ON-SITE PROFESSIONAL DEVELOPMENT:
USING DIFFERENTIATION TO SUPPORT
INSTRUCTION IN MIDDLE SCHOOL SCIENCE

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree
Doctor of Philosophy in the Graduate School of
The Ohio State University

by
Mary Lightbody, A.B., M.Ed.

*****
The Ohio State University
2004

Dissertation Committee: Approved
David L. Haury, Ph.D., Co-Adviser ______________________
Patricia A. Brosnan, Ph.D., Co-Adviser ______________________
Christopher L. Andersen, Ph.D. ______________________

College of Education
ABSTRACT

This mixed methodology study addressed two questions about instructional practices used by middle school science teachers in a large suburban district in a large Midwestern state. First, to what degree do the science teachers modify their regular instructional practices to meet differing needs of the students in their classes, including those who are identified as gifted? Second, to what extent was the amount of professional development support the teachers received a factor in the degree to which they implemented differentiated units of instruction? Twelve middle school science teachers participated in a graduate level course to learn principles of differentiated instruction using the Curry/Samara Model. In this model differentiation was defined as a process through which teachers modify content (what the students learn), processes (the levels of thinking in which the students engage), or products (how students demonstrate their learning). Teachers were provided professional development support for the duration of the study, ranging from individual conferences and planning sessions to model- and team-teaching in the classroom.

Initially the teachers evidenced no discrimination in instructional practices for gifted students in their classrooms, although they did modify instruction for students with learning disabilities. Teachers used several strategies related to questioning and
thinking skills with all their students, such as encouraging student participation in
discussions, but they did not ask different or higher-level questions of the gifted
compared to the regular students.

After participating in the course, all twelve teachers implemented some
differentiated practices and activities. Those teachers who had used inquiry or
constructivist theory to guide their practice were most able to implement differentiation
strategies without extensive professional development support, and implemented the
strategies on a regular basis through the remainder of the school year. A second group
of teachers saw increased student achievement through the use of differentiation, and
implemented actions necessary for differentiation with frequent support for actual
implementation. Teachers with outside commitments (i.e., young children, or other
obligations at the school) had the least amount of time to plan and implement
differentiated strategies, and need additional, consistent, and persistent professional
development support to continue to make changes in their practice.
DEDICATION

To my parents, James D. Lightbody and Patricia C. Lightbody,
who instilled a love of learning and a spirit of “doing-does-it”
that have become ingrained habits.

To my husband, Richard R. Noss, and our children, Amy, Charlotte, and John,
for their love and encouragement all these years.
ACKNOWLEDGMENTS

I am indebted to the cadre of teachers with whom I worked along the way, and in particular to the twelve teachers who participated in this inquiry. You opened your classrooms and your own work to view and study, graciously and kindly. Thank you.

I am indebted to many members of the faculty at the Ohio State University, but in particular my committee members, whose support has been invaluable. Thank you.

I am indebted to my graduate student colleagues who provided an intellectual community in which I grew and thrived. Thank you.

Thank you to the administrators in the school district in which I did this research, for the support in resources for the teachers, and to the students who gamely took on the new challenges and assignments provided to them by their teachers during this inquiry.

I also appreciated the help from John and Pat Samara (and their associates), and fellow researchers such as Drs. Deb Burns and Susan Amidon, who provided guidance as well.
VITA

July 17, 1952 ......................... Born, Battle Creek, Michigan

1974 ............................... A.B. cum laude, Harvard/Radcliffe College
1992 ............................... M.Ed., The Ohio State University

1975 - 1980 ......................... Faculty member
Milton Academy, Milton, Massachusetts

1992 - present ....................... Teacher
Columbus Public Schools, Columbus, Ohio
Hilliard City Schools, Hilliard, Ohio
Middleview1 City Schools, Middleview, Ohio

PUBLICATIONS


1 This is a pseudonym to protect the identity of the teachers in this study.


**FIELDS OF STUDY**

**Major Field:** Education

**Major area:** Mathematics, Science, and Technology Education

**Minor areas:** Gifted Education, Curriculum, Leadership, and Supervision
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CHAPTER 1

INTRODUCTION

Highly learned educators have been attempting to improve the level of student achievement in the United States, particularly in mathematics and science, for decades. Several factors can be cited as contributing to the difficulty of the task, not least of which is the fact that American public schools are designed to provide an education to all children in the country between the ages of 5 and 16, not just those who are well behaved or are able to pass a difficult achievement test at age 10 or 12 and continue in rigorous college-track academic programs. Our public schools are open to all, regardless of race, religion, financial status, previous educational experiences, and ability or disability.

For many American students the ultimate education level attained plays a significant role in career opportunities, making at least a high school diploma desirable and often necessary for employment, especially in times of economic downturn. At the same time, many states have passed legislation requiring students to pass a series of proficiency tests to graduate from high school; for some, this has made that diploma even harder to achieve. Federal No Child Left Behind (NCLB) legislation is now requiring all states to implement achievement testing programs, to raise academic
achievement for all children, and to take action to improve poorly performing schools (U.S. Department of Education, 2002). NCLB also requires states to certify teachers as “highly qualified,” and to provide increasingly detailed data analysis to document continuous improvement of students at all achievement levels.

The reality of NCLB and state testing requirements bring tremendous pressure to bear on teachers. In the United States, public school teachers, especially, cope with widely disparate student populations in their classes. Students have different levels of understanding of content. Many middle school and high school students have misconceptions that must be dislodged before learning can take place. Some have little interest in or affinity for the material no matter how it is presented, while others, who want to learn, struggle to concentrate and achieve amid the distractions in the classroom and their lives. Most teachers have students in their classes who are at opposite ends of an achievement spectrum and everyplace in between, with all manner of learning styles and needs. Teachers in middle schools face even more diversity by the very nature of the students in that age distribution.

During the three years of the typical middle school experience, variance among students can be pronounced. Every class of sixth-, seventh-, or eighth-graders is virtually guaranteed to have students with widely different levels of physical development and emotional maturity. Mood swings and hormone shifts can cause a particular student to be vastly different in attitude and demeanor from one day to the next, and sometimes even from one class period to the next. Growth spurts happen at different times for the two sexes and between any two students of the same sex. Middle school is also a time when many students seek more independence from parents, and most are far more interested in
their peers and classmates, especially those of the opposite sex, than in their school work. At the same time, educators also know that the middle school student’s intellectual capacity to learn is expanding rapidly (Lappan, 1998).

Helping students learn is the ultimate goal of every teacher. However, if we take as an ideal that every student (no matter the age, maturity level, or motivation) deserves to learn something new at school every day, then we must admit that in the typical classroom the ideal is not always achieved. In some areas of the country, smaller class sizes in primary grades, teaming and the middle school concept in grades 5 to 8, smaller learning communities at the high school level, and other organizational modifications have provided some relief and support for increased student learning. Unfortunately, these system-wide or building-wide alternatives are not always possible for individual teachers to implement.

Consequently, most teachers try to meet their educational objectives by providing instruction that is appropriate for the average student in the class and deliver the instruction at a pace suited to that average student, with the hope that the more able will help the less able, often through cooperative groups or a buddy system. Few teachers are able to offer opportunities for gifted and high achieving students to be challenged by new content or alternative assignments appropriate for their ability. Time for planning such lessons is a scarce commodity; having sufficient training and support to develop and manage alternative assignments is also rare. Teacher preparation programs often do not include course work on meeting the needs of students at the extremes, so teachers feel unprepared and perhaps unable to create or deliver instructional units that might meet the needs of all the students in their classes. We need to acknowledge that teachers do the
best they can. Indeed, thousands of teachers in their individual classrooms across the
country work valiantly every day to help their students learn as much of the curriculum as
possible, and many of them wish they knew how to change their instruction to better meet
the needs of all the students in their classrooms.

It is with these teachers in mind that this study was undertaken.

Background

The research and data collection for this mixed methodology study were done in
one of the largest school districts in a large industrial state in the mid-West. Middleview
City Schools lies in an urban fringe outside a large city in the state. One edge of the
school district boundary includes a portion of the large city, bringing greater student
diversity and tax dollars to the schools through a regional revenue sharing plan. Another
suburban district lies to one side, and rural but rapidly growing districts are located on the
remaining two sides. Students in the district are predominantly white (see Table 1.1).

The district has 16 elementary schools, 4 middle schools, and recently opened its
third high school. The district employs 771 teachers who are almost all white. Three-
quarters of the teachers are female, 65 percent have taught for 11 years or more, and the
average salary for teachers is just over $53,000 per year. In spite of that figure, the
district expenditure per pupil is less than the state average ($7,696 compared to $8,073)
(Ohio Department of Education, 2003).

3 This and all other school and teacher names are pseudonyms to protect the identity of the teachers.
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<td>Female</td>
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<tr>
<td>Male</td>
<td>50.7%</td>
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<tr>
<td>Gifted</td>
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<tr>
<td>Homeless</td>
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<td>Limited English Proficient</td>
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<td>Migrant</td>
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<tr>
<td>Students with Disabilities</td>
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<td>African American</td>
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<tr>
<td>Asian</td>
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<tr>
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<tr>
<td>Multi-Racial</td>
<td>3.7%</td>
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<tr>
<td>White</td>
<td>79.7%</td>
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Table 1.1: District student profile 2001 - 2002 (Ohio Department of Education, 2003).

The state Department of Education evaluates the performance of every district on 22 indicators of student achievement at grades 4, 6, and 9, and on attendance and graduation rates. The state then provides a district report card to the school district, its teachers, and the taxpayers. The 2003 District Report Card rated this district as Effective (the second highest of five designations), because it met 19 of 22 indicators. The three indicators with scores below the state standard (75 percent) are at the sixth-grade level, in mathematics, reading, and science (Ohio Department of Education, 2003). The values on these indicators fluctuate every year because a different group of students at the grade levels that are tested takes the tests; however, every teacher across the state works to improve the students’ scores, and schools are rated according to the results. Pressure on sixth-grade teachers in the district to help their students do better and achieve that 75 percent standard is very high, and teachers work hard to help their students be successful.
The NCLB legislation is causing some changes in the state proficiency testing, with testing in all content areas at grades 4 and 6 gradually shifting to a distribution of testing through multiple years. New state learning benchmarks and grade level indicators in the five major content areas (reading, writing, mathematics, social studies, and science) will be assessed through a new graduation test in tenth grade that is replacing the current ninth-grade test. Students must receive a passing score in each content area to graduate from high school.

The new graduation test will include for the first time assessment items that require students to provide short answers and extended responses; previously the ninth-grade graduation test was entirely multiple-choice. The state implemented field-testing for test items in the 2002-2003 school year with students in the graduating class of 2005, who are themselves accountable for the ninth-grade multiple-choice test now in use.

State-wide results on the field tests of the new graduation test were recently announced. Only 24 percent of the 10th-grade students taking the mathematics test achieved a passing score, which was set at 57 percent. Adjustments in the testing or the cut score may be made after one more year of field-testing, and after the reliability and validity of the test items have been studied. Students in the class of 2007 will be the first class responsible for passing the new graduation test. They will take the test in the spring of 2005 for the first time, but secondary content teachers in grades 7 through 10 face intense pressure now to help their students prepare for the new graduation standard. To perform well on the new graduation test and to perform well in high school, seventh-and eighth-grade students need to understand content and the outcomes identified in new state science standards for their grade, and they need to develop and use critical thinking skills.
Increasingly, middle school teachers across the state will be looking for methods for instructing students that effectively promote student achievement in both content and critical thinking. There are a variety of pedagogical strategies that may provide the tools teachers need to help their students be more successful, among them the thoughtful use of differentiated instruction.

Differentiation is a strategy for instruction that can be used at every grade level and in every content area by any teacher. To differentiate the curriculum, teachers modify the curriculum in response to the different learning styles, abilities, rates of learning, interest levels, and prior knowledge of their students (Tomlinson, 1999). This can be achieved through acceleration in some cases and content areas (notably mathematics), or through enrichment and variation in assignments. A variety of experiences can be provided for students through differentiation, including those that focus on more advanced content, more abstract concepts and thinking, or require students to create varied products.

Planning to differentiate instruction requires a sophisticated knowledge of the students and the content for which the teacher is responsible, as well as a firm grasp of classroom management skills and pedagogical strategies. Actually implementing the differentiated curriculum requires a teacher to accept a different role than is traditional. While most middle school teachers have four to six classes of students who rotate through their classrooms in a day, the instruction provided to all students is usually the same. Many teachers stand or sit in the front of the classroom, and students remain in their seats throughout the class, working quietly individually or occasionally in small
groups. Students are usually given the same assignments, do the same in-class work, and the same homework. Students are typically given the same assessments as well.

Differentiated instruction requires an entirely new set of behavior patterns and expectations of the teacher, and it is the process of implementing differentiated instruction in the classroom as much as the development of rich and challenging differentiated units that is the focus of this study. The results of this study will be of interest to teachers who are looking for effective ways to improve what they do in the classroom, and to principals and leaders who seek methods to help them be successful.

Theoretical Framework

The differentiated instruction used in this research study was based on a slightly modified Bloom’s Taxonomy (Bloom, 1956; Samara, 2003), with its various levels of thinking, and was informed by the work of learning theorists like Bruner (1964; 1966), Vygotsky (1978), and Bandura (1977; 1977b; 1986), and brain researchers such as Bransford (2000). Differentiated instruction has been described and delineated extensively by Tomlinson (Tomlinson, 1995, 1999; Tomlinson & Allan, 2000; Tomlinson & Eidson, 2003), and is a key element of the Curry/Samara Model (Micheller, 2002; Samara, 2003) used in this research. The theoretical framework provides a visual representation of my combination of these elements (see Figure 1.1).
Figure 1.1: An overlapping theoretical framework.

Taken together, the work of these theorists and researchers provides a model of instruction for teachers that promotes the use of alternative assignments and assessments, and includes a variety of tasks and a range of learning experiences for different students in the classroom based upon their learning needs and styles, their knowledge, and their understanding of the content under study. I asked teachers to reflect the processes through which scientific literacy may be achieved, including the Five-E model of inquiry (Bybee, 1997). I also suggested to teachers that they infuse technology throughout their instructional units, and integrate mathematics that the students were studying in their mathematics classes into the science activities and assignments whenever possible, as either type of integration would provide appropriate interdisciplinary extensions for students.
The professional development portion of this research study was based on the recommendations for best practice from the literature and from my previous experience. Guskey (1986; 1995; Guskey & Huberman, 1995) suggests a model for professional development in which teachers start by implementing a new strategy into their classroom practices. The new practice must be relatively easy to implement without significant disruption or extra work, and the new strategy should be explicit, clearly defined, and concrete. Continuous communication, regular feedback opportunities, and short assessments of the impact on student learning need to be provided as part of the ongoing support of the teachers. Ultimately if the new approach allows teachers to see benefits for their students (in student learning outcomes), the teachers’ beliefs and attitudes will then shift to accept the innovation, and the professional development will have promoted change. Providing the teachers with a professional development experience that was itself differentiated was guided by the recommendation that a principle designed to reform student learning should also guide the professional growth of the teachers (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Accordingly, my focus was for teachers to take slow but steady steps towards implementing differentiation in their classrooms, with the belief that teachers do want to be more effective in their instruction, and that the differentiation approach proposed would benefit all students not just the gifted and high achieving ones. The support that the school district provided for the teachers and for this professional development experience was critical as well, and in keeping with the National Science Education Standards for professional development and program planning (National Research Council, 1996).
For the two years prior to this research study, many high achieving students and most of the identified gifted students complained to me about being bored and frustrated in at least some of their classes. In this district at the middle school level, there has been limited opportunity for any alternative (and perhaps more challenging) assignments, and curriculum acceleration was available to them only in mathematics. At the same time, although as a gifted intervention specialist I offered pull-out programming for these high-end students, more than 30 percent of identified gifted students in grade 7 and more than 50 percent of identified gifted students in grade 8 chose not to participate in any of the programming. As evidenced by the low participation rate, pull-out programming does not necessarily meet the needs of the gifted and high-achieving students, either.

The students who chose not to participate in gifted program opportunities cited a variety of reasons for their choice, ranging from not wanting to attract attention to themselves by coming and going from their regular classes, to not being able to keep up with all the extra work that participation involved. Most of their teachers required them to make up the work they missed during the periods during they were participating in their gifted program activities, despite my requests that students be excused from their assignments if they understood the material. Missing even one period a week for six to eight weeks (and for some programs longer) put too much stress on some students. Many high-end achieving students are also perfectionists, so missing any amount of class time was very difficult to accept. Students who were involved in athletics or after school activities (and who therefore had less time for homework immediately after school) were
most likely to decline to participate. Identified gifted students who were not achieving, sometimes in all of their classes, were often not allowed to come to gifted programming, even though perhaps they needed intervention most of all. As I came to know the teachers better, I offered to come to their classes to work with them and their students.

Teaching is difficult to do well, and most teachers are accustomed to working alone in their classrooms, often with the door shut. It can be very threatening to invite another teacher into the classroom for any reason, even to work with a small number of students on a different assignment in one corner of the room. A high degree of trust is required, and developing such rapport takes time. Only a handful of the teachers ever invited me to work with them or help them develop even an occasional alternative assignment for the gifted students.

My concern for gifted students, especially those in danger of being turned off by the “one-size-fits-all” teaching (i.e. underachieving gifted students), grew over time. I was increasingly aware that my pull-out program was only partially effective, and that offering extensions and enrichment through classroom teachers was poorly accepted by the teachers. I began to wonder to what extent we could improve teaching within the classroom to meet the needs of gifted students through differentiated instruction. This formed the basis for the research.
Research Questions

1. Do middle school science teachers in the district modify their instructional practices and curricular materials to meet the differing needs of the students in their classes, including those who are identified as gifted?

2. To what degree will the amount of support middle school science teachers in the district receive be a factor in the extent to which they implement a unit of instruction that is differentiated to meet the needs of all the students in the classroom?

Initial Suppositions

Supposition 1: At the beginning of the research study I expect to find no difference in the curriculum that is taught to identified gifted students compared to that taught to other students in the class.

Rationale: I suspect that the science teachers in this study rarely (less than once a month) provide instruction for their gifted (and high achieving students) that is different from what they offer the other students. A national survey of the classroom practices of third and fourth grade students found this to be true (Archambault, Westberg, Brown, Hallmark, Emmons, & Zhang, 1993), and I do not believe that these middle school
teachers will be any different. I believe that science teachers in the district try to provide laboratory experiences for the students at least once every two weeks on average, that students conduct these experiments in controlled circumstances, and that all students work on the same investigation simultaneously.

_Supposition II:_ During this study the amount of support each teacher needs to implement differentiated instruction will vary from individual to individual, based on two factors. The first factor relates to the degree to which the individual teacher already uses constructivist instructional strategies and already teaches science through inquiry. The second factor includes the extent to which the teacher has time constraints caused by after-school commitments or family responsibilities (e.g. with young children).

_Rationale:_ I suspect that teachers who are already inclined to use inquiry as an effective instructional strategy and/or constructivism as a theory of learning will be able to implement differentiated instruction with less support than those who do not, and these teachers will continue to use the strategies developed during the differentiation course on their own. I suspect that the teachers with significant outside constraints on their time will implement differentiated instruction to a more limited extent unless additional time is available during the day to plan and prepare. Becker (2001) has shown that teachers who use constructivist methodology and inquiry to teach students are far more likely to be involved with their professional organizations. I believe that it also follows that teachers who use inquiry and support the use of constructivism in their approach to teaching and learning already will be more inclined to look for the benefit
to their students of new instructional strategies, and to make the necessary changes in their own instruction to incorporate the new strategies if they do prove to be beneficial to their students. These same teachers will be willing to invest time and energy to provide this type of curriculum and instructional practices regularly even after my support is no longer available. Not every teacher will be able to implement extensive differentiated instruction, even with my support and help, as there are some teachers who have other demands on their time and energy due to family or other outside commitments.

Delimitations

I elected to work exclusively with middle school science teachers from one school district in this research study. I am more knowledgeable in teaching middle school science, and to a lesser degree, middle school mathematics, than I am in other content areas. I had worked extensively with the sixth-grade science teachers integrating laptops into science instruction, and developing effective instructional units to teach the state’s sixth-grade proficiency outcomes in the two years prior to this study. These previous relationships provided a foundation for this new enterprise.

Differentiation of any curriculum demands strong content knowledge, and as wide a repertoire of instructional strategies as possible, so I chose to stay within the content areas in which I had this expertise. Differentiation also requires an understanding of the misconceptions that students are likely to have about the content and concepts under study, and deliberately plan “traps” for the students to force them to
discard the faulty conceptualizations they hold (Driver, Guesne, & Tiberghien, 1985; Stepans, 1996). I provided support for teachers who were interested in learning how to use these tools and strategies both during course meetings and individually, as requested.

I encouraged teachers in this study to incorporate extensive use of technology (including calculators, computers, probes, microscopes, and digital cameras), and the use of the discovery method, or inquiry, to help students work like scientists, to ask their own questions and build their own knowledge.

When it made sense to integrate mathematics into our science lessons, or when the students were covering a topic in mathematics that we also needed them to have for our differentiated science unit, I worked with the math teacher to provide differentiation for the students in the experimental group through their mathematics classes as well. For example, we needed students to understand time and distance line graphs, so I team-taught time and distance line graphs with the students’ pre-algebra/algebra teacher using Texas Instrument graphing calculators and Calculator-Based Rangers. In this way, the students benefited from the more complete integration of math and science concepts.

The differentiated units that were used with students for this investigation were developed and implemented by their classroom teachers. Differentiated instruction requires teachers to know and understand their students well (Wormeli, 2003). In order to place students in the most appropriate learning experiences, the teacher needs to know what students already know and understand, what learning styles they have, and what even modest intellectual frustration might do to them. Consequently the teachers
conducted pre-tests and selected students to participate in differentiated activities according to the pre-test results and their own experience with and knowledge of the students.

In another area, I decided quite deliberately not to incorporate the revised version of Bloom’s Taxonomy into this investigation, although different levels of thinking were a key component of the study (L. W. Anderson et al., 2001). The UnitWriter® software that the teachers used to create differentiated units is based on Bloom’s Taxonomy, but it does not reflect all the changes of the revised Bloom’s taxonomy (Curry and Samara, 2001). I could not revise the computer software and did not have sufficient time in the course to teach the subtle differences between the new and revised Bloom, much less between either version of Bloom and the Curry and Samara approach to the levels of thinking. Consequently, I elected not to introduce the revisions into the study.

Finally, there are also relatively large numbers of identified gifted students in the three middle school grades at this time in the district. A new standardized achievement test was selected for use with all students in the district in fifth- and seventh-grades for each of the last two years. The test was also used to identify students (those achieving nationally in the 95th percentile or higher) as gifted. A high percentage achieved that score, so we have large numbers of identified gifted students in the middle school grades.

Teachers do genuinely try to help all their students learn new material and to delight in the learning, but when the number of high achieving and gifted is small, it is common for teachers to focus attention on the larger number of average students in the
middle. When teachers experience classes with large numbers of gifted students, as many of these teachers faced, in my experience, they can be overwhelmed by the challenge of trying to teach them all, especially if there are extremely low ability students in the same class section. Ultimately, the teachers recognize that they need help, and they are more willing to ask for assistance from a resource teacher who has specific expertise in teaching the gifted.

Limitations

The research study I conducted into differentiated learning was implemented with a small sample of twelve middle school science teachers. All of the teachers volunteered to participate in the course on differentiated curriculum. The sample involved in this study was therefore one of convenience. All but one of the teachers took the course for the graduate credit. The one teacher who did not is facing termination of her contract because of the budget cuts in the district and could not justify the expense of the additional unit of credit, as she anticipates having to move to another district and perhaps another state to find employment. Of the twelve teachers taking the course, eight agreed to participate fully in the research components, including allowing me to videotape them teaching. The other four agreed to participate in all aspects of the research except the videotaping, but they did agree to allow me to observe in their classes as long as no cameras were involved.

The Survey of Regular Classroom Practices (Archambault et al., 1993) was completed by all the participating middle school science teachers and was used to
establish the extent to which the teachers modified their instruction for high achieving and gifted students as a base line and to determine whether the teachers in the course were qualitatively different from each other (see Appendix A). All participating teachers also agreed to provide exit interviews at the end of the course.

Additional information on the extent to which other science teachers in the district employ strategies of instruction that differ for their average and gifted students would be needed to conclusively determine whether any quantitative or qualitative differences existed among the 12 teachers who participated and the 21 who did not. Therefore measures beyond the Archambault questionnaire were used to gather additional data.

During the period of time in which the science teachers and I were actively working on implementing differentiation strategies according to the Curry and Samara Model into their classrooms, district administrators arranged for a team of presenters to hold an in-service professional development workshop for all middle school teachers in the district on an early release day. There was no communication from the administrators with me at the time, although all four middle school principals and the central office administrators making the arrangements did know that I was teaching a class on differentiation to district middle school science teachers at the time. Nonetheless, the topic for the two hour-long meeting was differentiation of instruction.

Consequently on the appointed day, a team of teachers and an administrator from a neighboring school district came prepared to work with all middle school teachers in five different breakout sessions by content area. The packet prepared and distributed included work done by Carol Tomlinson and others on differentiation but
did not include any of the Curry and Samara materials. This history represents a threat to internal validity of my study, and created a complication for my work, but was unavoidable and of relatively small impact because initial and lengthy announcements about our levy situation cut significantly into the presentation time.

It is possible that a confounding effect was caused by my relationship with the teachers in the study. My colleagues may have worked harder on their differentiated units or the subsequent implementation of those units than they might have otherwise because they wanted to help me. I attempted to reduce the possibility of this by explaining the purpose of the research study was to focus on the support they needed, not their ultimate success. I also did not make specific appointments for observations or videotaping sessions so the teacher were not able to plan or implement a differentiated activity simply because I was coming.

Our research period was limited to seven full months, which was just sufficient to introduce differentiated instruction and *UnitWriter®* to middle school science teachers in the course and to support the teachers as they implemented and taught at least one differentiated unit that they had created. We worked together from early November until the last week of school in June in one case. I believe that the length of time of the study was adequate to collect valid and sufficient information about the professional development needs of the teachers, and for the teachers to experience teaching through differentiation sufficiently frequently to allow them to draw conclusions about the possible effectiveness and value of the technique for their students, and the barriers to its implementation. Additional time would have provided confirmation of initial trends and more conclusive findings.
I would also have preferred to have some science teachers from the fourth middle school in the district participate in this professional development experience. For a variety of reasons none of the nine science teachers in that school was able to join us, despite repeated attempts on my part to encourage their participation. I did learn that the teachers who wanted to participate were either already committed to coaching after school or were already enrolled in other graduate classes at another local university.

I did not attempt to conduct any in-depth interviews with students in any of the differentiated instruction about how they felt about participating in differentiated instruction, or to what extent they or their parents valued and/or appreciated the opportunity. My major area of interest was the professional development of the classroom teacher, and my research study did not include the students. I know that teachers do not necessarily leap onto the newest bandwagon of educational change that comes along, yet they are often willing to change their instructional techniques if the methods do improve student learning. Student data on the contribution of the instructional approach to content development and critical thinking skills would be necessary to evaluate fully whether differentiation was an effective approach to meeting the needs of all the students in the classroom, but was beyond the scope of this study.

Definition of Terms

**Constructivism.** A theory of knowledge and learning in which learning is a self-regulated process. A teacher who supports this theory provides opportunities for
students to construct their own understanding through concrete experiences, hands-on investigations, collaborative discussions, and reflection. A science teacher using constructivism will pose problems of interest to the students, structure learning around the big ideas of science, provide opportunities for students to share their own points of view, adapt the curriculum by taking into consideration the students’ interests and prior knowledge, and weave assessment of student learning into their teaching.

**Curry/Samara Model.** An approach to differentiating curriculum, instruction, and product to provide appropriate challenge for all students in a classroom. Students engage in different learning experiences based upon their prior knowledge of the concept under study; the model uses a modified version of Bloom’s Taxonomy to present levels of engagement for each learning objective. The six levels in the Curry/Samara Model are (a) knowledge, (b) understanding, (c) application, (d) evaluation, (e) creative thinking, and (f) critical thinking. The Curry/Samara Model (2003) has been developed over the last 10 years by James Curry of Portland, Maine, and John Samara of the Curriculum Project, Austin, Texas.

**Differentiation.** A way of thinking about learning and teaching that begins where an individual is rather than beginning with a plan that ignores what students already know and understand; it is a process of creating learning experiences for students of different ability levels in the same classroom that suit their learning styles, needs, abilities, and prior knowledge and experiences. The teacher can modify the curriculum through the content (what the students learn), the process (the levels of thinking in which students engage), the product (how students demonstrate their understanding), and/or the learning environment (classroom conditions).
Five-E model. An instructional model developed at BSCS and articulated by Bybee (1997), in which instruction moves through five phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation. The instructional units created for this research study incorporated this model and others to engage students in learning.

Gifted. Identification of students for academic ability based on test scores on standardized achievement and ability tests. The “superior cognitive” category includes students with a score of 127 or higher on a standardized intelligence test. Content areas of identification include mathematics, reading, science, or social studies, with score at the 95th percentile or higher. Evaluation in the creative and performing arts is done through a portfolio collection of work or through a performance procedure.

The state mandates that districts identify the students according to these criteria, and that parents be notified of such identification, but it does not require service. Some minimal state support for minimal gifted programs has been provided in the past, and is still available in reduced amounts. Consequently service to identified students varies between districts; the school district in which this research was conducted had a more extensive program than most others in the state until recently.

Inquiry. An instructional strategy in which students develop knowledge and understanding of concepts through a process of scientific research and study. Student investigations may be controlled by their instructor (guided inquiry), or totally designed by the student from question formation through evidence gathering and formulating and justifying her or his own explanations (open inquiry) (National Research Council, 2000).
**No Child Left Behind (NCLB).** Federal legislation passed in 2001 that reformed the earlier Elementary and Secondary Education Act (ESEA) of 1965. NCLB includes stronger accountability for results, expanded flexibility and local control, expanded options for parents, and an emphasis on teaching methods that have been proven to work (U.S. Department of Education, 2002). States must collect and disaggregate data on student achievement, and have only highly qualified teachers in the classroom. NCLB focuses especially on a reading guarantee by third grade, and increased mathematics achievement at every grade level. Part of the data that states must monitor and report includes the achievement of its gifted students, so pressure on teachers has been increasing for these students to perform at their highest potential.

**Peer coaching.** A process of professional development in which two teachers work together in the classroom and outside it to enhance the instruction of one; roles can be reversed depending upon expertise of the two teachers who are working together and the goals of their interaction.

