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An intervention study of primary age gifted students with strong nonverbal abilities from low income and culturally diverse backgrounds

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AN INTERVENTION STUDY OF PRIMARY AGE GIFTED STUDENTS WITH STRONG NONVERBAL ABIILITIES FROM LOW INCOME AND CULTURALLY DIVERSE BACKGROUNDS

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AN INTERVENTION STUDY OF PRIMARY AGE GIFTED STUDENTS WITH STRONG NONVERBAL ABIILITIES FROM LOW INCOME AND CULTURALLY DIVERSE BACKGROUNDS

ABSTRACT

The prevalence of high nonverbal reasoning strength among children from low income, culturally diverse backgrounds challenges the education community to provide effective instruction for these students (Briggs et al., 2008; Koshy & Robinson, 2006; Olszewski-Kubilius, 2007; Robinson et al., 1997; VanTassel-Baska, 2003b; VanTassel-Baska, Feng, & Evans, 2007). Research on the well-being and progress of young gifted students confirms that stimulating material resources, association with intellectual peers, and formal educational interventions designed to optimize students' strengths improves the educational outlook for these students (Bittker, 1991; Campbell et al., 2001; Clasen, 2006; Corno et al., 2002; Morelock & Morrison, 1999; Ramey & Ramey, 2004; Robinson et al., 1997; Sarouphim, 1999; VanTassel-Baska, 2006; VanTassel-Baska et al., 2002; VanTassel-Baska, 2007). In this study, a Vygotskian perspective provided the framework for an instructional intervention (Vygotsky 1978 version, 1986 version, 1994 version). Consistent with the perspective, the intervention included intellectual scaffolding to support conscious thought and formal learning in science, and encouragement of individual learning in the zone of proximal development.

The researcher undertook this study to determine if the use of instructional strategies capitalizing on nonverbal reasoning strength would improve achievement in science learning with a William and Mary life sciences curriculum unit. A six week, 24 hour program in a southeastern Virginia urban district provided the venue for the study. Second graders from Title I schools who scored above the 80th percentile on the Cognitive Abilities Test (CogAT) nonverbal battery and significantly lower on verbal and quantitative batteries qualified for the program. Twenty-three students participated, resulting in a treatment group of 13 students and a comparison group of 10 students.

The nature of the intervention was a William and Mary Life Sciences unit modified for the treatment group. Treatment group teachers used enhanced instructional activities that incorporated the use of scientific symbols, active rehearsals of new knowledge, visual mental models, and descriptive writing, as recommended by Lohman and Hagen (2003) and others (Bransford, Brown, & Cocking, 2000).

Results of unit assessments indicated that both the treatment and comparison groups showed statistically significant increases in concept attainment ($p < .001$). However, the treatment group showed significantly higher mean scores than the comparison group in concept attainment ($p < .05$). Neither treatment nor comparison groups showed significant gains for scientific reasoning over time; however, the treatment group scored significantly higher in scientific reasoning than comparison students ($p < .001$). Both groups significantly increased their content knowledge ($p < .05$); and the treatment group made significantly greater gains from pre- to post-assessment ($p < .05$)

The findings suggest that students who are exposed to high-quality research-based instructional units tailored to and aligned with their cognitive strength in nonverbal reasoning may show gains in science learning. Future research should

employ larger samples, randomly assigned, to strengthen results and improve the ability to generalize the findings to school districts with similar populations of students with strong nonverbal reasoning skills from culturally diverse, low income backgrounds.

AN INTERVENTION STUDY OF PRIMARY AGE GIFTED STUDENTS WITH STRONG NONVERBAL ABILITIES FROM LOW INCOME AND CULTURALLY DIVERSE BACKGROUNDS

Chapter 1 Statement of the Problem

Fifteen percent or more of families in the United States (US) live in poverty (Hodgkinson, 2007). Among those families are some of the country's most promising students. Yet, because they lack economic resources, and are often black, and Hispanic, the intellectual, creative, and leadership potential of these children may be invisible to their teachers and their school districts (Loveless, 2008). Many educators have made focused attempts to raise achievement among low performing students but nonetheless seem uncaring about the intellectual needs and progress of their highest achievers (Loveless). Even more disconcerting is the reality that many high achieving students from low socio-economic backgrounds come to school with very different strengths from those of their more well-off contemporaries, and, consequently, their potential either goes unrecognized or is neglected by school curriculum and instruction.

The No Child Left Behind Act (NCLB) Focus on Achievement

The stated goal of NCLB is to close the achievement gap among white students and various subgroups identified in the legislation, including students from culturally diverse, low income backgrounds. Secretary of Education Margaret Spellings (in U. S. Department of Education, 2005) reiterated that intention in a banner quote on the department's website, stating ". . . We are . . . holding ourselves accountable for educating every child. That means all children, no matter their race or income level or zip code." In a Fordham Institute study of achievement in the years prior to NCLB and since, Loveless (2008) analyzed the data from the National Assessment of Educational Progress (NAEP) results and shed light on gaps that existed between achievement gains of low and high performers. From the years 2000 to 2007, gains in achievement showed steady progress. The achievement of the lowest performing students, those in the tenth percentile in grade four in mathematics and reading and in grade eight in mathematics, as measured on the NAEP, improved 13 to 18 percentile points. The NCLB legislation reinforces effort to produce such gains by requiring schools and districts to show Adequate Yearly Progress (AYP) in achievement as measured on tests of state standards for students in various sub-groups. Those already performing well usually go unnoticed, with most of the attention of educators focused on those who are not doing well. In fact, since AYP requires all students to pass minimum state standards, NCLB, for all intents and purposes, is silent on the progress of high achievers who pass such tests easily.

NCLB Lack of Focus on Gains for High Achievers

Students in the 90th percentile of NAEP have shown very little improvement over this same time period. The top achievers have gained only between three to ten percentile points in achievement (Loveless, 2008, p.19). Loveless examined the student-level restricted-use NAEP data for high achieving African American, Hispanic, and low socio-economic eighth grade students, representing approximately 53,000 students, and raised several concerns about their progress. First, fewer (9%) of these students took Algebra I in eighth grade than their better off peers and more (23.9%) enrolled in general math or pre-Algebra courses than the other high-achieving students (16.2% in general math or pre-Algebra). In fact, 13.3% of students in this group attended schools that did not offer Algebra I in eighth grade and 22% attended schools that were de-tracked, that is, in which all students learned in heterogeneous classes. Can students from low income and culturally diverse backgrounds be better prepared for advanced classes? Is there evidence of high intellectual abilities in the younger years that can be developed through challenging curriculum?

Test Results in Urban Districts

According to the *CogAT Interpretative Guide for Teachers and Counselors* (Lohman & Hagen, 2003), students who score in the eighth and ninth stanine in nonverbal reasoning ability on the Cognitive Abilities Test (CogAT) (Lohman & Hagen, 2001) and who also score more than 24 points below in verbal and quantitative reasoning are more prevalent in high poverty areas than in suburban and rural districts. Because high nonverbal reasoning is not related to high achievement in academic settings, the occurrence of high nonverbal reasoning abilities and the absence of high verbal and quantitative reasoning abilities present educators and cognitive psychologists with a dilemma (Lohman, 2003; Lohman, Gambrell, & Lakin, 2008; Snow, 1992, 1997). What is the nature of these students' talents? What educational approach will develop these students' talents? And can their talents be marshaled to support the growth of their verbal and quantitative abilities?

Conceptual Framework

The Power of Instruction in Development of the Intellect

Vygotsky's (1978 version, 1986 version, 1994 version) study of the development of intellectual thought and the process of learning in children provides tools with which to consider the acquisition of knowledge and skills by young students. His distinction between spontaneous thought and conscious thought informs our understanding of the role of learning in individual development. Vygotsky's conception of how young students learn, which he called the zone of proximal development, supports thoughtful flexibility in the education of young gifted students. Vygotsky's sense of the role of social interaction in the activation of the individual's zone of proximal development demonstrated the importance of conscious teacher engagement with students and the provision of high-powered curricular options to students who can handle them.

In *Thought and Language*, Vygotsky (1986) contrasted the use of spontaneous thought and conscious thought by second and fourth grade students. He noted that thought which was conscious, systematic, and deliberate spurred intellectual development. On the other hand, students engaged in spontaneous thought, or thought that was unreflective, simply accepted concepts as they appeared to be. In his study, *The effects of scientific concepts in childhood*, on the effects of formal learning as opposed to informal learning, Vygotsky explained that when second graders completed statements ending in *because* and *although* related to scientific concepts they completed the prompts with more accuracy (79.7% correctly completed) than when they completed prompts ending in *because* and *although* about everyday experiences (59.0% correctly completed). The role instruction plays in developing conscious thought related to a scientific concept was demonstrated in the research. Students learned to use scientific concepts through instruction, and they developed intellectually through such learning.

The Zone of Proximal Development

Vygotsky (1978, 1986) described how this happens in his discussion of the zone of proximal development. He defines the concept 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" (1978, p. 86). Today when student learning is measured by standardized tests, the student is described as having reached a specific level of intellectual development. This means that a standardized test result only identifies a child's state of intellectual development at its current level, not that which is possible in the future. Hence, it is critical that practitioners recognize that instruction should guide a student beyond the actual level of development indicated on a test to a higher level within a student's zone of proximal development. When an adult leads a student forward through a hint or well-placed question that directs the child's attention to more complex material, the student assimilates the more complex material within his own zone of proximal development. Not all students are alike in the amount of progress they can make. Instead, they move ahead in the acquisition of knowledge and skills in various degrees and at different rates. One student may advance with assistance in small increments whereas another may advance through material very quickly gaining a year's worth of curriculum in a short time. For the young gifted child, recognition of an individual child's zone of proximal development and support for moving more quickly through material is essential. How does this occur?

The quality of social interaction in the learning process affects a young child's educational experience. Vygotsky (1986) maintained that "with assistance, every child can do more than he can by himself – though only within the limits set by the state of his development" (p. 187). An adult reveals the logic of a concept to the child. This helps the child consciously understand and organize how the concept fits into a system of knowledge. In this sense, the adult acts as a guide, leading the child from sensory experiences that stimulate spontaneous thought to intellectual activity that Vygotsky characterized as conscious thought.

Implications of the Conceptual Framework to the Study

Vygotsky's (1978, 1986, 1994) studies and reflections continue to challenge educators to use scaffolding techniques for instruction that increase students' abilities to develop intellectually through conscious learning. Students with high nonverbal reasoning skills tend to navigate well when confronted with problems and novel situations but not so well when required to respond in a predetermined mode, as in typical school settings (Lohman, 2003; Lohman & Hagen, 2003; Root-Bernstein, 1989; Root-Bernstein & Root-Bernstein, 1999, 2003). Helping students who do not easily express themselves through language to become more comfortable with verbal expression is a social undertaking built upon healthy, trusting relationships (Moran & John-Steiner, 2003). For students from low socioeconomic backgrounds, an effective relationship with a teacher is an essential feature of academic success. But, having a good social relationship is not enough. Educators must focus on their dual role in the development of young gifted students whose needs for cognitively productive social interactions are so great.

Connecting students with thoughtful cognitive experiences sets them on the road to more complex learning. Understanding students' zones of proximal development and scaffolding students' thinking as they develop learning within a discipline area are demanding and complex tasks. Can this dynamic approach to instruction benefit students who reason at a high level; yet, also need support in the development of expressive and quantitative skills? Such considerations were at the heart of this study.

Purpose

The purpose of the study was to determine whether teaching and learning, based on specific nonverbal learning strategies and capitalizing on students' strengths and interests, identified by researchers and investigators (Bransford, Brown, & Cocking, 2000; Gohm, Humphreys, & Yoa, 1998; Lohman et al., 2008; Lohman & Hagen, 2003; Maker, 1996; Robinson, Abbott, Berninger, Busse, & Mukhopadhyay, 1997; Root-Bernstein and Root-Bernstein, 1999, 2003; VanTassel-Baska, Johnson, & Avery, 2002), would result in improvement in concept attainment, scientific investigation process skills, and content mastery skills among students with high nonverbal reasoning skills. It was hoped that an intervention study of effective strategies implemented by teachers in a six-week long Saturday Enrichment Program, based on a high quality curriculum unit, would contribute to the knowledge of how students with high nonverbal reasoning abilities learned best. To understand further students' abilities, a teacher focus group interview explored students' learning habits, motivation, and personal interests as delineated in research on this population (Bransford et al., 2000; Gohm, Humphreys, & Yao, 1998; VanTassel-Baska, 2003c).

Rationale for the Study

The findings of Lohman (2003) and Lohman et al. (2008) on the prevalence of high nonverbal reasoning abilities and lower verbal and quantitative skills among urban, low income students are consistent with the results of two years of district wide screening of all first grade students in a mid-sized urban school district in southern Virginia, referred to as "ABC Public Schools" in this study. Because 58% of students in the district are low income, that is they qualified for free and reduced lunches, this pattern of cognitive abilities was found in many of the Title I elementary school classrooms. The results of the Spring 2008 district CogAt screening indicated that, of the students scoring in the 8th and 9th percentile in any area, one-half to two-thirds of them score high on the nonverbal reasoning test only. How could these students reach their full potential?

Lohman (2005), Piechowski (2006), and Silverman (2000b) attest to the fact that gifted students commonly evidence asynchronous development; that is, they may excel in one aspect of development but not another or they may achieve well in one school subject but not in another. Additionally, Lohman & Hagen (2003) found that 40% of gifted students scored lower on at least one subtest of the CogAT. Recognition of the prevalence of asynchrony among gifted students compels experienced educators of the gifted to differentiate for gifted learners, usually by building on their strength area or areas.

Finding effective ways to build on the strengths of students with high nonverbal reasoning skills, especially in the first years of their schooling, is important in order to lessen students' vulnerability to underachievement as they grow older

(Lohman et al., 2008; National Association for the Gifted [NAGC], 2006). It was anticipated that the results of this intervention study designed to build on nonverbal strength and an exploration of teacher knowledge about students would result not only in student growth gains, but also, in useful understanding of instruction that works for these students and their teachers.

Definition of Terms

In this study, the following terms are used and are defined here to provide clarity.

