td>
<td>More class experiment simulations and HW internet searching in Gifted because they are willing and have access. Most of Tech activities are for lecture/demonstration. I internet search to “play on the Internet”. Gifted “can handle it more without me having to walk them through every single thing”. Tech asks for more help. Tend to do higher-level thinking activities with Gifted because of higher science ability, math and abstract things. More application—“how does this affect YOU at your house...” with Tech. Don’t require typing for lower science ability. More instruction with Tech.</td>
<td>More in depth activities with higher level. More at home activities with higher level. Lower requirements for lower level. Assignment adjustment for lower level.</td>
</tr>
<tr>
<td>RMY</td>
<td>More internet research activities with CP. Tech has less computer ability. Tech takes more time.</td>
<td>More activities with higher level.</td>
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<tr>
<td>ST</td>
<td>More internet research projects with CP because Tech “…would not do anything at home. They’re not motivated enough to take the time out at home to research the information, to put it together...where in College Prep—they are. They WILL go to the Media Center, they will manage their time to get it done”. Also, done for HW with CP. The 1 that Tech did was a lot more guided, and done at school. More internet research for note-taking with Tech. Tech needs more hands-on because they have a lower science ability.</td>
<td>More activities with higher level. Assignment adjustment for lower level. More low level activities with lower level.</td>
</tr>
<tr>
<td>PB</td>
<td>3 more Graphical Analysis labs with CP. Presentation project and computer for lecture only with CP. Project and HW internet search (extra credit) because CP has more computer ownership. More qualitative data analysis with Tech. Adjustment made for Tech doing Graphical Analysis lab (different equipment, more “mellow” lab report) because of behavior and low math ability.</td>
<td>More activities with higher level. Assignment adjustment for lower level.</td>
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Note: Numbers denote transcript line numbers for researcher’s reference.