**UnitWriter®.** An instructional software program developed by Curry and Samara (2001) for use by teachers to create differentiated curriculum according to the Curry/Samara Model through the use of a matrix. The software contains a structure for inserting verbs, content, products, state standards, and lesson plans.
Summary

This study focused on the professional development of middle school science teachers in one large district in the urban fringe of a large mid-western state. State-wide proficiency tests and federal legislation (NCLB) have brought intense pressure on teachers for students to receive increasingly higher achievement scores on mandated state tests. To help teachers in this district develop and deliver effective instruction in the classroom, a series of professional development opportunities were developed and implemented, featuring an instructional strategy known as differentiated instruction. I collected quantitative data through a questionnaire, and qualitative data through interviews, planning sessions, and participant reflections to answer the research questions of this study. I was interested in the extent to which the middle school science teachers in the district modified their instructional practices and curricular materials to meet the needs of the students in their classes, including those who are identified as gifted before and after they participated in a course on teaching through differentiation, and the differential levels of support teachers would need to plan, implement, and adopt differentiated instruction into their instructional repertoire.
CHAPTER 2

REVIEW OF LITERATURE

The use of differentiated instructional strategies with adolescent students has foundations in learning theories and its value is supported by findings from numerous research studies. Modifications to the organization of instructional settings began with the transition from junior high schools to middle schools that began over 40 years ago, as educators came to realize that the needs of the adolescent were not well served either by the scaled down versions of high schools or by extended elementary schools. Educators and researchers both recognized that the time spent in grades 6 to 8 is especially critical for young adolescents, who are learning content and concepts of the curriculum while they are also learning to relate to a more diverse peer group, members of the opposite sex, and adults in different roles (National Middle School Association, 1999). While they become increasingly responsible for their own behavior, young adolescents are in the process of firming up attitudes and values that will, in the long run, determine their success in high school and beyond, a reality that cannot and should not be ignored (National Middle School Association, 1995).

The very diversity of needs of the students in middle school classes today suggests that using a one-size-fits-all curriculum would be inappropriate. Given the pressures of the NCLB Act and our tendency to use state achievement test results to
evaluate the quality of education provided by individual schools and entire school districts, without consideration of significant variables that impact student achievement, more than ever teachers are looking for ways to improve the effectiveness of their efforts. While educational experiences designed for students need to take into consideration the nature, learning styles, and the social and emotional needs of the students, at no time is this as important as at the middle school level. This is when educators need to be particularly well versed in theories of learning and psychology, and implications of research as they relate to differentiating curriculum to meet the needs of the individual students in their classes (National Middle School Association, 1999).

To inform this research study several areas of the literature were examined. After creating a theoretical framework within which to bound my research, I looked for findings in the literature relating to the design of quality professional development for in-service teachers, to differentiation as an instructional strategy, and to the Curry/Samara Model of differentiation in particular. The major research findings for each of these have been summarized in separate sections in the remainder of this chapter, with a final summary at the end of the chapter.

Foundations in Theory

Teachers who know and understand theories of learning, and middle school teachers who understand the special characteristics of adolescents in particular, are better able to adjust their instruction to meet the needs of their students (Bransford,
Brown, & Cocking, 2000). Some middle school teachers continue to subscribe to 

Piagetian theory, which holds that students at this age are moving from the stage of concrete operational to formal operational, and contends that teachers who can assess their students’ level of cognitive process will be able to gear instruction appropriately (Piaget, 1952, 1962; Piaget and Inhelder, 1969). These teachers actualize Piaget’s theories by keeping students actively involved in learning, using incongruous events to maintain their interest, and providing opportunities for students to interact socially. Piaget’s theories limit science teachers, however, in that allowing students to use strategies of assimilation and accommodation precludes the use of more structured or directed experiences, and his theory did not address the need to balance thinking skills and knowledge, or to consider attitudes, creativity, and applications (McCormack, 1992).

Other theorists promoted slightly different models to explain how students learn. Jerome Bruner (1966) proposed a theory that focused more on how students represented knowledge than how their developmental level connected to their cognitive structures, as Piaget did. Bruner’s work considered different forms of cognitive processing, which he called *enactive, iconic,* and *symbolic.* His theory proposed that learners could assign meaning to experiences based on the form of cognitive processing developed to that point, combined with their prior experiences, and that additional exposure to the same experience would result in increasingly sophisticated understanding over time. This also allowed for individuals to be able to conceive of multiple aspects and representations of a concept at the same time. A middle school teacher using Bruner’s theory might introduce a new concept by having students use manipulatives (enactive);
watch, or better, create a short video of the concept (iconic); and use diagrams, drawings, and/or words to represent the concept (symbolic). According to Bruner’s theory, students taught through these methods would develop a deeper understanding of the concept as a result.

An even stronger proponent of constructivist thinking was Vygotsky (1978), who conceived of human thought processes in a different way. Rather than assuming learning occurred through metacognition or primarily because the student had achieved a particular stage of development, Vygotsky proposed that learning occurred when the environment interacted with human consciousness at a point just beyond the individual’s current ability, in the zone of proximal development (ZPD), which he defined as “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (p. 86). Thus a teacher who provided carefully sequenced learning opportunities for students, and provided just the right amount of challenge for each student, and sufficient support during class could expect students to learn, according to Vygotsky’s theory. While teachers may not be familiar with Vygotsky’s ZPD, many know and employ the process of scaffolding, which is a common application of the theory (Bandura, 1986; Burns, 2003; Wood, Bruner, and Ross, 1976). Instructional scaffolding provides support for students through a learning situation, beginning with the teacher modeling a skill for students, and then reducing support in small increments until the students are performing the skill independently.
These discoveries in cognitive science have advanced other approaches to learning and knowledge, including several types of constructivism. Constructivism in general relates to students actively constructing meaning from their environment, with more or less emphasis on what they learn from the outside world (exogenous), from previously acquired knowledge (endogenous), or from interactions with other people (dialectical) (Schunk, 2000). In all types of constructivism, what is already lodged in the student’s mind does matter. Brooks and Brooks (1993) held that learners engage in this process as they “internalize and reshape, or transform, new information” (p. 15).

If learning is a process controlled by the learner and is internal, it follows that teachers can not force the transformation. Teachers can work to help students confront conflicts between a new experience and prior perhaps naïve understandings. A teacher coming to instruction through constructivist theory might support students by offering learning experiences that are likely to create conflicts, and by allowing and motivating students to work through the conflict, often through discussions with their teachers and their peers (Brooks and Brooks, 1993).

To support constructivist learning, educators must be willing to consider an alternative approach to instruction, and must be willing to assume a different role in the classroom. For some educators the shift can be challenging, in that students who construct their own understandings must take more initiative themselves, and be more autonomous, instead of following the teacher’s every directive (Brooks and Brooks, 1993). The National Science Education Standards (National Research Council, 1996) advocate that teachers should guide student learning experiences from the side, not the front of the classroom, but many teachers understandably find this switch difficult.
because they were not educated themselves through this process, nor did they learn about constructivist theories during their training to become a teacher.

Teachers who promote more active construction of learning pay attention to the knowledge and beliefs students bring with them, and monitor their learning as instruction proceeds (Bransford et al., 2000). Helping students learn to think about their own cognition, and giving them time to link prior knowledge with the current concepts and content allows learning to take place. Providing structure and routine to a classroom has been shown to help students learn, as does giving students opportunities to have some level of involvement with decisions in the classroom (Jansen, 1998).

Teachers will readily agree that every student in every classroom across the country is an individual who has some commonalities with other students, and some very unique differences. Understanding that students have multiple intelligences (Gardner, 1983) allows teachers to help students learn through the areas in which they have strengths while also developing their weaker areas. Knowing that students do not all have the same learning style as each other or as the teacher is also important. A Sensing-Thinking teacher will have to use alternative instruction practices to help students with an alternate learning style be successful in the classroom (Myers, 1962). There is evidence that some students fail and drop out of school, not because they could not learn, but because they were not lucky enough to have teachers who could teach them in their learning style (Whitehurst, 2002). Providing experiences in the classroom to allow students to learn through their own learning style, and to understand how their preferences for certain types of thinking affect their learning helps students develop self-confidence in their own abilities to learn (Silver, Strong, and Perini, 2000).
Complicating the difficulty of effectively teaching students with different learning styles are the sometime faulty understandings that students bring with them to school. Students are not blank slates, as was once thought, and in some cases the preconceptions they bring with them can actually interfere with their ability to learn. Evidence that researchers have collected about student misconceptions allows teachers to plan to address these barriers to learning that students face. Their findings include detailed descriptions of student misconceptions for teachers to use, and specific instructional strategies to help teachers address the problem (American Association for the Advancement of Science, 1993; Driver et al., 1985; Stepans, 1996). However students’ naïve ideas can and do persist, even when they are not consistent with the experimental results students obtain themselves, the explanations they may hear or read or discuss, and other evidence. The misconceptions are uniquely personal, even incomprehensible to others, nonetheless the ideas often are stable and resistant to change (Driver et al., 1985). In these cases, experience becomes an important advantage for the teacher.

Time spent working with students in the classroom allows teachers to develop additional strategies for dealing with common student misconceptions, especially if the culture in their classrooms allows students to feel comfortable talking about what they know and understand, even if their ideas diverge from those of others in the class. Many of these teachers also have developed strategies for presenting curriculum to their students to take advantage of their learning styles and their intellectual behaviors. Studies on the effect of having such experienced teachers in the classroom, including a
large meta-analysis of the literature on school resources and student achievement, found teacher experience to have a significant effect (Greenwald, Hedges, and Laine, 1996).

Differentiated Instruction

Quality teaching involves knowing how and why students learn, knowing the content of the curriculum to be taught, and organizing it so that diverse students can learn by accommodating individual differences in talent and development (Rhoton, 2003; Stevenson, 1992). For the middle school student to be successful into this new century, *Turning Points 2000* (Jackson and Davis, 2000) calls for concept-based teaching and for classroom procedures and organization to promote self-sufficient and confident learners. To accomplish this, teachers are urged to implement standards-based instruction, and to plan backwards from the concept to be introduced, to how it will be assessed, and finally to plan how to teach it (Jackson and Davis, ; Wiggins and McTighe, 1998).

The strategies of differentiation dovetail neatly with these directives. Defined earlier as a process of creating learning experiences for students that suit their learning styles, needs, abilities, and prior knowledge and experience; differentiation of instruction can be explained more simply as a teacher’s response to her/his students’ needs. While the general curricular goals may be similar for all the students, the differentiating teacher will employ a variety of methodologies throughout a unit of instruction that are as varied as the students, but suit them (Theroux, 2003). Students are often involved in decisions about the process, the product, and to a certain extent,
Differentiated instruction involves respectful tasks, flexible grouping, and ongoing assessment and adjustment (Tomlinson and Allan, 2000).

Differentiated instruction is not a new way of thinking, as it has been a process used by teachers of gifted students for many years. Although differentiation may not have been widely used by classroom teachers, as shown in the national survey research conducted by the National Research Center on the Gifted and Talented (Archambault et al., 1993), educators of the gifted have used differentiation as one way to develop good curriculum for students who manifest varying degrees of advanced performance or potential. Research studies undertaken by experts in the field of gifted education have examined the relationships between gifted students’ academic performance and program design, school philosophies and practices, such as grouping strategies, and curricular materials and practices implemented by schools (Coleman, Gallagher, and Howard, 1997; VanTassel-Baska, 1993; Winebrenner, 2001). Among this body of research are a number of studies that specifically examined whether academic needs of gifted students in varied content areas were met through the use of differentiated instruction (Kulik and Kulik, 1991; Reis, Westberg, Kulikowich, and Purcell, 1998; Tieso, 2000; Troxclair, 2000; VanTassel-Baska, 1996). These studies showed that differentiation provided at least modest gains for the gifted students, and recommended that teachers should use differentiation when appropriate to address the learning needs of gifted students in their classrooms. At the same time some states developed their own resources (which include differentiated instruction) to help their teachers meet the needs of the gifted students in their states (California Department of Education, 1994; Idaho Department of Education, 1999).
As the results of these studies were published, some regular classroom teachers took note, and began implementing strategies of differentiation into their classrooms, supported by resources developed by Winebrenner (1992) and others. These include compacting the curriculum, using learning contracts, creating more challenging assignments, and using cluster grouping to allow gifted students to work together on projects of mutual interest. Research-based resource materials teachers may use to implement elements from this list are becoming widely available (Reis, Burns, and Renzulli, 1992; Renzulli, 2000; Tomlinson et al., 2002; Winebrenner, 2001).

Increasingly, differentiation has become recognized as an important tool for engaging the minds and interest of all students while simultaneously meeting their needs (Page, 2000; Theroux, 2003; Tomlinson, 1995, 1996; Westberg, 1995).

Of all the researchers on differentiation, Tomlinson is perhaps the most prolific. She has authored numerous publications designed to help teachers learn how to design and implement effective differentiation units based on her findings, and recently was the featured presenter at the well attended Association for Supervision and Curriculum Development (ASCD) Summer Conference on Differentiating Instruction (Tomlinson, 2003). She has studied and researched differentiation and current classroom practices, and has asked difficult questions across the country about how and why teachers do what they do.

Tomlinson’s (1995) qualitative case study of Midland Middle School (pseudonym) is a case in point. In an intense 18-month qualitative study of the teachers as they initiated differentiated instruction in their school, Tomlinson was able to develop some insights into characteristics of teachers who were early adopters of
differentiation, and what impeded and facilitated the teachers’ movements toward “appropriately differentiated classrooms” (p. 77). Tomlinson found that creating a differentiated classroom was not “a yes/no proposition, but rather a continuum along which teachers move as they develop skills of responsive teaching” (p. 80). She also found the greatest deterrents for teachers were: (a) not being convinced that change was needed, (b) not understanding what fully differentiated classrooms looked like nor how they were organized and structured, and (c) not receiving enough administrative support nor enough on-site professional support in the classroom.

Another descriptive study (Hootstein, 1999) focused on how teachers at the secondary school level used instructional methods to meet the diverse academic needs. Data were collected from almost 300 high school teachers in 28 separate high schools in seven local school districts, with a high rate of return (74 percent). Teachers identified from a list of 15 instructional practices which they used in their classrooms most often, which they found to be the most effective in helping students learn, and why. Among the most commonly used strategies were using small groups, modeling, lecture with questions and answers, instructional variety, teacher-led discussions, and adjusting questions. Teachers believed these were effective because students supported each other, teachers could reinforce content, students could use various senses (visual, kinesthetic, auditory), all students were involved, advanced students helped their peers, and students learned by doing. Hootstein found that the teachers made more adaptations for students with academic difficulties (such as making time to tutor students, providing individual help to students either before or after school, using technology and peer tutoring more frequently) than they provided challenges for capable students. He also found
statistically different responses by content area. For example, science teachers used experiments and a variety of materials more than other teachers, and math teachers used modeling and peer tutoring more. Teachers were also asked to evaluate factors that facilitated or inhibited their ability to address academic differences between their students, and what they would need to implement differentiated instruction. Teachers in the Hoostein study reported the lack of administrative support, large class sizes, and the lack of planning time as barriers.

Research findings in qualitative studies should be used to encourage those who read them to compare the descriptions and analyses to their own experiences and social world (Glesne, 1999). Tomlinson (1995) identified the significant impediments faced teachers as they developed their abilities to implement differentiation, such as the lack of administrative support, fear of change, and little inclination to recognize or address academic diversity. She also identified a few characteristics of teachers most likely to implement differentiation. For example, teachers who seek to learn about their students and use that information to inform their teaching, those who intentionally create disequilibrium at school to encourage student learning and growth, and those with a larger comfort zone and personal self-confidence are more likely to be able to implement differentiation. The Hootstein (1999) report adds details about the beliefs and feelings of high school teachers and reinforces Tomlinson’s findings about the importance of the building administrator and district policies. Both add considerable valuable information to the field and can be used to support the reflections and preparations of others who plan and deliver professional development for teachers in the use of differentiated instruction.
Another extremely well-designed mixed methodology study investigated the combined effect of flexible grouping and differentiated instruction on elementary school students’ achievement. The Tieso (2000) study used a pre-test, post-test comparison-group/experimental-group design involving 31 teachers and their fourth and fifth grade students, with an additional qualitative component focusing on affective issues of teacher and student feeling about the differentiated instruction and group modifications. Tieso developed an experimental standards-based mathematics curriculum, provided professional development support for the randomly selected teachers who used the curriculum in their classes, used several grouping strategies (notably, moving students between groups and between classrooms based on understanding and readiness) to organize instructional units, and measured student achievement outcomes. Her findings indicated significant positive differences in achievement between treatment groups that received the differentiated instruction in schools and districts where the teachers enjoyed strong administrative support for the teachers’ efforts in continuous improvement of their practice.

These studies and others like them (Householter and Schrock, 1997; Johnson, 2000) established that both learning to differentiate the curriculum and implementing it effectively require teachers to change their current practices in significant ways. Those who have studied teacher change (Fullan (2001) most notable among them) report that change is a complex process in which there are no shortcuts, the object is not necessarily to have the best idea or the most ideas, and there is always an implementation dip. Fullan promoted the idea that “change is a process not an event”
(p. 40), and that the implementation dip would occur for one of two reasons: fear of change, or the lack of the skill or understanding needed to make the change work.

Professional Development

Tomlinson (1995) contended that intense and sustained professional development for teachers is necessary to help them understand the rationale for differentiated instruction, recognize the advantages for students of this new way of thinking about instruction compared to their familiar habits, and begin to adopt the new ways of thinking that differentiation requires. Teachers who differentiate recognize students' needs, and plan different avenues to content, process, and/or product in anticipation of student differences. Teachers who differentiate serve in a different role in the classroom, and help students take responsibility for their own learning rather than control their every move. Teachers who differentiate use assessment to nurture and guide students, and to inform their own instruction more than to judge the students or compare them to others. In short, teachers who differentiate provide materials, ideas, activities, and products at a level of moderate challenge for every student. Knowledge of content, the students, and flexibility are required, along with a willingness to invest time and energy in the process.

To become such a teacher, who differentiates instruction in response to a student’s readiness level, interest, and learning profile, even the most willing teacher needs help. Professional development experiences should include an opportunity to see differentiation in action, and it should include sustained professional support that
adjusts to the teachers’ readiness, interest, concerns, and needs. Likewise, just as
students are supported by certain instructional strategies, teachers may also need
differentiated instructional scaffolding, modeling, a safe environment in which to
practice, recognition for the efforts and progress they make, and subtle pressure to
persist (Fullan, 1993; Guskey, 1995).

To plan and provide high quality professional development on differentiated
instruction, such as Tomlinson (1995) describes, for middle school science teachers in
our district would be a daunting task, were it not for the fact that the key to successful
implementation of new strategies lies not with the provider of the experience but, as
Guskey (1995) has shown, with the teachers who participate in it. The key lies in the
teachers’ capacity to “use deliberately and wisely the knowledge” (p. 126) of the
content they teach, of their students, and of the community. Other researchers concur.
Darling-Hammond and McLaughlin (1995) contend that the knowledge and the skills
teachers need to effectively teach for understanding relies heavily on the teachers’
abilities to see their complex content matter from the perspective of their students,
which can not be developed without considerable effort from the teachers. They must
have time to critically reflect on their own practice, to talk with colleagues, and to
fashion new belief systems based on the effectiveness of differentiation as they deliver
it, to make a difference to their students (Cook and Fine, 1997).

Designing professional development for the teachers thus becomes an issue of
understanding the adult learning process, and acknowledging that the accumulated
knowledge, skills and beliefs that teachers bring with them to the experience serve as
schemata through which they will perceive and interpret the new information and
themselves (Smylie, 1995). The implementation of significantly differentiated learning experiences (what Tomlinson (1995) calls *macrodifferentiation*) as a result of their participation in professional development experiences will not be possible unless (a) the teachers who participate recognize and admit to themselves that there is a problem with their routine practice and teaching style (Smylie, 1995) and (b) they are open to change.

Further, any change in the teachers’ behavior will occur, according to the social learning theory advanced by Bandura (1986), if the teachers believe that the outcomes (in this case, increased student achievement through the use of differentiated instruction) outweigh the risks and cost to themselves in time and energy invested in implementing differentiation, and if the teachers have sufficient confidence in their own ability (self-efficacy) to organize and implement the actions necessary to achieve the desired outcomes. Guskey (1986) has described a model in which significant changes in a teacher’s beliefs and attitudes about an innovation will only occur if teachers see that the innovation enhances the learning outcomes of their students, such as achieving higher-levels of achievement, becoming more involved in their own learning, or expressing a greater self-confidence in their ability to learn. On a positive note, Bandura (1977) also contends that if teachers believe they can influence student learning, they usually do.

Science and mathematics instruction that develops student skills in problem solving, and that actively engages students (such as providing opportunities for students to conduct inquiry-based investigations, use tools and instruments to collect data, work with manipulatives, and integrate technology), especially when organized through cooperative learning and group investigations, is well supported by national standards
(International Society for Technology in Education, 2000; International Technology Education Association, 2000; National Association for Gifted Children, 1998; National Council of Teachers of Mathematics, 2000; National Research Council, 1996). Such instruction is the backbone of effective science and math instruction, and happens also to be conducive to the implementation of differentiated instruction in math and science (Tomlinson, 2000).

The standards also describe professional development of science and math teachers in relation to four specific aspects of their practice. These include curriculum (what is taught), instruction (how it is taught), assessment (how learning is measured), and the learning environment (including the social culture of the classroom, the physical setting and arrangement). Teachers who focus on continuous improvement in these four areas by participating in professional development opportunities can significantly improve what happens in their own classrooms, and they can have a positive impact on other teachers in their schools (Loucks-Horsley et al., 1998). No teacher will be able to sustain this growth without support from building and district administrators, however, for it is their responsibility and leadership that provides the culture of collegiality and the commitment to continuous improvement that must continue within the school long enough for changes to take place (Hord and Boyd, 1995).

An informed and effective administrator, one who functions as a facilitator of teacher’s professional growth (Duke, 1993), can make a significant difference in other ways as well. Although what differentiation looks like in the classroom varies with content area, age of the student, and the experience of the teacher with the process of implementing differentiated instruction, it is safe to say that classrooms where
differentiation is taking place will probably not be quiet and most likely not all students will stay within the confines of the classroom walls during class time. Principals who have been part of defining the need for differentiation not only accept these conditions, but are supportive of them (Tomlinson and Allan, 2000), which ultimately impacts the degree to which teachers feel safe about trying to implement differentiation. As in any change process, things tend to get worse before they get better, and it is during this transition period that support from other change agents and from the principals are especially important (Fullan, 1993; Loucks-Horsley et al., 1998).

Teachers can differentiate certain elements of teaching and learning to ensure that students learn as much as possible as efficiently as possible: the content, the instruction, the assessment, the classroom environment, and the affective element including student social and emotional needs (Surber, 1984; Tomlinson and Eidson, 2003). Consideration of the affective domain especially may help students benefit from the increased opportunities for meaningful learning that differentiation offers, especially those middle school students who seem neither interested in the content nor in pleasing their parents or teachers, a group which can include gifted students, students with multiethnic or multicultural backgrounds, or those who have physical or mental handicaps (C. W. Anderson and Lee, 1997). A large hurdle for teachers starting to use differentiation, then, is developing one or more reliable and efficient methods to determine what all students in their classes already know, or think they know, at the beginning of a new unit.

Within reasonable time parameters teachers must learn and understand enough about each student to plan modifications in one or more of these different elements that
will provide effective learning experiences tailored to the students’ individual and collective needs. Some knowledge about the students builds over time naturally, but developing effective assessment methods to use at the beginning of a unit that are reliable, objective, and equally important, practical, could be a large enough barrier that teachers may not know how to begin. Teachers may use a variety of activities to discover students’ learning profiles (including learning style, intelligence preferences, and interests) early in the year, and they may elect to ask some students to complete end-of-unit tests at the beginning of the unit, but this approach may not be appropriate for all students and may miss some who may have developed coping strategies that mask ability (C. W. Anderson & Lee, 1997). The idea is to identify Vygotsky’s zone of proximal development for each student, not to overwhelm students with an out-of-level test that damages their self-efficacy.

Concept mapping may offer teachers an appropriate tool to help teachers learn what they need to know. Novak’s (1990, 1998) extensive research on the use and applications of concept maps indicates that the strategy does provide important information about what students know, and how they organize their ideas. Another researcher (Surber, 1984) found that concept maps provide unique insights into students’ thinking because both misconceptions and gaps in understanding become evident by what students choose to include in their maps and what they leave out. However concern about the validity and reliability of concept maps brought researchers Ruiz-Primo and Shavelson (1996) to call for further research into these two significant areas, and also suggested that the practicality of concept mapping for classroom teachers should be studied further. In reply to that proposal, another group of
researchers conducted additional studies, and found that (a) teaching students to create concept maps is time effective if teachers keep the actual mapping task simple at first: (b) scoring strategies have been developed which are reliable and efficient, are easily learned, and provide good inter-rater reliability; and (c) teachers should use concept maps with other measures to develop a more total picture of student understanding (McClure, Sonak, & Suen, 1999).

An additional supporting rationale for the use of concept mapping in this particular study is that the district in which the study was done has a district license for Inspiration, a computer program that can be used to create concept maps, and teachers and students in the middle schools are already using it frequently. Teachers were provided with a computer software program to support planning and implementation of differentiation units as well, so the abilities of the teachers to use computers (and other technology in their plans) were of interest. I arranged for laptop computers to be available so teachers could review Inspiration, and learn the mechanics of the program of the new software, UnitWriter® (Curry & Samara, 2001) (see Figure 2.1).

While teachers who are support their students learning through constructivism are also more likely to be proficient in the use of computers (H. J. Becker, 2001), there was no assumption that teachers involved in this research study would all be comfortable working on computers. Through strategic modeling of differentiation, therefore, hard copy Curry/Samara (2001) matrix folders and colorful stacks of post-it notes were available for those teachers who preferred to learn how to differentiate curriculum without using a computer or UnitWriter®. In an earlier action research study of teaching technology skills to teachers that I conducted with a colleague, we
found that teachers needed to learn at their own pace, that the scope of instruction should be limited to prevent the session from becoming overwhelming, and that a range of support should be provided over time (Lightbody & Jones, 1998). Other research provided additional verification that successful technology instruction must address a variety of adult learning characteristics, because teachers, like other adults, seek independence, feel solution-driven, are skill-seeking, and benefit from hands-on opportunities (Ference & Vockell, 1994).
Curry/Samara Model

Literature for one important aspect of this research proved elusive. Curry and Samara (2003) created a small educational services company called The Curriculum Project, and recently published *UnitWriter®* software based on a model of instruction they developed and have used with teachers for over 10 years in Illinois, Texas, Michigan, and Ohio. I could find no independent research that has been published on the use of the Curry/Samara Model to this date, indicating that additional research was needed. Several curriculum guides have been published with examples of differentiated units, and additional software products have also been developed, including programs for assessment, team planning and integration of content, and state standards support for the four states mentioned above. By contacting the Curriculum Project directly, I received two unpublished reports for my review (Gresham & Porter, 2003; Micheller, 2002). One additional report was received in early 2004 on the results of an analysis of 10 years of data collected about the Curry/Samara Model as it has been implemented (Connell, 2003).

My review of the two initial reports determined that neither was a research study. Both described the Curry/Samara Model and cited theoretical foundations for the model from research studies in constructivism (notably without mentioning Tomlinson) and authentic achievement [especially citing Newmann (1996)]. The Curry/Samara Model promotes the development of differentiated units that are similar to the Tomlinson articulation of differentiation as a way of thinking, but differ in two
important aspects. One is the suggestion that for each of three elements that teachers might differentiate for students, the elements should be thought of as ranging along a continuum: content (factual to global), thinking skills (basic to abstract), and products (traditional to innovative) (Micheller, 2002). The other aspect of the Curry/Samara Model that varies from the Tomlinson view of differentiation relates to its use of thinking skills that parallel Bloom’s Taxonomy (1956) very closely, with minor changes at the upper two levels of the taxonomy (see Table 2.1).

<table>
<thead>
<tr>
<th>Bloom</th>
<th>Curry/Samara Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level</strong></td>
<td><strong>Action</strong></td>
</tr>
<tr>
<td>Synthesis</td>
<td>Create it</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Judge it</td>
</tr>
<tr>
<td>Analysis</td>
<td>Examine it</td>
</tr>
<tr>
<td>Application</td>
<td>Use it</td>
</tr>
<tr>
<td>Comprehension</td>
<td>Understand it</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Know it</td>
</tr>
</tbody>
</table>

Table 2.1: Comparison of Bloom’s Taxonomy and the Curry/Samara Model.

According to the Curry/Samara Model, the first three thinking levels comprise abstract thinking, while the second set of three (application, comprehension, and knowledge) are basic thinking skills. This is reflected in columns in the *UnitWriter®* matrix. A delimitation to my study was to work with *UnitWriter®* and the
Curry/Samara Model as presented, without any attempt to modify either one to reflect the revised Bloom’s Taxonomy (L. W. Anderson et al., 2001). Beyond noting that none of the researchers cited for their work on differentiation mentioned the specifics of verb choice used, and there was no mention of Bloom’s Taxonomy, I prefer to save that problem for a future study. Ground level research should be completed before making modifications.

The second report included some additional information. Gresham and Porter (2003) outlined the background of the Curry/Samara Model, provided its research foundations, and explained the development of the UnitWriter® matrix design. In this article, multiple intelligences were included as important factors by which objectives and products may be modified, and correlations to state standards were mentioned. The authors do reference an unpublished dissertation done in 2000 by the director of the gifted and talented program in a Texas school district; I was not able to obtain that study nor have I been able to contact the researcher. Although the Gresham and Porter article included some of the data from that study, and some of its findings, I have been unable to evaluate the research questions that were asked, the methods, research design, or instruments that were used.

The Connell report (2003) provides an ex-post facto analysis of the impact of the Curry/Samara Model on student classroom performance, as measured by the Texas Assessment of Academic Skills for a six year period from 1997-2002. District administrators and personnel selected two similar elementary schools in the same school district for the study. In one building, teachers had adopted and were using the Curry/Samara Model extensively, and in the second but similar elementary school in the
same district the teachers were not significantly participating in the use of the Curry/Samara Model. Analysis of Variance (ANOVA) and Student-Problem Analysis (S-P Chart) were used to address the research concerns, which were to evaluate whether the Curry/Samara Model enables positive impacts upon student classroom performance, and to describe any positive benefits from continuously using the Curry/Samara Model over time. For all six years, the treatment school results exceed those of the control group, at significant levels for the four final years. Connell concludes that the Curry/Samara Model is a “successful program that offers a continuous and consistent framework with which student growth and performance is enabled” and that “numerous qualitative differences were found regarding the nature and type of student learning … [and] instruction” (p. 44).

I did not have this report when I began working with the teachers, and I did not know how well the Curry/Samara Model or UnitWriter® software would support the development of differentiated instruction in our district. My review of the software allowed me to conclude that the design of the program would make it a useful tool for teachers to develop differentiated units addressing specific instructional objectives in the district. The opportunity to insert state content standards directly within UnitWriter® would allow teachers to incorporate the standards into their differentiated units and embedded instructional plans, and would help teachers prepare students for the high-stakes state graduation tests. The research I conducted adds to the body of knowledge in the field, given the absence of other published research on either the Curry/Samara Model or UnitWriter® software.
Summary

Differentiated instruction, based on learning theories and constructivism, is a process teachers can use to offer higher quality educational experiences for all students according to their needs and interests by modifying their traditional curriculum. Previous work evaluating the effect of differentiation on gifted students has shown there to be positive effect, however most classroom teachers reported that they did not modify their curriculum to meet the needs of the high achieving and gifted students. Teachers in several studies were found to expend more effort on remediation of their instruction for students at risk in their classes than they invested in their gifted students.