1. Crystallized intelligence – Crystallized intelligence is a concept developed by Cattell (1971) to represent knowledge acquired through training and education.
2. Curriculum unit – Curriculum units are designed to engage students in the study of content and concepts, and the practice of related skill processes in a specific subject domain (VanTassel-Baska, 2003c).
3. *Budding botanists at work* (BB) (Center for Gifted Education, 2007a) - In this study, BB, a life sciences WM unit, comprised the basis for instruction and was implemented as written by the teachers of the comparison group of students.
4. *Budding botanists at work – Revised* (BB-R; Appendix A) – BB-R refers to the original BB unit with enhancements added for students with high nonverbal abilities which the researcher developed for the intervention study. BB-R comprised the basis of the intervention and was implemented by teachers of the treatment group of students.

5. Culturally diverse students – Differences among individuals and groups related to racial, ethnic, linguistic, religious, and socioeconomic backgrounds (Martin, Gibbens-Meador, Pattison, Sechler, & Agnew, 2004).
6. Differentiated activities – For gifted students, differentiated activities provide accelerated, complex, in-depth, challenging, and creative educational experiences (VanTassel-Baska, 2003a).
7. Fluid intelligence – Fluid intelligence is a concept developed by Cattell (1971) to represent knowledge that is accessed quickly by the individual when confronted with the need to solve a problem or act quickly. It is not dependent on education.
8. Gifted Students – Gifted students are defined in the district in this study according to the terminology adopted by the Commonwealth of Virginia. Gifted students are those "whose abilities and potential for accomplishment are so outstanding that they require special programs to meet their educational needs" (Regulations Governing Educational Services for Gifted Students,1995).
9. Integrated Curriculum Model (ICM) – ICM is a framework for developing curriculum units for gifted students. ICM integrates learning of advanced content, higher level thinking processes and products, and universal, over-arching concepts (VanTassel-Baska, 2003c).
10. Low socioeconomic status – Low socioeconomic status is defined in ABC Public Schools as qualifying for free and reduced lunches. In the 2008-

2009 school year, among students who attended Title I schools in the district, more than 80% qualified for free or reduced lunches. Twenty out of thirty-five elementary schools in the district were designated Title I schools (Virginia Department of Education [VDOE], School Nutrition Programs [SNP], 2008).

11. Nonverbal reasoning ability – fluid reasoning; inductive reasoning skills; visual spatial reasoning; the ability to handle novelty and to problem solve in new situations using cognitive resources (Lohman & Hagen, 2003).
12. Scaffolding – Bransford et al. (2000) conceptualized scaffolding as support for learning performances that includes thinking tools to assist learning and adult guidance to engage and sustain the child's interest in learning.

Synopsis of Methodology

This study was designed to answer four research questions. The research questions were:

Research Question One

To what extent did participation in a Saturday Enrichment Program contribute to academic achievement in the regular science classroom?

Research Question Two

What differences occurred in student learning gains related to understanding of an overarching concept, science investigation process skills, and science content in a Saturday Enrichment Program when one group learned through a WM Life

Sciences unit and a second group learned through the same high-quality unit enhanced for students who score high on nonverbal reasoning tests?

Research Question Three

To what extent did teachers successfully implement a prepared unit of study or the prepared unit with enhancements?

Research Question Four

What were teachers' perceptions of the learning abilities of students who performed well on nonverbal reasoning tests?

To respond to the first question, test results of the district's post-first semester/pre-second semester test and end-of-year post-test aligned with the district's curriculum measured student growth in regular science instruction during the same semester in which the intervention study was conducted. The unit of analysis for the intervention was five classroom groups.

To address the second question, the researcher used a pre-post control group design with random assignment of teachers. The third question required the researcher to adhere to the protocols for reliable observations and the fourth question necessitated the gathering, analysis, and interpretation of qualitative data from a one hour focus group interview.

Data sources were students and teachers. Student growth gains due to the implementation of the science unit and adaptations were measured on pre- and post-performance assessments that were included in the BB (Center for Gifted Education, 2007a) assessment package. Teacher fidelity was evaluated through the use of the Classroom Observation Scales – Revised (COS-R) (VanTassel-Baska, Avery, et al., 2007; Appendix F) and the Treatment Fidelity form (Center for Gifted Education, 2007b; Appendix G). Information was collected from teachers using focus group interview questions developed by the investigator and available in Appendix H.

The district tests, the pre-post performance assessment tools, the COS-R, and the Treatment Fidelity form have appropriate reliability and validity (VanTassel-Baska, 2009).

Data for the first research question was analyzed using a repeated-measures analysis of variance. The second question was analyzed using repeated-measures analysis of variance to determine mean differences between the two groups. Descriptive statistical analysis and independent samples *t*-tests were used to analyze the data gathered through the COS-R and Treatment Fidelity form, for the third question. The researcher analyzed and interpreted the focus group interview data, using content analysis techniques to answer the fourth research question.

Significance of the Research

This research sought to contribute to a better understanding of how young gifted students from low socioeconomic backgrounds learn and how they can further their intellectual and academic development through the use of their strength in nonverbal reasoning skills. Enhancements of the lessons of the unit capitalized upon nonverbal reasoning abilities and led to increased academic achievement, as measured by treatment students' growth in science content knowledge and understanding of the overarching concept of Systems.

The information gathered relative to teachers' abilities to implement the unit successfully and to use differentiation consistently in their instruction has provided professional development planners with further evidence of the necessity for well-conceived training aligned with effective curriculum materials.

The perspective of the teachers who participated in the study should help teachers and administrators understand, at an early point in young gifted students' school careers, how students perform and show their intelligence best, and how they naturally approach learning problems. This knowledge should build better understanding of, and appreciation for, the student population of this urban, low income district.

Context for the Research

The research was a response to a perceived need within ABC Public Schools for information regarding effective curriculum development and instructional practices for young gifted students who lacked sufficient abilities in areas that usually predicted academic success. The results of the research provided a strong basis for thoughtful selection of curriculum units that can be enhanced to build on nonverbal reasoning strengths. It also affirmed the importance of providing professional development to increase teacher use of specific instructional strategies and understanding of the nature of high nonverbal reasoning strength.

Limitations

The gifted education services office invited 88 second grade students with high CogAT nonverbal reasoning scores and lower verbal and quantitative scores. Parental decisions to have their children participate in the program affected the ultimate number and nature of students who comprised the treatment group and comparison group. Ultimately, 26 students participated in the Saturday enrichment program. Three of the 26 did not complete the post-assessments due to illness or attrition. Thus, 13 students comprised the final treatment group and 10 students comprised the final comparison group.

The small sample size created two problems. Equivalence of treatment groups was more difficult to create. Non-equivalence of treatment groups threatened the internal validity of the findings and the small sample size threatened the statistical power to show significant growth. In addition, the treatment groups were intact groups, assigned by the program administrator, rather than randomly assigned (Gall, Gall, & Borg, 2007).

The teachers of the treatment and comparison groups received six hours of professional development. The recommended duration of professional development is two full days (VanTassel-Baska, 2009). The shorter version of professional development is a limitation that may have impacted the strength of the results of the study (See Appendix C for the professional development plan).

The short duration of the Saturday program may have limited the gains made by students in the areas of content and scientific treatment design.

The redesign of the BB unit may not have been sufficient to show strong differential results with the treatment group. This may be partly due to the strength of the unit to begin with in the areas to be assessed, but it may also be due to insufficient remodeling of the unit to obtain strong differential learning gains.

Another limitation of the study was the fact that the teachers of the treatment group knew that they were assigned to the treatment group, and they were excited to participate in a study of this nature. This limitation, known as the Hawthorne effect, wherein research participants strive to perform well because of their role in the study, may have threatened the external validity of the study (Gall et al., 2007).

The researcher conducted and moderated all aspects of the study except the teaching of students, creating the potential for research bias in the interpretation of results.

Delimitations

The learning experiences were based only on the WM curriculum unit, BB (Center for Gifted Education, 2007a) and its instructional enhancements (BB-R, Appendix A) for students with high nonverbal reasoning skills. The students participated only in a six-week long self-contained Saturday Enrichment Program. Teachers used a researcher-designed schedule of lessons to move through the curriculum unit within the time allotted which guided teachers in keeping the pace accelerated for gifted students. The lesson schedule is available in Appendix B.

Because the Saturday Enrichment Program took place in a school other than the teachers' home schools, and away from teachers' usual resources, the researcher and program administrator provided all charts and graphics called for in the unit which teachers normally would provide for themselves. This facilitated teachers' use of the unit strategies and enhancements.

Chapter 2 Literature Review

Robinson (2006) critiqued research in the field of gifted education and challenged us to do better work in several areas. Evaluation of curriculum and instruction for gifted learners and research on the intellectual diversity of high achieving learners, particularly those from culturally diverse and low income backgrounds were two areas in need of investigation. This intervention study examined the effects of research-based, high quality curriculum on a specific type of diverse learner, one who reasoned and performed well with nonverbal tasks (Feng, VanTassel-Baska, Quek, Bai, & O'Neill, 2005; Swanson, 2006; VanTassel-Baska, 2008a; VanTassel-Baska, Bass, Ries, Poland, & Avery, 1998; VanTassel-Baska & Brown, 2007). The work of Vygotsky (1978, 1986, 1994) on how students learn, provided a constructivist conceptual framework for the study and is explored in this review. Other areas of the literature that were pertinent to this study included: research concerning young gifted learners from culturally diverse and low income backgrounds; the meaning of high nonverbal reasoning test results among populations of gifted students; and effective instructional strategies for gifted students with high nonverbal reasoning abilities.

Strand 1: The Conceptual Framework: Vygotsky on Constructivist Learning as Social Interaction in the Zone of Proximal Development

Lev Vygotsky (1978, 1986, 1994) attempted to reconcile various psychological paradigms to form one coherent framework. In the process, he developed a conception of conscious thought that affirmed the relationship of learning to human development; the importance of adults and more capable peers in the learning process of young children; and the need to challenge students beyond their confirmed, independent levels of intellectual development. By focusing on human consciousness and thought, rather than natural, biological reflexes only, as did some of his peers (Piaget, 1955; Thorndike, 1914), Vygotsky developed a conception of teaching and learning which continues to inform and inspire educators today who are struggling to deliver worthwhile instruction to all students.

The Importance of Instruction to Intellectual Development

In a chapter entitled *The development of scientific concepts in childhood: The design of a working hypothesis,* Vygotsky (1986) presented his research on the value of conscious thought to the development of the young child's intellect. Vygotsky found through a study of the ability of second and fourth grade students to respond correctly to statements ending in *because* and *although,* that when second grade students employed conscious thought about learned scientific concepts, they responded correctly (79.7%). In contrast, when students used spontaneous thought to respond to statements about everyday life experiences, they responded with more mistakes in their thinking (59%). Vygotsky concluded that instruction and learning built students' awareness of the organization of ideas into logical systems and provided students with tools for their intellectual growth overall. Learning is vital to the development of a child (Vygotsky).

The Importance of Social Interaction between Children and Adults

> The mechanism of social behavior and the mechanism of consciousness are the same. . . .We are aware of ourselves, for we are aware of others, and in the same way as we know others; and this is as it is because in relation to

ourselves we are in the same [position] as others are to us. (Vygotsky, 1986, p. xxiv)

From this recognition of awareness as essentially social in nature, Vygotsky developed an understanding of the important role of social interaction to the development of the child. In particular, he emphasized the role of the adult in introducing the child to culture, to environment, and to learning. The adult leads the child forward into the world of speech, language, and increasing levels of awareness of the external world (Vygotsky, 1978). The child accepts and assimilates adult knowledge when relations between the adult and child are safe and reliable (Moran & John-Steiner, 2003). Trust and positive social interaction between the adult and child are essential so that adult knowledge and logical thought can help the child advance to higher levels of learning.

The Zone of Proximal Development

Vygotsky (1978) described the zone of proximal development 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). The level of actual development is the level of competence which the child has achieved. In schools today, that level is measured in myriad ways, although typically by multiple choice standardized tests. It also may be ascertained by performance assessments or portfolios. The actual developmental level is a record of past achievement whereas proximal development refers potential future learning.

In school, the teacher is responsible for determining and providing for the zone of proximal development for each individual student. To accomplish this, the teacher must have in-depth understanding of the stages of child development, of a specific field of knowledge, and of pedagogical expertise in that field. A Danish study of the application of the concept of the zone of proximal development to unit planning and instruction in a third grade class demonstrated how teachers can create compatible classrooms that give students room to grow (Hedegaard, 1996). Ways to involve students in investigations of novel material included the use of objects and materials, exposure to museums, and confrontations with real world problems related to a particular concept under study. Hedegaard found that teachers could consider each child's development needs within the whole group setting when communities of learning were established that supported discussion and interaction among students and adults. Bransford et al. (2000) emphasized the importance of various technical cultural tools, particularly computer and Internet resources, to provide the zone in which students could explore and grow intellectually (Vygotsky, 1994).

Learning as Social Interaction in the Zone of Proximal Development

Vygotsky (1986) recognized the complexity of translating inner thought to external verbal and quantitative expressions, a particular concern of this study. The connection between thought and language revealed the tenuousness of the transformation of a thought into effective communication and from there into meaningful action. His characterization of inner speech as "thinking in pure meaning" (p. 249) and of language as an external understandable version of inner thought demonstrated students' needs for personal encouragement and social support in the sharing of their individual conceptions of reality. Vygotsky recognized that the solution was active leading of a child on the part of an adult into higher levels of knowledge expression.

Vygotsky (1978) posited that such teaching often was not pursued because of teachers' misunderstanding of mental intelligence test results and other diagnostic tools:

> Even the profoundest thinkers never questioned the assumption; they never entertained the notion that what children can do with the assistance of others might be in some sense even more indicative of their mental development than what they can do alone. (p. 85)

Learning is social. Vygotsky (1994) maintained that a person "is a social creature, that without social interaction he can never develop in himself any of the attributes and characteristics which have been developed as a result of the . . . evolution of all humankind" (p. 352). The child's social relations and interactions with parents, family members, and teachers have powerful, far-reaching impacts on the child's learning abilities.

Summary of Strand 1: The Conceptual Framework: Vygotsky on Constructivist Learning as Social Interaction in the Zone of Proximal Development

The concept of the zone of proximal development has several implications for the education of young gifted students from culturally diverse and low income backgrounds. The most obvious is the implication that one's actual development at one point in time does not constrain one's future development. While this may seem to be common sense, instruction today is influenced by the demands for accountability through test results. The focus is often on the actual level of the child's learning as a measure of a district, school, and teacher's success. A shift of focus back to students' development is needed so that students are provided with the necessary room and tools to grow.