When differentiation was implemented in classes for all students, student achievement rose, however sustained professional development was necessary for even modest change to occur. The use of the Curry/Samara Model and UnitWriter® software may provide tools and a level of structure that reduces the amount of support teachers need to implement differentiated instruction with their students; this is the area where research is the most lacking.

Many research studies that evaluated the effect of differentiation on teachers did not measure the achievement of students; this study was designed to analyze the professional development of the teachers, and to correlate the amount of support they needed to implement differentiation with their ultimate success.
CHAPTER 3

METHODOLOGY

During the previous school year the supervisor of the gifted service department in the district learned of the Curry/Samara Model and UnitWriter® software, and began investigating whether they would be suitable tools to use with middle school teachers and appropriate ways to indirectly meet the needs of gifted students through their regular teachers. Over the summer, eight administrators from the district attended the Association for Supervision and Curriculum Development (ASCD) Summer Conference on Differentiated Instruction in Chicago, Illinois, and learned more about differentiation as an instructional strategy and about the research that supports it. Of this group, the science supervisor and the gifted and talented supervisor in the district in particular were interested in promoting the use of differentiated instruction. Subsequently, these supervisors and I arranged to provide professional development support at the district level for middle school science teachers who were interested in learning about differentiation as a tool to meet the needs of all their students. My position in the district as a gifted intervention teacher/coordinator includes providing both direct and indirect service to gifted students; this work on differentiation falls within the indirect service component of my position.
I am one of two middle school gifted intervention teachers/coordinators for the district; I work in two middle schools with teachers and gifted students while the other teacher/coordinator works with teachers and students in the other two middle school buildings. I have National Board Certification in Early Adolescence/Science, and previously had taught science at the middle school level for many years. I had taught a graduate course for fifth and sixth-grade science teachers in the district two years prior to this research study, and had worked on a collaborative project involving the use of wireless laptop computers with sixth-grade science teachers and their students at all four middle schools in the district the previous year. I was interested in learning about the effect of this effort in differentiation for the teachers, and in making this work the focus of my doctoral research.

Before I started conducting the research on differentiation, I secured all appropriate district and university human subject review board approval. I had full support from the Able and Talented Supervisor and the Science Supervisor, the district Secondary Curriculum Supervisor, and the superintendent. I received a letter of support from the district’s Executive Director of Labor Relations. I had personal conversations before the school year began with the principals to explain the research and to answer any questions, and secured their permission to conduct the research. The middle school principals also received an official notice about the course and my research project from the science supervisor as the school year began.
Research Design

This mixed methodology study examined first the professional practice of some of the district’s middle school science teachers as a baseline and then the extent of their professional growth in the use of differentiated instructional practices as a result of participating in a graduate course on differentiation that I taught.

My first research question required that I collect information on the actual classroom instructional practices employed by the teachers prior to the course and its professional development support for the teachers on the use of differentiation. These data were collected through the use of a teacher survey developed by Archambault and his associates at the University of Connecticut for a 1993 study (Archambault et al., 1993) (see Appendix A). In this study, teachers were asked to think of one specific group or class of students about whom to answer the questions in the survey, and to answer each question first with respect to the average students and then with respect to the gifted students. The responses for each item in the questionnaire used numerical values for the following response range: never (0), once a month or less (1), a few times a month (2), a few times a week (3), daily (4), and more than once a day (5). The data provided on this questionnaire were evaluated to obtain baseline information on the extent to which the teachers initially modified their instructional practices and curricular materials (i.e., employed differentiation strategies) with their students. Later observations and videotaping with the teachers were done with this same group of students for consistency, to remove the selection of the student group from the variables in the study, and to allow for triangulation of the data.
The initial Archambault study (1993) grouped the 39 items on the questionnaire into six qualitative factors, which strategy I also used to analyze the responses of the teachers in my study. Questionnaires from over 3,000 teachers were collected and analyzed in this study; principal factor analysis was used to determine whether the responses on the 39 items related to each other in any way. Through this effort six factors emerged. These factors were: 1. Questioning and Thinking (items 22, 35 - 38); 2. Providing Challenges and Choices (items 18, 23 - 34); 3. Reading and Written Assignments (items 3, 5 - 7, 9 - 10); 4. Curriculum Modifications (items 12 - 13, 15 - 16, 19); 5. Enrichment Centers (items 11, 17, 20 - 21); 6. Seatwork (1, 2, 4, 8). As my sample size was very small in comparison (n = 12), and theirs so large, I used the same factors to analyze the responses on the questionnaire provided by the teachers in my study.

A qualitative component was added to the research design to allow me to consider the patterns and trends that emerged through my analysis of the teachers’ responses on this questionnaire. I collected data for this qualitative analysis through the use of classroom videotapes, classroom observations, and exit interviews. I videotaped most of the 12 teachers participating in the research study (n = 8) for one class period of at least 40 minutes both before and after the differentiation course. These eight teachers asked the parents of the students in one specific class period for written permission for me to come into their rooms to videotape the teacher, as the children would appear on the videotapes during the course of a normal class period of instruction. Neither the students themselves nor their work or achievement were part of this study. I conducted
two classroom observations with those teachers who preferred that I not videotape their instruction (n = 4), again for at least one class period of 40 minutes at the beginning and at the end of the study.

Among the characteristics that vary in this study are a number which I could not manipulate, including the experience of the teachers, their gender and age, their own content knowledge, the extent to which they previously used inquiry instruction or instructional practices guided by constructivism theory with their students, how frequently they engaged their students in hands-on investigations, their self-confidence, classroom management strategies, rapport with students, professionalism, and to a certain extent, the extent of administrative support from the building principal. My sample represented a diverse group of teachers, and most of these attributes could not be controlled.

Inherent in the research design was the threat of external validity, as I did not attempt to have all the middle school science teachers in the district complete the Archambault questionnaire. Consequently, I can not determine the degree of variance of the sample of teachers who participated in the course against those who did not. Table 3.1 provides a general comparison of the teachers in the course and those in the district; on most parameters the sample appears to be representative of the teachers in the district.

A minor threat to internal validity (history) occurred when an after-school district in-service for all middle school teachers one day during the study addressed the concept of differentiation. The experience did not unduly influence the teachers in this study, as the presentation was limited in time and scope to an hour-long general
overview of differentiation. The in-service did help to promote the idea that the use of
differentiation in the classroom was a district priority, and some teachers in my study
found useful information in the lengthy handout that was provided. Therefore I
concluded that the threat to internal validity of my work was minor.

Subject Selection

All middle school science teachers in the district (n = 35) were invited to enroll
in a graduate level course on differentiation. The teachers were notified about the
opportunity through a flyer that was placed in their mailboxes at their schools (see
Appendix B). In addition I spoke with the teachers early in the school year during
science department meetings in each school to share information with the teachers about
the course and the professional development support I would be able to provide if they
were interested in participating. I also informed the teachers that there would be a
research component opportunity for those who wished to participate.

Teachers who enrolled in the differentiation course would receive their choice of
one semester hour of credit at a local university where I am an adjunct faculty member,
or one unit of district professional development credit. A fee of $138 was required from
those teachers who wished graduate credit. This fee covered the university’s charges
only; I received no payment for my work or time. Participation in the course and its
research component was voluntary, and teachers were told that they could drop out of
the course or the research portion of it at any time without penalty. For some teachers
participating in professional development experiences such as this course could lead to
a salary increase; for others the graduate credit could be used towards a master’s degree or designation as a “highly qualified teacher” under the new No Child Left Behind federal legislation. The course syllabus is presented in Appendix C.

Once teachers enrolled in the course (n = 12) they were told specifics about the research methodology that I would use in this research. Those who wished to participate in the research component of the course signed a letter of consent (see Appendix D) before the first class meeting. Eight were willing to participate fully; four teachers opted to participate in every aspect of the research except the videotaping.

Most of the district science teachers who elected not to enroll in the course had other after-school activities that prevented them from participating. These activities ranged from coaching fall or winter quarter sport teams, serving as an academic advisor of an after-school club or activity for students that met the same day as this course, having enrolled in other graduate courses, parenting young children, or having other commitments. Three highly experienced middle school science teachers who planned to retire at the end of the year also elected not to participate.

The profile of the teachers who enrolled in the course represents the diversity of the science teaching staff district-wide. As stated earlier, almost all of the 771 teachers employed in the district are white. Three-quarters of the teachers are female, 65 percent have taught for 11 years or more, and the average salary for teachers is just over $53,000 per year (Ohio Department of Education, 2003). Teachers in the differentiation course ranged in age from 25 to 54. They ranged in experience, backgrounds, and gender. They were a mix of teachers with secondary (grades 7 - 12), middle school (grades 4 - 9) and elementary (grades 1 - 8) certification. All but two taught only
science; the two each taught mathematics in addition to science. Some of the teachers were married; some were not. Some had children; some did not. One teacher was pregnant during the course and subsequently was out for part of the spring on maternity leave; she completed writing and teaching her differentiated unit, all data collection, and the exit interview prior to her leave.

Table 3.1, which provides information about the group, has been summarized here from the responses provided by the teachers on the first section of the Archambault questionnaire. Information about the district averages is also provided.

<table>
<thead>
<tr>
<th>Population aspect</th>
<th>Distribution of Sample (% in course vs % in district)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>male: 4; female: 8 (66% vs 75% female)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Caucasian: 11; African-American: 1 (8.3% vs 2.74%)</td>
</tr>
<tr>
<td>Years teaching experience</td>
<td>range 4 – 29.5 years, (14.5 years vs 15.3 years)</td>
</tr>
<tr>
<td>Highest degree earned</td>
<td>BA/BS: 4 (33% vs 38%); Masters’ Degree: 8 (66% vs 60%)</td>
</tr>
<tr>
<td>Training in teaching the</td>
<td>No training: 9; district in-service: 2; workshop</td>
</tr>
<tr>
<td>gifted</td>
<td>provided outside district: 1</td>
</tr>
<tr>
<td>Grade level teaching</td>
<td>Sixth gr.: 6; Seventh gr.: 4; Eighth gr.: 2</td>
</tr>
</tbody>
</table>

Table 3.1: Known characteristics of teachers in sample population.

All course participants were expected to attend all course meetings, complete homework as assigned, and schedule regular meetings with me during and subsequent to the four class meetings for consultations, peer coaching, team teaching, or other support as needed. Occasionally a teacher missed a class due to illness, but the teacher and I always arranged a time for the teacher to make up the time and the work; these meetings were usually scheduled during after-school time.
UnitWriter® software was provided to the teachers on the second meeting of the course, and district laptops were used for hands-on instruction on proper installation of the software and the basics of its use. Additional support with the software was provided one-on one as requested by the teachers.

Outcome Measures

To determine whether middle school science teachers in the district modify their instructional practices and curricular materials to meet the needs of the students in their classes, including those who are identified as gifted, I asked the science teachers who participated in my research study to complete a questionnaire (see Appendix A) at the beginning of my research, to establish current practice.

The instrument used for the questionnaire in this study was created for a 1993 national study done by the National Research Center on the Gifted and Talented of over 7000 elementary school teachers in six different sample groups across the country; 3,880 were returned for a return rate of 53 percent, and at relatively consistent rates within each sample group (Archambault et al., 1993).

The instrument was developed over time, and it was both field tested and revised based upon the results and comments from the field test. The questionnaire was carefully formatted to allow teachers to rate themselves on each item in the third section (related to their teaching practices) for the frequency with which they used the strategy addressed in the item with their gifted and with their average students. Directions that accompanied the instrument were clear. The questionnaire originally included items at
the beginning related to their background in the first section, related to the policies of their schools and districts related to gifted students in the second section, and finally asked 39 items about the classroom practices of the teachers.

I debated whether to remove the section about district practices as I would be using it only with teachers in my own district, and I already had the information. However, I elected to leave the questions in place to preserve the reliability and validity of the questionnaire, and also to identify how much each teacher knew about district policies and programming for the gifted in the district.

The 39 items comprising the third section of the instrument were reduced by the original authors to six different measurement scales using factor analysis. The items were not clustered together however, but were randomly distributed throughout this section of the questionnaire. The six scales and their alpha reliabilities were (a) Questioning and Thinking (.83); (b) Providing Challenges and Choices (.79); (c) Reading and Written Assignments (.77); (d) Curriculum Modifications (.72); (e) Enrichment Centers (.72); and (f) Seatwork (.53); the variance accounted for was 38 percent.

The questionnaire was used originally with elementary school teachers, who usually have a broad range of instructional responsibilities in multiple content areas. I used it with middle school science and mathematics teachers, who may not be familiar with common elementary practices that were specifically mentioned in the original questionnaire. I elected to modify some terminology very slightly to make items useful and applicable to middle school teachers. For example, item #4 on the original questionnaire asked whether teachers used “self-directional instructional kits such as
S.R.A”, which I knew would be meaningless for middle school teachers, so I deleted the words after “kits”, and allowed the question to be more open and unstructured.

Conditions of Inquiry

Data were collected at separate times during this investigation. Data were collected through the use of a questionnaire, interviews, planning sessions, analysis of the lessons created and presented to students after a period of on-site professional development support, written teacher reflections, and exit interviews. The questionnaire was provided for all course participants on the first day of class, and time was provided for all to complete the questionnaire. Teachers were told that all information they provided would be kept in the strictest confidence, and responses would not be identified with any individual. I told the teachers that I would assign a participant code number or pseudonym only to connect all information that teachers complete for my inquiry. The teachers were not asked to put their names on the questionnaires; however they knew that a small number of teachers were completing the questionnaire and that if I wished to know who completed which questionnaire I could have matched the profile information provided on the first page of the questionnaire with the information I already knew about the teachers. Had I asked the teachers to do the questionnaire a second time at the end of the course, I would have needed to know who completed which questionnaire to match and compare the changes in the responses. I elected to look for indicators of increased incorporation of differentiation strategies through the observations, videotapes, and interviews.
I asked teachers to bring their class rosters and gifted student lists (if they had them) to the first meeting. During the time the teachers worked on the questionnaire, those teachers who did have access to these lists were better prepared to answer specific questions about the students. Those who did not bring these lists commented that if they had their class rosters and lists of identified gifted students in their grade level, they could be better able to answer the questions accurately. I encouraged them to do the best they could estimating the numbers of students and the percentages who were gifted in that particular class, and assured them that the answers to the last section of the questionnaire were by far the more important and did not require the specific information contained in the lists or rosters. A few teachers did request to update their answers on sections one and two at a later time; we were able to arrange for this.

Data collection done with the classroom teachers who agreed to videotaping could not begin until signed permission forms were sent home and collected back again. This first set of videotapes was completed within two weeks of the first class period, however, before teachers began making any efforts to incorporate differentiation into their instruction. Neither at this time nor later did the classroom teachers know exactly which day I would be coming to make these videotapes or classroom observations. More than once I arrived unannounced to find the class schedules had changed for the day, or the teacher was absent and a substitute was working with the students, or the students were taking a test. On those occasions I did not conduct the taping or observations, and simply returned on another day.
Treatments

All teachers in the differentiation course received the same instruction in the graduate course, although some differentiation was used in the course to provide a model for the teachers and to meet their different learning needs. Differentiation in the course was provided through providing teachers their choice of a paper folder or a computer program to plan and develop a differentiated unit for instruction, and during individual meetings tailored to the teachers individual needs. The graduate level course consisted of four after-school sessions, each lasting two hours. Course meetings were held at the various middle schools, depending upon the facilities and equipment needed for the course session. I planned and presented the workshop meetings, and scheduled the follow-up sessions at the convenience of the teachers. The course syllabus has been provided in Appendix C. The course started in the late fall and continued through the winter, to provide teachers time to learn how to differentiate, how to plan and write a differentiated unit, and to implement the differentiated unit they created. The course also included a series of collaborative and individual sessions with teachers during the school day throughout the seven-month time period between November and May.

All teachers participating in the course received instructional materials provided through the district professional development department. These materials allowed me to teach about differentiated instruction, to help teachers learn how to use the Curry/Samara matrix (through computer software or an alternative process using paper folders) as a tool to plan differentiated units, and how to implement the units in their classrooms. Each teacher received print materials on differentiation, a copy of
UnitWriter® software as a tool to create differentiated units and support materials from the Curriculum Project (Curry & Samara, 2003) including Product Guides (purchased by the district for the teachers), and a copy of Tomlinson’s book on differentiation at the middle school level (Tomlinson & Eidson, 2003).

UnitWriter® is a commercial educational software program developed by James Curry and John Samara at The Curriculum Project, Austin, TX. UnitWriter® software provides a format for designing lessons with planned activities and opportunities for all students, by pre-planning for those who already know the content in the unit, and for those who have particular learning styles and needs. Based in general upon Bloom’s Taxonomy, UnitWriter® is a multi-faceted program that allows the teacher to vary instruction using a wide range of thinking skills and learning styles, and provides a matrix framework for teachers to plan differentiated activities that allow all students to engage in meaningful activities according to the Curry/Samara Model. This model suggests that teachers should differentiate their teaching through modifications to content, process (thinking level), or product (see Table 3.2).

Sample units in many content areas were available from the websites of other districts in this and other states that have been using the Curry/Samara Model for planning instructional units. (One unit on energy [developed by a teacher in the course] has been included in Appendix F, along with an assessment developed by another teacher in the course for an astronomy unit in Appendix G.) Teachers were asked to create their own units using the software with support from me as needed and desired. I provided an alternative paper-and-pencil approach to creating differentiated units through the use of a Curriculum Project paper folder and post-it-notes. These materials
Table 3.2: Categories of thinking and verbs in the initial UnitWriter® matrix.

were also purchased for all teachers through the district professional development program. The paper folder consists of a chart with blank cells in a seven by six grid (see Figure 3.1). Teachers used post-it-notes to fill the first vertical column with the content to be covered in the unit, ranging from factual information to global. Then specific standards-based activities at varying degrees of thinking (according to the Bloom’s Taxonomy) were used to fill as many of the open cells in the unit as possible (see Figure 5.1 for an image showing this). Each activity statement would have a cognitive verb, a content objective, and a product to demonstrate the students’ learning. Each folder had a flap on the right and left, one with sample verbs at the six levels of thinking, and the other with sample products. Product possibilities were sorted into four modalities: kinesthetic, oral, visual, and written (see Table 3.3 and Figure 5.6 for examples of product possibilities), and ranged widely in scope and opportunity.
Figure 3.1: The Curry/Samara model folder for planning differentiated units.

<table>
<thead>
<tr>
<th><strong>Product Possibilities</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kinesthetic</strong></td>
</tr>
<tr>
<td>Dramatization</td>
</tr>
<tr>
<td>Role play</td>
</tr>
<tr>
<td>Finger puppets</td>
</tr>
<tr>
<td>Simulation</td>
</tr>
<tr>
<td>Charade</td>
</tr>
<tr>
<td>Mobile</td>
</tr>
</tbody>
</table>

Table 3.3 Sample product possibilities suggested for teachers to use with students.
By providing the paper folder and post-it-notes, I was able to model the use of differentiation for the teachers themselves, openly acknowledging that there are teachers who prefer alternatives to computer software, and those who prefer to use technology. Both were available, and teachers were free to experiment with them both to determine which approach worked better for them. Each approach used the Curry/Samara Model of differentiating the process, the content, or the product. (Specific examples of units and assessments that were developed through both processes have been provided in Chapter 5 and Appendices F and G.)

All teachers who participated in the professional development were able to request my individual help during the school day (or before or after school in some cases) in planning and implementing differentiated instruction in their classrooms. I provided help in multiple ways, such as:

- serving as a sounding board and helping to generate ideas,
- answering questions about differentiation in general or about using the folders or the computer software to create a differentiated unit,
- helping teachers plan how to explain differentiation for the first time to their students, or how to counter anticipated parent questions, and
- helping teachers think of extensions or homework assignments which offered some degree of differentiation as well.

Some teachers sent email messages to me requesting help when they needed it; others would stop me when we met by chance near the teachers’ mailboxes or in the hallways in the schools. The teachers would then either ask their question or questions right then, or we would schedule a more structured time to meet. Such conferences
lasted anywhere from five minutes up to an hour in a few instances; I did team-teach with two teachers for an entire day, to provide assistance to them by modeling how to introduce and manage a differentiated assignment or lesson. Such activities were planned by the two of us, and always related to the unit under study by the teacher at the time.

When the request involved the use of UnitWriter®, I arranged to work with the teacher at his or her own computer workstation, and we installed the software and worked with it together. In every case I showed the teachers how to personalize the settings so the units being developed could be saved to their section of the server, or to a floppy disk, rather than to the hard drive of that computer. In every case the teacher manipulated the computer mouse and did the work while I provided commentary and assistance verbally.

Whenever possible I allowed and encouraged the teachers to initiate the requests for my time or information or help. With a few teachers I noted that no contact was made between meetings of the class, so I started to seek them out, by sending them email or stopping by their classrooms to ask how the work was progressing. I did not want the teachers to delay creating their differentiated unit or the implementation of the strategies they planned, and I took it upon myself to provide additional support by initiating the contact. In all cases the teachers welcomed my offer of help and had questions that we were able to discuss to their satisfaction.

The third class session was used largely for collegial discussions of their units, by grade level. The sixth-grade teachers formed two groups of three, the four seventh-grade teachers met together, and the two eighth-grade teachers met together. All groups
shared their progress and problems creating the differentiated matrix, and made suggestions to the others. To help the teachers consider the process and the steps for implementing their new differentiated units, I provided the teachers with a checklist with indicators of implementation (see Figure 3.2). The checklist was developed by considering elements of effective instruction, including those from standards-based education, suggestions from Wiggins and McTighe (1998), and specifics related to the Curry/Samara Model. The teachers and I brainstormed a long list of observable behaviors that one might see in the classroom of a teacher who was implementing differentiation. That list, and the indicators of implementation were provided to help teachers implement specific aspects of a differentiated classroom in stages. I used the list to look for differences between teacher work in the classroom at the beginning and end of the study.

I also provided two sets of Product Guides per middle school. These were designed by the Curriculum Project for teachers to use with students, as a tool to guide the students’ work and to facilitate the transition from every student doing the same work to some engaging in different learning experiences. Each product guide listed the components of the product, and provided specific information about each component that represented high quality work. Each set included four kinesthetic products (board game, demonstration, dramatization, model); four oral products (informative speech, mock interview, oral report, and panel discussion); four visual products (bar graph, concept cube, poster, and timeline); and four written products (business letter,

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4 The Curriculum Project provides a much more complete checklist, including not only indicators for content, thinking, and products, but also indicators in assessment, facilitation, and reflection that were beyond the scope of this inquiry.
### Content Implementation Indicators

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>asks questions and/or uses graphic organizers</td>
</tr>
<tr>
<td></td>
<td>refers to Matrix to see big picture</td>
</tr>
<tr>
<td></td>
<td>discusses calendar to share pacing and progression of learning</td>
</tr>
<tr>
<td></td>
<td>relates daily activities to curriculum</td>
</tr>
<tr>
<td></td>
<td>refers to state standards</td>
</tr>
<tr>
<td></td>
<td>displays learning objectives (verb .. Content .. Product)</td>
</tr>
<tr>
<td></td>
<td>uses computers to access information in and out of classroom</td>
</tr>
<tr>
<td></td>
<td>discusses applications outside subject area</td>
</tr>
<tr>
<td></td>
<td>teaches independent study/research skills</td>
</tr>
<tr>
<td></td>
<td>questions students frequently</td>
</tr>
<tr>
<td></td>
<td>uses variety of materials to engage students with content</td>
</tr>
</tbody>
</table>

### Thinking Implementation Indicators

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>references thinking skills visual aids for students</td>
</tr>
<tr>
<td></td>
<td>writes and explains learning objective(s)</td>
</tr>
<tr>
<td></td>
<td>questions students at all thinking levels</td>
</tr>
<tr>
<td></td>
<td>asks convergent and divergent questions (right answer and open-ended)</td>
</tr>
<tr>
<td></td>
<td>generates and uses visual aids on thinking procedures on proficiency</td>
</tr>
<tr>
<td></td>
<td>assigns homework that uses different thinking skills</td>
</tr>
<tr>
<td></td>
<td>provides choices in HW and activities for students to select</td>
</tr>
<tr>
<td></td>
<td>thinks aloud to model for students</td>
</tr>
<tr>
<td></td>
<td>uses sufficient wait time</td>
</tr>
<tr>
<td></td>
<td>uses general praise statements</td>
</tr>
</tbody>
</table>

### Product Implementation Indicators

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>shows and discusses examples</td>
</tr>
<tr>
<td></td>
<td>provides and explains product guides</td>
</tr>
<tr>
<td></td>
<td>relates products to rubrics or product guides</td>
</tr>
<tr>
<td></td>
<td>compliments students orally and in print</td>
</tr>
<tr>
<td></td>
<td>allows for student choice</td>
</tr>
<tr>
<td></td>
<td>references learning style terminology (written, kinesthetic, oral, visual)</td>
</tr>
<tr>
<td></td>
<td>displays student work</td>
</tr>
<tr>
<td></td>
<td>provides opportunity for students to use technology</td>
</tr>
<tr>
<td></td>
<td>coordinated project schedules across team or grade levels</td>
</tr>
</tbody>
</table>

Figure 3.2: Checklist of indicators of implementation.
newspaper story, poem, and report). Each set also contained a blank template for a guide so teachers could create their own guide for a product that was not included in the set, but modeled after the ones that were included. The two sets were at different levels, so I provided one set with the middle school-level standards for the sixth- and seventh-grade teachers, and one set of the high school-level standards for the eighth-grade teachers. Each school received two sets, whether eighth-grade teachers were participating or not.

Materials alone do not ensure the successful implementation of new teaching strategies. Structured into the course was time for me to work with the teachers as they implemented the units with their students. In some cases teachers asked me to review their differentiated units before they started using them, and during the unit if they needed or wanted to make some changes in the plans. Often I made suggestions for modifications to increase the diversity of strategies and the range of products that students would be asked to create to show what they had learned. I also worked directly with the teachers in their classrooms in all three of their middle schools.

Data Analysis

To investigate the degree of support middle school science teachers needed to use differentiated instruction, I conducted in-depth interviews, observations, and planning meetings with all of the participating science teachers. These exchanges provided rich qualitative data about the process of implementing differentiated curriculum in their classrooms. Throughout the course and the meetings with teachers I
took copious notes of our conversations, noting the time spent with the teachers, the content of the discussion, the outcome, and the nature of the assistance I provided. This information became part of the data I collected and analyzed.

For internal consistency I used the same observation protocol to evaluate the extent to which the teachers implemented differentiation strategies, making moot the issue of whether I observed them or videotaped them. The checklist of implementation indicators (e.g., the teacher posted instructional objectives for the day, the teacher questions students at all thinking levels) that I provided the teachers facilitated this process (see Figure 3.2). During the third meeting of the course, and in subsequent individual meetings, we discussed the implementation indicators, and considered how an observer would know that differentiation was being implemented, for example, what would the teacher be doing, what would the students be doing, and how would classroom activities be different if they were differentiated. The teachers and I also considered the strategies (outlined in the indicators) as a support structure when they started to use differentiation with their students. I asked teachers to use the indicators as a checklist in their planning, not that every activity would be visible every day, or in every activity, but that enough of the differentiated strategies contained in the checklist would be employed over the course of the unit to make the classroom experience qualitatively different for students and the teacher alike. My task was to quantify the frequency with which any of the indicators was used by each teacher during a thirty-minute observation interval both before and after the professional development course.

Using the indicator lists as a tally sheet I recorded any separate instances of an indicator being implemented by the teacher I was observing. I evaluated the results of
these observations using standard descriptive statistics, presented in this dissertation through box-and-whiskers graphs (to show quartiles, median, maximum, and minimum). The number of teachers in the study was relatively low, yet these graphs did help in my analysis of the degree to which teachers in the course were able to implement differentiation. The data has been included and analyzed in Chapter 5.

In addition to these descriptive statistics, I calculated t-statistics with the results to gauge their relative significance. This information has also been included in Chapter 5. The small sample size does mean that the probability of a beta error is higher than it would have been had my sample size been larger, however the quantitative analysis was never meant to stand alone, given the substantial amount of qualitative data collected during this study. The significance testing of the teachers’ use of the implementation indicators before and after the course provided additional information to evaluate the extent of changes in the teachers’ instructional practices.

Finally I conducted exit interviews with all the teachers after they taught their differentiated unit (see Appendix F for a sample unit). Ultimately the amount of support that the teachers needed to make changes in their pedagogy and the degree to which they were successful were evaluated through in-depth qualitative analyses of the teachers’ beliefs, feelings, abilities to deliver differentiated instruction, and reflections before, during, and after the study period.
CHAPTER 4

INITIAL CLASSROOM PRACTICES

The focus of my research centered first on the characteristics and instructional practices of the teachers in my study, with specific attention to the extent to which they provided any modifications to meet the varying levels of their students’ learning styles, rates of learning, interests, previous knowledge, and abilities. After working with the teachers in the professional development course and through individual meetings, the focus of my research shifted to the amount of support the teachers needed, and the extent to which they were able to implement differentiated strategies. The results of the teachers’ responses on the Archambault classroom practices questionnaire will be presented and discussed in this chapter, and then the qualitative data regarding degree of support and implementation collected through videotapes, classroom observations, and interviews will be shared and analyzed in Chapter 5.

As previously discussed in Chapter 3, the sample of teachers in this study was a representative sample of district teachers as evidenced by their ages, years of teaching experience, gender, ethnicity, and education levels (see Figure 3.1). The responses the teachers provided on the questionnaire provided a snapshot of initial teacher behavior and instructional strategies for the gifted and average students in their classes. The
responses for each item in the questionnaire used numerical values for the following response range: never (0), once a month or less (1), a few times a month (2), a few times a week (3), daily (4), and more than once a day (5) (see Table 4.1).

Table 4.1 provides some data derived from the responses of the teachers about their own classroom practices with average students and gifted students. Means (\(\bar{x}\)) and standard deviations (\(\sigma\)) are provided, along with the differences between the means (Cohen’s \(d\)), and the effect size of that difference. An effect size of 0.8 or larger is considered large; effect sizes between 0.5 and 0.8 are medium; between 0.2 and 0.5 are small, and below 0.2 is negligible (Cohen, 1988). The effect size was calculated by dividing the mean difference by the square root of the pooled within-group variances (L. A. Becker, 1998). Of the 39 items on the questionnaire the teachers reported absolutely no difference in their strategies for average and gifted students on 26 items. They reported a negligible effect on another 9 items, a small effect on one item (#18) and a medium effect on three items (#19, 30, and 31).