Other rich insights into student learning are gained from the concept of proximal development. Adults such as teachers, parents, coaches, and day care providers, armed with understanding of the natural instinct of children to learn from them, can develop their own repertoire of productive connections with young children. Teachers can share ideas which parents and other adults can build upon to engage in the intellectual development of children, such as reading together and exploring the properties of household food items that relate to the topics of study in school (Hedegaard, 1996).

Further consideration by educators of the processes through which children develop conscious thought, formal concepts, and subject area systems of thought can transform children's school experiences from instruction designed to lead to right answers on tests to instruction, based on explorations, designed to lead to deep understanding of subject areas. This consideration also should impel administrators and teachers to change classrooms that are deprived of stimulating materials, as documented by Ford (2003, 2007), to environments that attract students to learning and ideas through easy access to books, visuals, and models.

Strand 2: Young Gifted Learners

This section of the literature review examined the research on the young gifted child and implications for the current study. As Simonton (2008) noted, recognizing young gifted learners in order to support the development of their potential both for their own fulfillment and for the betterment of society is the basic function of gifted education programs (National Association of Gifted Children, [NAGC], 2006; Pfeiffer & Petscher, 2008). NAGC (2006) noted that young gifted children use advanced vocabulary, develop early reading skills, evidence "keen observation and curiosity, unusual retention of information, periods of intense concentration, early demonstration of talent in the arts, task commitment beyond same-age peers, and an ability to understand complex concepts, perceive relationships, and think abstractly" (p. 1). Does this also describe young low income, minority children who are gifted?

Research on Young Children

High/Scope Perry Preschool Study. The High/Scope Perry Preschool Study inspired federal and local commitment to Head Start Early Childhood Programs for culturally diverse, low income children. Begun in the 1960s by special education teachers in Ypsilanti, Michigan searching for ways to address the plight of underachievement plaguing their school district, the program model was based on Piaget's understanding of childhood development. The model emphasized the child as the primary initiator of learning with the adult as a guide to help the child plan, implement, evaluate, and reflect upon learning experiences. To ensure the provision of effective preschool experiences to young low income children, the developers studied the long-term effects of preschool attendance beginning with the 1970 Perry Preschool Study (Schweinhart, 2003; Weikart, 1978).

The Perry Preschool Study utilized random assignment of three year old and four year old African-American students from low socioeconomic backgrounds to treatment and control groups, with the treatment group attending the High/Scope Perry Preschool Program and the control group not attending preschool. The program consisted of 2.5 hours each weekday of preschool attendance, home visits for 1.5 hours a week, and parent group meetings with teachers.

A series of longitudinal studies first reported in the 1970s and since extended to include studies of the original cohort of students at age 10, 19, 27, and 40 years of age have analyzed numerous social and economic factors in the lives of the children as they grew into adulthood (Belfield, Nores, Barnett, & Schweinhart, 2005; Weikart, 1978). The benefits to participants were found to include reduction of the incidence of criminal activity, increased earnings and economic status, higher educational attainment, and, among women, higher marriage rates and lower single parenthood rates (Belfield, Nores, Barnett, & Schweinhart, 2006; Weikart, 1978). Researchers demonstrated a substantial dollar savings when the costs of the program were weighed against the benefits to society, gaining much positive attention to the program from various stakeholders (Belfied, Nores, Barnett, & Schweinhart, 2005; Schweinhart, 2003).

Other programs have developed from the model, including a High/Scope K-3 curriculum. The curriculum is described in much the same terms as the preschool program, as an "open framework of educational ideas and practices, based on the natural development of children" (Scweinhart, 1991). The program includes maintenance of daily routine and active learning experiences in mathematics, language, science, art, social studies, movement, and music. More recently, technology has also been added to the curriculum. Thinking skills training emphasizes problem solving and independent thinking. Research published by the High/Scope Educational Research Foundation indicates that a 1991 study of school achievement of three High/Scope elementary classes found statistically significant higher achievement among the High/Scope classes in comparison to the non-High/Scope classes (Schweinhart & Wallgren, 1993).

Preschool experiences and the value of direct instruction. Research on the effectiveness of educational programs for young children indicated that children who need them most have benefitted substantially and persistently from high-quality preschool and primary school experiences. In randomized, treatment-control group studies, Ramey and Ramey (1998; 2004) and others (Campbell, Pugello, Miller-Johnson, Burchinal, & Ramey, 2001; Martin, Ramey & Ramey, 1990; and Ramey et al., 2000) demonstrated the importance of direct instruction carried out by teachers who participated in on-going professional development, particularly for higher performing students. Campbell et al. (2001) found that positive differences in intellectual and academic development continued into adulthood for students enrolled in high quality programs in preschool.

Ramey and Ramey (2004) specifically described social-emotional practices that characterized environments, whether at home or in school, which supported intellectual and cognitive development in young children. They included permitting children to explore their environments, supporting the development of basic skills through practice, guiding children to advance their skills when ready, protecting children from harsh criticism and punishment, engaging in rich conversations with children, and providing guidance and limits to children's behavior. These practices contributed to the high-quality of educational interventions that were effective, in tandem with good direct teaching practices.

These findings (Belfield et al, 2006; Campbell et al., 2001; Martin et al., 1990; Ramey et al., 2000; and Schweinhart, 2003) were important because of their relationship to the need for educational interventions and other experiences to stimulate brain development in young children. Recent neurobiological advances indicate that gene activation through experiences, rather than heredity alone, stimulates brain development and therefore intellectual growth and learning (Shore, in Ramey & Ramey, 1998). Ramey and Ramey (1998) also found that low income background combined with low maternal education levels predicted lack of readiness for school. Research, therefore, supports the implementation of well-conceived educational interventions to stimulate brain development, especially for students from low income backgrounds, whose parents rely on public education and may have few outside educational options from which to choose.

Research on Young Gifted Children

Practitioners and policymakers have not grasped the importance of early identification and programs to meet the needs of young gifted children. Many states mandate gifted education programs in the elementary grades but few require services to gifted children before eight years of age (Koshy & Robinson, 2006). Reasons for this include: legitimate concern for students at the other end of the ability spectrum, hesitancy to give more to those who are seen to have much already, teacher reluctance to label young children as gifted, and lack of parental organization for political influence and action (Koshy & Robinson). Nonetheless, the provision of appropriate programs and experiences for young gifted learners, children up to the age of seven or eight, holds promise for enhancing the physical, intellectual, emotional, and social development and well-being of these children.

Recognizing giftedness. Koshy and Robinson (2006) found that suburban parents identified children with fairly high accuracy for a preschool program developed at the University of Washington in the mid-1970s. Over half of the children whose parents volunteered for a preschool gifted program attained an IQ score over 132 on a standardized ability test. Many who did not attain the high IQ score evidenced giftedness in specific domains. Louis and Lewis (1992) found that parents identified children well when they reached domain-related milestones early, as evidenced, for example, by their recognition of early reading and speaking abilities. However, parents did not recognize gifted children's unusual memory skills or advanced visual spatial reasoning abilities as readily. The asynchronous development of physical, emotional, and social skills in young gifted children also confounded parents.

To assist parents and teachers in the identification of gifted children, many practitioners and scholars have developed lists of behaviors that suggest giftedness (Davis & Rimm, 1998; Rogers, 2002; Silverman, 2000b). Koshy and Robinson (2006) provided refinements to the usual checklist format that included concise nuances of characteristics seen in young children of differing circumstances. For example, they contrasted the experiences of young children in positive environments who may welcome and enjoy challenging work, to those in less favorable circumstances, such as low socioeconomic conditions or lack of parental understanding, who tend to protect themselves by avoiding challenges that may prove too difficult. Further, the incorporation of descriptions of young children's emotional reactions to their asynchronous understanding of the environment provided a particularly helpful addition to the literature.

Language and the gifted learner. The development of language is important for all learners yet may lag behind other abilities and skills in young children who have advanced nonverbal reasoning skills. Koshy and Robinson (2006) suggested that studying young gifted children could help educators develop appropriate school experiences to address extreme developmental differences, particularly characteristic of young gifted children. Work with preschoolers by Jackson (in Koshy and Robinson) and Robinson, Dale, and Landesman (1990) demonstrated that the development of receptive language, that is, the ability to understand language, was fairly universal among gifted students but that the development of expressive language was not. Children who read early attracted the attention of parents and teachers because they did not need the same reading instruction as others. However, early reading ability did not necessarily indicate advanced verbal ability. Nor did early receptive verbal ability necessarily lead to early reading.

The value of programs for young gifted children. Observations of students in programs designed for gifted studens facilitated teachers' and scholars' understanding of the extreme differences which young gifted children experience. Children revealed their advanced and different abilities more readily when they were in classrooms with others of like ability than when they are in classrooms with students of mixed abilities. In mixed ability classrooms, gifted students may be viewed as outside the norm, and for that reason, gifted children may try to fit in and conform to the norm. In their research with young gifted students, Morelock & Morrison (1999) found that the homogenous setting benefited students who were not verbally gifted specifically because their nonverbal strength was not as evident to regular classroom teachers as verbal strength was, given the dynamics of the mixed ability classroom.

Based on just such observations of young gifted children, Morelock and Morrison (1999) developed a curriculum of differentiated science units that incorporated activities at different stages of higher level thinking. Diezman and Watters (in Koshy & Robinson, 2006) found that a ten-week science learning enrichment program led to enhanced science skills, greater independence, and increased motivation to learn. Even students who are deaf or have low verbal skills demonstrated their advanced skills in science through the doing of science, rather than through verbal expression.

Robinson et al. (1997) reported on the positive effects of a two year long Saturday Club, an educational intervention consisting of rich problem-solving experiences for young mathematically gifted children set in a socially warm community environment. Students delighted in conversations with their older intellectual peers and showed an increase in verbal skills by the end of the two-year study. Koshy and Robinson (2006) noted this same effect in action research projects in the United Kingdom (UK).

Young Gifted Learners from Culturally Diverse, Low Income Backgrounds

Seeking to gain insight into the success of a group of high achieving students of poverty, Robinson, Weinberg, Reddin, Ramey, and Ramey (1998) and Robinson, Lanzi, Weinberg, Ramey, and Ramey (2002) created a subset of data on high achieving pre-schoolers from the National Head Start/Public School Early Childhood Transition Demonstration Project (Head Start) database. The Head Start database was developed as a result of a follow–up study on the progress of former Head Start pre-schoolers. In a longitudinal study over three years, the investigators examined student achievement and attitudes toward school, parental involvement with school, teacher attitudes, and characteristics of families that affected the pre-schoolers. This material yielded a substantial amount of information about influences on the lives and progress of these students. Robinson et al. (1998) and Robinson et al. (2002) analyzed the data to undercover the strengths and fragilities of the families of high-achievers.

The original databases included achievement and socioeconomic data sets on 5,142 former Head Start students at the end of first grade and, again, on 5,400 students at the end of third grade. The researchers examined the data related to students who comprised the top 3% academically; they analyzed variables in the academic progress, and the make-up of families in these groups of high achieving students. At both analysis points, researchers found that economic factors and the degree of well-being of family caregivers played critical roles in school success and in children's satisfaction with school. The students demonstrated increasing success in achievement from year to year as measured by their performance on nationally standardized tests, the Woodcock-Johnson Tests of Achievement, Revised (WJ-R) and the Peabody Picture Vocabulary Test, Revised (PPVT-R). Their responses to questions regarding their perceptions of how well they did in school were significantly more positive than their peers. The data shed light on how this high-achieving group differed from their same-age peers.

Researchers found that family economic status distinguished the high achieving group from their less successful peers. The families of these high achieving students were slightly better off than other former-Head Start families, although in 1998, 53% of the families of high achieving students reported monthly incomes of $1,000 or less and in 2002, 64% of the group reported monthly incomes of $1,500 or less. However, the families also tended to have fewer children, fewer family challenges such as chronic illness or homelessness, and higher educational levels (Robinson et al., 1998; Robinson et al., 2002).

The impact of low income background on young gifted children. Scholars have highlighted issues faced by young gifted students who come from low socioeconomic backgrounds. Problems related to lack of financial and social resources led these students to use their substantial abilities more on survival or maintenance concerns than on development of talents or pursuit of formal education. In school, they needed scaffolding to achieve academic goals and benefit from programs. Academic support such as instructional front loading of background content before delving into formal lessons, and the social-emotional and academic support that comes from exposure to reliable, caring, and accomplished adults committed to programs represented successful interventions in programs for young gifted students (Briggs, Reis, & Sullivan, 2008; Olszewski-Kubilius, 2007; VanTassel-Baska, 2003b).

It is important to note that searching for improvement in their lives, research (VanTassel-Baska, 2003b) has found that many young gifted students of diverse backgrounds develop learning characteristics that can be built upon to shape curriculum. These students tend to view the world with openness, independence, creativity, and pragmatism. They may develop strong oral skills, though not so strong written skills, and a facility for expression of thoughts and feelings in a straightforward way. Recognition of verbal speaking abilities and provision of opportunities to use them, particularly in pursuit of challenging knowledge, gives marginalized students opportunities to express themselves in productive and important ways (Patton, 1998; VanTassel-Baska, 2003b).

The impact of minority membership on young gifted students. In a historiometric study of eminent African Americans, Simonton (2008) defined giftedness as "precocity, as gauged by accelerated expertise acquisition and performance" (p. 252-253) in a specific domain and culture. His research indicated, through the analysis of both majority culture and minority culture works, that eminent African Americans are recognized as more highly gifted when ranked by those who share their culture, than when ranked by those of the majority culture. Other researchers (Baum, 2004; Bernal, 2007; Brody & Mills, 1997; Ford, 2003, 2008; Frasier et al., 1995; Jenkins, 1936) also contributed to the understanding that diversity whether related to poverty, race, disabilities, linguistic, or cultural differences, historically has complicated the identification of young gifted children in mainstream United States society.

Summary of Strand 2: Young Gifted Learners

Parents of all socioeconomic backgrounds had difficulty recognizing young children's exceptional abilities in visual spatial reasoning and other specific types of giftedness. Circumstances that further limited parents' abilities to both recognize their children's abilities and provide needed stimulation to help them flourish included poor socioeconomic conditions and low education levels (Belfield et al., 2006; Campbell et al., 2001; Koshy & Robinson, 2006; Martin et al., 1990; Ramey & Ramey, 1998, 2004; and Ramey et al., 2000; Schweinhart, 2003; Weikart, 1978). Young gifted children, especially those who needed vital intellectual stimulation to activate their cognitive growth, benefited from preschool programs that were well-conceived, provided direct instruction, and were implemented by well-trained teachers.

Strand 3: High Quality Curriculum and Culturally Diverse Young Gifted Students

In a study of instructional practices for gifted students spanning the past 150 years, Rogers (2007) emphasized the uniqueness of every gifted child and the need for planning geared towards the individual. Confronted with the prevalence of the cluster grouping model in elementary school education, Rogers maintained that high quality curricula and materials were essential for student gains in learning. Others attested to the positive impact on teacher development that the long term use of high quality curriculum materials with professional development produced (Avery, as cited in VanTassel-Baska & Brown, 2007; Ford, 2007; Swanson, 2006).

High Quality Curriculum Characteristics

This section examines best practice learning principles synthesized from research on the science of learning by Bransford et al. (2000) of the National Research Council (NRC) and provides research-based standards on which to evaluate the quality of curriculum units. For example, examination of the instructional features and the student learning activities in the WM Life Science unit, *Budding Botanists* (BB) (Center for Gifted Education, 2007a) revealed the prevalence of the principles in the unit. Each of the learning principles is summarized below.

Recognition of students' preconceptions and misconceptions. Children learn naturally. Research indicated that infants constructed their own learning in so-called "privileged domains" that included knowledge of physical and biological concepts, number sense, an understanding of causality, and interest in language (Bransford et al., 2000, p. 81).

Learning occurs in home and community environments embedded in a wider cultural environment. In diverse, modern societies where exposure to a body of common knowledge varies according to ethnic and cultural traditions, and where teachers and students may not share a common ethnic and cultural background, teacher understanding of students' preconceived knowledge of a topic and any misconceptions students may have is critical to successful student mastery of new knowledge.

Inclusion of embedded formative and summative assessments. Effective curriculum and instruction incorporate assessment of student learning within each lesson. Formative assessment makes student thinking visible so that teachers and students recognize when understanding is strong and when it is not. Summative assessment, in contrast, measures the results of learning at the end of a unit of instruction or at other end points in instruction, such as at the end of a course.

Formative assessment should flow through lessons in a natural way so that teachers and students monitor understanding routinely (Bransford et al., 2000).

Research suggested that the design of assessments should be based on understanding the nature of students' cognitive activities; that is the degree of the complexity of content knowledge and the range of depth in process skills (Bransford et al.).

Placement of new information and knowledge into relevant conceptual frameworks. In a discussion of the differences between expert and novice differences, Bransford et al. (2000) found that experts developed recognition of meaningful patterns in their understanding of a domain. They knew how to classify problem types so that they could select a solution approach that fit the problem. They had the ability to place new information within a conceptual framework from which they could develop deep understanding and greater meaning.

Extent of flexibility to adapt curriculum and instruction to specific needs and goals. How well does the curriculum unit lend itself to adaptation to specific student needs and teacher and student goals? Does the curriculum unit address national and state standards? Can the curriculum be differentiated for students who need reading, writing, or quantitative scaffolding? Specific to this study, does the curriculum unit lend itself to enhancements that facilitate learning for students who reason well yet lack advanced verbal and quantitative skills?

Time for students to develop fluency through deliberate practice rather than time on task. Research indicated that students needed time to develop deep understanding, to practice skills over time and in different contexts, and to develop fluency. Time considerations are challenging in the presence of external pressures from federal mandates related to standardized testing and accountability. How does the curriculum unit provide time for students to practice and develop fluency? Are there extended times available for students who need more practice or who take longer to become fluent in specific skills (Bransford et al., 2000).

Development of metacognitive skills. Metacognitive skills help students analyze and revise their approaches to learning and encourage adaptation to new learning challenges and needs. Studies related to young children's abilities to plan, self-regulate, and problem solve indicated that metacognition is a natural and necessary part of the young child's cognitive repertoire (Bransford et al.). Does the curriculum unit allow enough time for metacognition in terms of individual reflection, informal discussion, and revision?

Summary of Learning Principles Reflected in Curriculum Unit

The WM BB unit (Center for Gifted Education, 2007a) was designed to guide learners to understand and apply the overarching concept of *Systems*, to use concept maps in different contexts, and to build fluency in the use of the Wheel of Scientific Investigation and Reasoning. Each lesson after Lesson One helps students organize knowledge through progressive development of these features. The unit is strongest, relative to the frequency of the other learning principles, in guiding students to organize their knowledge.

The provision in the unit of opportunities for the development of fluency in the use of new knowledge is strong but dependent on adult support in the home. On-going assessment of student learning within the classroom occurs throughout instruction. Students engage in metcognition through frequent discussion and journal writing. The instructional plans include periods during which students work in groups. This provides opportunities for teachers to differentiate instruction, as needed. Although the unit included some provisions for clarifying misconceptions, students who excel in nonverbal reasoning ability but not in verbal ability may need more attention in this area. This is an important part of the learning process, particularly in the learning of science, according to the studies of Bransford et al. (2000).

The Importance of High Quality, Research-based Curriculum

The WM science units. The WM science units are based on the ICM in which advanced content knowledge, scientific research process and products, and interdisciplinary, real world issues and themes are incorporated into units of study for elementary school students. Science units have been developed, implemented, and evaluated for Grades 2 – 8 over the past 16 years at the Center for Gifted Education of the College of William and Mary. Research results indicate significant student achievement in scientific reasoning skills for students taught through WM science units compared to students who were not taught through the units (VanTassel-Baska & Brown, 2007).

Research summary. Research and evaluation of the WM science units found evidence of significant and important student growth in scientific reasoning in students from suburban as well as urban, low income school districts (Feng, VanTassel-Baska, Quek, Bai, and O'Neill, 2005; VanTassel-Baska, 2008a; VanTassel-Baska, Bass, Reis, Poland, & Avery, 1998). Fifth grade students appeared to make significant though small gains in scientific reasoning after as little as 24 hours of instruction with the science units compared to students who were not instructed through the units (VanTassel-Baska et al, 1998). In longitudinal studies, researchers found that students made significant gains in scientific reasoning skills in grades 3, 4, and 5 using the units. The size of students' gains increased when students were exposed to the units over a period of two to three years (Feng et al., 2005).

Project Clarion units. Research on Project Clarion science units' effectiveness is particularly pertinent to this study because BB (Center for Gifted Education, 2007a) is a Project Clarion unit. Through Project Clarion, a five-year scale up project funded by the federal Jacob Javits Program, science curriculum units for gifted students in Grades K-3 were developed, piloted, revised, and implemented in Title I classes in three school districts and prepared for wider dissemination. Researchers assessed student growth using a standardized science achievement test, a test for critical thinking, and the unit performance-based assessments. The results suggested significant growth in science achievement, critical thinking skills, and in performance-based assessments of the unit's components: content mastery, scientific reasoning, and concept attainment (VanTassel-Baska, 2008a).

Project Promise results. Through another Javits Program project, Project Promise, which is geared towards the needs of low-income young students in grades PreK-3, life science, earth science, and physical science units were developed to promote early science talent development. Evaluation results indicated that students taught through the units for as little as one year outperformed students who were not taught using the units on the Grade 3 Virginia Standards of Learning (SOLs) Science test. Students exposed to the units for two to three years scored higher than those who were not exposed to the units on reading comprehension and vocabulary tests (Virginia Department of Education, n.d.).

Research-based curriculum, as developed in the WM units, is designed to offer young gifted students opportunities to work with complex and challenging content, to develop sophisticated reasoning processes, and to address contemporary issues as they learn. Their science learning activities resemble the activities of real scientists. Recursive elements of the units, such as the Wheel of Scientific Investigation and concept development activities, appear to scaffold the learning of science for young learners from all socioeconomic backgrounds and may prepare students to undertake more advanced science study in later grades. Research suggests that the effects of these units are cumulative, gaining in significance over years of exposure (Kim, VanTassel-Baska, Bracken, Feng, & Bland, under review).

Project Breakthrough

Swanson (2006) described Project Breakthrough, a demonstration project funded through the federal Jacob Javits Program. In this project, teachers in South Carolina used WM science units and other high quality materials with all students in three elementary schools with high concentrations of African American students from low income backgrounds for three years. Through the process of professional development and implementation of the units, the teaching models embedded in the units, such as Paul's Wheel of Reasoning, and the use of overarching concepts, such as *Systems* in science, teachers learned how to teach content in a way that challenged all students to improve their performance. Swanson and her team collected achievement score data and pre-post performance assessments data to measure student achievement. They conducted observations, collected data from teacher logs, and analyzed responses to teacher questionnaires and surveys to develop a picture of teacher learning.

The Project Breakthrough results indicated that students made significant gains in achievement, and teachers became more aware of their students' potential. Discoveries of talents through the use of high quality curriculum materials, such as the WM units and the Foss science kits, and the dissemination of findings from research projects paved the way not only for more equitable gifted identification but also for more stability in the provision of a needed high quality education (VanTassel-Baska, 2008c, 2008b; VanTassel-Baska et al., 2002).

High Quality Curriculum and Professional Development

The role of teacher education in the delivery of high quality science instruction continues to be an issue. A national study of curriculum effectiveness (VanTassel-Baska et al., 1998) yielded findings related to student achievement that suggested the need for increased professional development for elementary teachers of science. Teachers, although satisfied with student response to the WM units, evidenced their own need for deeper content knowledge, specific content pedagogy, and more refined ability to guide children's scientific thinking.

Longitudinal data indicated that the implementation of WM science units over three years increased students' level of achievement (VanTassel-Baska et al., 2005). Again, however, teachers indicated their need for more in-depth understanding of science content and pedagogy. Hence, in an analysis of effective curriculum models, VanTassel-Baska and Brown (2007) highlighted the importance of enlisting the support of principals and central office administrators in the provision of on-going professional development specifically linked to high quality science curriculum for young gifted students.

Summary of Strand 3: High Quality Curriculum and Culturally Diverse Young Gifted Students

High quality curriculum alone will not provide the firm educational foundation that young gifted students need to develop their talents. Effective programs for young gifted children depend upon ongoing, professional development activities for their teachers, specifically related to content and teaching models embedded in curriculum and instruction. Teachers can provide children with thoughtful and consistent guidance in the development of advanced thinking skills in content areas. Good curriculum interventions need to continue throughout the school years in order to support the academic achievement of culturally diverse, low income learners (Olszewski-Kubilius, 2007; Swanson, 2006; and VanTassel-Baska et al., 2005).

Strand 4: Reasoning Strengths as Measured by Nonverbal Tests

Because a significant portion of students of diverse cultural backgrounds score high on nonverbal tests only, understanding reasoning ability, as measured with nonverbal tests, is key to developing effective curriculum for a significant portion of young gifted students in poverty. Lohman and Hagen (2003) reported that the percentage of students taking the CogAT (2001) who scored high in nonverbal reasoning strength alone, according to ethnicity are: 11.4% (white), 17.5% (African-American), 27.4% (Hispanic), 32.0% (Asian American) and 19.6% (Native

American). In this strand, research on what nonverbal tests measure, according to three researchers who have developed nonverbal tests; understanding the strengths of high ability learners who demonstrate their ability solely on nonverbal tests; and the implications of these results for the education of these particular gifted students are presented.

Nonverbal Reasoning Strengths According to Nonverbal Test Developers

The Cognitive Abilities Test (2001). Lohman and Hagen (2003) developed the CogAT (2001) based on Snow's (1992, 1997) conception of aptitude and its role in the learning and intellectual development (for in depth consideration of Snow's work, see Corno et al., 2002). Snow (1992) espoused an understanding of the concept of aptitude rooted in early Roman writings and prevalent in Western thought until the 17th century. He characterized aptitudes as "initial states of persons that influence later development, given specified conditions," (p. 6) and conceived of aptitudes and learning as reciprocally affecting each other; of, in a sense, growing each other. According to Snow, one's aptitudes include not only propensities for certain endeavors but also personal motivation, emotional attraction, and attachment to specific interests and activities.

Availability to the learner when knowledge is needed quickly or for the short term is another aspect of an aptitude. When confronted with new material, a verbal learner or one who depends on auditory, sequential intelligence almost automatically reads directions, or mentally replays something recently heard. In contrast, the nonverbal learner who may depend on visualization and spatial learning may approach a novel situation by looking carefully at a diagram or at the object of study itself. Individual learning aptitudes add to the complexity of the instructional process (Snow, 1992).

Snow (1997) placed intelligence metaphorically above nonverbal and verbal reasoning skills. He maintained that children with high mental ability do well in school no matter how material is presented. They are able to fill in what is not directly taught and they can "infer the missing concepts, relations; or procedures to do so and learn" (p. 9).

Lohman (2005), the author of the CogAT test battery, connected results of aptitude tests with specific academic readiness and achievement. He defined aptitudes as "the degree of readiness to learn and perform well in a particular situation or domain" (p. 123). This understanding of aptitudes aligns well with the use of cognitive abilities tests to match students' strengths with educational programs (Lohman, 2002).

The Naglieri Nonverbal Abilities Test (NNAT). Naglieri (2008) confronted the contradictions of using an ability test like the CogAT to measure intelligence, arguing that the items measure what a student learned in school or in an enriched home environment. He cited the underrepresentation by some 50% to 70% of black, Hispanic, and Native American students in the nation's gifted programs as evidence of problems with traditional tests. He maintained that the Naglieri Nonverbal Abilities Test (NNAT), a group-administered nonverbal test of general ability, is a fairer test of intelligence than others because it does not require verbal or quantitative skills in order to demonstrate intelligence. Findings from research conducted by Naglieri and Ford (2003) on the effectiveness of the NNAT in identifying culturally diverse gifted students demonstrated that its use yielded similar proportions of White, Black, and Hispanic students scoring at the 95th percentile.