These last four items therefore deserve some closer study. The effect size for the first item (#18) is considered to be small. The item asks whether teachers allow students to leave the classroom to work in various locations, such as the media center or the school library. Of the twelve teachers in my study, two registered different behaviors on this item for their average or gifted students. One reported providing this opportunity for gifted students a few times a week, while the other provided the opportunity a few times a month.
<table>
<thead>
<tr>
<th>Classroom Practices Item (truncated)</th>
<th>Average</th>
<th>Gifted</th>
<th>( \bar{x} )</th>
<th>( \sigma )</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Use basic skills worksheets</td>
<td>2.85</td>
<td>0.80</td>
<td>2.85</td>
<td>0.80</td>
<td>0.00</td>
</tr>
<tr>
<td>2 Use enrichment worksheets</td>
<td>1.83</td>
<td>1.03</td>
<td>1.92</td>
<td>1.00</td>
<td>0.08</td>
</tr>
<tr>
<td>3 Assign reading of more advanced level work</td>
<td>0.67</td>
<td>0.65</td>
<td>0.75</td>
<td>0.62</td>
<td>0.08</td>
</tr>
<tr>
<td>4 Use self-directed instructional kits</td>
<td>0.77</td>
<td>0.60</td>
<td>0.85</td>
<td>0.69</td>
<td>0.08</td>
</tr>
<tr>
<td>5 Assign reports</td>
<td>1.08</td>
<td>0.64</td>
<td>1.08</td>
<td>0.64</td>
<td>0.00</td>
</tr>
<tr>
<td>6 Assign projects or other work</td>
<td>1.31</td>
<td>0.63</td>
<td>1.31</td>
<td>0.63</td>
<td>0.00</td>
</tr>
<tr>
<td>7 Assign book reports</td>
<td>0.23</td>
<td>0.44</td>
<td>0.23</td>
<td>0.44</td>
<td>0.00</td>
</tr>
<tr>
<td>8 Use activities such as puzzles or word</td>
<td>1.31</td>
<td>0.63</td>
<td>1.31</td>
<td>0.63</td>
<td>0.00</td>
</tr>
<tr>
<td>9 Creative writing assignments: teacher’s topic</td>
<td>1.54</td>
<td>0.78</td>
<td>1.54</td>
<td>0.78</td>
<td>0.00</td>
</tr>
<tr>
<td>10 Creative writing assignments: student’s topic</td>
<td>0.31</td>
<td>0.48</td>
<td>0.31</td>
<td>0.48</td>
<td>0.00</td>
</tr>
<tr>
<td>11 Time for self-selected interests</td>
<td>0.85</td>
<td>0.90</td>
<td>0.85</td>
<td>0.90</td>
<td>0.00</td>
</tr>
<tr>
<td>12 Pretests to determine mastery</td>
<td>0.77</td>
<td>1.01</td>
<td>0.77</td>
<td>1.01</td>
<td>0.00</td>
</tr>
<tr>
<td>13 Eliminate material students have mastered</td>
<td>0.77</td>
<td>1.01</td>
<td>0.77</td>
<td>1.01</td>
<td>0.00</td>
</tr>
<tr>
<td>14 Repeat difficult concepts for some students</td>
<td>2.31</td>
<td>1.18</td>
<td>2.08</td>
<td>1.12</td>
<td>-0.24</td>
</tr>
<tr>
<td>15 Different work for students mastering work</td>
<td>0.85</td>
<td>1.14</td>
<td>0.85</td>
<td>0.99</td>
<td>0.00</td>
</tr>
<tr>
<td>16 Alternative instructional formats</td>
<td>1.54</td>
<td>0.97</td>
<td>1.38</td>
<td>0.87</td>
<td>-0.15</td>
</tr>
<tr>
<td>17 Various locations around the classroom</td>
<td>2.23</td>
<td>1.17</td>
<td>2.31</td>
<td>1.11</td>
<td>0.08</td>
</tr>
<tr>
<td>18 Work in location other than class</td>
<td>0.77</td>
<td>1.01</td>
<td>1.00</td>
<td>1.22</td>
<td>0.23</td>
</tr>
<tr>
<td>19 Different homework based on student ability</td>
<td>0.77</td>
<td>1.09</td>
<td>0.31</td>
<td>0.48</td>
<td>-0.46</td>
</tr>
<tr>
<td>20 Use learning centers to reinforce basic skills</td>
<td>0.46</td>
<td>0.88</td>
<td>0.46</td>
<td>0.88</td>
<td>0.00</td>
</tr>
<tr>
<td>21 Use enrichment centers</td>
<td>0.15</td>
<td>0.55</td>
<td>0.15</td>
<td>0.55</td>
<td>0.00</td>
</tr>
<tr>
<td>22 Teach thinking skills in the regular classroom</td>
<td>2.62</td>
<td>1.33</td>
<td>2.62</td>
<td>1.33</td>
<td>0.00</td>
</tr>
<tr>
<td>23 Teach unit on a thinking skills</td>
<td>0.77</td>
<td>1.30</td>
<td>0.77</td>
<td>1.30</td>
<td>0.00</td>
</tr>
<tr>
<td>24 Competitive thinking skills program</td>
<td>0.38</td>
<td>1.12</td>
<td>0.38</td>
<td>1.12</td>
<td>0.00</td>
</tr>
<tr>
<td>25 Contracts for independent study projects</td>
<td>0.38</td>
<td>0.65</td>
<td>0.46</td>
<td>0.66</td>
<td>0.08</td>
</tr>
<tr>
<td>26 Time in day for independent study projects</td>
<td>0.62</td>
<td>0.87</td>
<td>0.62</td>
<td>0.87</td>
<td>0.00</td>
</tr>
<tr>
<td>27 Work from a higher grade level textbook</td>
<td>0.23</td>
<td>0.44</td>
<td>0.23</td>
<td>0.44</td>
<td>0.00</td>
</tr>
<tr>
<td>28 More advanced curriculum unit</td>
<td>0.23</td>
<td>0.44</td>
<td>0.23</td>
<td>0.44</td>
<td>0.00</td>
</tr>
<tr>
<td>29 Group by ability across classrooms at grade</td>
<td>0.42</td>
<td>0.76</td>
<td>0.42</td>
<td>0.76</td>
<td>0.00</td>
</tr>
<tr>
<td>30 Higher grade level for specific instruction</td>
<td>0.15</td>
<td>0.38</td>
<td>0.62</td>
<td>1.19</td>
<td>0.46</td>
</tr>
<tr>
<td>31 Establish interest groups</td>
<td>0.15</td>
<td>0.38</td>
<td>0.38</td>
<td>0.51</td>
<td>0.23</td>
</tr>
<tr>
<td>32 Consider students’ opinion in allocating time</td>
<td>1.23</td>
<td>1.36</td>
<td>1.23</td>
<td>1.36</td>
<td>0.00</td>
</tr>
<tr>
<td>33 Programmed materials</td>
<td>0.62</td>
<td>1.19</td>
<td>0.62</td>
<td>1.19</td>
<td>0.00</td>
</tr>
<tr>
<td>34 Encourage long range projects</td>
<td>1.19</td>
<td>0.85</td>
<td>1.19</td>
<td>0.85</td>
<td>0.00</td>
</tr>
<tr>
<td>35 Questions to encourage reasoning</td>
<td>2.85</td>
<td>1.34</td>
<td>2.85</td>
<td>1.34</td>
<td>0.00</td>
</tr>
<tr>
<td>36 Ask open-ended questions</td>
<td>2.92</td>
<td>1.17</td>
<td>2.92</td>
<td>1.17</td>
<td>0.00</td>
</tr>
<tr>
<td>37 Encourage higher-level questions</td>
<td>2.85</td>
<td>1.13</td>
<td>2.85</td>
<td>1.13</td>
<td>0.00</td>
</tr>
<tr>
<td>38 Encourage student participation in...</td>
<td>4.08</td>
<td>1.19</td>
<td>4.08</td>
<td>1.19</td>
<td>0.00</td>
</tr>
<tr>
<td>39 Use computers</td>
<td>1.69</td>
<td>0.95</td>
<td>1.77</td>
<td>0.93</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Table 4.1: Research participants’ responses on section IV: Teacher practices - average (\( \bar{x} \)), standard deviation (\( \sigma \)), Cohen’s \( d \), and effect size.
The other three items with a medium effect size were more significant. Item #19 had the largest effect size of any item, at 0.55. The item asked teachers to report how frequently they assign different homework based on student ability. There was a negative difference for this item ($d = -0.46$), meaning that teachers provided different homework for the average students, not the gifted students. Three teachers reported a difference on this item. Two provide different homework assignments for their average students either less than once a month or a few times a week, but do not make any arrangements for different assignments for their gifted students. The third teacher reported sending different assignments for average students daily, and for gifted students once a month or less.

Items #30 and 31 had a medium effect size ($d = 0.53$ and 0.51 respectively), but carry different significance. Responses for one (Item #30) might be colored by the teacher’s knowledge of district policies, while the other (Item #13) reports on an infrequently used practice. Item #30 asked whether the teacher sends students to a higher-grade level for specific subject area instruction. In this district, a few sixth-grade students each year have been accelerated two years for mathematics, taking pre-algebra as sixth-graders, algebra as seventh-graders, and often honors geometry at the high school in eighth-grade. A larger number of seventh-graders have been accelerated one year, taking pre-algebra in seventh grade and algebra in eighth grade. In addition, 50 - 60 students each year (often overlapping with the accelerated mathematics students) have been invited to consider taking a foreign language in eighth-grade; most have accepted, and enrolled in the foreign language class of their choice. They also enrolled in a single class period of eighth-grade language arts instead of a double period.
Teachers in this study who remembered these policies, or who knew students participating in either acceleration, might have answered this question with a higher frequency value than other teachers. Indeed one teacher indicated by his or her response that this classroom practice happened daily, which is does. Acceleration is not possible in science however, so other teachers may have responded to the item in reference to their own classroom practices.

Item #31 (effect size 0.51 and $d = 0.23$) asked how frequently teachers established interest groups to enable their students to pursue individual or small group interests. Three teachers reported a slight difference, each offering this opportunity less than once a month to their gifted students.

The practical significance of the effect size is minimal, as the teachers overall did not report any extensive use of alternative strategies for any type of learner in their classrooms, much less the gifted students. The frequency with which any of these four strategies were used varied between “never” and “less than once a month”. Most gifted and high achieving children in the middle school science classrooms received neither alternative assignments nor particular challenge from the regular classroom materials.

Another way to examine the results of the questionnaire would be to sort the items into factors, and analyze classroom practices in general, to ascertain whether some strategies or factors are used more regularly than others. As mentioned earlier the six factors that emerged in the Archambault study were used in this study as well. These factors were:

1. Questioning and Thinking (items 22, 35 - 38);
2. Providing Challenges and Choices (items 18, 23 - 34);
3. Reading and Written Assignments (items 3, 5 - 7, 9 - 10);
4. Curriculum Modifications (items 12 - 16, 19, 39);
5. Enrichment Centers (items 11, 17, 20 - 21); and
6. Seatwork (1 – 2, 4, 8).

When the responses teachers provided on the questionnaire were sorted according to these factors, a number of patterns emerged. First, while it is true that the responses on strategies used with average students and with gifted students indicate no differences from each other in “Questioning and Thinking,” the averages for that factor were higher than for other factors, suggesting that teachers in the study were using questioning and other strategies that encouraged reasoning and the development of logical thinking for all their students at least a few times each week (see Table 4.2).

<table>
<thead>
<tr>
<th>Classroom Practices Item (truncated)</th>
<th>Average</th>
<th>Gifted</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \bar{x} )</td>
<td>( \sigma )</td>
<td>( \bar{x} )</td>
</tr>
<tr>
<td>22 Teach thinking skills in the regular classroom</td>
<td>2.62</td>
<td>1.33</td>
<td>2.62</td>
</tr>
<tr>
<td>35 Questions to encourage reasoning</td>
<td>2.85</td>
<td>1.34</td>
<td>2.85</td>
</tr>
<tr>
<td>36 Ask open-ended questions</td>
<td>2.92</td>
<td>1.17</td>
<td>2.92</td>
</tr>
<tr>
<td>37 Encourage higher-level questions</td>
<td>2.85</td>
<td>1.13</td>
<td>2.85</td>
</tr>
<tr>
<td>38 Encourage student participation in discussions</td>
<td>4.08</td>
<td>1.19</td>
<td>4.08</td>
</tr>
<tr>
<td>Factor statistics</td>
<td>3.06</td>
<td>1.30</td>
<td>3.06</td>
</tr>
</tbody>
</table>

Table 4.2: Statistics for factor 1: Questioning and thinking.

The final strategy in this list, encouraging student participation in discussions, was reported by the teachers on average to be a strategy they used daily with all students. Science is not a subject that lends itself well to lecture; state and national standards encourage hands-on investigations, inquiry activities, and discussions of the results to help students make sense of their investigations, to clarify areas of cognitive dissonance, dispel misconceptions, and to promote comprehension of the processes of
science and science as a way of knowing. That the teachers should engage their
students in discussions daily would be expected, and would be indicative of standards-
based science instruction. As there were no differences in what was asked or expected
of the gifted students, however, these results indicated that within this factor, the
science teachers in this district did not routinely ask gifted students to consider higher-
level questions that would be more appropriate for their cognitive abilities, and might
provide at least some degree of intellectual challenge for them.

Similarly the factor “Providing Challenges and Choices” overall did not suggest
that teachers in the study provided any different opportunities for gifted students, even
though two of the three items with medium effect size and the one with small effect size
fell into this factor. The results, provided in Table 4.3, showed that none of the teachers
in the study indicated any regular use of the 13 strategies in this factor; the collective

| Classroom Practices Item (truncated)                        | Average | Gifted | Effect
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\bar{x})</td>
<td>(\sigma)</td>
<td>(\bar{x}_G)</td>
</tr>
<tr>
<td>18 Work in location other than class</td>
<td>0.77</td>
<td>1.01</td>
<td>1.00</td>
</tr>
<tr>
<td>23 Teach unit on a thinking skills</td>
<td>0.77</td>
<td>1.30</td>
<td>0.77</td>
</tr>
<tr>
<td>24 Competitive thinking skills program</td>
<td>0.38</td>
<td>1.12</td>
<td>0.38</td>
</tr>
<tr>
<td>25 Contracts for independent study projects</td>
<td>0.38</td>
<td>0.65</td>
<td>0.46</td>
</tr>
<tr>
<td>26 Time in day for independent study projects</td>
<td>0.62</td>
<td>0.87</td>
<td>0.62</td>
</tr>
<tr>
<td>27 Work from a higher grade level textbook</td>
<td>0.23</td>
<td>0.44</td>
<td>0.23</td>
</tr>
<tr>
<td>28 More advanced curriculum unit</td>
<td>0.23</td>
<td>0.44</td>
<td>0.23</td>
</tr>
<tr>
<td>29 Group by ability across classrooms at grade</td>
<td>0.42</td>
<td>0.76</td>
<td>0.42</td>
</tr>
<tr>
<td>30 Higher grade level for specific instruction</td>
<td>0.15</td>
<td>0.38</td>
<td>0.62</td>
</tr>
<tr>
<td>31 Establish interest groups</td>
<td>0.15</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td>32 Consider students’ opinion in allocating time</td>
<td>1.23</td>
<td>1.36</td>
<td>1.23</td>
</tr>
<tr>
<td>33 Programmed materials</td>
<td>0.62</td>
<td>1.19</td>
<td>0.62</td>
</tr>
<tr>
<td>34 Encourage long range projects</td>
<td>1.19</td>
<td>0.85</td>
<td>1.19</td>
</tr>
</tbody>
</table>

Factor statistics | 0.55 | 0.93 | 0.63 | 0.99 |

Table 4.3: Statistics for factor 2: Providing challenge and choice.
mean ($\bar{x} = 0.55$) indicated a low frequency of use overall. Only two practices have a mean greater than 1, a frequency of use less than once a month.

Three of these have already been discussed (items # 18, 30, and 31). In addition, one teacher indicated that he or she used contracts (item #25) with students for independent projects occasionally (“less than once a month”). The effect sizes for the rest of the practices in the factor were negligible, which also indicated the relative insignificance of these practices for the teachers when we started this study. Only five teachers from the twelve in the study indicated that they used any of these items differently for gifted students. Only two of the strategies in this factor (# 32 and 34) were used with any regularity, and “less than once a month” did not suggest that the teachers modified their instruction to take into consideration how gifted students learn, the rate at which they learn, how they felt about school or the assignments and work they were given by their teachers.

A third factor, “Curriculum Modifications,” including item #19, related to homework assignments, previously discussed. This factor also included one item that must be used regularly by teachers who use differentiation: pretests. According to their own responses in Table 4.4, teachers almost never used pre-testing strategies to determine mastery, and consequently did not gather evidence about which students might already understand the material to be addressed by the lesson for the day.

The fact that none of the teachers in this study used pretests with their students more frequently than once every couple of months ($\bar{x} =0.85, \sigma = 0.9$ for both groups) suggested that the teachers were not differentiating their instruction at the beginning of this study. One of the basic tenets of differentiation is that choices and opportunities are
Table 4.4: Statistics for factor 4: Curriculum modifications.

provided based on the students’ previous experiences and knowledge: if a student already knows what the teacher is about to teach, that student should receive a differentiated assignment. There are multiple ways to pretest students, from quick writes to concept maps to K-W-L charts to chapter tests. Other relatively effective ways to differentiate instruction were also included in this factor, ranging from allowing students to skip over lessons relating to concepts they already understand by substituting different assignments and modifying the classroom environment.

For item after item in this factor, the responses on this questionnaire revealed that the teachers in the study did little if any differentiation of instruction when we started this study. For example another strategy, the use of alternative instructional formats for students who learn better using an alternative approach (#18), had a 0.17 effect size, and therefore a less than negligible effect. The item also had a negative difference, suggesting that if teachers modify their instruction at all it would be for average or low achieving students, or perhaps special needs students, but not their gifted or high achieving students. Another strategy, repeating difficult concepts, was done a
few times a month by the group of teachers on average, and again more frequently with average students than gifted. This continues to support the contention that teachers at the beginning of this study did not appreciably, consciously, or reliably offer opportunities for gifted students to learn something new every day, an opportunity according to this data that would be experienced more frequently by the average or lower achieving students.

The three remaining factors had little differences among them between practices teachers used for average students compared to gifted students, but there were a few strategies that the teachers used more frequently than others. In “Reading and Written Assignments” for example, one teacher assigned reading of more advanced level work for gifted students less than once a month, but he or she did not use that strategy with average students. Four of the other teachers never used this strategy, six used it more frequently but still less than once a month, and one teacher used the strategy a few times a month, but with both average and gifted students (see Table 4.5).

<table>
<thead>
<tr>
<th>Classroom Practices Item (truncated)</th>
<th>Average</th>
<th>Gifted</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assign reading of more advanced level work</td>
<td>0.67 0.65</td>
<td>0.75 0.62</td>
<td>0.08 0.13</td>
</tr>
<tr>
<td>Assign reports</td>
<td>1.08 0.64</td>
<td>1.08 0.64</td>
<td>0.00 0.00</td>
</tr>
<tr>
<td>Assign projects or other work</td>
<td>1.31 0.63</td>
<td>1.31 0.63</td>
<td>0.00 0.00</td>
</tr>
<tr>
<td>Assign book reports</td>
<td>0.23 0.44</td>
<td>0.23 0.44</td>
<td>0.00 0.00</td>
</tr>
<tr>
<td>Creative writing assignments: Baseline</td>
<td>1.54 0.78</td>
<td>1.54 0.78</td>
<td>0.00 0.00</td>
</tr>
<tr>
<td>Creative writing assignments: student's topic</td>
<td>0.31 0.48</td>
<td>0.31 0.48</td>
<td>0.00 0.00</td>
</tr>
<tr>
<td>Factor statistics</td>
<td>0.85 0.77</td>
<td>0.87 0.77</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.5: Statistics for factor 3: Reading and written assignments.
While “Questioning and Thinking” was a factor including strategies that teachers used most frequently (on average a few times a week) but without discrimination among students, teachers in this study tended to use several of the practices grouped as “Seatwork” more frequently than other four remaining factors. Included in this group were using basic skills and/or enrichment worksheets, and activities such as puzzles or word searches. The mean for all the strategies in the group was 1.69 for average students and 1.73 for gifted students. Despite frequent use none of the effect sizes, which ranged from 0 to 0.12, can be rated even as “negligible,” so gifted students did not receive different worksheets or puzzles or assignments in this category of classroom practices either (see Table 4.6).

<table>
<thead>
<tr>
<th>Classroom Practices Item (truncated)</th>
<th>Average</th>
<th>Gifted</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use basic skills worksheets</td>
<td>2.85</td>
<td>0.80</td>
<td>0.00</td>
</tr>
<tr>
<td>Use enrichment worksheets</td>
<td>1.83</td>
<td>1.03</td>
<td>0.08</td>
</tr>
<tr>
<td>Use self-directed instructional kits</td>
<td>0.77</td>
<td>0.60</td>
<td>0.08</td>
</tr>
<tr>
<td>Use activities such as puzzles or word searches</td>
<td>1.31</td>
<td>0.63</td>
<td>0.00</td>
</tr>
<tr>
<td>Factor statistics</td>
<td>1.69</td>
<td>0.91</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 4.6: Statistics for factor 6: Seatwork.

The final factor to be discussed is the use of enrichment centers. Middle school science teachers have a different mind set, and structure their classes very differently from elementary school teachers of science, who tend to use enrichment centers more frequently. A few teachers reported making different arrangements for gifted students in this category as frequently as a few times a month. However the data behind the average for Enrichment Centers indicated that only two teachers made arrangements for
gifted students that were different from what the other students received; one provided
time more frequently for gifted students to pursue his or her own interest (#11), while
the other provided more opportunity for gifted students to move around the classroom
(#17) than average students, perhaps through small group investigations (see Table
4.7).

<table>
<thead>
<tr>
<th>Classroom Practices</th>
<th>Average</th>
<th>Gifted</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item (truncated)</td>
<td>( \bar{x} )</td>
<td>( \sigma )</td>
<td>( \bar{x} )</td>
</tr>
<tr>
<td>11 Time for self-selected interests</td>
<td>0.31</td>
<td>0.75</td>
<td>0.38</td>
</tr>
<tr>
<td>17 Various locations around the classroom</td>
<td>2.23</td>
<td>1.17</td>
<td>2.31</td>
</tr>
<tr>
<td>20 Use learning centers to reinforce basic skills</td>
<td>0.46</td>
<td>0.88</td>
<td>0.46</td>
</tr>
<tr>
<td>21 Use enrichment centers</td>
<td>0.15</td>
<td>0.55</td>
<td>0.15</td>
</tr>
<tr>
<td>Factor statistics</td>
<td>0.79</td>
<td>1.19</td>
<td>0.83</td>
</tr>
</tbody>
</table>

Table 4.7: Statistics for factor 5: Enrichment centers.

Summary

Students in science classrooms are generally engaged in science experiments
and investigations, which would correlate with the relatively high scores for item #17
related to the location in the classroom where students worked. All other strategies in
this category received very low scores, indicating that teachers do not allow students
time to pursue their own interests, and the teachers neither provide learning centers nor
enrichment centers to provide stimulation for their gifted students with any frequency.

The science teachers in this study reported classroom practices that differed
slightly in numerical values from the national results reported by Archambault, et al.
(1993), but not in substance. Both studies revealed similarities and parallel patterns
even though the averages reported by Archambault, with an enormously larger sample size (over 3,000 compared to 12) were higher and more consistent between items. In general the findings were similar. Strategies grouped into the factor called Questioning and Thinking Skills were used most often in the classroom to meet the needs of students, but were not used significantly differently for gifted students. Few differences were found in either study, suggesting that teachers made no significant modifications to their classroom practices to accommodate the needs of gifted students, although some pointers suggested that attempts were made to accommodate the needs of average or lower end students, through additional instruction, modified assignments, or different homework requirements.

The questionnaire also provided information about previous experience the teachers had in gifted education, and about their knowledge of the gifted program in the district. Eight of the teachers had no prior training in the teaching of the gifted and talented, two had participated in a district in-service program, one had attended a course outside the district, and one had taken a college course in gifted education. They all knew that the district employed a coordinator of programs for the gifted, perhaps in part because the person in that position had previously been the science coordinator in the district for several years, and was therefore an administrator with whom the science teachers had prior experience. The teachers also knew that there was a part-time middle school gifted resource teacher working in their middle school. Only half of the teachers knew that students in their school were transported to another school to participate in gifted program (acceleration in mathematics or foreign language), and only half knew that students in their school went to a resource room for instruction provided by the
middle school resource program teacher. The teacher responses indicated that the teachers did not know exactly how students were identified for the gifted program, or whether the district had a policy on the acceleration of the regular curriculum for high ability students.

The questionnaire provided a picture of the classroom practices used by the teachers in my study for their instruction in science. Consequently I knew when we started the course that the teachers would need some information about how gifted students are identified, how they are different from other students, and how their learning needs could be supported by differentiation. An early written assignment in the course provided additional information about how the teachers saw their role in the classroom.

The next step was to visit the classrooms, to observe or videotape the teachers working with a class of students on a typical day, early in the study. This classroom visit allowed me to compare the picture of the group of teachers in general with the specific and individual teachers, so I could begin to identify the individual strengths and various approaches to teaching that each used with their students. Just as I was asking the teachers to learn about differentiation strategies, it was my intent to teach the course through differentiation. The questionnaire and early classroom observations provided the prior knowledge that I would need to be effective in that role, and to teach by modeling the strategy itself.
CHAPTER 5

IMPLEMENTING DIFFERENTIATION

This research was effected through the participation of science teachers in the school district in a course on differentiation. Eleven of the 12 teachers who enrolled in the class paid to obtain credit at a local university (a grade of satisfactory/unsatisfactory was stipulated), and the twelfth teacher opted for district professional development credit. All class meetings were held after school in a middle school science room in the district. Teachers learned how to develop a differentiated unit using the Curry/Samara Model through four class sessions and a series of individual meetings, and were supported through the use of the matrix folder and/or the UnitWriter® software, and other readings. All of the teachers were willing to participate in the research component of the class, and gave me permission to document their work with students either through classroom observations or videotapes. Each teacher also responded on audiotape to a series of questions (see Appendix E) and provided a window into the experience from her or his own perspective.

The research questions were qualitative in nature, and the report of the data and the findings must also be qualitative. The variables that were involved in the study were numerous, were often beyond my control, and represent a threat to external
validity. Variables included the personalities of the teachers, their work ethic and professional goals, their ages and levels of experience, their formal education, their style of teaching, the level of rapport achieved with students, the classroom management strategies used, the demands on the teachers’ time outside of the school (ranging from children or other family considerations to coaching or other after school activities), and the extent of support for their efforts from their building principals. My analysis of the teachers’ ability to implement differentiation must be colored by these variables, yet several patterns and trends did emerge.

A brief glimpse of each teacher will be provided in the next sections, with a discussion of the trends and patterns to close the chapter. In the group of teachers in my study were six teachers at the sixth-grade level, four at the seventh-grade level, and two at the eighth-grade level. Direct quotes were taken from the video- or audio-tapes, or my notes from conversations with the teachers. Conclusions and recommendations for further study may be found in Chapter 6.

Sixth-grade Teachers/Middle School

*Ellen/Baker*

Ellen has been teaching for 8 years, has an undergraduate degree in biological sciences, and holds both secondary certification (grades 7 - 12) in biology and middle school certification (grades 4 - 9) in science. Courses for the middle school certificate, the differentiation course, and one final course taken during the spring semester allowed Ellen to complete the coursework and master’s project requirements for a master’s degree in science education. Ellen and her husband, who teaches mathematics at the
high school in the district, have a two-year old daughter, and recently moved to a house
in the district to shorten their commute. Ellen arrives at school at 7:30 a.m. now, and
works until at least 4:00 p.m. most days. She works at home every day for about an
hour, and often works between five and ten hours on the weekends, catching up with
grading and making plans for new labs.

William/Baker

Only one middle school of the four in the district, Baker, holds a Science Fair
each year, because William is the only teacher in the district who is willing to
coordinate and promote the event. While other teachers in the building encourage their
students to do a science fair project, William requires it of his students, and works long
hours during Science Fair season to help them, and anyone entered in the program. He
has taught for 28 years, has a bachelor’s degree in geography, and holds elementary
certification (grades 1 – 8). He organizes hikes to a local state park regularly, and
grows marigolds with the students every year that they plant in late May outside the
school. He has taken a few additional courses related to helping students be more
successful on the state proficiency tests, and has taken additional workshops through
SEPUP, Project WET, Project WILD, and others. William arrives at school at 6:30
a.m., and usually leaves by 4:00 p.m., although he sometimes stays an additional hour if
he has labs to set up. During most of the school year he works an hour or two on work
at home every night, including the weekends. Between January and the beginning of
March he regularly spends an additional 20 hours or more every week helping students
with their science fair projects.
**Sue/Forest Oak**

Sue wanted to become a teacher because her father’s best friend, a Disney Teacher of the Year, “had a way with kids that was just magical,” and she wanted to be just like him. She did not intend to become a science teacher, but her first and only teaching assignment so far was sixth-grade science. Her background in science courses includes biology and chemistry in high school, and one course, biology for educators, at college. She has elementary certification (grades 1-8), and has taught for five years. She arrives at school before 7:00 a.m. every day, and leaves by 3:30 or 4:00 p.m., depending upon how efficient she was with the grading from the day. Sue prepares hands-on investigations for her students about twice a week, and uses the time early in the morning to get those set up. Another teacher uses her classroom the last two periods of the day, so every lab has to be planned to have a quick clean-up, using carts which she can wheel into an adjacent prep room as soon as her teaching assignment is over for the day. Sue spends less time now at home than she did previously; the first year she “studied hard to make sure I understood what I needed to teach,” occasionally asking her husband, who has a strong background in science, to help clarify a concept. Every year since the first was easier, and she now spends time outside of school just to catch up with grading, one task she never seems to finish during the day.

**Sally/Forest Oak**

Sally attended school in and graduated from the same school district for which she is now a science teacher herself. No small measure of that can be attributed to two “awesome” science teachers she had, one in grade 6 and one in Biology in grade 10.
Both instilled in her a love of science and greatly influenced the course of her career. Throughout high school and college she took many science classes, especially in biology and chemistry; her original goal was to be a pediatrician. During her senior year in college Sally admits that she switched to teaching in order to have the opportunity to work with children over a longer period of time, a change that was supported by her parents, both of whom were also teachers. Sally suspects that she made the switch because teaching was “part of my character”; she has an elementary certificate (grades 1 - 8). Most days Sally arrives at school at 7:00 a.m. or earlier, and stays until 4:00 p.m.. She is in her fourth year of teaching this year.

*Nancy/Kingsview*

Nancy has taught for 19 years, and in the spring of this year worked for the first time with a student teacher. Her undergraduate concentrations were in mathematics and science, and she holds an elementary certificate. Nancy became a teacher because she likes the ability to interact with her students, and she particularly likes the variety in teaching science, which she has taught since she started, even though her original intent was to teach mathematics. She has attended many workshops such as A.I.M.S, and SEPUP, and attended three National Science Teacher Association (NSTA) conventions, and at least one state science convention. Attending the conventions was a professional high spot, because she was able to bring back so many excellent labs, which were teacher tested and ready to use. She now has a Master’s Degree plus 30 (additional semester hours of graduate credit), which brings her to a higher-level on the salary scale. She arrives at school at 7:00 a.m. and leaves by 3:30 p.m. most days to pick up
her children from child care. She has arranged with students in her last period study hall to be science lab assistants, and together they set up hands-on investigations if she has something scheduled for the next day. Her classroom is always meticulous and well organized. She routinely uses her conference and planning period to get grading done, but averages five to eight hours a week at home grading papers and running to the store to buy something for class.