Naglieri (2008) asserted that, contrary to the thought of Snow (1992, 1997), Lohman (1994, 2002), and Lohman and Hagen (2003), nonverbal tests do not measure types of intelligence but, rather, measure general intelligence using nonverbal methods. Therefore, he further maintained that students identified through nonverbal testing require the fast-paced, accelerated curriculum that all gifted students need despite the fact that their communication abilities may not be commensurate with their nonverbal skills.

Universal Nonverbal Intelligence Test (UNIT). The Universal Nonverbal Intelligence Test (Bracken & McCallum, 1998) is a nonverbal test of general intelligence in which directions are provided through nonverbal communication; the items on the test are nonverbal as well. Bracken (2008) explained that the test is low in cultural content and uses common items known to all children. The developers found reductions in differences of gifted representation within various samples when they used the test to identify students for gifted programs. For example, the UNIT was used as part of a battery of tests to identify students as gifted in Project Athena, a demonstration intervention study funded by a Javits grant through the United States (US) Department of Education. The researchers found that when they used the CogAT Verbal and Nonverbal tests and the UNIT, African Americans were identified as gifted nearly in proportion to their representation in the sample (i.e., twenty-one percent were identified from a sample that was 27.5% African American) (Bracken, VanTassel-Baska, Brown, & Feng, 2007).

The Nonverbal Test Dilemma

Test developers differed regarding the usefulness of the nonverbal reasoning tests yet all of them agreed that the tests measure general intelligence (Bracken, Lohman, & Naglieri, 2008). Consideration of the contributions of each reviewed here indicated that students who scored high on nonverbal tests were gifted intellectually but their strength in academic subjects was not readily apparent (Lohman, 2005). Further, these students were big picture thinkers who were cognizant of details, though they may not have expressed themselves well in this regard (Naglieri, 2008). And, finally, they needed academic opportunities, geared to gifted students in pacing and ability levels, which addressed their strengths (Bracken et al.).

Research Related to National Talent Searches

Mathematics and nonverbal reasoning ability. Benbow and Minor (1990) compared the structure of intelligence in students identified as gifted mathematically and gifted verbally through two national talent searches. The sample of students came from the Study of Mathematically Precocious Youth (SMPY), a 1980 to 1983 national talent search that identified students who scored at least 700 on the SAT Mathematics test before the age of thirteen, and another talent search conducted by the Center for Talented Youth at John Hopkins University for students who scored at least 630 on the SAT verbal test at about age thirteen. Supplementary tests were administered to test students' primary abilities such as verbal comprehension, spatial knowledge, associative memory, perceptual speed, general reasoning, mechanical comprehension, and language usage. The Raven's Progressive Matrix/Advanced was used to measure intelligence nonverbally. The researchers found that, among the mathematically gifted, nonverbal reasoning skills were highly developed and represented fluid intelligence that students employed to see complex relationships within larger concepts. In contrast, students who were gifted verbally were found to be more proficient in verbal skills and general knowledge or crystallized knowledge generally learned formally in school. They concluded that gifted students can be very different from each other in the way they think and, therefore, they require program options to develop their talents. They particularly endorsed the development of programs to serve students who were nonverbal thinkers.

Nonverbal reasoning and interests. Gohm, Humphreys, and Yao (1998) used data from the 1960 Project Talent Data Bank to examine the top 1% of 12^{th} grade students in two ability areas. One group was high in mathematical ability and lower in spatial reasoning; the other was high in spatial reasoning and lower in mathematical ability. They found significant differences between the two groups, despite the fact that they all scored one to two standard deviations above the mean on both mathematical and spatial reasoning tests. The interests of the high spatial reasoning group included hands-on learning and reading science fiction, for example, and did not match the curriculum usually available in schools. Many of these students underperformed relative to their abilities throughout their lives, with many more of the spatially gifted learners graduating only from high school in comparison to their mathematically talented peers who graduated from college and attained advanced degrees. In addition to the loss of earning potential that this represented, the loss to society of scientific and creative talents and contributions was well recognized.

Nonverbal strengths and academic and career decisions. In a 20 year longitudinal study, Shea, Lubinski, and Benbow (2001) examined connections between students' spatial abilities and their academic and career decisions at ages 18, 23, and 33 years. Between 1976 and 1978, the participants, ages 12 to 14 years, were identified as mathematically gifted in the SMPY study and scored at least 500 on the SAT Mathematics test and 430 on the SAT Verbal test. The Differential Aptitudes Tests: Mechanical Reasoning (DAT-MR) and Space Relations (DAT-SR) were administered to measure spatial visualization abilities. In follow-up questionnaires, the researchers explored students' favorite and least favorite high school courses, selection of undergraduate majors, graduate degree majors, and careers over a 20 year span. They found that the spatial abilities measure added clarity to the understanding of students' abilities and interests. Those who had strong spatial ability relative to verbal ability tended to select engineering and computer science as careers while those with stronger verbal ability than spatial ability were more likely to select humanities careers, such as the legal profession, social science, or medical arts.

Shea et al. (2001) noted earlier research (Humphreys et al. in Shea et al., 2001) that indicated that half of the top 1% of students who are gifted in spatial ability would not be recognized in talent searches that select only the top 3% in mathematical and verbal ability. They concluded that practitioners must develop ways to identify high spatial visual students; provide needed instructional options; and offer appropriate academic and career guidance that meets these students' exceptional needs. They further argued for the addition of assessments to national talent searches that would identify students with "this critical dimension of nonverbal ideation" (p. 604).

Effects of difference. Park, Lubinski, and Benbow (2007) used data from a 25-year follow-up of the first three cohorts of the Study of Mathematically Precocious Youth (SMPY) to examine the career choices and creative contributions of students. They were able to show that the ability tilt, that is, each student's mathematics score minus the verbal score on the SAT taken by the age of 13, predicted their field of accomplishment as adults. The researchers also cited the work discussed above and supported the call for testing of spatial abilities to predict areas of success and to form the basis of differentiated programs and services for talented students.

Qualitative Research on Nonverbal Strengths

Qualitative research provided nuanced insight into the workings of creative and productive minds and offered rich details about the experience of learning and thinking (Rossman & Rallis, 2003). Root-Bernstein and Root-Bernstein (1999, 2003) conducted retrospective, qualitative research by interviewing eminent scientists, innovators, and artists who described their thinking processes during their formative years, as well as in their adult, productive years.

Conceptions of thinking differences. Investigators (Root-Bernstein & Root-Bernstein, 1999; 2003) concluded that nonverbal reasoning is actual thinking and that verbal and quantitative processes are not thinking itself, but, rather, expressions of thought. They defined nonverbal thinking as intuitive cognition and included in their conception of nonverbal thinking, human activities and sensations such as, observing, body language, gut feelings, and other physical and emotional responses as ways in which humans access the world and knowledge. They emphasized nonverbal thinking as a rich source of insight and solutions. The pre-linguistic quality and non-logical aspect make it of no less value than expressions of thought. In fact, like Sternberg (in Corno et al, 2002), they characterized verbal and quantitative expressions as tools of the thinking process, which is nonverbal.

The benefits of nonverbal thinking. The particular uniqueness of the Root-Bernstein (1989; 1999; 2002) and Root-Bernstein and Root-Bernstein (1999, 2002) work resided in their finding that nonverbal thinking was related to all the senses. Through all the senses, we learn and understand life and knowledge. Students who have high ability in nonverbal reasoning skills need opportunities to use and perfect them because they, like Einstein, a body-thinker, find them useful, or because, like Feynman who "continued the picture as the method, before the mathematics could really be done, " (Root-Bernstein, 1999, p. 5) they think best and at a high level in pictures (Isaacson, 2007).

Summary of Strand 4: Reasoning Strengths as Measured by Nonverbal Tests

The views of test developers varied on the usefulness of nonverbal tests of reasoning ability in predicting academic success and providing direction for curriculum and instruction (Bracken, 2008; Lohman, 1994, 2002; Lohman & Hagen, 2003; Naglieri, 2008). Nevertheless, nonverbal testing yielded positive results in efforts to find gifted youngsters of diverse cultural and economic backgrounds (Bracken, 2008; Naglieri, 2008; Shea et al., 2001). Given the added potential to predict strengths, these test results must be understood as an expression of an aspect of intelligence.

Longitudinal analyses of the abilities, interests, careers, creative accomplishments, and innovations of highly gifted adolescents as they matured in their adult lives provided evidence of the predictive quality of nonverbal tests. Investigators have found nonverbal tests to be valid indicators of practical, scientific, and mathematical interests and abilities (Benbow & Minor, 1990; Gohm et al., 1998; Shea et al., 2001).

Qualitative research characterized nonverbal ways of knowing as intuitive cognition accessed through all one's senses, including gut feelings and other bodily sensations (Root-Bernstein, 1989, 1999, 2002; Root-Bernstein & Root Bernstein, 1999, 2003). The experiences of highly creative people who attested to discoveries and innovations, coming to them intuitively and seemingly as a whole, contributed to the development of a series of nonverbal tools which many can use to deepen their own creative experiences.

Throughout the literature, researchers consistently concluded their studies with the observation that school instruction and curriculum must adapt to the strengths of children who are highly capable thinkers but have not mastered the communication skills needed to share their insights and knowledge.

The next strand in this literature review will examine empirical research related to the types of formal instruction and other academic supports that investigators have found to be beneficial to the intellectual progress of young students who excelled on nonverbal tests of reasoning ability.

Strand 5: Responding to Needs of Gifted Students Identified Through Nonverbal Testing

The provision of instructional programs for students who are identified gifted through nonverbal tests is not as straightforward as program planning for high performing students with mathematical or verbal ability. Investigators and practitioners have concluded that identification of gifted students through the use of nonverbal tests challenges schools to develop programs that match their unique abilities (Bittker, 1991; Clasen, 2006; Sarouphim, 1999; VanTassel-Baska, 2006; VanTassel-Baska, Feng et al., 2007; VanTassel-Baska et al., 2002). Success thus far in the area of identification of these students is heartening but the work of extending these gains to students' educational experiences remains (Clasen, 2006; VanTassel-Baska, Feng et al.). This strand examines the contributions of the research of Corno et al. (2002) and Lohman and Hagen (2003) to the development of instructional adaptations that address the learning strengths of students who evidence high nonverbal reasoning skills.

The *CogAT®, Form 6, Interpretive guide for teachers and counselors* (*Interpretive Guide*) (Lohman & Hagen, 2003) presents ways in which teachers and counselors can use the scores obtained on the nationally standardized nonverbal test to adapt instruction to the needs of students. Summarizing numerous studies over 50 years on Aptitude by Treatment Interaction (ATI), Corno et al. (2002) concluded that the most effective way to instruct is to adapt the instruction to the dominant symbol system used by the child. In this way, students would have opportunities to master specific content not through a style of learning but through reasoning in their dominant symbol system. They recommended that students use their dominant symbol system to scaffold development of their weaker systems. At the same time, the most important purpose of instruction is to build content knowledge and skill in the child's dominant symbol system. Thus, Lohman and Hagen (2003) proposed four general principles of adaptation: build on strength, focus on working memory, scaffold wisely, and emphasize strategies.

The *Interpretive Guide* (Lohman & Hagen, 2003) provided instructional suggestions for each learning abilities profile according to the student's dominant symbol system and level of ability. Acknowledging the scarcity of empirical research on instruction for students with high nonverbal reasoning skills specifically, the authors offered evidence from testing data to guide adaptations. They emphasized the importance of formal education in spatial reasoning and visual thinking skills to prepare students for higher education and creative careers in fields such as mathematics, the sciences, engineering, computer science, and the visual arts.

To build on students' strengths, adaptations for nonverbal reasoning included providing procedures and strategies for solving novel problems, using visual mental models, as well as physical models, and offering detailed illustrations of concepts, especially with primary age children. To conserve working memory which operates at near capacity in students who are weak in verbal ability, hearing speech at a moderate, rather than fast pace is important. Technology that does not permit the pausing or slowing of speech can frustrate students who need this scaffolding; whereas, small reductions in the use of working memory can create comfortable and reasonable learning environments for these students (Lohman & Hagen, 2003).

Strategies that assist learning include using analogies and metaphors particularly in science, to connect the unfamiliar to the familiar, employing drawing to complete math problems, and constructing concept maps for note taking. In the language arts, guiding reading comprehension by asking students to envision the scene, and encouraging writing by asking the child to describe a subject can assist the student in translating his considerable nonverbal insights into verbal symbol systems (Lohman & Hagen, 2003).

As such adaptations are developed, it is critical to remember that the dominant symbol system will carry the day and should be developed with the passion and intensity that goes into developing any extraordinary ability or talent. Spatial reasoning skills, visual thinking abilities, and the development of visual arts skills are essential for the full development and progress of an individual who is gifted with high nonverbal reasoning skills (Lohman & Hagen, 2003; Root-Bernstein, 1999).

Summary of Strand 5: Responding to Needs of Gifted Students Identified through Nonverbal Testing

The use of nonverbal and performance tasks has resulted in more equitable identification of gifted children of diverse cultural and economic backgrounds (Briggs et al., 2008; Lewis et al., 2007; Maker, 1998; Sarouphim, 1999; Swanson, 2006; VanTassel-Baska, Feng, et al., 2007; VanTassel-Baska et al., 2002). Young children who demonstrate high reasoning ability on nonverbal tests will respond to curriculum and instruction that adapts to their visual spatial and other nonverbal strengths. Direct instruction assists these children in constructing their own learning and in mastering the tools they will need to be successful. Capturing students' imaginations through immersion in hands-on scientific and artistic activities will enhance the development of future scientists, engineers, artists, and computer programmers (Clasen, 2006; Gohm et al., 1998; Root-Bernstein, 1989; Root-Bernstein, 2002; Root-Bernstein & Root-Bernstein, 1999; Shea et al., 2001).

Summary of the empirical studies related to developing adaptations for students with high nonverbal reasoning skills.

Table 1 outlines specific studies that formed the foundation for understanding this study and correspond to the strands of literature explored.