*John/Kingsview*

The lone African American in the class, John admitted that teaching found him, because he was in retail sales for 11 years prior to teaching. The transition occurred because “the economy in retail wasn’t so good” and the local school district was looking for substitute teachers. The fact that he had a bachelor’s degree (in psychology) qualified him to substitute, so although he was “right off the streets and knew nothing about the classroom” he started as a permanent substitute for an eighth-grade science teacher, and has not looked back. After completing certification courses in one year through a special program while he was working as a substitute, he completed a Master’s Degree in Curriculum and Instruction the next year. He has taught nine years now, and attends as many science workshops and in-service programs as he can during the summer. He arrives at school by 7:00 a.m., to have time to get into “the teacher mode” before the students come in, and rarely leaves before 4:00 p.m.. Technology interests John, and he tries to integrate his science instruction with computers and the other content areas by planning special projects with his teaching team. John is in the
National Guard, and has to schedule summer professional development workshops around that commitment.

Seventh-grade Teachers/Middle School

Anne/Baker

Another 19 year veteran teacher, Anne arrives the earliest and leaves the latest of any of the teachers who took the course, and during the day she “does not sit down at all”. She is always at school by 6:15 or 6:30 a.m., does not leave until after 5:00 p.m. most days, and often comes to school on weekends and over the summer. She has an undergraduate major in science education, and took as many science and mathematics courses as she could through college. She also holds a Master’s Degree, and should complete the additional coursework for the next salary step, the “Plus 30,” by the end of the summer. Anne has taken almost every available science workshop and professional development course offered in the area every summer for as long as she can remember, and expects to continue taking them as long as she is teaching. She is working with a different team of seventh-grade teachers this year, because she wanted to work on integrated projects throughout the year. This year all the students and the other teachers on her team have been reading science biographies, and doing related activities, during their team study time.

Christie/Forest Oak

After six months at the Post Office just over fifteen years ago, Christie switched careers to teaching. She has elementary certification for grades 1 - 8, has a Master’s
Degree in Curriculum. She has extensive undergraduate coursework in science and mathematics, and teaches both during the day on a two person seventh-grade team. This structure allows her flexibility that teams with more teachers do not have; she and the other teacher on her team often take advantage of this fact to schedule special events for their students. Christie teaches science in Sue’s classroom at the end of the day, so she uses a cart for her science supplies and materials for labs when she does them. She arrives at school about 7:15 a.m. every day, leaves by 3:30 p.m. to pick up her children, and spends on average an hour a day on her school work and three or four over the weekends. Christie was the only teacher in the course who had taken a course in gifted education previously.

Joan/Kingsview

Although Joan originally wanted to be a guidance counselor, once she started teaching she loved it, and decided not to pursue counseling after all. She has taught for ten years, five of them in this district, and prefers teaching science. Her certificate is elementary (grades 1 - 8), and she started taking coursework in science and mathematics towards a Master’s degree. Joan spends three or four hours every day preparing for class, getting lab materials ready, and grading papers. She also regularly puts in between two and ten hours on the weekends. If she has to teach something she does not feel competent about, she spends more time getting ready. Before her daughter was born three years ago Joan taught and coordinated the teachers at a local residential summer science camp for gifted girls. She and her husband also have a new baby (born in March of this year), so the Master’s degree has “been set aside for now.”
Lisa/Kingsview

Lisa classifies herself as “a math and science kind of person,” and wanted to teach science because she had really good science teachers in high school. She has a comprehensive secondary science certificate for grades 7 - 12, plus middle grade certification in science and mathematics for grades 4 - 9. She has more than 200 hours of college and graduate level science content classes, and another 30 in mathematics. She had taken lots of science workshops as well, such as neurology, energy, and weather. She attended the National Science Teachers’ Association convention in California and a regional meeting in the mid-West a number of years ago, and the state science teachers’ convention more recently. She and her husband have two small boys, aged six and four, and Lisa has not taken many workshops since they were born. She arrives at school at 7:30 a.m. now, and leaves to get the boys by 3:30 p.m. most afternoons. She does get up very early every other week to grade papers, and feels “overwhelmed trying to juggle family and work.”

Eighth-grade Teachers/Middle School

Thomas/Kingsview

Thomas had trained to be a microbiologist, and was scheduled to begin a job with the government in 1989, but the Berlin Wall came down, and his position was cancelled. His mother suggested that he should be a teacher instead, and as he had coached and liked working with students, he decided she might be right. He went back to school to get a teaching certificate, and holds secondary certificates in both science and social studies. He has since completed a Master’s Degree in Curriculum and
Instruction, and has taught for 12 years. He still coaches track in the spring, but no longer coaches football because he and his wife (who also teaches at the same school) have four children under the age of 10, and he no longer has the time. In the summer of 1993, Thomas enrolled in Project Discovery, an intense graduate level content and pedagogy course on teaching through inquiry; Thomas credits the way he teaches now to that course. Thomas arrives at school at 7:30 a.m. and leaves at 3:15 p.m. He has two planning periods at the end of the day to complete his grading. A few years ago he created many new labs, which took much more time, but now he only has to upgrade and change those labs to make them useful, and continues to use them. He still invests time creating new labs, and works at home at least an hour a day. New textbooks in the fall will mean more time as he learns how to use the new material and resources they will provide.

Richard/Kingsview

Richard has a strong Earth Science background in particular, and has secondary certification in Comprehensive Science for grades 7 - 12. He has a Master’s Degree plus 30 additional hours, and the maximum in-service credits the district allows. Richard has taught science for 30 years in grades 7, 8, and 9, and has no plans to retire yet. He continues to participate in summer workshops and professional development courses because he likes “to be exposed to new strategies,” and likes to make judgments on his own about what to incorporate from the courses. He arrives at school at 7:00 a.m. every day, checks his mailbox and email, and gets ready for his first period class. During the day, he adjusts his instruction to match the class, so he provides additional
structure to those class periods that need the scaffolding, and removes it for the ones that do not. He grades papers at home after school, and usually puts in under two hours a night with the grading and preparing for class the next day.

Creating Differentiated Units

Introduction

These 12 teachers work in three of the four middle schools in the district, and knew each other at least slightly at the beginning of the course through other district in-service planning with the science department, such as curriculum writing and textbook selection. Six taught at Kingsview Middle School, two from each grade level. The other two schools each had three teachers in the course: in both cases two sixth-grade and one seventh-grade teacher. I knew nine of the twelve because I was assigned to work with gifted students at Baker and Kingsview; I had worked with the three teachers from Baker for two years, and knew them rather well. I did not previously know the three teachers from Forest Oak, and only worked with them through this course.

I encouraged the teachers to select a standard and content area that they knew well when they started to develop a differentiated unit using the Curry/Samara Model, because to differentiate such a concept would be easier than one they had not taught previously or did not know well. I also suggested that the teachers try to develop different units from each other to address different standards and content areas, if possible, so the finished units could be shared, thus increasing the number of planned differentiated units at each grade level. Three of the sixth-grade teachers created units on energy in spite of this suggestion, perhaps because of the timing of the course and
the units they were scheduled to teach in the mid-winter. (Each version is different, and reflects the strengths of the authors.)

To ensure that each teacher would understand the flow of each unit being created, and the specific activities incorporated in them, I encouraged the communication between teachers and provided time during the course meetings for sharing at their grade levels. Consequently, in addition to working with me, most of the teachers also communicated directly with each other. They collaborated on units, discussed their progress, and sought help from each other as they planned and designed their differentiated units. Teachers also collaborated to develop pre-testing strategies, especially as the teachers had not commonly used pre-testing previously.

Some of the teachers in different buildings communicated frequently with each other via district email during the course, because they already had been in the habit of working and sharing with each other; this was true of Ellen, John, and Sally in particular, although two of the seventh-grade teachers, Anne and Lisa, reported that they had shared ideas a couple of times as well. William and Ellen teach at Baker in adjacent classrooms, and developed both of their units together initially, meeting after school two or three times per unit. The two eighth-grade teachers, Thomas and Richard, work at Kingsview, have the same teaching schedule, and also collaborated together frequently during their planning periods before, during, and after the course.

Using UnitWriter® and the Curry/Samara Model Unit Matrix Folder

The Curriculum Project has created two physical structures to help teachers develop differentiated units using the Curry/Samara Model. Both involve a matrix, with
concepts moving on a continuum from factual to global down the first vertical column on the left, and the thinking verbs from Bloom’s Taxonomy (refer to Figure 3.2), moving from concrete (or basic thinking) to abstract thinking while moving from left to right across the horizontal. Most of the teachers in my study preferred the folder option, and used post-it-notes to complete each cell (see Figure 5.1). Two teachers, William and Christie, submitted a photocopy of the post-it-notes in their folders and had not yet tried to save the unit using the software when I collected a copy of their units.

Figure 5.1: William’s unit on density using the Curry/Samara model folder.
The others at least were able to provide a copy of their unit in the *UnitWriter®* format, but many said they used *UnitWriter®* primarily to save the unit so they could re-use the folder.

Although it is not evident from the William’s unit, most teachers struggled to complete some cells, usually those numbered 35 or 36 in the fourth quadrant of the Curry/Samara matrix (see Figure 5.3). The fourth quadrant, with higher-level cognitive verbs and more global concepts, required activities at a more challenging level than teachers normally address, but would be important learning opportunities for students. Most of the teachers felt comfortable completing the matrix across the six cells in the first row, with factual content progressing through the thinking levels from basic to abstract. For example William used this activity statement in the factual concept/comprehension cell, #2 in his unit: “Describe the formula for finding density of a solid and show understanding by finding the density of a number of objects.” In Cell #6 at the far right of the first row, he had this activity statement: “Predict whether a large rock will weigh more than a small rock, and demonstrate understanding through a Type I writing.”

Moving down one row was also not difficult for the teachers, judging from their comments during class or our planning meetings. However trying to complete cells with the higher-level thinking cognitive verbs and global concepts moved teachers out

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5 Middleview City Schools have adopted the tenets of the Baldrige in Education model, designed to help administrators examine their school or district by focusing on the following areas and questions: Leadership, Strategic Planning, Student and Stakeholder Focus, Data Analysis, Faculty and Staff Focus, Educational and Support Process Management, and Organizational Performance Results. Teachers are encouraged to use certain strategies, like the quickly-written Type I writings, with students as a self-assessment tool. A Type I writing might be used at the beginning of a new unit of study to find out what students know and understand before teaching begins, while a Type II writing would be more formal and polished statements of what a student has learned after instruction.
of their normal comfort zone, and was evident in the gaps in their matrices. I told the teachers that I would not require them to complete every cell, because the teachers knew their students well by this time of year, and did not necessarily need an activity for every thinking level and every cell. I did ask them to have at least two activity statements in each vertical column and horizontal row, and to complete as many cells as they could to provide the greatest flexibility in their planned unit.

A smaller number of teachers preferred *UnitWriter®,* the computer software, for planning their units. (Refer to Figures 5.2 - 5.8 for a series of screen shots of *UnitWriter®* in use.) John, Sue, and Ellen were the most inclined to use *UnitWriter®,* saying that once I showed them how the software program worked during class and one individual session later, it was “very easy.” Sue echoed that sentiment, saying that she started developing her unit right on the computer, and liked it a lot better. She stated:

> I can’t just sit down and write it out, I have to be on the computer. I figured out how to add the extra verbs and products to the lists, and I used the computer program to create the unit, clicking on the <V> and the <P> for products as I went through.

John stated that he was able to develop his differentiated unit quickly once he understood the program, and the program helped him “because the list of verbs were right there, so I could use the right vocabulary to ask the kids to do something”. John also spent some time modifying the standard set of five verbs by adding more verbs, such as *identify, locate, name, tell, identify,* or *recite* at the knowledge level, and *investigate, differentiate, survey,* and *analyze* at the analysis level. In much the same way John also added to the product lists some of the Baldridge tools that he used regularly, such as *Type I or Type II* writings. Adding new verbs to the lists at each

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6 See Figure 5.2 for a visual for this reference.
cognitive level and new products at each modality of learning increased his effective
use of the program; leaving him time to work on improving the variety in the activities
and adding the standards. John also worked to match cognitive verbs to logical
products, and to reflect about whether the activities he presented to the students taught
his learning objectives.

*UnitWriter®* was not a complex software program to learn to use. (Screen shots
have been provided as Figures 5.2 - 5.8 to assist the reader conceptualize the process.)
Teachers began by typing the concepts for the unit as the entries in the columns on the
left of the screen. The green arrows allow manipulation of the concepts into typical
outline form, with some entries subordinate to others. Content progressed from factual
to global in nature; refer to the energy concepts in Figure 5.5.

Only the content would need to be typed in using keystrokes, as clicking on the
<V> in any cell would cause a text box to pop up, with verbs in the selected column
available for use in the activity. Once the verb was entered, the teachers typed in the
text for the content, then clicked on <P> (for the product list) to select the method of
assessment through which learning might be demonstrated or assessed. Examine Figure
5.6 (and Table 3.2) to review examples of the available items in the product bank.
Figure 5.3 shows the four quadrants of thinking tasks that might be part of a
differentiated unit, should a teacher want to concentrate on one quadrant or another for
balance between units without completing the entire matrix. State science standards
may also be added to the unit, either at the beginning of the planning of each cell
activity, or later (see Figures 5.7 and 5.8). Should a teacher wish to add a lesson plan to
any cell activity description, that is also possible through *UnitWriter®*. 
Figure 5.2: *UnitWriter® 1.6.0* screen shot of Ellen’s energy unit in initial planning stages, showing only the first three columns of thinking levels. Additional commentary has been added to help the reader note the options available in each cell.
Figure 5.3: The same unit (Ellen’s on energy) in a whole screen view on 17” monitor, showing the four quadrants in the matrix.
Figure 5.4: The cover page of Ellen’s energy unit in *UnitWriter®*. 
Figure 5.5: Content outline view of Ellen’s energy unit in the planning stages.
Figure 5.6: Ellen’s energy unit under development, using the product bank (available by clicking on the <P> to complete the entry in the first cell. A similar option box appears for <V> (verbs) and <L> (lesson template), not shown.
Figure 5.7: Inserting state science standards into Ellen’s energy unit (available by clicking on the <S> in any cell). The selected standard will appear as a numerical reference in the cell, following the activity statement. This is evident in Figure 5.8.
Figure 5.8: A screen shot of Ellen’s almost completed energy unit, showing some of the difficulties with the program. Multiple activities were contained in certain cells (cell #1 for example), but these were not visible on the screen. This unit printed on seven separate sheets of paper (see Appendix F for the completed matrix for this energy unit in its printed format).
The majority sentiment however was that the drawbacks to the UnitWriter® software made the program difficult to use effectively. Some of the cognitive dissonance related to the comparison of the program with other more sophisticated software, such as Windows Office Suite, and no doubt is related to the relative size of the two software developers, and the power of Microsoft. Even while appreciating this issue, and working within the confines of the program, the teachers found the software issues troublesome.

The software issue mentioned most frequently related to an inability to see the whole unit at one time. Unless one used the software on a monitor with a screen at least 17 inches, it was not possible to see all vertical columns at the same time (see Figure 5.3). If multiple activities were created using the a,b,c, or d tabs in a cell, these were not visible at the same time in any case (see Figure 5.8). With the paper folder and post-it-notes, the whole unit was visible, although the folder view posed its own limits. For some teachers the inability to see the entire unit on the computer screen at one time was a serious drawback that made the software too hard to use. This was more true of those teachers who were mildly “computer-phobic”, but included teachers who were very proficient with computers as well. For example, Sally explained why she found the program difficult from her perspective:

I tried to use the computer, but I could not see it well enough. I am a more visual person, and I needed to see the whole matrix at once, and I couldn’t move things around well, so then I switched to the folder. I would probably go back and put it all onto the computer after I was done making the matrix. I liked that we were using post-it notes, because I could move things around, and that worked for me.
Most of the issues with UnitWriter® involved the limitations of the program more than a conceptual difficulty manipulating ideas. Lisa explained that she found “limitations with the software, in terms of how it printed out, because I could not get it to print out on one page, condensed down. I had seen some examples on the Internet that were condensed down, which I thought would be helpful.” (Ellen’s Energy unit has been included in Appendix F as an example of the way UnitWriter® prints out a unit.) Thomas struggled with the same problem, but solved it by moving the unit out of UnitWriter® into a complete lesson plan format using a word processing program:

I started out at first organizing it with the folder, and that was OK to get me started with where I wanted to go. The only thing I didn’t like, was when I got to the computer program, and tried to print it, the program breaks the matrix up onto different pages, like you saw. So you lose the flow of it. It was my own work, and I couldn’t figure out how the lessons would flow. I thought, “Man, no one else will be able to figure this out.” So I put it into a fixed format, so it would be easier to read, to look down through it, and see, this is the differentiated piece, this is the standard part that everyone is doing. Part of it was that I decided I was not going to use the computer program as the final product. I can go from the matrix to my lesson plans without the separate step. I wish they could improve the computer program to allow a one page spread of the unit that could be printed out. That would make it much nicer.

Other drawbacks for teachers in the course who use computers for all their work involved limitations in standard editing commands. It was not possible to cut and paste in the program, and there was no “undo” action to rescue words that were deleted accidentally. Richard suggested “they need to develop a few more bells and whistles” and did not use the program to plan his unit once he discovered that the limitations in the program interfered with his thinking.
Conceptualizing a Differentiated Unit

As evidenced from the initial questionnaire that the teachers completed, none of the teachers were consistently or frequently using differentiation strategies with their students. It would not be surprising to learn that the challenge of creating an entire unit of differentiated lessons using the Curry/Samara Model was overwhelming. Most of the teachers spoke of the struggles they worked through, whether they used the folder or the computer software. All of the teachers used the same initial strategy: they gathered together their state science standards, their textbooks, and assorted notebooks and files of lessons and activities they had used in the past, and attempted to use them to identify and select the concept(s) and activities for their new differentiated unit. But moving on from there was more difficult. Sally expressed her frustration:

It was overwhelming at first. I had all this stuff, the content, but I wasn’t sure exactly how to break that down and put in onto the matrix. And sometimes I felt like I was pulling at straws, like, was I putting that onto the matrix to fill up the hole or was I putting it there because it was the best piece of differentiation for the spot? I felt like I wanted to make sure all the kids got all the concepts, and I had a hard time accepting, no, making sure, the high-end, high-level products had the same understanding of the concepts that got them there.

For Anne determining the appropriate level and location within the matrix for the activity she envisioned doing with the students was the most challenging:

Some of the things I thought were in one category were really in another. For example, I planned to read “Little Miss Muffet” about the curds and whey, and that didn’t fit on the continuum where I thought it was going to. I thought it was a lower-level thinking task, but the question that I asked the students brought it up to the higher-levels. From then it made me think that maybe there are other things that I do, and I had to rearrange my thought pattern. It was a classification of verbs issue, because I do more higher-level thinking things than I do knowledge level. I am not saying I think on that level, but I plan for that
level, and I want the kids on that level, so I had more things at the higher-levels and not enough basic thinking. So I tried to fill in some basic thinking.

For another teacher the more complex portion of the assignment did not relate to the level of thinking but to the continuum of the concept from factual to global. Global concepts might be thought of as the “big ideas” in science. Ellen shared this:

The global part was really hard. The factual part was pretty easy but when we started getting into the 35 /36 blocks\(^7\), the global part was pretty hard. We could do some parts easier than others but I still have a couple gaps in there, actually where I just couldn’t think of something. Maybe now stepping away from it for a couple weeks I might be able to go back and think of some things.

When I worked with Ellen on her energy unit, she had written three entries in the first cell, all at the factual level. The first one asked students to “list the 6 forms of energy and 2 states of energy with definitions, and demonstrate proficiency through a set of flash cards.” Another asked students to review energy trade books to find six new facts the student had not known before, and discuss the new ideas with the group. To move the concept of energy to a global issue, we discussed the balance of power in the world, and related that balance to energy consumption. We discussed the problems related to energy in the world, and whether any one country has a vested interest in fossil fuel and other non-renewable energy sources that would eventually cause problems for other countries.

We then discussed how students might engage these issues. The global activities that we wrote together for Ellen’s final row were challenging activities, but did represent appropriate and respectful opportunities for the high achieving and the creative students in Ellen’s classes. For example at the application/global content level, students were asked to “design a small town that uses nothing but renewable energy and

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\(^7\) Cells 35 and 36 would fall in Quadrant IV, already identified as a challenging level for which to plan.
demonstrate understanding through a story map.” At the creative thinking level/global content, students were challenged to “generate a policy for the school district to use and conserve energy and to invest in renewable energy sources and share ideas through a multimedia presentation.” Ellen found these cells hard to fill because she had not included global concepts in her energy unit previously, but found these activities to be most meaningful for her students when she implemented the unit with them.

The collaborative nature of the planning for the differentiated units was powerful. Not only did Ellen successfully complete most of the cells in her unit, but she gained an appreciation of the power of discussing the stumbling blocks that had tripped her up. It developed that another teacher felt the same. William collaborated and bounced ideas around with Ellen while working on his matrix because he knew that he did not “work well in a vacuum”. Even working with her though, he felt “really pushed to think how I could challenge these kids in creative ways.”

Only two teachers averred that they found creating the differentiated units easy. Joan was able to identify what she felt that creating a differentiated unit, and more importantly she knew why. She said that “the thought process was not difficult, because it was so similar to the way I already teach,” although she did allow that using colored post-it notes helped her follow the concepts across the thinking levels in the horizontal rows. The other teacher acknowledged that the thinking required to differentiate a unit “came easy,” but Thomas was not able to identify as clearly what allowed for his success:

I am lucky because I can just sit down and see how stuff is going to fall together. So I just sit and make labs and put stuff together. I can just see how to make the pieces fit. For myself it wasn’t hard at all; I’ll just need this and this, and then
Thomas’ units were indicative of his success in seeing how concepts fit together. He created several differentiated units through the winter and spring, and still had not stopped using differentiated tests at the end of the school year (see Appendix G for his differentiated Astronomy test). His first differentiated unit was inspired. Thomas pulled the four or five state standard indicators on genetics, heredity, and evolutionary theory (part of the new eighth grade standards) into a combination with the more numerous earth and space science indicators. He managed to create a highly captivating activity on alien life, heredity, and adaptation that was simultaneously linked to astronomy. All of his students started the unit by creating an alien that was adapted for life on “their” planet, which was unlike Earth. Some students were then selected by virtue of their answers to a Type II writing prompt to be members of a “climate council,” either for desert conditions or for arctic conditions. When conditions on the “planet” changed, what was the impact on the creatures? Students created a phenotype for their organism, a “baby’s first photograph,” and worked on what adaptations would allow a specific individual and a population to survive in a more hostile environment (i.e., the desert or the arctic). Students raved about the activity for weeks, and yet Thomas had just “seen” how to fit it all together and could not articulate how he had done it!
The units that the teachers ultimately created covered a wide variety of concepts, ranging from sixth-grade units on energy, simple machines, density, and Newton’s laws to seventh-grade units on genetics, bacteria, and vertebrate animals, and to eighth-grade units on plate tectonics and alien life, heredity, and adaptation. Most of the teachers included the state standards into their units when they typed them into UnitWriter®, but a few did not. More typically the teachers did not include standards if they used the matrix folder option. The units they developed do all address state science standards, and were part of the district course of study.

I tried to make sure that teachers understood that one clear advantage of using the UnitWriter® software over the folder for developing units was the ease with which the entire unit could be correlated to the state standards. Using the concept of backward planning presented by Wiggins and McTighe in Understanding by Design (1998), a teacher would ordinarily start planning a unit by determining which standards were to be taught. Teachers doing differentiation should start there as well. Teachers should start by asking which assessments could be used to determine the depth of student understanding before launching the unit; they can identify assessments to be used to assess student understanding during instruction, and modify the instruction accordingly, and after instruction. Only then should teachers select the activities and specific lessons through which they would teach the concepts of the unit. This can be done using UnitWriter® because the standards for our state have been included as a seamless part of the software. Several teachers did insert the standards into their units when they either typed them in or copied them in from the posters. None started with the standards to plan the unit. Two teachers mentioned this possibility as we concluded our
work with differentiating units of instruction, and both reflected on what they would do differently for the next unit. Christie put her thoughts this way:

I am going to try to force myself to do more differentiation with my next unit, and hopefully I’ll plan it on the computer next time. I do think that maybe I should be starting with the standards instead of doing it the opposite way around, looking at the unit and coming up with activities. I think I will start first with the standards and then work down into a variety of activities at different levels that meet those standards and indicators along the way.

I reviewed the units with the teachers during the development process, and helped them evaluate their own units by working through some checkpoints for the content outline and the cell entries. For example, each activity statement was to include a verb from the set in that column or level of thinking, six to eight words to define the content for the activity, and a product through which the students would show what they had learned. I worked with teachers to help them match the products to the level of challenge suggested by the cognitive verb selected for the activity as well. Although not all cells were filled in every matrix, we agreed that by the time the units were turned in every teacher understood how to develop a differentiated unit by modifying the level of thinking, the content, or the product using the Curry/Samara Model. The next step, with support from me as needed, was daunting for some, exhilarating for others, and hopefully worthwhile for all: implementing at least part of their differentiated units with their unsuspecting students.
Implementing the Differentiated Units

For most of the teachers I have two sets of videotapes, one taken as the differentiation course was beginning, and one taken when differentiation was due to be implemented by the teachers. I was able to observe in most of the classrooms, and was able to document the teachers’ efforts. Just as creating the units had been more challenging than most of the teachers expected, implementation proved a challenge for most of them as well. Sally made a perceptive comment when I talked with her about the whole process:

None of us had ever done this before. Normally in a school if you are trying something for the first time, there is someone around who you can go to, who has done this before. But none of us had done this, and we were all at the same place. So it felt like we were all sitting and spinning our tires because none of us knew where to go next.

As a relatively new teacher, Sally found that her normal coping strategy, finding a teacher with more experience for help and advice, did not work this time around. My support became more important, and I served as a resource and as a sounding board for her doubts and concerns. (I found that my expertise in differentiation was in sudden demand from most quarters; others must have been feeling this hesitancy as well.) What I saw in Sally’s classroom, though, was a teacher who explained clearly to her students what she had planned, what the options were, what would be expected of students who selected the option, and a smooth transition to students engaging in their tasks.

When we get to the computer lab you will be using the web sites we bookmarked to create your cube for our 3-D periodic table. You will have two programs open simultaneously, both Word and Internet Explorer. You may
print one page in color, so copy images you find and the URL where you found them into a *Word* document. Those of you who are doing the differentiated project may want to sit near each other so you can help each other with your task. Bring your assignment task descriptions with you! Are there any questions before we move to the lab?

Sally’s self-doubts were not evident; the students worked enthusiastically on the tasks she provided, and there were clear differences in those tasks. Most of the students were expected to create a simple cube with basic knowledge level information on six faces, relating to one element on the periodic table. Students who accepted the differentiated task presented basic knowledge on four faces, and answered higher-level questions on the other two faces: “What would happen if this element were not available anywhere in the universe?” and “Of all the ways this element has been used, identify the most important use and explain with specific details why you ranked that use the most important.”

In contrast Ellen’s strategy from the very beginning was to introduce differentiation for the first time to one class in particular of the four she met every day:

I was a little nervous because I was stepping outside of my box, luckily I did it with a safe class, because the students in that class are really open and they really work well together. I think if I tried it in one of my other classes I would not have been as successful because they are a little more close-minded, and they think you are favoring one or the other. I did it with all of my classes, but I started it with my safe kids first, because they are so flexible. With my other groups I should have started them out with this at the beginning of the year. They just were not as open, and they were a little nervous about it themselves, and said ‘It won’t be fair.’ and ‘Is he going to do more work that I?’ and ‘Are we going to get the same number of points?’ It helped me to try it out the first time with a group who was positive, and gave constructive comments. They are really good about that. So that helped me.

The initial success from that class gave Ellen sufficient experience and self-confidence that she was able to work out her own concerns before she had to also soothe the
worries of the students in other classes who did not have as positive an attitude or were as resilient in character as a class. Knowing the students strengths added to her own ability to take the risk and to try a new strategy. Their positive reaction helped her continue with the others.

The first time I videotaped Ellen teaching, few of the indicators of differentiation were evident. When I came back again three months later she had implemented a number of observable strategies and procedures that helped them be successful with their early differentiation experiences. For example she had posted clearly what she wanted the students to learn, and where the lesson fit into a timeline of the concepts. She used an overhead projector to show them a product guide rubric, highlighting the components of a quality final product. For example a demonstration would include an introduction, the presentation, a conclusion, a discussion with the class, as well as voice, visual aids, body language, and organization. For each component she had specific pointers to help students understand the function of the component, and what attributes of that component made it high quality. For example the organization of the presentation would be logical, allow all students to have a role, stay within the time limits, and include all important points for the topic. She provided scaffolding for student thinking as well, asked questions at different levels, modeled her thinking out loud for the students, and assigned homework that used different thinking skills. I heard her say “How could we find out?” more often than I heard her answer a student’s question directly.

In contrast to Sally and Ellen, who felt anxious about implementing differentiation, John copied the matrix for his energy unit for the students, shared it with
all of them, and launched his unit with considerable enthusiasm. Some of the projects described in the activity statements were very open, and allowed for high levels of student creativity. For example, his students could construct a flip book slide show of things in motion (potential to kinetic), or they might write a skit and act out a form of energy, or they might give a television style sports or weather report using forms of energy transformation. All of his students were invited to select any one of the projects, and were “very excited about it from the very first day”. Students shared the matrix and their choices with their parents, and John confided with me that he received many positive comments back from the parents about the challenges and opportunities the energy matrix provided for their children.

My observations in his classroom revealed changes in observable behaviors as well. John had written on the board the learning objectives for the day, which related to friction, and included a definition of the term (the force that resists relative motion between two bodies in contact), and three types of friction, fluid, rolling, and sliding. John started the class by recapping what they had done in the previous week, and pointed out the schedule on the board for class that day. John and the students discussed the ways two objects in contact with each other experience friction, using demonstrations and graphics. John then launched a discussion with the students, saying, “Who can explain one of the key concepts of friction?” For the next ten minutes John asked the students more questions, at higher-levels, with some divergent open-ended questions that evoked considerable and well informed class discussion about friction.
If we were to go outside, and I were to put on my rollerblades, and skate around on the grass, on the gravel area by the back door, and on the blacktop area by the basketball hoops, which would create the most friction for me? Which would provide the least? How can you explain that? If we were going to design a rollerblade park, what surface would be best?

In this process of the class discussion John suggested applications of the concepts outside the subject area, used more visual aids than I had seen previously, and specifically complimented students for good thinking and for contributing to the discussion.

John’s initial approach to differentiation was to offer the opportunities to all his students, but not all the teachers were so inclusive. Several other teachers limited the opportunity for differentiated assignments to a relatively smaller and from their perspective more manageable number. One teacher shared the higher-level thinking topics with all of her students who had been receiving As on their assignments. The students could decide whether to select one of the challenge topics or not, with the understanding that their work on the topic could boost their grade to an A+. Another pulled a small group aside and sent them to the media center to work on their differentiated assignment. A third teacher was even more subtle, and implemented differentiation in the classroom with a few students by changing two questions on a lab activity sheet she used in class that day.