Table 1

Summary of Empirical Studies Related to Development of Nonverbal Reasoning Instructional Adaptations

Literature on Young Children		
Type of study	Researcher(s) and year	Major findings
Cost-benefit analysis of a randomized, treatment intervention study	Belfield, Nores, Barnett, Schweinhart, 2006	Socioeconomic benefits of high-quality one to two year preschool experience persisted through adulthood. Benefits of program in social and economic gains for individuals and for society far outweighed costs.
Randomized trial treatment design, longitudinal study of effects of early child care on cognitive development	Campbell, Pugello, Miller-Johnson, Burchinal, & Ramey, 2001	Early childhood program positively affected: cognitive and academic performance through adulthood, drop-out rates, and attendance at 4-year colleges
Randomized trial, longitudinal study of effects of day care program over 4 years	Martin, Ramey, & Ramey, 1990	Children of mentally retarded mothers developed above normal IQs when exposed to early educational experiences.

Literature on Young Children

Type of study	Researcher(s) and year	Major findings
Linear trend analysis of effects of duration of preschool intervention	Ramey, Campbell, Burchinal, Skinner, Gardner, & Ramey, (2000)	Cognitive and academic benefits were proportionate to duration of early childhood intervention, with larger effect sizes for reading gains in programs of longer duration.
Summary of studies of early intervention programs using high-quality research designs	Ramey & Ramey, 1998	Researchers identified mediating processes from literature that supported development of all children. Program quality and consistency over time affected benefits to child. High performing children benefited from direct instruction.

Literature on Young Children		
Type of study	Researcher(s) and year	Major findings
Randomized controlled interventions; replication studies	Ramey & Ramey, 2004	Participation in high-quality preschool program with direct teaching of verbal and mathematical concepts/skills led to significant increases in individual standardized ability test performance. Replication studies confirmed gains in vocabulary development, receptive language, and reasoning for 3 year olds.
Longitudinal study of effects of a randomized, treatment intervention study	Schweinhart, 2003	Treatment participants who attended one to two years of High/Scope preschool program maintained beneficial effects on educational performance, economic status, and social responsibility at the ages of 10, 15, 19, and 27.

Literature on Young Children

Type of study	Researcher(s) and year	Major findings
Treatment-Control Comparative study	Schweinhart & Wallgren, 1993	Children in classes using High/Scope K-3 Curriculum performed significantly better on achievement tests than comparison group.
Longitudinal study of effects of a randomized, treatment intervention study	Weikart, (1978)	Preschool experience had positive effect on academic aptitude/achievement; aptitude differences between treatment and control groups lessened; academic achievement differences increased over time; teacher social emotional maturity ratings of treatment group improved over time in comparison to ratings of control group; treatment students were more successful in school than comparison students

Literature on Young Gifted Learners

Type of study	Researcher(s) and year	Major findings
Comparison of results of parental questionnaire on children's IQ levels	Louis & Lewis, 1992	Parents were accurate in judgments of children's IQ levels; parental beliefs conformed to intellectual characteristics of children's actual levels of giftedness, as measured on nationally standardized tests
Descriptive comparison of implementation of model	Morrison & Morelock, 1999	Researchers' observations of gifted learners in homogeneous classes revealed wide range of asynchrony requiring individualized differentiation, especially for those with extreme asynchrony.
Treatment control correlation and longitudinal study	Robinson, Abbott, Berninger, Busse, & Mukhopadhyay, 1997	Participation in a 2 year Saturday Club for young mathematicians led to increased performance in mathematics, and higher correlation with visual spatial reasoning factors,

Literature on Young Gifted Learners

Type of study	Researcher(s) and year	Major findings
		probably resulting from exposure to advanced spatial concepts and hands-on visual spatial experiences. Verbal discussions about math problems may have contributed to higher correlation between mathematics and verbal factors.
Longitudinal study of top 3% former Head Start preschoolers	Robinson, Lanzi, Weinberg, Ramey, & Ramey, 2002	By third grade, families of high achieving former Head Start preschoolers evidenced slightly greater social and economic resources, fewer long term stressors, and a more open parental style.
Longitudinal study of top 3% of former Head Start preschoolers	Robinson, Weinberg, Reddin, Ramey, & Ramey, 1998	By first grade, families had fewer children, slightly more financial /social resources; children were socially skilled/modest about achievements.

Literature on Young Gifted Learners		
Type of study	Researcher(s) and year	Major findings
Longitudinal analyses of demographic variables; analysis of 2 year performance of students identified gifted through performance tasks on a high-stakes test	VanTassel-Baska, Feng, & Evans, 2007	Identification of gifted students through performance tasks resulted in 20% increase in underrepresented population; 72.5% of students identified through performance tasks were identified using nonverbal tasks. Researchers noted mismatch between nonverbal strengths and program options, and nonverbal strengths and high-stakes test objectives.

Nonverbal Reasoning Ability Patterns		
Type of study	Researcher(s) and year	Major findings
Comparison study of structure of intelligence of students identified as gifted mathematically with student identified as gifted verbally	Benbow & Minor, 1990	Findings indicated that two types of intelligence exist, verbal and nonverbal; students gifted in nonverbal intelligence may be less balanced in cognitive development and in need of programs to develop their talents.
Longitudinal study of students gifted in spatial ability compared to students gifted in mathematical ability	Gohm, Humphreys, & Yao, 1998	Students gifted in spatial ability underperformed in academic and career endeavors. Spatially gifted and math gifted students differed in interests, motivation, performance, and aspirations. High school guidance counselors reinforced lower aspirations. Home environments favored hands-on, practical activities over intellectual pursuits.

Nonverbal Reasoning Ability Patterns		
Type of study	Researcher(s) and year	Major findings
25 year longitudinal study of gifted students identified through SAT test in middle school	Park, Lubinski, & Benbow, 2007	Ability tilt (math SAT score minus verbal SAT score) predicted areas of accomplishments; ability level (sum of math SAT score and verbal SAT score) predicted level of accomplishment, as measured by education, career accomplishments.
A 20 year longitudinal study	Shea, Lubinski, & Benbow, 2001	Results of SAT-Math, SAT-Verbal, visual spatial tests and questionnaires completed as adults showed gifted students' spatial ability added predictive power to math and verbal scores for course, degree field, occupation choices. Researchers urged attention to visual spatial, mechanical reasoning abilities.

Importance of High Quality Curriculum		
Type of study	Researcher(s) and year	Major findings
Longitudinal assessment of performance-based tests	Feng, VanTassel-Baska, Quek, Bai, & O'Neill, 2005	Examined effects of William and Mary (WM) science units on research design skills over a six year period. Students exposed to units in Grades Three, Four, and Five showed increased gains on pre- post-assessment scores in research design by their third year of exposure.
Comparison study of individual standardized test scores before and after program implementation	Swanson, 2006	All students made significant gains over 3 years of exposure to the WM science units. Teachers had opportunities to recognize giftedness through the unit use. Teachers improved in teaching abilities by using units and by participating in curriculum unit-based professional development.

Importance of High Quality Curriculum		
Type of study	Researcher(s) and year	Major findings
Quasi-treatment design to measure effects of inquiry-based science units on student achievement and critical thinking	VanTassel-Baska, 2008a	All students showed significant gains in science achievement, critical thinking, and on unit pre-post-performance assessments. Treatment fidelity ratings indicated uneven teacher effectiveness in unit implementation.
Pre-test, Post-test control-group design with treatment and comparison groups	VanTassel-Baska, Bass, Ries, Poland & Avery, 1998	Assessed students' growth on science process skills after 20 to 36 hours of WM unit instruction. Students evidenced small but significant growth in science process skills. Researcher found teacher knowledge of science, science pedagogy, and ability to guide students' scientific thinking more critical to student success than grouping.

Importance of High Quality Curriculum		
Type of study	Researcher(s) and year	Major findings
Summary of effectiveness studies on units based on Integrated Curriculum Model (ICM)	VanTassel-Baska & Brown, 2007	Problem-based learning enhanced development of science process skills, regardless of grouping approach. Large effect sizes for growth in science skills through practice of research design over a three year period.
Treatment design with treatment and control teacher groups	VanTassel-Baska, Feng, Brown, Bracken, Stambaugh et al., 2008	With three years experience teaching WM units, teachers showed significantly higher ratings in effectiveness and use of differentiation strategies than comparison group teachers.

Nonverbal Strategies for Instruction		
Type of study	Researcher(s) and year	Major findings
Based on evidence from Aptitude by Treatment Interaction (ATI) research (Corno et al., 2002)	Lohman & Hagen, 2003	Authors recommended focus on students' developed reasoning abilities. Found student ability to reason in a specific symbol system in a domain supported advanced learning.
Overview of research on learners, learning, teachers, teaching	Bransford, Brown, & Cocking, 2000	Students come to learning with pre-conceptions that must be uncovered so learning can occur. To become competent, students must know, understand facts in conceptual framework, organize them for retrieval and application. Students will progress if they use metacognition to control, define, and monitor their learning.

Chapter 3 Methodology

This chapter includes an overview of the conceptual framework, the research design, the research questions, a description of participants, the instrumentation used in the study, the study procedures, and the data analysis techniques. It also provides additional commentary on the intervention and delineates the professional development approaches employed with the treatment and comparison teachers.

Conceptual Framework

The work of Vygotsky (1978, 1986, 1994) on cognitive development provided a conceptual framework for considering the development of academic skills, in this case scientific concept, process, and content skills, in young gifted students whose culturally diverse and low income backgrounds may have inhibited the full development of verbal and quantitative skills. As Vygotsky (1978) explained, a social constructivist perspective holds that one learns by progressing through processes which involve internal negotiation of available resources and external, social interaction.

> Our concept of development implies a rejection of the frequently held view that cognitive development results from the gradual accumulation of separate changes. We believe that child development is a complex dialectical process characterized by periodicity, unevenness in the development of different functions, metamorphosis or qualitative transformation of one form into the other, intertwining of external and internal factors, and adaptive processes that overcome impediments that the child encounters (Vygotsky, 1978, p.73).

In other words, thought development has an organic rather than linear quality. A child has to work out perceptions of reality internally; these processes result in eventual adaptation to internal and external realities, whether they are supports or impediments. Therefore, educators must recognize that students are active in their own learning. Students with high nonverbal reasoning abilities may navigate well when confronted with problems and novel situations but poorly when required to respond in a pre-determined mode (Bracken, 2008; Ford, 2008; Lohman, 2003; Lohman & Hagan, 2003; Naglieri, 2008; Root-Bernstein, 1989; Root-Bernstein & Root-Bernstein, 1999, 2003; Swanson, 2006).

Application of Concepts to Current Conditions

This study of nonverbal reasoning in the cognitive development of children from low socioeconomic backgrounds took on new meaning when viewed from a Vygotskian perspective. Scholars such as Ford (2007), Hodgkinson (2007), and Bernal (2007) highlighted the lack of literacy materials in the homes and schools of children from such backgrounds and of the vocabulary development differences between these children and their middle class peers. Poverty and the kinds of social interaction that produce learning often have an inverse relationship. Lack of material and personal resources may limit students' access to the kinds of interactions that lead to the full development of cognitive concepts and skills. Thus improving the quality of students' social, academic relationships with teachers and peers and providing high quality, research-based curriculum units to teachers may increase cognitive abilities in targeted areas of learning.

Research Design

This study was a quasi-treatment study with a pre-post design and the random assignment of teachers to treatment and comparison classrooms. Students were grouped according to criteria that honored gender and ethnic balance considerations. Initially, three teachers were randomly assigned to three comparison group classes of ten students each and three teachers to three treatment groups of ten students each. The researcher assigned the teachers using the research randomizer available at www.randomizer.org and recommended by Gall et al. (2007).

Once students were registered for the program, the program director assigned one of the treatment teachers to another grade level, leaving two treatment group teachers with eight students each and three comparison group teachers with eight students each. Attrition over the course of the six week program resulted in the participation in the study of 13 treatment group students and 10 comparison group students.

The dependent variable or outcome of the unit intervention segment of the study was students' learning gains in concept attainment, scientific investigation process skills, and science content knowledge, as measured on the unit's pre-post performance-based assessments.

Demographics and Context for the Study

The second grade student participants attended Title I elementary schools in a mid-sized urban district in southern Virginia. Eighty percent or more of the students qualify for free or reduced price lunches (VDOE, SNP, 2008). Twenty of thirty-five elementary schools in the district were 2008-2009 school year Title I schools.

District program for potentially gifted students in Title I schools. The study was conducted in the context of a six-week long Saturday Enrichment Program conducted by ABC Public Schools as a special intervention for Title I students who demonstrated high nonverbal reasoning scores and lower verbal and quantitative scores on a nationally standardized measure. The three comparison group teachers used the WM Project Clarion Life Science unit, BB (Center for Gifted Education, 2007a), and the treatment group teachers used the same unit with enhancements for students with high nonverbal reasoning skills, BB-R (Appendix A), for instruction. The unit promoted student learning in the areas of conceptual knowledge development and application, scientific investigation process skills, and science content. The treatment treatment provided enhancements specifically designed to tap into and build upon high nonverbal reasoning ability to facilitate academic growth. (See Appendix A for examples of the unit enhancements and Appendix B for a schedule of the lessons). These enhancements were designed for each lesson in the unit and constituted the basis for the study of a differentiated intervention for the treatment group.

The school-based science program. Students who participated in the Saturday enrichment program received science instruction in the regular classroom for a half hour a day or 2.5 hours a week. Teachers followed the district curriculum and adopted text, both of which were aligned with the Virginia science standards of learning (SOLs). Features of the curriculum included the SOL objectives, essential vocabulary, overarching essential understandings, essential questions, background notes on the standards, essential knowledge, skills and processes, and a resource list.

The adopted text, *Science* (Frank et al., 2002), published by Harcourt School, presented an opening unit on how scientists work and scientific investigation processes. Major topics of the curriculum during second semester included a unit scheduled after the end of the Saturday enrichment program on plant life cycle, important plant products, effect of plant availability on the development of geographic areas, and the benefits of plants in nature. Determining the academic growth of Saturday Enrichment Program treatment and comparison participants in their regular science classes, compared to the progress of students who also fit the high nonverbal CogAT learning profile but did not attend the program, provided another means of verifying the program's impact as a value-added science learning vehicle.

The assessment of the school-based program. Second grade classroom teachers administered a mid-year multiple-choice science test aligned with the district's science curriculum to all second grade students in December and at the end of the year in late May and early June. The mid-year test was a post-first semester, pre-second semester test. The end of the year test was a post-first and post-second-semester test. Individual student results were available through the district's test data system. The researcher collected and analyzed the pre- and post-test data to provide a picture of baseline science achievement and growth in core areas of the Saturday enrichment program.

Teacher roles in the study. The investigator observed the frequency and effectiveness of teacher use of differentiation strategies and key instructional models and assessed teacher fidelity of implementation of the unit. In addition, the researcher elicited the perceptions of program teachers related to the learning abilities, interests, and habits of these high nonverbal reasoning students. It was anticipated that the findings would lead to better understanding of the learning patterns and academic potential of students with this learning profile and culturally diverse, low income background and of the power of a high quality curriculum unit tailored to their strengths.

Research Questions

Four research questions, related to effective instruction for high ability students, teacher fidelity to an instructional unit as written, and teachers' perceptions of their students' cognitive development drove the study. They are presented in Table 1 after further descriptions of the instruments used to assess each of the questions, and the data analysis techniques employed.

Research Question One

To what extent did participation in a Saturday Enrichment Program contribute to academic achievement in the regular science classroom? The difference in learning gains, as evidenced on the district's December and Spring second grade science tests, between students who participated in the enrichment program and students who met the criteria for the study and did not participate, were compared.

Research Question Two

What differences occurred in student learning gains related to the understanding of an overarching concept, science investigation process skills, and science content in a Saturday Enrichment Program when one group learned through a WM Life Sciences unit and a second group learned through the same high-quality unit enhanced for students who score high on nonverbal reasoning tests? The BB (2007a) unit included pre-assessment and post-assessment instruments and scoring rubrics that measured student growth in concept attainment, scientific investigation process skills, and science content.

Research Question Three

To what extent did teachers successfully implement a prepared unit of study or the prepared unit with enhancements? The WM Classroom Observation Scale – Revised (COS-R) (VanTassel-Baska, Avery, et al., 2007) was used to record the frequency and effectiveness of teacher use of differentiation strategies and is available in Appendix F. The Treatment Fidelity form (Center for Gifted Education, 2007b) was used to record the frequency and effectiveness of teacher use of key instructional models and is available in Appendix G.

Research Question Four

What were teachers' perceptions of the learning abilities of students who performed well on nonverbal reasoning tests? The researcher conducted a focus group interview to gather information on teacher perceptions of students' motivation to learn, students interests, and student learning habits. A focus group interview is a qualitative research tool in which a small group of people interact in response to open-ended questions. The process is designed to build meaning about a topic that is of interest to the researcher. Those interviewed as a group share their views and consider the perspectives of others. The data, thus gathered, is nested in a social context through the interaction among the individual participants (Feng & Brown, 2004; Patton, 2002; Rossman & Rallis, 2003). Appendix H contains the teacher focus group interview questions.

Overview of procedures. To answer research question one, the growth in science learning as measured by the district December and Spring tests of the students who comprised the treatment and comparison groups in the study, and students with the same CogAt profile who did not participate in the study, were compared. The researcher obtained the district scores for the three groups of students and used a repeated-measures analysis of variance (ANOVA) to compare students' scores on the December and Spring district tests.

To answer research question two, the treatment and comparison groups of students were matched on the demographics of CogAT ability profiles and socioeconomic status (SES). Treatment group teachers used BB-R (Appendix A) and comparison group teachers used BB (Center for Gifted Education, 2007a) to instruct students. Student gains as measured by pre- and post-test performance assessments were analyzed to determine the extent of growth in science learning in the areas of scientific process, concept application, and content for both groups and the difference in the growth for the group exposed to the enhancements.

To answer the third research question, related to teacher fidelity to the unit, the researcher observed each teacher at the beginning, the middle, and the end of the study on two instruments. The results were analyzed to determine the frequency and effectiveness of teacher usage of differentiation strategies and key instructional models used in the unit.

To answer the fourth research question, the researcher moderated a one hour focus group interview with teachers during the week after the end of the Saturday Enrichment Program. Teachers responded to semi-structured questions related to their perceptions of teaching students with high nonverbal reasoning skills and of the students as learners. The researcher gathered the information, carried out a content analysis of the data, and reported on the major themes generated, as recommended and described by Feng & Brown (2004).

Participants. The study was conducted with a convenience sample group of 26 second grade students, drawn from the 20 Title I schools in the district based on their CogAT Learning Profile, whose parents accepted invitations for their children to attend a six week Saturday enrichment program. Twelve students comprised the comparison group, and 14 students comprised the treatment group. A centrally located Title I elementary school served as the site for the district- wide Saturday Enrichment Program.

The second grade students completed the CogAT as first graders in a district-wide screening for gifted identification. The test results are reported with nationally normed age percentile scores organized in Ability Profiles that suggest a cognitive ability pattern for each student (Lohman & Hagen, 2003). The test authors use E to identify students with a discrepancy of 24 points or more among their Standard Age Scores (SAS) on the Verbal, Quantitative and Nonverbal Batteries. The letter B indicates that one score is above the other two scores, meaning there is a one stronger score though the discrepancy is not as extreme as in an E profile. N+ indicates an extreme strength on the Nonverbal Test.

To identify potential participants for this study, the researcher first selected students with the E, N+ profile who scored at or above the 80th percentile on the Nonverbal Battery, then, included B, N+ profiles. In the district, 120 second grade students in Title I schools fit this profile. However, in order to satisfy a district requirement of four students from each Title I school, the researcher included seven students with nonverbal scores in the 75th to 79th percentiles. For two schools, students with an A profile were selected. The A profile is one where nonverbal strength is less than that of the B profile but the pattern of difference in selected students is the same. Fifteen students had a B profile, and two had an A profile. In total, the gifted education office invited 80 second grade students to participate in the Saturday Enrichment Program and anticipated that 60 students would attend.

The district and CogAT documents identified students' cultural backgrounds as Black, Asian, Hispanic, White, and Other. Table 2 shows the breakdown of qualifying students by gender and race.

Table 2

Second Grade Students Invited to Saturday Enrichment Program by Race and Ethnicity

Ethnicity	Gender		Total
	Female	Male	
Asian	1	3	4
Black	28	25	53
Hispanic	2	2	4
Other	2	5	7
White	6	6	12
Total	39	41	80

Teacher Participants

Six district teachers volunteered to teach in the Saturday Enrichment program. All the teachers were female. The group consisted of two black teachers and four white teachers. All the teachers held endorsements in gifted education in Virginia which requires 12 credit hours of gifted education college coursework. A teacher demographic survey provided information related to teachers' experience in the regular classroom, experience as teachers of gifted students, and formal education and professional backgrounds. The Teacher Participant Information Survey is available in Appendix E.

Instrumentation

To address research question one, growth in science learning in the regular classroom was measured by teacher administration of a district second grade science multiple-choice pre-test on two sets of objectives: Life Processes, Living Systems and Science Reasoning curriculum. Students were assessed in December, and again in the Spring. To address research question two, growth in scientific learning was measured with BB (Center for Gifted Education, 2007a) unit pre- and post-performance assessments. To address research question three, The COS-R (VanTassel-Baska, Avery, et al., 2007) measured the frequency and effective use of differentiation strategies and a Teacher Fidelity form reported the frequency and effective use of key instructional models in the curriculum units. To answer research question four, the moderator and the focus group protocol, as instruments, gathered data on teacher perceptions (Feng, 2004). The instruments are described below with available validity information.

District December and Spring Assessments

The district assessments consisted of seven multiple choice questions to measure student understanding of the scientific reasoning process and twelve multiple choice questions to measure student understanding of life processes and living systems. Reliability data on these tests indicated they have appropriate test reliability of .8651 as measured using the Kuder-Richardson 20 (KR 20) Formula (Department of Research, 2009). The KR 20 measures how consistently students answered questions within a test. The district senior coordinator of science education verified the content-validity of the test items.

Pre-post Performance-based Assessments

The Saturday Enrichment teachers administered the Project Clarion pre- and post-performance-based assessments of an overarching concept, scientific investigation process skills, and science content knowledge to matching treatment and comparison groups of second grade students. The instruments for pre-assessment and post-assessment required the same thought processes and presented the same format for assessing knowledge of the scientific investigation process but presented students with different research questions. Use of different research questions reduced the threat of growth gains due to prior practice on the assessment.

The internal consistency of the Project Clarion Science Units performance-based assessments for measuring growth in concept understanding is .68, for measuring growth in process skills is .75, and for measuring growth in content knowledge is .69. The inter-rater scoring reliability for the performance assessments for concept understanding is .85; for process skills is .88; and for content knowledge is .89. (VanTassel-Baska & Stambaugh, 2006).

The WM COS-R (VanTassel-Baska, Avery, et al., 2007).

The WM COS-R (VanTassel-Baska, Avery, et al., 2007) allowed the user to record and to evaluate the extent to which teachers implemented critical elements of the unit as it was written. According to VanTassel-Baska and Stambaugh (2008), the overall reliability of the observation scales is >.90 and between .65 and .89 by subscale. The content validity for the scale is high at .98.

The researcher used two parts of the COS-R. Part 1 is a teacher observation tool for the collection of general information about the students in a classroom, desk arrangements, service delivery model, lesson outline, texts and materials used, and a set of questions for a teacher interview about the lesson observed.

Part 2 of the instrument is a teacher observation tool which incorporates a scale for rating checklist items as effective, somewhat effective, ineffective, or not observed. The checklist items are grouped into categories of curriculum planning and delivery, and categories related to the differentiation of instruction for gifted learners. These areas are: accommodations for individual differences, problem solving, critical thinking strategies, creative thinking strategies, and research strategies. In total there are 25 items and a section for narrative comments. The COS-R instrument is available in Appendix F.

Treatment Fidelity Form (Center for Gifted Education, 2007b)

The Treatment Fidelity form (Center for Gifted Education, 2007b) rates teaching behaviors, related to key instructional models of the Project Clarion science units, as effective, somewhat effective, ineffective, or N/A and includes a section for comments. The tool is designed to be completed collaboratively with an observation partner after completion of observations. The Treatment Fidelity form is available in Appendix G. In this study, the investigator conducted the teacher observations and completed the COS-R and Treatment Fidelity instruments independently.

The Teacher Perception Focus Group Interview

The moderator used a focus group protocol to guide the interview. Five semi-structured questions and related probing questions comprised the focus interview questions, available in Appendix H. The questions were based on the research findings of Gohm et al. (1998) who noted significant differences in the intellectual and social interests of students with high nonverbal ability compared to high mathematical ability students. The questions also probed different ways that students learn as explicated in research exploring nonverbal reasoning and learning (Lewis et al., 2007; Pierce et al, 2007; Root-Bernstein, 1999; Samaha & De Lisi, 2000; Scott, Deuel, Jean-Francois, & Urbano, 1996; VanTassel-Baska et al., 2002). A motivation question probed student differences in the value they place on learning, as found in the studies of Bransford et al. (2000).

The semi-structured focus questions were:

1. How would you characterize your experience teaching this group of students?
2. What have you learned from this experience of teaching this group of students?
3. What did you find was most interesting to most of your students?
4. What do you think motivated your students to learn?
5. How do you think elementary school teachers can support the academic success of students with high nonverbal reasoning scores?

Procedures for the Intervention Study

Five district teachers of the gifted with endorsements in gifted education instructed 26 students arranged in five classes of eight students each for the treatment teachers and four or five students each for the comparison teachers. Each Saturday session consisted of four hours of instruction from 9:00 am to 1:00 pm on six consecutive Saturdays in early spring. The total contact time was 24 hours.

Letters to teachers explained the purpose and details of the intervention study and of the classroom observations. The Teacher Intervention Study information letter and consent form are available in Appendix I.

Letters of explanation about the study and a parental consent form for their child's participation in the study were distributed to the parents. The parent information letter and consent form are provided in Appendix J.

Another letter to teachers explained the purpose of the teacher perception focus group interview. Teachers received focus group interview information letters and they signed consent forms for focus group interview. The teacher perception focus group interview information letter and consent form are available in Appendix K.

On the first day of the program, the comparison and treatment teachers administered three unit performance-based pre-assessments to measure concept attainment, science content knowledge, and scientific process skills. At the conclusion of the unit, the teachers administered three unit performance-based post-assessments to measure growth in the same areas. The researcher scored the pre- and post-assessments, according to the unit rubrics.

Focus Group Interview Procedures

In this segment of the study, the researcher facilitated a focus group interview with four teachers of the comparison and treatment group classes. A focus group interview gave participants an opportunity to share their perceptions with each other in a safe environment. Conduct of a focus group on teachers' perceptions of learning, motivation, and interests of students who scored high on a nonverbal test drew attention to the importance of the issue and of the role of the teacher in adapting instruction for these students.

The researcher followed procedures for conducting the focus group interview recommended by Feng & Brown (2004) who conducted gifted program evaluation with the Center for Gifted Education at The College of William and Mary. First, the researcher/moderator asked the teacher/participants to write their responses to five semi-structured questions. Then, the moderator facilitated a discussion of each question and managed the interaction so all had a chance to respond equally. The moderator processed the discussion and asked for clarifications when thoughts or opinions expressed seemed unclear. The researcher/moderator also probed new related themes, and re-directed the discussion when participants raised themes or issues unrelated to the focus questions. The researcher/moderator recorded the major points of the discussion on a flip chart. This provided an immediate check of understanding of the teachers' perceptions and discussion. Teachers' written responses to questions and the flip chart notes comprised the qualitative data. The content of the data was analyzed to discern the dominant themes.

The researcher submitted the required proposal for permission to conduct research with human subjects to the College of William and Mary Institutional Review Board (IRB) and submitted the proposal for review and approval to the Department of Research, ABC Public Schools.

Description of the Curriculum Unit Intervention

Overview

The intervention consisted of instruction on six Saturdays using the eleven lessons of BB, a Project Clarion unit developed, piloted, and evaluated by the Center for Gifted Education at The College of William and Mary (2007a), for the comparison group. An enhanced unit, BB-R (Appendix A), based on student learning abilities profiles and on research related to teaching students with high abilities in nonverbal reasoning was used with the treatment group (Bransford, Brown, & Cocking, 2000; Corno et al., 2002; Lohman & Hagen, 2003; Root-Bernstein, 1999 & VanTassel-Baska et al., 2002).

A Jacob K. Javits Program grant funded Project Clarion units which were designed to provide high-quality instruction to disadvantaged students using teaching models and strategies found to be effective with gifted students. Research has shown that all groups benefit from science instruction when the units are implemented faithfully and when scaffolding and differentiation are provided (Swanson, 2006; VanTassel-Baska & Brown, 2007).