The day I stopped in to videotape a second time in Joan’s classroom, she had a brief outline of the unit under study in class posted on a bulletin board, and she referred to it as she started class. She helped the students connect what they were going to do in class that day with what they had done the day before, and with what they would do the following day as well. After giving instructions for the guided-inquiry lab for the day,
and as students were retrieving materials and getting started, Joan moved around the room to four students in turn, writing on their lab papers, and quietly discussing the new questions she had written with each student in turn. Throughout the rest of the class period, as she circulated between the groups, her conversation with those four students was consistently on a different plane from her conversation with other students. The question on the original student lab sheet read, “How many different types of plants do you think are possible according to this code?” Next to this question Joan wrote another, “Explain how you calculated this number.” She also modified the final question. From “Would you expect to find a great variety of living things on this planet?”, the new question became, “Explain how this activity relates to chromosomes.”

With most of the students she talked about the progress of their work, encouraging them to continue on-task, and she asked knowledge level questions about the lab and what the students were learning. “Oh, I see you pulled a blue square; how long a stem does that mean your plant has? Let’s see you draw that on your paper. Where should your stem stop?” She asked others equally guiding questions about the shape of the flower, the color of the petals, the width of the leaves, pushing and prodding the students at each step along the way to complete the lab investigation. Some students worked steadily and independently, but many seemed to require Joan’s constant help.

Her questions and the tenor of the discussions changed as she moved around to the four students, who were calculating the probability that a particular phenotype would appear, given the genes available in the population of plants under study. Her questions became: “How does theoretical probability compare to the actual probability
in the classroom? How could you find out? What happens if you have a larger sample population?” Joan knew from their previous work which students already understood the concept of the lesson, that DNA carries the code for genetic inheritance, and smoothly shifted it to a higher-level, one that provided great intrigue and considerable cognitive effort from the students. It happened, during the lesson I was taping, that one other student, sitting near two of the boys to whom Joan gave the challenge, was so intrigued by their discussion that he asked Joan if he could answer the new questions too. Her answer was, “Yes, of course.”

Implementing differentiation was not as smooth for all the teachers. One selected a unit to differentiate that he finished teaching before he finished creating his matrix of differentiated instruction for it; the other selected a topic for her differentiated units that she addressed much later in the year than the others. These were the two teachers who did not contact me on their own, rather I had to track them down to talk, and I scheduled meetings with them to discuss their progress and concerns. Both professed to be concerned about how to manage introducing differentiation, as they expected that students would challenge them, or worse, their parents would, citing fairness. Both did finally try a at least one differentiated lesson with their students, and bits of others.

William worked with another teacher from the course to plan both his own unit on density (that he was unable to use this year), and another on energy. He was able to implement a few differentiated activities from Ellen’s energy unit, and an activity of his own which he added to the unit, adapted from one he had done years ago. I learned
about this after the fact and was not able to observe the implementation of the lesson, although I did observe on the creature testing day, and talked with him about it.

William’s lesson was highly creative: students were asked to design and build a small creature with a hollow interior, with the added proviso that the organism be able to conserve heat energy through the addition of an outer layer of insulation. He provided a list of requirements, the first of which was that the completed organism had to pass through a 9”x 6” (22.8 cm x 15.25 cm) open rectangle cut from a larger piece of cardboard. Other requirements included that students use a small cardboard cylinder (a recycled corn meal container was provided for those who needed one) and maintain the access opening to the interior for testing. William provided a list of suggestions for materials that students could use to create their organism and insulate it. Some covered their creature with cotton balls, others used feathers, and one tried paper-maché. All students had the same assignment, but were able to make substitutions in the materials used if they wished, and apply what they knew from previous experiences. Those with a stronger content knowledge used polyester, fiberglass, or polypropylene insulation material, and concentrated on quality in construction. Several students found a way to add interior insulation to improve the creatures’ performance on the temperature testing requirement.

On the day the creatures came to school, each was tested against the requirements, starting with the size requirement. Those who fit through the opening were then tested for their ability to keep 200 mL of water with initial temperature of 50º C within five degrees of the initial temperature after ten minutes. Students enjoyed the
activity, and those who were able to apply what they had learned about the conservation of energy and the relative advantages of insulating materials created creatures that performed well.

When William and I discussed the lesson later he explained that he asked students to write about the activity in their journals as an assessment. I suggested that he could provide a differentiated journal writing assignment for the students, to be completed the day after testing them against the requirements. For example, those students whose creatures did not fit through the opening could be asked to explain first, what they would do if they could make another creature to ensure that it would fit through the opening, and second, to explain what they had learned about designs that were successful in the temperature testing phase. Those who had organisms that fit through the opening, but did not perform well in the temperature test could be asked to reflect on improvements to their creature that would result in a better performance by comparing their design to that of a creature that was successful at this challenge. Those who had creatures that passed all requirements could be asked how the assignment could be modified to allow all students to be successful the first time, and to suggest additional requirements that could be added to provide additional challenges related to conservation of energy or the transformation of energy. William agreed, said he had not thought of that, and added the suggestion to his creature lesson plan for next year. I concluded that although William did not implement his density unit because of timing, he did support the concept of differentiation, and would implement some strategies another year, especially if I were still available to promote the use of differentiated strategies and help him with the planning.
The other teacher who struggled with implementing differentiation finally invited me to help her in the classroom the second to last week of the school year, when she planned to implement a differentiated activity for the first time. Her first attempt involved a whole class assignment, in which the students were allowed to select one of three final products to show what they had learned about biomes. The assignment included both Internet and print resources; during class the teacher and I both helped students find resources that answered the questions she provided about the specific biomes. My technology skills are stronger than Lisa’s by far, so my availability to work with her in class supported her by removing a concern about the computers.

The lesson was differentiated through the product choices. Students could select one of three final products to show what they had learned; all were to show plants, animals, and terrain common to the biome they had selected. The choices were a 3-D model, a half sized poster, or a 4 sided-rectangle fold (the size of four pieces of construction paper, taped along the edges and standing up, open on the top and bottom). The students were enthusiastic, and their products (when I saw them at the end of the week) were well done. I did not see that any one of the products was more challenging, or required higher-level thinking than another, although the model option was three-dimensional, and involved more materials than the others. Some students used images cut from magazines, others printed images from Internet sites, and added handwritten or printed text. An additional component of differentiation was added to the lesson when Lisa provided the option to some high-end students to include the impact of humans on the biome, and to show that impact through images as well as text. Many of the
high-end students took on that additional challenge, and represented mostly negative
human impacts on the biomes, relating to loss of animal habitat or hunting animals to
extinction.

Lisa was pleased with the results, saying that the students “seemed to really like
being able to choose. This was something I had not done before, so that was something
I liked.” She went on to say:

The ideas of pulling kids out, and trying to have them do a specific activity – I
have not done that yet, although I know that other teachers have – you know,
when you pull 6 kids aside, and that seems difficult to me. I do want to try that,
I just didn’t this year. The classroom maintenance is what worries me – I
haven’t tried it yet, so I don’t know how the students are going to react. If 6 are
doing this and the rest of the kids are doing something else. Some of the kids
just can’t handle unstructured time like that, like when we were dissecting.
Most of them were fine, but a couple of them just can’t handle the freedom. So
I couldn’t see how to have this group of students doing this activity and the
others having less structure and not behaving or doing what they should – and
that type of thing – I haven’t experienced different students reactions, and I
don’t know what they will say – like ‘Why do they get to do that?’ – or ‘What
are they doing?’ Without teaming and team study next year, I’m not sure how
I’ll be able to have kids work on some things. I did have some students work on
things during team study this year. That would be ideal – to just have some of
the kids work on something during our team study – but we won’t have that next
year – so…I’ll have to see if I can work more differentiation into the regular
classroom.

The two teachers who struggled more with implementing differentiation shared
a number of characteristics. Both were teachers who gave me permission to observe in
their classrooms but were not interested in having me videotape them with their
students. Both were experienced teachers with strong science backgrounds. When I did
observe in their classrooms I saw no posted unit outlines or concept maps, nor any
indication (verbal or written) of what the students were expected to learn through the
activity or lesson scheduled for the day. Other indicators of differentiation that would
provide evidence of their efforts to change their instructional practices (modeling thinking, differentiated tests, providing choices in homework, praising thinking, asking divergent questions) were not obvious when I made observations. Both teachers told me they planned to implement more in the following year, and referred to small steps they had taken this year. I would consider these teachers to be excellent teachers of science who need continued support to implement differentiation with their students. The fact that both struggled with implementation may point more to the barriers that can impede full implementation than to an unwillingness on their part to use the strategies.

Data Analysis of Implementation Indicators

For each aspect of differentiation (e.g. content, thinking, and product), I completed tally sheets for specific indicators of implementation while I observed in the classrooms or while I reviewed the videotapes of the teachers in the study. Different instances of an indicator were counted as separate events. Each observation was conducted for a 30-minute interval, timed from the beginning of class. I acknowledge that the observations captured only a moment in time and should not be construed as complete evidence of confirmed change in teacher behaviors. However the observations did paint a picture of the steps teachers were able to make towards differentiation, and allowed me to examine the relative degree of professional development support required to produce results with each teacher. The tally sheets were analyzed using a variety of descriptive statistics. Two types of information have been included in graphs, provided here in pairs as Figure 5.9 through Figure 5.14.
The first figure of each pair provides the total number of instances particular indicators were observed in the twelve classrooms per 30-minute interval. This data was gratifying, but it did not provide sufficient information on the changes observed for individual teachers, so additional analysis was also done using descriptive statistics. The second figure of the pair provides box-and-whiskers graphs for the same indicators, with the median, quartile distribution, maximum, and minimum scores.

The information shown reflects the work of the twelve teachers. I was interested to note that none of the teachers, either before or after participating in the differentiation course, referred to state standards even one time during their instruction (see Figure 5.9, the fifth indicator). However, I noted that the data substantiated what I believed to be true: on almost every indicator of implementation the number of instances was higher after the teachers learned about differentiated instruction and its merits than before. The box and whiskers graphs show that the increased incidence of implementation of the indicators was distributed across the majority of the teachers, and the relatively low maximum number of the instances indicate that the composite information was not dominated by one or two teachers. In all three categories (content, thinking and product) increases are evident for every statistic. However for most indicators the minimum remained zero at the conclusion of the study, indicating that at least one teacher provided no evidence of implementing an indicator during my observation period, and that additional support would be needed to confirm implementation.

Finally a review of the t-statistics (provided in Figure 5.15) showed that many of the before and after comparisons were statistically significant at the 90% and 95% confidence level.
Figure 5.9: Content implementation indicators (total number of instances observed in twelve classrooms per 30-minute interval).
Figure 5.10: Box-and-whiskers graphs of content implementation indicators (showing maximum, minimum, median, and quartiles).
Figure 5.11: Thinking implementation indicators (total number of instances observed in twelve classrooms per 30-minute interval).
Figure 5.12: Box-and-whiskers graphs of thinking implementation indicators (showing maximum, minimum, median, and quartiles).
Figure 5.13: Product implementation indicators (total number of instances observed in twelve classrooms per 30-minute interval).
Figure 5.14: Box-and-whiskers graphs of product implementation indicators (showing maximum, minimum, median, and quartiles).
<table>
<thead>
<tr>
<th>t-Statistics</th>
<th>BEFORE</th>
<th>AFTER</th>
<th>Significant at:</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Mean</td>
<td>Variance</td>
</tr>
<tr>
<td><strong>Content Implementation Indicators</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>asks questions/graphic organizers</td>
<td>4.00</td>
<td>0.33</td>
<td>0.24</td>
</tr>
<tr>
<td>refers to Matrix</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>uses pacing calendar</td>
<td>1.00</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>relates activities to curriculum</td>
<td>2.00</td>
<td>0.17</td>
<td>0.15</td>
</tr>
<tr>
<td>refers to state standards</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>displays learning objectives</td>
<td>4.00</td>
<td>0.33</td>
<td>0.24</td>
</tr>
<tr>
<td>uses computers to get information</td>
<td>1.00</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>applies lesson to outside world</td>
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<td>0.42</td>
<td>0.45</td>
</tr>
<tr>
<td>independent/research skills</td>
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<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>questions students frequently</td>
<td>16.00</td>
<td>1.33</td>
<td>0.79</td>
</tr>
<tr>
<td>uses variety of materials</td>
<td>11.00</td>
<td>0.92</td>
<td>0.81</td>
</tr>
</tbody>
</table>

| **Thinking Implementation Indicators** |        |       |           |             |     |     |
| uses thinking skills visuals | 0.00 | 0.00 | 0.00 | 2.00 | 0.17 | 0.15 | -1.48 | X |
| writes and explains learning objective(s) | 2.00 | 0.17 | 0.15 | 5.00 | 0.42 | 0.27 | -1.91 | X |
| questions students at all thinking levels | 13.00 | 1.08 | 0.81 | 24.00 | 2.00 | 1.09 | -4.75 | X |
| asks convergent and divergent questions | 7.00 | 0.58 | 0.81 | 25.00 | 2.08 | 1.72 | -4.18 | X |
| has visual aids on thinking procedures | 3.00 | 0.25 | 0.20 | 10.00 | 0.83 | 0.88 | -2.24 | X |
| assigns HW using different thinking skills | 4.00 | 0.33 | 0.24 | 23.00 | 1.92 | 0.99 | -4.18 | X |
| provides choices in HW and activities | 2.00 | 0.17 | 0.15 | 21.00 | 1.75 | 1.11 | -5.06 | X |
| thinks aloud to model for students | 8.00 | 0.67 | 0.42 | 12.00 | 1.00 | 0.55 | -1.30 |    |
| uses sufficient wait time | 7.00 | 0.58 | 0.45 | 13.00 | 1.08 | 0.45 | -2.17 | X |
| uses general praise statements | 10.00 | 0.83 | 0.52 | 14.00 | 1.17 | 1.42 | -1.08 |    |

| **Product Implementation Indicators** |        |       |           |             |     |     |
| shows and discusses examples | 3.00 | 0.25 | 0.20 | 12.00 | 1.00 | 0.55 | -3.45 | X |
| provides and explains product guides | 1.00 | 0.08 | 0.08 | 13.00 | 1.08 | 0.63 | -4.06 | X |
| relates products to rubrics or product guides | 1.00 | 0.08 | 0.08 | 11.00 | 0.92 | 0.99 | -2.80 | X |
| compliments students orally and in print | 6.00 | 0.50 | 0.45 | 13.00 | 1.08 | 0.45 | -2.55 | X |
| allows for student choice | 3.00 | 0.25 | 0.20 | 18.00 | 1.50 | 1.18 | -3.36 | X |
| references learning style modality | 0.00 | 0.00 | 0.00 | 16.00 | 1.33 | 1.33 | -4.00 | X |
| displays student work | 6.00 | 0.50 | 0.27 | 12.00 | 1.00 | 1.27 | -2.17 | X |
| students use technology | 1.00 | 0.08 | 0.08 | 16.00 | 1.33 | 1.33 | -4.10 | X |
| projects across team or grade levels | 1.00 | 0.08 | 0.08 | 6.00 | 0.50 | 0.45 | -2.16 | X |

Figure 5.15: Descriptive statistics for the three implementation indicators showing significance at 90% and 95% for each indicator.
Barriers to Implementing Differentiation

In a much-quoted saying, change is proclaimed to be a process, not an event. Teachers implementing new strategies, such as differentiation, would be expected to experience some resistance, either internal or external, that would make progress slower at times and in certain circumstances. For the six teachers in this study who are sixth-grade teachers, the state proficiency test, administered in mid-March to all sixth-grade students in the state in five content areas, has dictated for many years both the content and the pace of instruction. Changes in the state testing program will move the science test from sixth-grade to fifth in the 2005 - 2006 school year, so the sixth-grade teachers face now only one more year of state proficiency testing at their grade level. William cited the proficiency test as being the largest barrier in his mind:

To be honest I don’t know how much I’ll be able to implement differentiation until after the proficiency tests are over. It is only one more year. But the following year I think we will almost have to use it, only because we have been so conditioned to cram cram cram content in, but suddenly we are going to have very little content to teach. We have 5 major topics now, with some other stuff added, like lunar cycles, but we will only have 4 units to cover in a whole year. So by necessity we are going to have to do that, and that is going to help. Those kids who need extra time can get it and the upper end kids are going to be able to do something that is a little bit more challenging and self-directed.

Sally agreed, saying, “We are all freaked out by the proficiency test, like, if we do this differentiation are we going to be able to cover our standards? This weighs a lot on sixth-grade teachers especially.”

Other teachers cited a variety of factors that made implementing differentiation challenging. Some were most concerned about finding the time necessary to plan the unit and find appropriate resources or to develop new assessment strategies, while
others mentioned the classroom management issues, and worried about the reactions of students and parents. Sue combined these issues when she described the aspect of implementing differentiation that she found most difficult:

I wish I had more time with the kids in smaller groups, where we could go into the subject a little bit deeper. I did feel like, because there were a smaller group of them, and a larger group who were not working on the project, then I was kind of hurried in giving them their instructions. I just told them, ‘This is what you have to do, now go do it.’ I wish I had more time to just sit down with them and say, ‘Ok, this is what we are looking at…’ I did it as well as I could without having the other kids being squirrely.

For John especially access to computers and the loss of the sixth-grade computer class this year both conspired to impact his ability to differentiate with as much technology as he would have liked. “The students don’t have computer class anymore,” he explained, “so I have to teach them more about how to use the computers, and that takes time.”

Initial forays into any change in the classroom require a certain amount of courage. “The biggest barrier was the unknown,” said Richard. “Whenever you start something new, you are not sure what is the best way to do it.” Lisa was overwhelmed by the decisions she would have to make:

I struggle with not knowing where to start. I have all these ideas in my head, but just actually implementing and getting started is a struggle for me. If I started to do with it one time I would stay with it for a couple of units. For me I guess I am more overwhelmed by everything, and thoughts like, ‘It needs to be this way.’ So instead of just jumping in, it takes me a while to prepare and get ready to try something new. Hopefully I’ll be able to take some time this summer to plan, and hopefully it will be successful, and I can maintain it and do it more. I think it is just that first time is the hardest.

One final and non-standard reply came from Anne. She wanted the students who were involved in differentiated activities to move to a different location, so neither they nor other students in the class would be distracted by what the others were doing.
For Anne, therefore, “finding a place for the students to work, outside the classroom, where they could be supervised and have access to the Internet and use the technology that was available” was the hardest hurdle to move past. She arranged with the media specialist for a small number of students to come to the media center to work on four specific computers that were to the side, away from classes that might have been scheduled to use the media center, and for the media specialist to keep an eye on the students. Because all the students she sent for this opportunity were high achieving, highly motivated students, who kept themselves on task, this was not an onerous burden on the media specialist, and solved the problem. Most teachers do not like to regularly ask other teachers to help them by taking responsibility for their students, so for Anne this poses a perpetual dilemma.

Pre-testing and Knowing the Students

My initial research indicated that teachers in this study did not use pre-testing regularly with their students. For the sixth-grade teachers the proficiency test, and the pressure to increase the students’ scores every year, produces an undeniable tension. Nancy worried, “I need to cover what I need to cover and everyone needs to hear it because I am afraid I will lose someone.” Nancy also admitted that pre-testing was also hard because of the time constraints forced onto her teaching by the proficiency, and that when she did pre-test “it turned out that the students didn’t know much.” Sally was another who felt disheartened when she pre-tested the students because “when they get here in sixth-grade they have very little background knowledge, so they get frustrated
by pre-testing because they have to turn in something that is not their best, because they don’t know the answers.” William solved the problem by having the students do a Type I writing in their journals at the start of a unit: “write down what you know about the rock cycle and rocks”. The students took five or ten minutes to write everything they knew about that topic, and William walked around the room to see what they were writing. At other times he had the students create a class list of ideas and information on the board, which they copied into their journals, and reviewed at the end of the unit to see what misconceptions they had and how much more they learned. John’s solution was to use a knowledge level assessment at the beginning of a unit (“Name the six simple machines” or “What are the different forms of energy?”). He also used a few assessments that he did not put into the grade book to gauge the students’ level of thinking through some writing assignments. “I actually enjoy reading these assignments because they let me see inside their heads.” Sue brought a new element into the process, by considering the underachieving students in her classes as well:

I did not necessarily use a pre-test to select the kids for this project, because if I just used grades, then I would not necessarily get kids who could handle being in a group working independently. So I used what I knew about the students. I had one student who really just did terribly all year, but I knew that this was just the right project for him, because he just loves cars. This was his thing. He is a smart kid, he is just not motivated, so I thought, here is the carrot, this could be it for him, and he did it, and did just an awesome job. It was his idea to call up the dealers. He has a “C” in my class now, where he had an “F” before. So I did not necessarily just take grades into consideration. I did take into consideration those kids who were identified in science, interest, grades to a certain extent, maybe for those kids whom I knew were not identified but could use just a little extra challenge.

The seventh- and eighth-grade teachers do not have the pressure of the proficiency test, but wanted to help their students develop the fundamental
understanding they will need to be successful on the new state graduation test they will
face in tenth grade. Content taught in seventh and eighth-grades in science is included
on their achievement tests, and provides the foundation for ninth and tenth grade
science benchmarks and indicators, which comprise the new graduation test. Anne, one
of the seventh-grade teachers in the study, worried about the students, and took her
responsibility for them very seriously. She addressed the issue straight on:

I have the philosophy that just because they know the ten questions on a pre-test
they may not know the unit sufficiently well, so it is hard for me to let the
students go off to do something else. It is really rare for students to really know
everything that I want them to know before I teach it.

Yet another seventh-grade teacher used pre-testing for the first time with her students as
she prepared to teach her differentiated genetics unit. Joan was amazed “to see the
different levels of understanding, so now I have to know what they already know so I
can plan for them better from now on.” She also noted that pre-testing had a down-side:

At least in one case there was a student that I totally cut her self-esteem with that
pre-test, so she basically shut down for the entire unit, which she had not done
before. So the pre-test was so overwhelming to her that she said, “I don’t know
any of this.” That was her attitude from then on through the rest of the unit; she
quit trying. So I need to work on my questioning so that it is more accepted by
the kids, so they can say to themselves, “It’s Ok that I don’t know this.”

Joan planned to work on learning more about how to pre-test over the summer so she
could start the year using pre-testing regularly. Lisa admitted that she needed to do
more assessment prior to instruction next year, so she could better meet the needs of the
upper level students in her classes.

I did not pre-test a lot this year, but I really need to, because I don’t feel that I
am meeting their needs. I tend to focus on the middle group, that is more what I
have sitting in front of me, perhaps, but I know I have upper kids who are above
and beyond the other kids in the class.
The eighth-grade teachers were more experienced with pre-testing, but differed from each other. Thomas shared that he has always used pre-testing since he took the Project Discovery class. At first he used the version he learned through that program, such as creating concept maps, but now he now mixes in some Type I writing, which he simply reads to see what spectrum of knowledge he has in each class. Typical Type I writing assignments were: “Write as many facts about stars and the universe as possible in the next five minutes,” or “Pretend you are talking to someone who knows nothing about why the continents are the shapes they are, or what earthquakes and volcanoes are all about. Write down how you would explain these concepts.”

Richard’s approach to identifying the needs of his students included assessment of each class of students, as well as more formal individual snapshot for the unit:

I see how first period goes, and if first period needs modifying, then I modify it for second period, something that doesn’t work out, you know, and then you see in some classes I have to have things more structured than others. I generally know after the first few weeks of school which classes I’ll have to do that for.

Richard thought through how he would explain to the students about the new opportunities that were available. He was concerned about student reactions, but used information gleaned from a writing pre-test, and presented the differentiation opportunity carefully:

I had some questions about how the kids are going to deal with it: “Well, gee how come he gets to do that?” and ‘When am I going to get the chance to do that?” It was a pleasant surprise that I did not get any of that. And I anticipated some parent phone calls, and that didn’t happen either. I presented it to the kids that I was going to give them a Type II writing and from this I’m going to choose some people to do some special work for me, and so do your best on the writing and then we’ll see. I told them that this had no bearing on how smart or anything they were, but it would tell me what they knew about the subject area. And so they accepted it, because it seemed fair. It helped that they could see
that some of the kids that are not A&T [Able and Talented] were doing some of the activities, because they could say, “Wow, he’s not lying to me.”

Perhaps the concept of teachers being fair is more accepted by eighth-graders, because Thomas also reported that the students accepted his decision to use information from pre-tests to determine for whom the differentiated experiences were appropriate. “I explained that everybody was working at different levels and you are all learning the same thing, just through a different experience.” I videotaped Thomas working with students through a hands-on simulation of the concept of isostasy, relating to the balancing of the forces of gravity and buoyancy in the earth’s crust. Students either added washers to floating blocks of wood (increasing the density to cause reduced elevation) and burning a birthday candle in a beaker of water (decreasing density through “eroding” away material to increase elevation). Students in the class were interested in what other groups were doing, because one activity was very concrete while the other was more abstract and more challenging to quantify and relate to the earth’s crust, but no students verbalized any complaint or concern because their teacher’s explanation was upfront, honest, and based upon their own work. Thomas had used their pretest to substantiate the decision about who should be in which group, and the students respected his decisions. Students were also reassured that there was no advantage to being in one group or the other, as Thomas clearly stated that both activities “were designed to teach the same thing, have the same background information, and are just two different ways to look at it. The idea is to understand the balance between the crust and the mantle. It doesn’t matter which one you are doing.”
Impact on Students

Assessing the work produced by the students through differentiated instruction was not part of the data collected for this inquiry. However many teachers articulated their impressions of the impact of their efforts with differentiation, because they were watching carefully to see if the additional effort they had invested in developing a differentiated unit actually impacted student achievement. The results, according to the teachers, were mostly positive. Christie teaches seventh-grade mathematics and science, and was the most prone of all the teachers in the study to doing statistical analyses on her students. She volunteered that she was pleasantly surprised that students did much better than she anticipated on the differentiated unit. First she admitted that the implementation of the unit was relatively easy because she had thought so much out in advance. “I felt more confident and comfortable in having so many ideas and resources to send kids in different directions,” but how much the students learned impressed her the most:

The scores at the end were one of the significant things. They had some different questions that they could answer depending on where they were and what activity in particular they had done, so they had some choices. The mean average for both classes was in the 80s, for one class it was an 81, and for the other it was a 83. But the thing that I found most significant was that I had fewer low-end scores, and more that were in the middle to higher range, even though the mean was still a low 80, there were more B scores, and high C scores, and not so many in the lower range. And I would feel like, in looking at my mean average, oh yeah, that’s because of those low scores pulling the mean down, but here I felt like the bottom was pulled up, and the top was also pushed up. So I was pleased with the results in the end.

John spoke more generally about changes he had seen in his students, with considerable enthusiasm and delight:
The differentiated teaching does open up new avenues for the students and they are so amazed. I can just see their self-confidence level rising, and they are just outdoing each other now. And they will say “Wow, how did you do that?” Their PowerPoint projects are so well done I decided to save them and present them to my students next year as examples of quality work. ‘This is what you will be learning this year.’ I have seen learning and effort and interest and excitement about science this year that I had not seen before. I am excited about doing more.

Sally admitted that her high-end students like doing differentiated activities. She frankly supposed them thinking, “Thank goodness, I get to do something that is not mundane.” Sally appreciated the time differentiation provided her to focus on the lower achieving students while the high-end students worked more independently, which she saw as a bonus for the lower students. Likewise Ellen shared that the entire range of her students performed far better than she had been expecting:

From most of the students I saw better work than before. What was especially nice was that I got a product from everybody, and that rarely happens. I want to say this was because they had more freedom, and could invest more ownership in their work, because they got to pick what to do and how to present it. Their comfort level increased and allowed them to be more successful. For my low-end kids, just struggling making an energy collage, and finding pictures to represent that form of energy and explaining why those represent energy was for them very difficult, and that is where they needed to be. So for them it was a good experience to go through too.

Ellen’s comments addressed a issue that each teacher in the study faced. Students are grouped heterogeneously across the district in middle school, resulting in significant diversity within the classrooms. The Curry/Samara Model was selected for this study in part because it provided teachers the option to use differentiation strategies with all their students, not just the high achieving students. For John, some of the most impressive evidence of the impact of differentiation on his students came from a low-achieving student, who had earned a failing grade the first semester:
Some of my lower achieving kids were able to bring in models, and demonstrate. I was so overwhelmed by one of my students who does not function in class at all, and if there was an excuse not to have his work then he would have it. But he brought in his guitar and he demonstrated on his guitar all the transformations of the forms of energy. I was just so amazed. This really allowed the lower kids to perform at a higher level, and to be more creative.

The differentiated assignment that John offered his students provided sufficient motivation for this student, with effects that were long lasting and cumulative. John used the projects as an assessment, and found evidence of learning and increased knowledge from a wider range of students than before. Other teachers had similar experiences with differentiated assessments.

Thomas created an entire new system for assessing his students, one he picked up from the packet of information provided at the district in-service. One of the teachers involved in that in-service had included a sample test that she had created using Bloom’s Taxonomy. In the test a number of questions were written at each of the six levels of thinking, with increasing point values through the levels. Students were instructed to build a test worth 100 points by selecting questions from any level, and answering them. This technique resonated with Thomas, who created a differentiated test using this structure for his very next unit test (see Appendix G). He made a few modifications as noted below, but continued to create differentiated tests through the end of the school year. He shared the results with the other teachers at the last class meeting:

[My students] love the differentiated tests, and they are doing better on their tests, because they can answer what they know and stretch what they know, and they still have the state standards at the top for the first two or three questions. I am going to adapt that next year, and make it ten multiple choice to cover the state standards, and a couple of essays on the state standards, like short answer or extended response questions, and then the rest will be differentiated. The
tests will be about half state standards and about half differentiated on the other stuff that we know about the concept or content. [The students] are more responsive to this type of test, they are not so stressed about the test because they know they will be able to tell me about what they do know and understand. If they don’t quite remember it right they can select other options. They are much more relaxed going into the tests now.

On a separate issue, an unforeseen but not unusual scheduling problem developed for which neither the teachers nor I had planned: an unexpected teacher absence. As Sue was working with her students, she had to miss a couple of days of school during the middle of their research. One group of her students had elected to investigate and compare the combustion car engine with the hybrid car engine. Sue started them on their work, and the students on their own wrote a list of questions, planning to telephone car dealers to get the answers. When Sue left the lesson plans for the substitute she included the groups’ timeline and plans, and explained their need for independence. Fortunately Sue reported that all went well, and that the substitute just let the students go off to the prep area off the classroom to make their phone calls. The students were on task, and “did a great job” the entire time, much to the amazement of the substitute. This issue should be considered if students are conducting lengthy investigations or require support from the classroom teacher that a substitute would not be able to provide.

The impact of differentiated instruction was generally positive in other areas as well. Many teachers reported that students were more interested in their differentiated assignments, because they had some choices, and because the assignments allowed them to be more creative. Still others commented on the impact the differentiated
assignments had on specific students, with almost awe in their voices. Joan told me about one such student:

She turned in a fabulous paper about why some people make such a difference and a contribution to our knowledge about science and why others are such a burden to society. She had many different reasons why the outcome could have been different. It was a really thoughtful paper, and she would not otherwise have had the opportunity to do this. She is a very quiet girl, but had gotten 30 points on my genetics pre-test, so she already knew a lot about genetics, and I wanted to challenge her. I thought that was great opportunity because the girl is so shy, and this might encourage her to speak up more in class too.

Thomas noted that the high-end students in his classes were no longer able to breeze through their assignments, which earned the same amount of points and the same amount of work, but which provided more appropriate challenge for them.

The kids were working more at their ability, and they liked working at that level. On the earthquake thing, where we were doing a triangulation on a computer program, I had two ways to accomplish the goal. The basic one, almost all the kids could do it, but the more advanced one the really good kids couldn’t do it so fast, and they weren’t done with 15 or 20 minutes left to go in class. They worked at the same pace as the others because they had deeper thought processes to go through, but they didn’t necessarily have more steps to do. But they were responsible for creating their own graph as they went through, and things like that. They liked the challenge. The same thing happened when I did the differentiation in class, where I pulled out the “Climate Council” and they were responsible for creating a rubric system and scoring it. I think it went fine.

Not every teacher experienced complete success with their students’ achievement on their differentiated assignments. Nancy’s students were selected to work in a small group on a challenging and creative whale project that Nancy had done years ago with all her students. When she tried to implement the same activity as a differentiated activity, she worked out a schedule that provided her an additional class meeting during a team study-hall time for all 40 students who would be involved. She explained the entire project, and answered questions, so they would know what to do.
when they came to class over the next five days. She reflected on the effort required
both from the students and herself:

The differentiation added to the work load because it turned out to be two
lessons going on at the same time, so it was giving directions differently, getting
things set up differently, grading separately. It was more confusing and
complicated, but it was good in the whole picture, and worthwhile, but it is hard,
so I would not want to do it all the time. Once it was underway it was OK,
because I had pulled out those top kids, they were all totally on their own. At
the end one of the kids said that he didn’t get enough of my attention, but I
didn’t think that was true because I kept bopping in to answer their questions.
His score wasn’t as high either, so that might have been part of it. He felt
neglected. But another student said how fun it was that they got to break off and
do this special unit. This time the students were very independent, and they
handled that really well. I would probably do that one again, because it was
easy.

Additional valuable information about the effects of differentiation on student
learning would add to the significance of my findings. Had the district been able to
implement pre- and post-tests that had been developed by a small group of science
teachers at each grade level over the previous summer, that data could have been
included in this study as I had intended, and could have been used to verify the
anecdotal evidence presented here of the impact of differentiation on student learning.

Additional tests for problem solving, using such commercial products such as the
Cornell Critical Thinking Test, would also have provided valuable information; budget
cuts in the district impacted the funds that might have been available for these tests to
have been used. Either or both of these quantitative assessments of the impact of
differentiation on students learning could be added in the future to a study such as this
one to augment and validate these findings. Change theory suggests that teachers will
change their instruction if they have concrete evidence that their efforts make a
difference for their students; better quantitative student data would help in that effort.
Professional Growth and Lessons Learned

As is often the case with teachers, collegial discussions of and reflecting about their professional work leads to new ideas and revived enthusiasm for the work involved in the implementation of those ideas with and for students. I knew from Tomlinson’s research (1995) that teachers would need consistent and intense support if they were to implement any changes in their classrooms, so part of the course and this inquiry involved first providing the support and then analyzing with the teachers what aspects of the support that I provided or they provided for each other were critical to their success.

Over the course of the study I met with all of the teachers at least twice for an hour; we also communicated regularly by school email. I always replied to any email message within hours of receiving it. Sometimes I just answered a question or provided ideas for alternative assignments or questions the teacher might use as homework or differentiated tasks during class. Sometimes the teachers and I made appointments by email to meet so I could help them work through UnitWriter® issues or help with matrix planning collaboratively. I videotaped eight teachers twice and observed the other four once or twice. I had many short conversations with the teachers, sometimes quite casually when we met at the photocopier or by the teacher mailboxes. I made a point of stopping at the teachers’ doors before or after school, or when I knew from their schedules that they had a planning or conference period, to see if they had questions. These casual meetings happened easily at Baker and Kingsview because I teach in the buildings as well; it was harder to meet the three teachers at Forest Oak
casually, so I contacted those three teachers by email at least once a week, and made actual appointments to see them if a meeting was requested. After the first meeting of the class, I always planned time for the teachers to share their work and ideas with each other, and encouraged an open dialogue between them.

The teachers were able to verbalize that the very fact that I was available, had a flexible schedule, and could meet with them, usually within a week of their request for a meeting, was important. For John, who has not stopped teaching through differentiation since he learned how to develop and structure differentiated instruction, the fact that I taught a water cycle activity with his students in his classroom while he observed was pivotal:

It really helped me out, because to a certain extent, if I see something then I can understand it, but when you came in and modeled the water cycle, your background and expertise on that gave me a bigger spectrum to look at. That helped out, letting me pick your brain, that gave me some open doors. I tend to think outside the box a little bit more now.

Ellen asserted that my availability was critical to change occurring in her classroom, saying, “I know that if I got stuck and couldn’t call on you for help, I would have put this at the back burner, and gone on with what I usually did, and never made any changes.” For Lisa, who started using differentiation later in the year than either of us expected, continued support through the next year will be critical. She admitted this herself, “I think that the support will probably be even more important next year –when I try to do a little bit more with it – that you will still be available.” Joan admitted that participating in the course and the research itself provided extra motivation:

I knew you would be coming eventually to do the videotaping, which prompted me to be sure that I was following through, because the papers up on the bulletin board that say what topic we are on, were never going to get done except you
were coming in. It wasn’t a top priority for me at first. I am so glad that I did get that done, because now that the papers are posted, and I have seen how the kids benefited from having that framework, I will keep doing that. The kids look at it every day, and mention something. In fact today, I had a girl who thought that the answer to a question I asked was there on the outline, because it happened to be on mutations. So now I know that they look at those, unfortunately, because it will take some time on my part to keep those papers posted, but I know that I’m going to have to do that again.

All of the teachers stated that the opportunity to meet and work on differentiation with their colleagues in the science department, both those teaching at the same grade level, and at the other middle school grades, was very helpful. Several suggested fervently that the district or the science department ought to provide a series of professional development sessions for teachers to meet to plan more differentiated units next year if in fact teaching through differentiation is being encouraged. The district does schedule early release days for teacher professional development; this year we all went to one on differentiation and another on teacher study groups. The first was one event that all middle school teachers attended, the second was held at each middle school, but all the teachers participated. Christie articulated her feeling, which reflect the sentiment of all:

I felt good about doing this first differentiated unit, but there is a long way to go and so much more to learn. We need to have the support, either a class or a support group – like when we had our early release day on Looking at Student Work\(^8\), that would have been an opportunity to talk about more differentiation activities, not just the assessment component, but to talk about the projects that we were doing to promote differentiation. So it would be “I’m having a problem. My problem is I need to better meet the needs of all levels of students in my classroom, what I have done is…, does anyone have any input on this?” Having a variety of people to provide input on that might be an advantage – like having the math person or the art person, who would provide a different perspective.

\(^8\) This type of lesson study was promoted by those who plan district-wide professional development for all middle school teachers for a professional development program for teachers in the spring.
All 12 teachers in the course experienced teaching through differentiation, despite having little or no prior experience providing differentiated opportunities for students in their classrooms. Of course there was a range in the extent of implementation. Some understand now what differentiation is and how it benefits their students; tried a few differentiated activities; and plan to do more in the next school year. One teacher wrote a valid suggestion on the course evaluation, namely that it would have helped to try a couple of differentiated activities with students before tackling the task of creating an entire differentiated unit. This might have been a homework assignment with two choices, or an activity with a choice of products, but would have provided the experience necessary to understand the challenge and the opportunity differentiation offers.

In spite of the challenge of the assignment many of the teachers in this inquiry developed and implemented major portions of new differentiated units, and shared and used each other’s units. They were able to significantly change their instruction by regularly offering students intellectual challenge at the level optimal for each student through more choice of work during class and/or their choice of homework assignment. “The trick,” Thomas said, “is to find multiple activities that teach the same idea but at different levels.”

Other teachers shared that colleagues were interested in learning about and using differentiation as well. One teacher worked at home on her differentiated unit using UnitWriter®, and talked about what she was doing with her husband, a high school mathematics teacher. Ellen showed him how to use the program, and shared this story:
I introduced this to my husband too. We started thinking about geometry, because he is the most comfortable with that, and with all the projects they could do, we thought it would be easier for him to integrate into the matrix some of what he is already doing. He shared it with his principal too, because he was observed. The principal said to my husband, ‘you know your lesson plans are kind of vague,’ and my husband replied, ‘well, you know, I have this matrix, where it is differentiated, and I can put in the state standards…’ and the principal thought that was cool.

In the spring Nancy had a student teacher working with her, which gave her additional opportunities to share differentiation strategies with other teachers:

I will have a student teacher in another week or so who is very interested in doing differentiation, so I will be working with him on that, which is probably really good. He was a smart gifted kind of kid, so he is probably interested because he experienced the boredom himself. And that will keep me interested. Also one of the teachers on my team expressed an interest in doing some differentiation, so I plan to work with her this spring too.

The teachers shared additional insights and wisdom they gained through using differentiation with their students, thus revealing that they spent time reflecting on their work after class, and were considering how best to proceed with differentiation in the fall when a new group of students arrive at their doors. Ellen struggled with her most gifted students resisting her efforts to challenge them in new ways:

I really had a hard time pushing them to the higher end because they wanted to go with something they had a little bit of prior knowledge on. They didn’t really want to do research anything new and different. I think I had one or two groups but not as many as I’d like. I’ve got to think of a way to weasel myself in there. Maybe next fall I can start out with the baby steps for them in differentiation and build the expectation, so they don’t know anything different.

Sue felt that differentiation would meet the needs of the gifted and high achieving students, and that she finally had a tool that would help her be more successful providing academic challenges for them.

I really enjoyed this. It was an eye-opening experience for me. I was just waiting for something like this to come along, because I do have kids on so
many different levels, just as everybody does, but I feel like so much of our time is devoted to the low-end kids. I have had several meetings with parents who have A&T [Able and Talented] kids, and they would ask ‘What are you doing for my child?’ and before I used to say ‘not a whole lot’, but now I have more that I can say.

Joan realized that the assessment strategies she used in class might make a difference to how students learned the standards-based units she teaches. When Thomas shared in the last class meeting what he had done with creating differentiated tests for his students, Joan picked up on the strategy too. After trying a differentiated test on a unit, she reflected:

I wonder how much more reflective questions you might get from the kids during the unit, because they will ask all sorts of in-depth questions so they can be prepared for the test. I wonder if they start preparing and learning differently because they know there will be a different test.

Differentiated assessments struck a chord with Richard as well. He realized that providing assessment items specifically tailored to all of the students would allow them to show him what they had learned and understood far better than assessments he had been using:

My goal next year is to develop a couple of differentiated activities for each unit, and I’ll continue to work with Thomas so between us we will have some good units for the kids. I plan to start the year using those differentiated tests that Thomas developed too. I have two levels of tests, but I’m going to develop a third level, and I’m going to tell the kids, ‘I think you are ready for this test..., or that test...’, and that way I’ll build the challenge for them from the beginning of the year. I have one test structure now with fewer questions and less writing that is easier for my tutored [special education] students. I just take an essay question and break it into sections so they don’t have to remember and respond to so much, and then I have a regular test for the rest of the students. Now I’ll add a third level. It also is important to me to make sure that the majority of my test points are all related to the state standards, so the students will know enough to be successful on the graduation test.
Thomas also had the insight that differentiation offered perhaps the perfect strategy for teaching important concepts to students over a shorter period of time. Instead of involving all students in every lesson and every activity to make sure that he meets all the different learning styles and learning needs, he plans to identify each student’s individual learning style and needs, and differentiate the classroom activities to suit them.

Before I just always wanted to make sure that the kids got all of the activities from a different viewpoint, so everybody would do all of them. Now I could get them all to get everything from the viewpoint suited to them in one day, and that would work if I get to know my kids well enough. This is why the writing is so important, because it lets me get to know the students better. I can read all their writing, especially early-on in the year, I should give lots of essay tests and lots of writing assignments, so within a month I have a good idea of what the students are capable of, and how they think. I could say, “Boy, this person is really math oriented.” And I can tell you that I have some kids who can think mathematically and some others who just can’t. So I think it would be a different way to teach it and be just as effective, if not more so.

Many teachers do in fact teach the same concept two or three different ways, to help students who learn more slowly, or those who need a learning experience to suit their own learning style. Thomas’ insight would allow him to teach the same concept three different ways on one day, by allowing students for whom the activity is uniquely suited to participate in that experience instead of all of them. The time he gains can be spent working through other differentiated activities, or the time could be used for those concepts in science that are difficult to teach or difficult to learn.

One additional theme that emerged through the teachers’ reflections became relegated to the side lines as a non-issue. Many of the teachers expressed a fear or a hesitation about implementing different lessons for the students. In fact, however, only one teacher mentioned that the students complained at all. Thomas admitted that the
first time some students were leery, but relaxed when they saw that participation in the
differentiated activities was based each time on a Type II writing or some other pre-
assessment to identify the students for whom that activity was suitable. Richard
mentioned specific student reactions that he anticipated: “well, gee how come he gets to
do that and when am I going to get the chance to do that?” but did not in fact get any
comments like that. Sally’s process for selecting students to participate was more
subjective than the process Richard or Thomas used, which potentially could have been
challenged. It was not. She explained that she “based the selection for the
differentiated activities based on their previous work ethic, and what I knew they knew
and understood.” Students usually accept that teachers do know and understand them,
and none of Sally’s students questioned her decisions. Christie also mentioned briefly a
little hesitancy, that came to naught:

I was pleasantly surprised by the lack of barriers with the kids and the parents. I
thought it went very smoothly, and much more smoothly than I would have
anticipated going into the implementation of my unit. I guess after it was all
said and done, I found myself thinking, well, that was all?
CHAPTER 6

CONCLUSIONS

This research investigation sought to answer two questions. First, at the time the inquiry began in November 2003, did middle school science teachers in this public school district modify their instructional practices and curricular materials to meet the needs of the students in their classes, including those who are identified as gifted? Second, to what degree would the amount of support middle school science teachers in the district received be a factor in the extent to which teachers participating in a professional development course on using the Curry/Samara Model for differentiation would be able to implement a unit of instruction that was modified to meet the needs of all the students in the classroom?

Using the data collected through the classroom practices questionnaire, I concluded that among the 12 teachers in this study there were no significant differences between the curriculum they taught to identified gifted or high achieving students and that taught to other students in the class at the outset of this study. When we started working together the teachers reported that they attempted to engage all their students in small- and large-group discussions a few times a week by consistently using questioning strategies and thinking skills activities, but none of them made a concerted
or organized effort to offer the gifted or high achieving students a different set of
questions or opportunities to address the content of their lessons at a different and
higher-level. The results did indicate that the teachers modified at least some aspects of
their curriculum, instruction, or assessment for low-end students, but did little or
nothing for the high-end students. Only one or two teachers indicated that they made
attempts even occasionally to offer their gifted students some assignments that might
offer a challenge.

The results on some items on the questionnaire may have been skewed due to
misinterpretation of the question, or due to misconstruing district policy because of poor
information. For example some teachers in the study may have assigned a higher value
to the practice of allowing students to leave to work at a different location if they had
gifted students who went to pull-out Able and Talented Resource program activities.
Thus this item on the questionnaire (#18) might have been interpreted differently by
teachers, depending on their first-hand knowledge of the opportunities students have in
our middle schools. Teachers also may have given a higher frequency response to
sending students to a higher-grade level for instruction (item # 30) if one of the students
who had been accelerated in mathematics were in their classes or homerooms, or if the
teachers either taught mathematics in addition to science or knew about the policy from
a colleague.

My observations of the classroom teachers corroborate these survey results. I
did not see content implementation indicators (such as concept maps or learning
objectives) posted in the classrooms. I did not observe teachers modifying content or
the level of thinking for students who had strong comprehension, even though these
very students often were either monopolizing the class discussions and answering every question the teachers posed, or totally ignoring the instruction in class while they read a different book or doodled on their papers. I did not see any acknowledgment that the gifted and high achieving students learn quickly, and just might have learned the objective for the lesson the first time it was presented, or that any of their students might come into the classroom with a strong understanding of the concept to be taught that day based on the student’s prior experiences or particular interests. Although the teachers were providing interesting learning experiences with a variety of hands-on investigations, wet or dry laboratory activities, or paper and pencil work, all the students were doing the same work.

The teacher interviews confirmed that pre-testing, which is one means of identifying the level of students’ prior knowledge, was neither a frequent practice nor a high priority. Most of the sixth-grade teachers believed that their students came to middle school with weak science and mathematics skills, and that they themselves had the full responsibility for teaching every one of their students everything he or she would need to know to score well on the high-stakes state proficiency test just seven short months into the school year. The seventh-grade teachers also worried about students missing out on crucial information or learning if they were allowed to be out of class engaging in another learning activity. Having students in class and participating in the learning experiences planned for them all would be the only way the teachers would feel confident that their students had learned the content. The two eighth-grade teachers knew the standards assigned to be taught in eighth-grade would not be repeated in
subsequent science classes before their students faced the new graduation test in two years, and felt equally pressed to cover content in depth with all their students.

In the exit interviews and classroom observations after participating in this professional development course and research study, all 12 teachers demonstrated that they recognized differences in student learning needs and the importance of identifying students prior knowledge. They all expressed an intent to change their habits and their approach to better meet the needs of their students, and to change and improve their curriculum, instruction, and assessment.

Conclusions regarding the second research question, whether the amount of professional support middle school science teachers in the district received was a factor in the extent to which they implemented differentiated classroom practices to meet the needs of all the students in the classroom, are qualified by the many attributes of the teachers beyond my control. For example, the personalities of the teachers, their experience, gender and age, their own content knowledge, the extent to which they previously used constructivist theory or inquiry instruction with their students, how frequently they engaged their students in hands-on investigations, their self-confidence, classroom management strategies, rapport with students, and to a certain extent, the extent of administrative support from the building principal, all colored the results. While these attributes and the small sample size limit the degree to which my results can be generalized to a larger population, the demographics of the teachers in the study do mirror the demographics of the teachers in this district, and perhaps of teachers in other large suburban districts. These limitations not withstanding, the following
conclusions may assist educators who wish to implement differentiation through the curriculum, instruction, and assessment practices they provide their own students.

I suspected at the start of my study that those teachers who already used instructional strategies that supported constructivist theories, and who already taught science through inquiry, would be able to implement differentiated instruction with less support than those who did not, and that these teachers would continue to use the strategies developed during the differentiation course on their own after the course and the study were over. I also believed that those teachers who had after-school commitments or family responsibilities with young children would be able to implement differentiated instruction to a more limited extent unless additional time was available during the day for them to plan and prepare differentiated instruction. On both counts these predictions proved to be supported by the data.

Two excellent and highly self-confident teachers asserted that differentiation strategies were easy to incorporate into their usual teaching practices; I confirmed this by observations in their classrooms, and through our planning meetings and exit interviews. One teacher in particular has taught extensively through inquiry\(^9\), the other through a more active process supportive of constructivism. Neither of these two teachers needed much support from me; I merely provided positive feedback that their efforts, ideas, and plans were appropriate and even exemplary. They both realized that planning in advance for students’ individual learning needs and for those who already

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\(^9\) He had participated in Project Discovery almost ten years before this study. Project Discovery, a state systemic initiative program funded by the National Science Foundation, was an intense professional development experience over a sustained period of time that taught middle school science teachers both particular science content and the process of teaching through inquiry. Project Discovery proved to have a lasting impact on the teachers who participated in the program; this teacher was another example of that.
knew the learning objective for the day would allow them to create appropriate learning experiences for all of their students. They appreciated that differentiation would be beneficial both in the short and the long term, and were willing to invest considerable time creating differentiated units for their students. Consequently from the time these two teachers started implementing their first units of differentiated instruction shortly after the first meeting of the differentiation course, their students were challenged at suitably difficult and challenging levels, and had opportunities they would not otherwise have been able to experience. Both teachers created additional differentiated units and sustained the implementation of differentiated instruction and assessment to the end of the school year with little additional effort on my part, to my delight and professional satisfaction.

As the rest of the teachers in this study and I worked together more closely over the course of the winter, through four class sessions and individual meetings, an additional group of teachers came to believe that the outcomes (in this case, increased student achievement through the use of differentiated instruction) outweighed the risks and cost to themselves in terms of time and energy invested in implementing differentiation. The teachers in this second group had sufficient confidence in their own ability (self-efficacy) to organize and initiate the actions that were necessary to implement differentiation, but sought frequent support from someone more experienced in differentiation, for actual implementation.

A third group of the teachers in this study was able to use only a few differentiated strategies this year. One felt very stressed by the pressures of her teaching responsibilities and the demands on her energy brought to bear by having two
young children and a busy husband at home. Another spent enormous amounts of time on the science fair program, while a third took on a leadership role with district affairs and became very active in union negotiations. All of them had less time and energy left to work differentiation strategies into their teaching practices than they would have liked.

All 12 of the teachers echoed the comment that my availability to consult or help in the classroom at any time while they attempted to implement differentiation was critical to their continued efforts. Their wish for continued support next year was also strongly voiced, and not unexpected. The progress that these teachers made in the first year is not completely confirmed; it can take several years of continued support and encouragement (from district administrators and those responsible for the teachers’ professional growth) for differentiation to be routinely and consistently used. The teachers who implemented the fewest differentiation strategies will need even more support in the year to come if their initial efforts are to continue. The teachers recommended that the district provide time during early-release or other professional development activities for continued work on differentiation.

This research has focused on the factors involved in initial adoption of differentiated strategies for instruction. Looking longer term, additional consistent and persistent support may be needed to avoid the Implementation Dip, described by Fullan (2001). With support the differentiation strategies learned and practices in this training can be implemented into the teachers’ instructional practice more frequently and confidently. Without that support the risk it that they will continue with their current practices, and no change will occur.
The Effectiveness of the Curry/Samara Model

Many teachers find that creating and implementing differentiated instruction is difficult to do, and many hours of thinking and planning goes into preparing for a differentiated unit. It is true that differentiation can be accomplished in many ways, and we only touched on that diversity in the course. The Curry/Samara Model was used in this research as the strategy of choice to support the teachers while they learned initially how to design and deliver differentiated instruction. Teachers discovered how the content of a unit in their curriculum could be differentiated along a spectrum from factual understandings to global ones, that thinking could be differentiated from basic to abstract, and that the products used to show what students had learned could be differentiated from simple to complex. The matrix planning folders in particular proved to be a tool that was very flexible and easy to use or re-use. While there were certain aspects of the UnitWriter® software that were frustrating to the teachers (namely the inability to print the unit on one page, or even to see it that way on the computer screen, and the lack of word processing-type editing functions), the process of creating differentiated units using either the matrix planning folder or the UnitWriter® software through modifying the content, level of thinking, and product was understandable. For some the software became the method of choice, for others it is an option to be explored and used more extensively in the future.

All twelve teachers in this study learned both to differentiate their curriculum using the Curry/Samara Model and to implement differentiated instruction to some degree with their students. The units that the teachers created all included well thought-

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out differentiated activities, related to the standards the teachers were responsible to use in their instruction, but with high-end alternatives for high-end students. For these twelve teachers, the Curry/Samara Model provided a structure that was readily understood, and created a foundation for their future work with differentiated instruction.

The UnitWriter® software would be of greater utility to teachers if it were extensively updated to be more user-friendly, and more similar to other software programs with which teachers are already familiar, to reduce the learning curve on the software itself. Improving the software to the level of sophistication expected by the teachers would also remove many of the implementation barriers the teachers felt while using the program. Based on the groups’ experiences during this research, the creators of UnitWriter® should:

- upgrade the graphical user interface to include standard functions found in Microsoft Windows software, such as
  - a file menu with a page setup option to set page margins and to control printing
  - an edit menu with copy, paste, and undo
  - a format menu to manipulate font type and size
  - a table menu to control column widths and margins.

- consider taking advantage of the formatting powers in Microsoft Excel by releasing an Excel template with the matrix grid and a macro for inserting standards, verbs, and products, and offering this template at more affordable cost for classroom teachers.
Additional Reflections and Implications

Teachers who start a new instructional practice during the school year often find that the students resist the change; starting differentiation in the fall would alleviate that resistance to some degree. Teachers commented in this study that the high-end students were sometimes worried about taking the risks of completing different assignments, and needed to be encouraged. Many gifted students are also perfectionists, and fear failure. Teachers would be well advised to be extremely clear about how the work will be evaluated, and to define the expectations clearly early in the year so there are no unexpected consequences for the students, lest the students be unwilling to take a risk at the next opportunity.

Teachers of science bear a number of unique responsibilities that other teachers often do not face. An important mandate is to ensure the safety of their students in laboratory investigations. Differentiated instruction must be carefully designed with all appropriate safety measures in place, and teachers must monitor their students at all times to ensure that the safety measures and procedures are followed. Students working on differentiated activities out of the classroom or in an adjacent space need to be monitored as well. Teachers of science also face the challenge of providing all the appropriate materials for student use in laboratory investigations. Differentiated activities need to be planned carefully so the amount of materials needed for all the activities students may undertake does not overwhelm the teachers’ time and detract from the instruction.
In this study, two teachers participated who had already established a close working relationship with each other. Their collaboration is symbiotic in nature, as one has extensive classroom experience, and a wide repertoire of activities and materials gathered over the years, while the other had a commitment to teaching science through inquiry, and a flexible mind that allowed him to readily make connections for the students between two activities and between the activities and the real world. The two teachers shared an additional advantage that is unique in teaching: identical teaching schedules. This provided them adequate time during the day to plan units of instruction together, to reflect on how a particular lesson went, and to work together to constantly improve their teaching. Any building principals who can arrange teachers’ schedules to provide a common planning period also enhance their teachers’ ability to collaborate with each other to the advantage of the teachers and the students alike.

The theoretical framework that provided a foundation for this inquiry allowed aspects of differentiated instruction to intersect with principles of learning theory and guidelines for quality professional development of teachers. The work of the theorists and researchers cited, such as Tomlinson, Curry and Samara, Guskey, Lockes-Horsley, Bybee, and Bransford, provided a model of instruction for this study. The use of Bloom’s Taxonomy and the Curry/Samara Model at that intersection supported the efforts of the teachers to incorporate new ideas and strategies to better meet the needs of their students.

A classroom is differentiated if the teacher understands, appreciates, and builds upon student differences. The classroom is differentiated if all students participate in respectful work, that is just beyond the boundary of their abilities so they have to stretch
and grow. A classroom is differentiated if the teacher is able to adjust content, cognitive processes, and products in response to the students’ readiness, interests, and learning needs. And finally, the classroom will be differentiated if the teacher and the students are flexible and honest, and collaborate with each other in all areas of learning.

Recommendations for Further Study

If I were to repeat this study I would change at least four aspects of the design of this study, which required more time than I had, and I would have asked more of the teachers who did participate. First, I would ask all 31 middle school science teachers in the district to complete the Archambault questionnaire on teacher practices, so I could more definitively know whether the teachers participating in this study were a representative sample of the middle school science teachers in the district, or merely a sample of convenience. Second, I would like to have compared the performance of the students through the use of pre- and post-tests for content knowledge, and through a test such as the Cornell Critical Thinking Test for a more general analysis of thinking skill development. The district had planned to implement pre-and post-tests of content knowledge this year; that did not take place because a district operating levy failed at the polls twice during the year, and district-wide budget cuts curtailed the assessment initiative. Thirdly, I would include science teachers from the fourth middle school in the study by scheduling the course earlier in the year and by sending the course flyer out sooner so teachers could make plans to participate.
And finally, I would work with the teachers longer, and observe their implementation of differentiated units over more consecutive days. I feel that the observations I was able to make left me with a snapshot of the larger picture. Conversations with teachers in the study frequently involved the teachers relating an experience they had with differentiation that I had not observed. Lessons were introduced, implemented, and concluded without my having an inkling that they were proceeding apace. A longer period of time would also allow me to confirm that the differentiation practices I saw being implemented are still in the repertoire, and that students are still benefiting from the teacher’s efforts. Tomlinson’s work suggested that differentiation took several years to become a confirmed practice. While several teachers jumped on the band wagon and are now driving the wagon down the road, a few stepped off the wagon at the first corner, and are still trying to get back on. Others are getting settled and may well continue to increase the frequency with which they implement differentiation, provided they have continued support.

If it were possible to do so, I would also make this a stronger investigation of the benefits of differentiation as an instructional strategy by asking all middle school science teachers to participate in a study in which teachers would be randomly assigned to an experimental and to a control group. As it stands now I do not know if any middle school science teacher who participated in a course on the use of the Curry/Samara Model would be as successful as the teachers in this study, who volunteered to participate, to create differentiated units, and to implement them with their students. Whether the teachers took full advantage of the support I was able to provide or not,
they were all at least reasonably successful at implementing some differentiated activities with their students.

Additional longitudinal research could be done in the coming year to follow the students who were in the classroom of a teacher who participated in differentiated instruction this year. Because six teachers at Kingsview Middle School participated in the study, two at each grade level, fully two-thirds of the sixth-grade students moving to seventh-grade, and two-thirds of the seventh-graders moving to eighth-grade have experienced differentiation to some extent. To what extent are the students more willing to take on differentiated assignments provided by their new teachers if they have some experience with these assignments already? How would the growth of their achievement in content and thinking skills compare to those who have never experienced differentiation? A research study on the value-added achievement (and perhaps their attitudes towards science) of these students with their new teachers, particularly comparing those who are in classes with the two teachers who were so successful at incorporating frequent differentiated activities, would be illuminating as well.
APPENDICES
APPENDIX A

Classroom Practices – Teacher Questionnaire
Classroom Practices - Teacher Questionnaire

Adapted from the 1993 study by the National Research Center on the Gifted and Talented

This study focuses on the nature of regular classroom practices used in schools in our district. You can help us learn more about these practices by taking a few minutes to complete this questionnaire. Please be assured that your answers will be kept strictly confidential and that all reporting will be done at the group level. Please try to answer every question, but you may skip a question if you would prefer not to answer it or do not understand the question.

I. Teacher Information

Please check the box that describes you.

1. Gender
   □ Male   □ Female

2. Ethnicity
   □ Hispanic-American   □ African American   □ Native American
   □ Caucasian-American   □ Asian-American/Pacific Islander   □ Other ____________

3. Years of teaching experience ____________

4. Highest Degree Earned
   □ BA/BS   □ MA/MS   □ Sixth year/Special Ed.
   □ Ph.D./Ed.D.   □ Professional Diploma   □ Other ______________

5. Training in teaching of gifted and talented (Check an that apply)
   □ None   □ District In-service   □ Workshop outside district
   □ Course(s) at college/university   □ Educational degree in area

6. Grade level now teaching ______

II. School and District Information

Please answer the following questions about your school and district.

1. Using the scale below, what percent of students in your school belong to each of the following ethnic groups?
   O = 0%,  1 = Up to10%,  2 = 11% to 25%,  3 = 26% to 50%,  4 = 51% or more,  5 = Don’t Know
   ___ African-American
   ___ Asian-American/Pacific Islander
   ___ Hispanic-American
   ___ Native-American
   ___ Caucasian-American
   ___ Other

2. Has a formal definition of giftedness been adopted by your district?
   □ Yes   □ No   □ Don’t Know

3. What is the lowest grade level for which there as a formal gifted program in your district? ________
4. Which of the following measures and/or checklists does your district use to formally Identify gifted students? (Check all that apply)

- [ ] IQ Tests (Group or Individual)
- [ ] Teacher Nomination
- [ ] Creativity Tests
- [ ] Achievement Tests
- [ ] Parent Nomination
- [ ] Don’t Know
- [ ] Grades
- [ ] Student Self-Nomination
- [ ] Other, Specify: ______________
- [ ] Teacher Rating Scales
- [ ] Student Interview
- [ ] Peer Nomination
- [ ] Student Products/Portfolios
- [ ] Peer Nomination
- [ ] Other, Specify: ______________
- [ ] Parent Nomination
- [ ] Don’t Know
- [ ] Grades
- [ ] Student Self-Nomination
- [ ] Other, Specify: ______________
- [ ] Student Products/Portfolios
- [ ] Peer Nomination
- [ ] Other, Specify: ______________

5. Does your district have a policy regarding the acceleration of the regular curriculum for high ability students?

- [ ] Yes
- [ ] No
- [ ] Don’t Know

*If yes, which of the following applies?*

- Classroom teachers are encouraged to accelerate students into the next level or the next academic grade.
- Classroom teachers are encouraged to provide higher-level or enriched content material in their classrooms, but are not permitted to accelerate students into the next level or academic grade.
- Classroom teachers are not allowed to provide advanced level curriculum for higher ability students and are not permitted to accelerate students into the next level or academic grade.
- Other (Specify _________________________)

6. Does your school district employ a coordinator of programs for the gifted?

- [ ] Yes
- [ ] No
- [ ] Don’t Know

7. Is there a fulltime teacher of the gifted in your school building?

- [ ] Yes
- [ ] No
- [ ] Don’t Know

8. Is there a part-time teacher of the gifted in your school building?

- [ ] Yes
- [ ] No
- [ ] Don’t Know

9. Do students in your school building participate in gifted program in which they are transported to a different school or site?

- [ ] Yes
- [ ] No
- [ ] Don’t Know

10. Do students in your school go to a resource room (pull-out program) for instruction provided by a teacher of the gifted?

- [ ] Yes
- [ ] No
- [ ] Don’t Know

III. Classroom Issues

Please answer the questions below regarding issues in your classroom.

1. Which of the following best describes the type of class you teach?

- [ ] Intact or self-contained class (i.e., the same students all day)
- [ ] Departmentalized arrangement (i.e., teach one or more subjects to different classes)

2. If you teach an intact class, please skip to question 3 and answer the remaining questions in this section for that class. If you teach in a departmentalized arrangement, please select one (1) class and answer the remaining questions in this section based on that class. Please indicate which class you have selected.

- [ ] Science
- [ ] Social Studies
- [ ] Language Arts
- [ ] Math
- [ ] Reading
- [ ] Art
- [ ] Other (Specify _________________________)

3. What is the enrollment of your class by gender? (Give number) _____ Boys _____ Girls

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4. Indicate the number of limited English proficient students in your classroom. ______

5. Indicate the number of students in your classroom for each of the following groups.
   __ Visually Impaired
   __ Hearing Impaired
   __ Physically Handicapped (Muscle Impairment)
   __ Other Health Impairment (Specify ___________________)

6. What is the number of students in your class for each of the following ethnic groups? (Give number)
   __ African-American
   __ Asian-American/Pacific Islander
   __ Hispanic-American
   __ Native-American
   __ Caucasian-American
   __ Other

7. What is the number of formally identified gifted students in your classroom? ______

8. Which of the following measures and/or checklists do you use (or if you don’t have a gifted program, would you use) to identify gifted students in your classroom? (Check all that apply.)
   □ IQ Tests (Group or Individual)  □ Teacher Nomination  □ Creativity Tests
   □ Achievement Tests  □ Parent Nomination  □ Don’t Know
   □ Grades  □ Student Self-Nomination  □ Other, Specify:
   □ Teacher Rating Scales  □ Student Interview  □
   □ Student Products/Portfolios  □ Peer Nomination  □

9. Are there students in your class you believe are gifted but have not been formally identified as such by your district?
   □ Yes  □ No  □ Don’t Know

10. Indicate the number of limited English proficient students in your classroom who are formally identified as gifted and also those who may be gifted but are not formally identified as such.
    Formally Identified  May be Gifted But Not
    As Gifted  Formally Identified

11. Indicate the number of students in your classroom formally identified as gifted and also those who may be gifted but are not formally identified as such for each of the following groups:
    Formally Identified  May be Gifted But Not
    As Gifted  Formally Identified
    Visually impaired  ______  ______
    Hearing Impaired  ______  ______
    Physical Handicapped  ______  ______
    Other Health Impairment (specify)  ______  ______

12. How many boys and girls in your classroom have been formally identified as gifted and how many may be gifted but have not been formally identified as such for each of the ethnic groups listed below?
    Formally Identified  May be Gifted But Not
    As Gifted  Formally Identified
    African-American  ______  ______
    Asian-American/Pacific Islander  ______  ______
    Hispanic-American  ______  ______
    Native-American  ______  ______
    Caucasian-American  ______  ______
    Other  ______  ______
IV. Classroom Practices
This section is designed to provide information about the instructional strategies and approaches you use in your classroom. It is very important that the answers you provide reflect actual practices. Please be assured that your individual responses will be held in the strictest confidence.

Above you told us whether you teach an intact class or specific subject(s) (i.e., departmentalized arrangement). If you teach an intact class, please respond to the following items for that class. If you teach in a departmentalized arrangement, please respond to the following items using the same class you selected earlier as your point of reference. PLEASE DO NOT CHANGE CLASSES.

Please read the directions below, check one of the boxes, and then proceed as directed.

1. If you have students in your class formally identified as gifted by your district, circle box one (1) and respond to items #1-39 for Average AND Gifted students.

2. If you do not have students in your class formally identified as gifted by your district but have students you believe are gifted, circle box two (2) and respond to items #1-39 for Average AND Gifted students.

3. If you have neither students formally identified by the district as gifted nor students you believe are gifted, circle box three (3) and respond to Items 1-39 for Average students only.

Please use the following response scale based on the academic year to indicate what actually occurs in your classroom. Circle the most appropriate response.

<table>
<thead>
<tr>
<th>Response Scale</th>
<th>Average Students</th>
<th>Gifted Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - Never</td>
<td>1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>1 - Once a month, or less frequently</td>
<td>1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>2 - A few times a month</td>
<td>1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>3 - A few times a week</td>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>4 - Daily</td>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>5 - More than once a day</td>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
</tbody>
</table>

1. Use basic skills worksheets
2. Use enrichment worksheets
3. Assign reading of more advanced level work
4. Use self-directed instructional kits.
5. Assign reports
6. Assign projects or other work requiring extended time for students to complete
7. Assign book reports
8. Use activities such as puzzles or word searches
9. Give creative or expository writing assignments on topics selected by the teacher
10. Give creative or expository writing assignments on topics selected by the students
<table>
<thead>
<tr>
<th>Average Students</th>
<th>Gifted Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>11. Make time available for students to pursue self-selected interests</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>12. Use pretests to determine if students have mastered the material covered in a particular unit or content area</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>13. Eliminate curricular material that students have mastered</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>14. Repeat instruction on the coverage of more difficult concepts for some students</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>15. Substitute different assignments for students who have mastered regular classroom work</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>16. Modify the instructional format for students who learn better using an alternative approach</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>17. Encourage students to move around the classroom to work in various locations</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>18. Allow students to leave the classroom to work in another location, such as the school library or media center</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>19. Assign different homework based on student ability</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>20. Use learning centers to reinforce basic skills</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>21. Use enrichment centers</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>22. Teach thinking skills in the regular classroom</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>23. Teach a unit on a thinking skills, such as critical thinking or creative problem solving</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>24. Participate in a competitive program focusing on thinking skills/problem solving, such as Future Problem Solving, Odyssey of Mind, etc.</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>25. Use contracts or management plans to help students organize their independent study projects</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>26. Provide time within the school day for students to work on their independent study projects</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>27. Allow students within your classroom to work from a higher grade level textbook</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>28. Provide a different curricular experience by using a more advanced curriculum unit on a teacher-selected topic</td>
<td>0 1 2 3 4 5</td>
</tr>
</tbody>
</table>
Response Scale
0 - Never
1 - Once a month, or less frequently
2 - A few times a month
3 - A few times a week
4 - Daily
5 - More than once a day

<table>
<thead>
<tr>
<th>Average Students</th>
<th>Gifted Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>29. Group students by ability across classrooms at the same grade level</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>30. Send students to a higher grade level for specific subject area instruction</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>31. Establish interest groups that enable students to pursue individual or small group interests</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>32. Consider students' opinion in allocating time for various subjects within your classroom</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>33. Provide opportunities (or students to use programmed or self-instructional materials at their own pace</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>34. Give assignments that encourage students to organize their own work schedule to complete a long range project</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>35. Provide questions that encourage reasoning and logical thinking</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>36. Ask open-ended questions</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>37. Encourage students to ask higher-level questions</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>38. Encourage student participation in discussions</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>0 1 2 3 4 5</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>39. Use computers</td>
<td>0 1 2 3 4 5</td>
</tr>
</tbody>
</table>

COMMENTS
Please provide any comments you believe will help us in understanding classroom practices within your school.

Thank you very much for your help.
Please return to: M. Lightbody, Middleview City Schools, Baker Middle School

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APPENDIX B

Flyer for Differentiation Course
Using Differentiation to Teach Middle School Science

Would a professional development course in a strategy known as differentiation be of interest to you?

Would you like to work with other science teachers in Middleview to develop differentiated units directly correlated with the science content and concepts you teach at your grade level?

Would you like to receive a computer program and print materials designed to make this process easier?

Would you like to have help implementing the strategies and the unit(s) you create with your students?

Did you answer YES? You may want to enroll in a Leverett University class for one semester hour ($138) or district CEU’s (free).

When: 3:15 – 5:15 pm on Mondays,
    First meeting: November 10, 2003 (tentative)
    Last course meeting: mid-January, 2004

Where: Baker Middle School for Meeting #1

Instructor? Mary Lightbody, A&T Resource program

Are you willing to participate in a research project as a member of a Focus Group? Please see over for the fine print and specific details about this course! To sign up, return the tear off to Mary!

1 Pseudonyms have been substituted for the district and school names throughout.
The details
Course participants will also receive classroom-based professional development support on implementing some of the strategies of differentiation. I am inviting only the middle school science teachers in our district to participate in this course. If other teachers on your teams or at your schools are interested, please let me know. If there is sufficient interest, I may be able to offer the differentiation course again for all content area middle school teachers in the future.

As part of this course I would like to investigate whether the types of services provided for gifted and talented students in the regular science classroom will change if teachers participate in a professional development course on differentiated instruction. Participation in the research component is completely voluntary, and separate from the course. You may take the course and not participate in the research component at all, without any consequences.

Course participants will receive:

- Computer software (the Curriculum Project’s UnitWriter®)
- An alternative hardcopy curriculum design tool
- Resources on differentiation and brain-based learning
- Instruction in the use of differentiation strategies such as:
  - adapting class work for individual learning styles
  - creating and using independent or small group work on assigned topics
  - modifying or compacting the curriculum
  - offering high-level content for some students
  - providing open-ended thinking and problem solving opportunities
  - using new technology tools to facilitate planning differentiated instruction
  - assessing the quality of student learning

The course will begin in November, and will consist of four class meetings and four individual planning and implementing sessions. During this time I will provide individualized support for each teacher in the planning and implementation of the instructional strategies discussed in the course using the specific grade level curriculum for which the teacher is responsible. Do join us!

Please tear this off and return it to Mary Lightbody’s mailbox (Baker and Kingsview) or via school mail to Baker Middle School (Forest Oak and Parkland) by Friday, October 31, 2003

Name ____________________________ School __________________

Please check all that apply:

☐ I would like to enroll in this. Please send me information about the time and place.

☐ I would like more information about ☐ the course ☐ what differentiation is other ☐

☐ I am not able or do now wish to participate in the course. Thanks anyway.
APPENDIX C

Course Syllabus
LEVERETT UNIVERSITY
Professional Development Services
Site-Specific Workshop Syllabus

ED#6150 F5

Clinical Hours: 12.5
Semester Hours: One (1)

Workshop Title: Using Differentiation to Teach Middle School Science

Workshop Description/Purpose:

This course is designed for middle school science teachers in Middleview. Teachers who enroll in the course will learn how to plan and implement differentiated science instruction for their students. The teachers will learn to use a modified Bloom’s Taxonomy to vary the levels of thinking, process, and product for their students. At regularly scheduled class meetings teachers in the course will meet with the instructor individually or in small groups by grade level to plan and create specific differentiated units for the science content they teach using UnitWriter® software. Teachers will also learn to assess student work using Curry/Samara Product Guides. Specific strategies of differentiation will be covered, as listed below, and course participants will receive materials to support this professional development experience.

Workshop Objectives: (List)

☐ Course participants will learn aspects of instruction using differentiation strategies such as:
  + adapting class work for individual learning styles
  + creating and using independent or small group work on assigned topics
  + modifying or compacting the curriculum
  + offering high-level content for some students
  + providing open-ended thinking and problem solving opportunities
  + using new technology tools to facilitate planning differentiated instruction
  + assessing the quality of student learning

☐ Course participants will learn how to use computer software designed to create differentiated units and to assess the student work that is created in the process (e.g., UnitWriter®, Product Guides).

☐ Course participants will learn how to use an alternative hardcopy curriculum design tool.

☐ Course participants will read and discuss resources on differentiation including:

Special Materials to be Provided:

Materials Provide for the course include UnitWriter® computer software program, the Tomlinson book, and the alternative, Matrix Planning Folder, from the Curriculum Project. In addition product assessment cards will be provided.

All these materials will be provided for teachers who enroll in the course by the Middleview City Schools through the district professional development program.

---

7 Curry, J., & Samara, J. (2001). UnitWriter (Version 1.5.0) [Windows]. Austin, TX: The Curriculum Project, Inc.

1 Leverett is a pseudonym for the graduate school.
Syllabus, page two

LEVERETT UNIVERSITY
Professional Development Services
Site-Specific Workshop Syllabus

ED# 6150 F5  Workshop Title: Using Differentiation to Teach Middle School Science

Session 1
Date: November 10, 2003 (Mon.)  Location: Baker Middle School
Time: 3:15- 5:15 pm
Content to be addressed:
- Completion of a questionnaire of classroom practices to establish a baseline;
- Discussion of Curriculum, Assessment, and Instruction;
- Observable behaviors that make for an instructionally effective environment in the classroom;
- What is meant by "differentiation"? (ASCD videotape)
- 3 building blocks of Differentiation;
- How can Bloom's Taxonomy be used to support these strategies?; and
- Where do the Science standards fit in?

Assignment: Write a description of a typical class you teach during the day. Describe a student who is unsuccessful in that class, and a student who is successful, and reflect on the characteristics that contribute to your categorization. Read through Part I in Tomlinson book, and be ready to discuss in small groups.

Session 2
Date: November 17, 2003 (Mon.)  Location: Kingsview Middle School
Time: 3:15- 5:15 pm
Content to be addressed:
- Discussion of Typical Class/Successful/Unsuccessful Students and Tomlinson Reading
- Review: the Elements required for Effective Teaching:
  Rapport, Management, Content, Differentiation, Collaboration;
- The Curry/Samara Model of planning differentiated units
  3 Building Blocks for Differentiation
  4 Modalities
- Using the Curriculum Project matrix and post-it notes to create a unit of study (the low-tech way);
- Using UnitWriter® to continue to develop the unit of study (the high tech way).

Assignment: Using either the matrix folder or UnitWriter®, complete the initial unit matrix started in class. Elements to be included: Thinking Skill (basic → abstract), Content (factual → global), Product (traditional → innovative)

Session 3
Date: December 8, 2003 (Mon.)  Location: Forest Oak Middle School
Time: 3:15- 5:30 pm
Content to be addressed:
- Discussion of Early Release Differentiation Presentation
- 3 Building Blocks of Differentiation vs other methods to differentiate
- Review of Unit Matrix efforts and where do the standards fit in?
- Product Guides – what they are and how to use them

1 Leverett is a pseudonym for the graduate school.

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Assignment: Complete the matrix for the unit, make copies, and be prepared to share the unit. Read the differentiated unit on Weather, and compare it to the Curry/Samara unit on Weather. Be prepared to discuss the differences between the units, and to discuss the implementation of your unit with your students.

Session 4
Date: January 21, 2004 (Wed.)  Location: Kingsview Middle School
Time: 3:15-5:50 pm
Content to be addressed:
  o So what does this look like in the classroom: ASCD video tape and discussion
  o Sharing units and matrices developed by course participants
  o Differences between the Curry/Samara Matrix and the Weather Unit in the Tomlinson book

Assignment: Engage your instructional team or another teacher in a discussion of differentiation, sharing with the teacher(s) the additional units provided in Tomlinson’s book. Reflect on the personal difficulties, barriers, and problems encountered so far in the course or in the implementation process.

Session 5
Date: to be arranged  Location: One of the Middleview middle schools
Time: 3:15-5:15 pm
Content to be addressed:
  o Access additional units that are available on the Internet
  o Brain-based research: what do we know about how middle school students learn science?
  o Science misconceptions revealed
  o Instructional strategies to promote high-end thinking by even low achieving students

Assignment: Implement the differentiated unit constructed during the course; and engage in a professional discussion with the instructor of what worked, what was more challenging, and where improvements could be made.

Session 6
Date: to be arranged  Location: One of the Middleview middle schools
Time: 3:15 – 5:15
Content to be addressed:
Class discussion of the implementation, what worked and what didn’t, and why
Course evaluation, final discussion and closure

Assignment: Continue to work on using as much of the matrix developed during this course, refining the matrix where necessary, and resolve to implement differentiation strategies especially with students who benefit from the additional opportunity to learn and grow.
APPENDIX D

Teacher Consent Form and Parental Permission Form
CONSENT FOR PARTICIPATION
IN SOCIAL AND BEHAVIORAL RESEARCH

Protocol Title: ON-SITE PROFESSIONAL DEVELOPMENT:
USING DIFFERENTIATION TO SUPPORT INSTRUCTION
IN MIDDLE SCHOOL SCIENCE

Principal Investigator: Dr. David Haury, MSAT, College of Education
Co-Investigator: Mary Lightbody, graduate student, MSAT,
College of Education

Please place a check mark (✓) in the box in front of every statement with which you agree.

☐ I consent to my participation in research being conducted by Dr. David Haury of the Ohio State University and the Co-Investigator in this research, Ms. Mary Lightbody.

☐ The investigators have explained the purpose of the study, the procedures that will be followed, and the amount of time it will take. I understand the possible benefits, if any, of my participation.

☐ I know that I can choose not to participate without penalty to me. If I agree to participate, I can withdraw from the study at any time, and there will be no penalty.

☐ I consent to the use of audiotapes and videotapes. I understand how the tapes will be used for this study.

☐ I have had a chance to ask questions and to obtain answers to my questions. I can contact the investigators at (614) xxx-8440 at any time. If I have questions about my rights as a research participant, I can call the Office of Research Risks Protection at (614)688-4792.

☐ I have read this form. I sign it freely and voluntarily. A copy has been given to me.

Print the name of the participant: ________________________________

Date: ________________ Signed: ________________________________

(Participant)

Signed: ________________________________

(Principal Investigator or his authorized representative)
Student Release Form  
(reduced to 82 percent original size)  

Student Release Form  

Dear Parent/Guardian:  

This year I am the Middle School Able and Talented (A&T) Resource teacher at Baker and Kingsview Middle Schools. I am also working on my Doctorate in Math, Science, and Technology Education at the Ohio State University. This fall and winter I will be conducting an inquiry study with science teachers at all four middle schools in the district. The purpose of my inquiry is to explore the effectiveness of a particular instructional strategy that is designed to meet the needs of all the students in the classroom.  

As part of the project I will be making short videotapes of science teachers in their classrooms teaching in your child's class. I have received permission from some of the teachers who are participating in the professional development course to come into their classrooms to videotape their instruction before and after the course. The primary focus is on the teacher and the teacher's instruction, not on the students in the class. However in the course of taping, your child may appear on the videotape. If you prefer that your child not appear on the tape, we will have the child sit in a section of the classroom where the camera can not record him or her, but where he or she will still be able to participate in the instruction.  

The classroom teacher and I are the only two people who will see the videotapes, which will be destroyed after my study is completed. The form below will document your permission for this activity. Please complete the form and return it to the classroom teacher.  

Sincerely, 

Mary Lightbody  

Cut/Tear off here.

Please complete and return to the classroom teacher named below. Thank you.  

PERMISSION SLIP  

Student name __________________________ School/Teacher __________________________  

Your Address: ____________________________  

I am the parent/legal guardian of the child named above. I have received and read your letter regarding the videotaping of my child's teacher during class time and agree to the following:  

☐ I DO give permission to you to include my child's image on videotape as he or she participates in a class conducted at __________________________ by __________________________.  

(Name of School)  

(Teacher's Name)  

☐ I DO NOT give permission to videotape my child.  

Signature of Parent or Guardian __________________________ Date: __________________________  

8 pseudonyms assigned for this publication
APPENDIX E

Exit Interview Questions
Reason for the course: differentiation is a strategy that many people use to meet the needs of high-end gifted students in the classroom, but can be used to meet the needs of all students in the classroom.

What were some of the factors that facilitated what you were doing in the classroom and what were the barriers that made it difficult to do differentiation in the classroom?

Did the Curry-Samara Model (content, thinking, product modification) provide something that was beneficial to your students and did it add a dimension that was valuable to you?

What were the differences among the classroom teachers in the amount of support they needed to implement differentiation? What were the variances among the teachers?

Give me a window into the variable between teachers that may influence how much differentiation you were able to do...

What made you want to be a teacher? Did you want to be a science teacher?

What is your background like in science? Have you had a lot of coursework?

In the summer or after school, have you taken additional courses or workshops?

Please tell me about your typical day as a teacher.

How much time do you spend on school work outside of school time?

Let’s talk about the Differentiation class. How much time did you spend developing your unit?

Can you describe what that was like? Developing the matrix?

Did you use the unit for instruction, and how was that? Describe the impact of differentiation.

Did you tell them how they would be scored or evaluated? Are they projects that have a product guide?

Have you regularly done pre-testing, or is that new? Will you continue doing pre-testing?

Could you describe what you envision for the future? How will your future units be different than they were in the past?

Can you identify some barriers to implementing differentiation?

Did you try to use the lesson plans? How did that work/not work for you?

Consider the support that I provided. How and what did I do that helped?

Is there anything else that you have been thinking about that I didn’t ask?
APPENDIX F

A Sample Differentiated Unit
Energy

1. Types of Energy
   a. Forms
   b. States

2. Energy
   a. Energy Transformation
   b. Conservation of Energy

3. Sources of Energy
   a. Renewable
   b. Nonrenewable

4. What are the problems?
   a. Renewable
   b. Nonrenewable

5. What are the solutions?
   a. Address energy consumption in US, in world
   b. find new sources of energy
   c. reduce cost of non-renewables
   d. federal support for energy conservation
   e. "green"energy

6. Who has and who uses the most energy?
   a. 1st world vs 2nd world vs 3rd world countries
   b. variation among US population
   c. variations among manufacturing, industries
   d. power and balance
<table>
<thead>
<tr>
<th>Energy</th>
<th>Basic Thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Types of Energy</td>
<td>Knowledge Comprehension</td>
</tr>
<tr>
<td>a. Forms</td>
<td>1a. List the 6 forms of energy and 2 states of energy with definitions and demonstrate proficiency through a flash cards. (7.Sc.PS.3, 7.Sc.PS.2)</td>
</tr>
<tr>
<td>b. States</td>
<td>1b. Restate the 6 forms and 2 states of energy and demonstrate proficiency through a lotus diagram.</td>
</tr>
<tr>
<td>1c. List six new facts after reviewing energy trade books and demonstrate proficiency through a round table discussion.</td>
<td>2a. Explain the main form(s) of energy found in pictures of household items and demonstrate understanding through a pyramid fold.</td>
</tr>
<tr>
<td>Application</td>
<td>Analysis</td>
</tr>
<tr>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>3a. Categorize the different appliances in your home according to the six forms of energy and demonstrate understanding through a(an) concept map.</td>
<td>4a. Compare differences between early century machines and modern machines and share ideas using a magazine advertisement. (6.Sc. ST.3)</td>
</tr>
<tr>
<td>2. Energy</td>
<td>7a. List the forms of energy and their transformations using magazine pictures and demonstrate proficiency through a flow chart.</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>a. Energy Transformation</td>
<td></td>
</tr>
<tr>
<td>b. Conservation of Energy</td>
<td></td>
</tr>
<tr>
<td>8a. Describe the energy transformations in lighting up a light bulb and demonstrate understanding through a(an) concept map.</td>
<td></td>
</tr>
<tr>
<td>3. Sources of Energy</td>
<td>13a. Recognize different sources of energy in magazines and trade books, and find examples of both and share ideas using a pyramid fold. (6.Sc.PS.8)</td>
</tr>
<tr>
<td>a. Renewable</td>
<td></td>
</tr>
<tr>
<td>b. Nonrenewable</td>
<td>14a. Explain the differences between renewable and nonrenewable resources and demonstrate proficiency through a type ii writing.</td>
</tr>
<tr>
<td>4. What are the problems?</td>
<td>19a. Recount two problems that each of these forms of energy have (i.e. time, cost, finite resource) and demonstrate proficiency through a type ii writing.</td>
</tr>
<tr>
<td>a. Renewable</td>
<td></td>
</tr>
<tr>
<td>b. Nonrenewable</td>
<td>20a. Explain the differences between problems associated with renewable and nonrenewable resources and demonstrate proficiency through a flow chart.</td>
</tr>
<tr>
<td>9a. Apply your understanding of energy transformations shown with the Energy Bike and the student riding the bike and demonstrate understanding through a(an) sequence puzzle.</td>
<td>10a. Determine the correct sequence of a series of pictures and describe the energy transformation and states of energy shown in each picture and demonstrate understanding through a(an) sequence puzzle.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>15a. Categorize the different sources of energy into renewable and nonrenewable and demonstrate understanding through a(an) felt board.</td>
<td>16a. Research sources of energy using trade books and demonstrate understanding through a(an) magazine article. (6. Sc.PS.5, 6.Sc.PS.6)</td>
</tr>
</tbody>
</table>
5. **What are the solutions?**
   a. Address energy consumption in US, in world
   b. find new sources of energy
   c. reduce cost of non-renewables
   d. federal support for energy conservation
   e. "green"energy

6. **Who has and who uses the most energy?**
   a. 1st world vs 2nd world vs 3rd world countries
   b. variation among US population
   c. variations among manufacturing, industries
   d. power and balance

31a. List the ways 1st World countries and 3rd world countries use energy and technology to conserve (if any) and share ideas using a t-chart. (6.Sc.ST.1)
32a. Explain how energy is used in different places in the US and demonstrate understanding through a(an) letter to the editor. (6.Sc.ST.2)
| 27a. If one solution to energy problems is to conserve, identify where in your home you could conserve energy and demonstrate understanding through a(an) display. |
| 28a. Research in which countries fossil fuel is found using trade books and connect with your Geography class. |
| 29a. Generate a flow chart to trace the movement of energy through a system, including at least two forms of green energy and demonstrate proficiency through a television commercial. (7.Sc.PS.1, 7.Sc.PS.2) |
| 30a. Through research and oral presentation, compare and contrast a regular gas engine, hybrid car, and electric car, 30b. Using the information from cell 30a, create a debate among two car salesmen from different companies explaining why someone should purchase their vehicle. |
| 33a. Design a system to conserve energy in your community and demonstrate proficiency through a poster. (6.Sc.ST.5) |
| 34a. Determine whether the amount of energy used by 1st World countries like the US represents a fair share of the energy available and share ideas using a persuasive essay. (6.Sc.SWK.4) |
| 35a. Generate a policy for your school district to use to conserve energy and to invest in renewable energy source and share ideas using a multimedia presentation. (6.Sc.PS.8, 7.Sc.PS.4) |
| 36a. Justify a required conservation plan in 1st world countries by proposing a shift in the power and balance of energy consumption and demonstrate proficiency through a radio commentary. (6.Sc.PS.6, 6.Sc.PS.5) |
Appendix G

Astronomy Test - The Universe
Astronomy Test - The Universe

**Directions:** Select any combination of questions to total 100 points. As you chose each question, write the questions number and point value at the start. Be sure to keep a running total of your points in the margin of the answer sheet. Write all answers on the answer sheet.

**Knowledge Level (5 points each)**
1. What are constellations?
2. What are galaxies and what characteristic do we use to classify them?
3. What contributions did Edwin Hubble make to astronomy?
4. What is the name and type of galaxy in which we live?
5. What does a spectroscope do?
6. What is a light year?
7. What role did gravity play in the formation of the galaxies?
8. According to the life cycle of a star, what are the 3 possible fates for any star?

**Comprehension Level (10 points each)**
9. Explain the difference between a circumpolar and a seasonal constellation.
10. Diagram and label the four types of galaxies according to the Hubble classification.
11. Rank stars by size from smallest to largest.
12. Rank stars by temperature from hottest to coolest.
13. Tell why scientists find it necessary to measure interstellar distances in light years.
14. How does the spectroscope enable astronomers to determine the characteristics of distant stars and galaxies?

**Application Level (15 points each)**
15. Construct a Hubble tuning fork diagram. Draw and label the appropriate galaxies from EO to E 5 to SO, from Sa to Sb to Sc and from SBa to SBc to SBc.
16. Discuss the Big Bang Theory and two pieces of evidence to support it.
17. Use a Hertzsprung-Russell diagram to describe the features of the following stars: Betelgeuse, Capella, Sirius B, Algol, and the Sun.

**Analysis Level (20 points each)**
18. Compare the life cycle of 3 stars of varying solar masses. Star A has a mass of 1.2 solar mass units, Star B has a solar mass of 2.5 solar mass units and Star C has a mass of 6.8 solar mass units.
19. Distinguish between absolute magnitude and apparent magnitude.
20. Explain the Hertzsprung-Russell diagram and why most stars fall on the main sequence.
21. What is "red shift"? What is "blue shift"? Why are they important to astronomers?
22. Why are supernovas considered factories for the production of heavy elements?
23. What do 'Open' and 'Closed' universe models mean. What role does dark matter play in these models?
Synthesis level (25 points)
24. Use your imagination to describe what you would experience on a trip to a black hole.
   Use the following terms: gravity, space-time, event horizon, spaghettification, singularity.
25. Create your own 12 step cosmic ladder beginning at the sub atomic level and ending with the universe.

Evaluation Level (25 points)
26. List the 5 most important facts that you have learned about the universe. Rank them from 1 to 5 and give 4 reasons why you selected your most important fact.

[Author Note: A Hertzsprung-Russell Diagram was included on the Astronomy test, but was omitted here in accordance with copyright laws. Please refer to the Internet (for example http://en.wikipedia.org/wiki/Hertzsprung-Russell_diagram) or a science textbook if a copy of the diagram is important to your understanding of this test.

This Astronomy Test was created by Thomas, a pseudonym for a teacher in this study. In accordance with Thomas’ expressed wishes the test may be used or modified by educators for their use with students but may not be copied for commercial use, and is protected by copyright laws.]


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