The core science curriculum intervention

Teachers of a Saturday Enrichment Program implemented the BB-R (Appendix A) and BB (Center for Gifted Education, 2007a) units with the treatment and comparison groups. Examples of four BB-R lessons with enhancements for the treatment group are presented in Appendix A. They were designed to meet the following criteria:

1. Make students' thinking visible and external to themselves (Bransford, et al., 2000);
2. Use students' natural strengths and interests in hands-on, creative activities (Gohm et al., 1998; Root-Bernstein & Root-Bernstein, 1999);
3. Use enhancements that support frequent visual thinking, spatial reasoning, nonverbal symbol systems (Lohman & Hagen, 2003);
4. Emphasize vocabulary development, background knowledge, and language use through probing of pre-conceptions and misconceptions (Bransford, et al., 2000; Lohman & Hagen, 2003).
5. Provide affective support to relieve undue burden experienced by high ability students with weak verbal and mathematical skills (Lohman & Hagen, 2003; VanTassel-Baska, 2003b).

Activities such as using metaphors and analogies, directing students to write descriptive paragraphs rather than narrative, conducting discussions after hands-on activities, and creating detailed diagrams are examples of the activities recommended by the CogAT authors (Lohman & Hagen, 2003) for the extreme high nonverbal learning profile student.

A graphic organizer summarizes the development of the intervention study. The research literature base and how it relates to the intervention enhancements and focus group questions are explicated in the chart found in Appendix D.

Professional Development

The professionl development plan. The professional development plan for the treatment group teachers and the comparison group teachers encompassed three separate training sessions. Each group attended two (2) two-hour professional development sessions with a one-hour follow-up session during the program (See Appendix C for an outline of the professional development plan).

The professional development sessions for both groups incorporated learning related to the curriculum features as they applied to the lessons of the unit. The treatment group teachers practiced the features using the lessons enhanced to include visual thinking models, spatial reasoning, and nonverbal symbol systems.

Incentives for participation. The gifted education office of the school district paid teachers for professional development participation. Teachers received the BB unit and other materials specified in the unit, including all charts and student materials. The researcher provided small tokens related to botany and plants throughout the program as well as snacks and drinks for the teachers during the professional development sessions.

Data Collection

District Assessments

ABC Public Schools recorded the second grade science assessment results on a district database made available to the researcher. The researcher collected the pertinent curriculum objective question results from the December and Spring test administrations, transformed all scores to percentages, and created a record of the treatment group results, the comparison group results, and the results for the invited students who did not participate in the study.

Pre-post Performance-based Assessments

The teachers of the treatment and comparison groups administered the pre- and post-performance-based assessments on the overarching concept, the scientific investigation process, and the science content. The researcher evaluated the assessments according to the unit's rubrics.

Observation Forms

The researcher observed each teacher three times during the study. Since the program ran for six Saturdays and five teachers were involved, the researcher observed two to three teachers each Saturday, using the COS-R (VanTassel-Baska, Avery, et al., 2007; Appendix F) and the Treatment Fidelity (Center for Gifted Education, 2007b; Appendix G) form.

The Teacher Perception Focus Group Interview

Focus interview questions guided the teacher focus group discussion. The teacher focus group questions can be found in Appendix H.

As recommended by Feng and Brown (2004), first, teachers recorded their responses to the focus group interview questions on note cards, and then, the major points of the focus group discussion were recorded on a flip chart (See Appendix H for the teacher focus group questions. The flip chart notes and the participants' written responses comprised the data from the interview. The researcher analyzed the data and identified themes by using the majority rule practice in which a perception or point is considered a theme if 50% of the group mentions it. Reporting on the themes includes elaboration of the theme and examples from the interview.

The use of the flip chart and note cards for the written responses supported the integrity of the findings since participants could correct mistaken notes immediately and they provided their responses in writing, as well. The reliability of conclusions was enhanced by careful analysis of the notes and teachers' written responses.

Data Analysis Procedures

District Assessments

A repeated-measures analysis of variance (ANOVA) of the December and Spring second grade science assessments for the treatment, comparison, and non-participant students indicated whether there were gains in scientific process and scientific content learning in the regular classroom. The assessments measured the growth in learning during the same semester in which the Saturday program occurred.

Pre- and Post-Performance-based Assessments

A repeated-measures ANOVA for the pre- and post-performance-based assessments of the treatment and comparison groups indicated whether the gains of the treatment group were significantly different from the gains of the comparison group (Gall et al., 2007).

COS-R

The COS-R (VanTassel-Baska, Avery, et al., 2007; Appendix F) provided data on teacher frequency and effectiveness of differentiation strategies use. The researcher applied descriptive statistical analysis and conducted a t-test analysis of mean of means scores of treatment and comparison teacher effectiveness over three classroom observations.

Treatment Fidelity Form

The Treatment Fidelity form (Center for Gifted Education, 2007b; Appendix G) was used to record the frequency and effectiveness of teacher use of the key instructional models. The researcher applied descriptive statistical analysis, conducted a t-test analysis of mean of means scores of treatment and comparison teacher effectiveness over three classroom observations, and conducted a Pearson correlation on the effectiveness means for differentiation strategies use and key instructional models use.

The Teacher Perception Focus Group Interview

The researcher conducted a content analysis of the focus group data, examining teachers' demographic characteristics collected on a teacher participant information survey and considering relevant connections with the collected data. Themes were derived from the focus group results, using appropriate coding schema (Miles and Huberman, 1994; Creswell, 2005). (See Appendix E for the Teacher Particpant Information Survey).

Table 3 provides the summary of the research questions, instrumentation, and data analysis techniques for the study.

Table 3

Alignment of Research Questions, Research Instruments and Type of Data Analysis

Research Questions	Research Instruments	Data Analysis
Question One: To what extent did participation in a Saturday enrichment program contribute to academic achievement in the regular science classroom?	District designed pre- and post-assessments for curriculum objectives related to scientific reasoning and life processes and systems related to plants	Repeated-measures analysis of variance
Question Two: What differences occur in student learning gains related to understanding of an overarching concept, science investigations process skills, and science content in a Saturday Enrichment Program when one group learns through a William and Mary Life Sciences unit and another group learns through a William and Mary Life Sciences unit enhanced for students who score high on nonverbal reasoning tests?	Pre-post Assessments for Overarching Concept, Scientific Investigation Process, and Science Content, (2^{nd}-3^{rd} Grades), *Budding Botanists at Work*	Repeated-measures analysis of variance

Question Three: How well do teachers implement a prepared unit of study and modifications to the unit?	The William and Mary Classroom Observation Scales Revised, Treatment Fidelity form	Descriptive statistical analysis and interpretation, Independent samples analysis of variance, Pearson correlation
Question Four: What are teachers' perceptions of the learning abilities of students who perform well on nonverbal reasoning tests?	Teacher Participant Information Survey, Teacher Focus Group Interview Questions	Content analysis, coding, and thematic interpretation

Time Frame for the Study

October, 2008 – Drafted first three chapters of the study: Educational related literature; literature review; and methodology

November and December, 2008 – Continued revision of first three chapters; designed nonverbal reasoning enhancement for the intervention unit of instruction

January, 2009 – Prepared focus group protocol

February, 2009 – Gained approval of dissertation proposal, university IRB approval, and school district research approval

February 21, 2009 – Began intervention unit, including pre-assessment of comparison and treatment group; began treatment fidelity observations

March, 2009 – Continued treatment fidelity observations; concluded intervention unit on fourth Saturday, March 28, 2009

June, 2009 – Completed data analysis and compilation of descriptive and statistical results, findings, and implications

Late June, 2009 – Completed revisions of Chapters 4 and 5, based on Chair's feedback

Late June, 2009 – Submitted dissertation to committee for review

July 9, 2009 – Oral defense of dissertation completed

Confidentiality and Other Ethical Considerations

Because this study involved primary age children, confidentiality and protection of children was an important obligation. The investigator obtained informed consent of students' parents or primary caretakers in order for students to participate in the study and explained the project to the parents in an accompanying explanatory letter (See Appendix J). As Gall et al. (2007) recommended, the investigator followed sound research procedures and did not expose students to risk. The units, BB (Center for Gifted Education, 2007a) and BB-R (Appendix A), posed no known risk to students. Students learned safety procedures in the beginning of the unit however they did not handle hazardous materials or instruments. Students' growth through the unit of instruction remained confidential and was shared only with the students' parents or primary caretakers and the students' regular classroom teacher, at the end of the study. Sharing this information with students' regular classroom teachers should benefit students since teachers then may provide more effective instruction to these students, given their academic growth through participation in this unit of instruction.

The investigator informed the study treatment and comparison teachers that participation in the teacher demographic survey (Appendix E) and the teacher focus group interview (Appendix H) was voluntary and that they could cease participating at any time. The interview was conducted in private and the teachers' responses were confidential. The responses were not shared with supervisors or school administration personnel, such as principals and assistant principals.

The investigator coded the observation results so that the teachers' names are not attached to them. Further, no one other than the investigator had access to the raw data. Assurance was given to participating teachers in writing that none of the observation material gathered or the information it yielded about individual teachers would be shared with teachers' supervisors or school administration personnel, such as principals and assistant principals.

Chapter 4 Results

This study was conducted to determine whether or not instructional strategies developed to build on students' nonverbal reasoning strengths could be incorporated into a high-quality, gifted education curriculum unit such as BB (Center for Gifted Education, 2007a) and enhance the success of students with high nonverbal reasoning scores with the unit, as well as students' achievement with science curriculum in regular classes. Numerous researchers who have studied nonverbal intelligence among gifted students have called for incorporation of such enhancements into educational offerings for these students. This study proposed an example of such a targeted curriculum, BB-R (Appendix A), and examined the results of its implementation which are presented here.

One interesting result reported in this chapter involves the school district's second grade science assessment given before and after the second semester which evaluated student learning of science objectives related to the study. A repeated-measures analysis of variance (ANOVA) was employed to determine learning growth and significance. The results of an ANOVA of gains derived from the use of BB (Center for Gifted Education, 2007a) and BB-R (Appendix A) also are reported. These results address the question of whether students who score high in nonverbal reasoning on a national standardized test learn better when instructional enhancements that draw on their nonverbal reasoning strength are implemented. In addition, descriptive statistics, that is frequency and effectiveness means, and the results of *t-test* analyses are reported for observations of treatment and comparison teacher behaviors using the COS-R (VanTassel-Baska, Avery, et al., 2007; Appendix

F) and the Treatment Fidelity (Center for Gifted Education, 2007b; Appendix G) form. These results provided indications of teachers' fidelity to BB and BB-R and they also provided a measure of teachers' effectiveness and frequency of use of differentiation strategies and key instructional models. Finally, focus group data are analyzed and presented in narrative form to share teachers' understanding of effective teaching strategies with this group of students.

Overview of the Setting and Participants

The researcher conducted the intervention study during the district's gifted education Saturday Enrichment Program. The program provided science enrichment opportunities for second grade students from low socioeconomic backgrounds across six sessions.

Twenty-six students participated in the study. The researcher subsequently found that two students were included who did not match the criteria and one student who did not take all the pre- and post- assessments. These three were deleted from the study results, leaving a total of 23 participants. The population sample was divided fairly evenly by gender with 12 boys and 11 girls. The boys were divided evenly between the treatment and comparison groups; however, there were seven girls in the treatment group and only four girls in the comparison group. The size of the groups differed also, with 13 students in the treatment group and 10 in the comparison group. The student population was ethnically diverse.

Five teachers were assigned randomly to the treatment and comparison groups. Initially, six teachers were assigned, however one was reassigned to another grade level due to low registration numbers at the second grade level. This led to the creation of two treatment classes and three comparison classes.

As reported on the teacher participant information survey (Appendix E), both teachers of the treatment classes had more than 15 years of teaching experience. One of the treatment teachers was an elementary gifted resource teacher and the other was an elementary classroom teacher. The three comparison group teachers had varying levels of teaching experience. One, an elementary school gifted resource teacher, had more than 15 years teaching experience; another, also an elementary school gifted resource teacher, had 5 to 10 years experience, and the last, an elementary school classroom teacher, had less than 5 years experience.

All the teachers were endorsed in gifted education and had received training through university courses prior to participating in the study. The teachers, all females, represented diverse ethnic groups, with one Black teacher, three White teachers, and one who identified herself as Other.

Research Question One

Research question one asked: To what extent did participation in a Saturday Enrichment Program contribute to academic achievement in the regular science classroom?

Analysis of District Results

To answer question one, the researcher analyzed test results from the school district's second grade science pre- and post-assessments administered by classroom teachers in December and in late May and June. The assessment results were grouped by scientific reasoning objectives and life processes and living systems objectives. The objectives addressed the second grade science Virginia Standards of Learning (SOLs) (Virginia Department of Education, 2003) objectives cited in BB.

A repeated-measures analysis of variance (ANOVA) was conducted to determine if there were differences in achievement on two sets of district science objectives among the treatment group, the comparison group, and students with strong nonverbal reasoning skills who were invited but did not attend the Saturday Enrichment Program. For the life processes/living systems objectives, all three groups made learning gains over time, $F_{1, 96} = 35.897, p < .001$. The results also demonstrated gains for all three groups in the science reasoning objectives, $F_{1, 96} = 5.855, p = < .05$. Table 4 presents the data related to these results.

Table 4

Analysis of Variance Results for District Assessments

Source	Measure	*df*	*SS*	*MS*	*F*	η^2
			Between subjects			
Program	Life	2	1569.55	784.776	.741	.015
Status	Processes/Living Systems					
	Science Reasoning	2	2159.90	1079.95	1.244	.025
			Within Subjects			
Time	Life	1	11949.252	11949.252	35.897**	.272
	Processes/Living Systems					
	Science Reasoning	1	2442.61	2442.61	5.855*	.057

Note. η^2 = partial eta squared; partial effect size.

*p = < .05 **p = < .001

Differences among Treatment, Comparison, and Non-participant Groups on District Assessments

Further examination of the mean differences on the district assessment among the three groups showed that the students who participated in the Saturday Enrichment Program achieved more growth in the life processes/living systems objectives than the group of students who did not participate in the program. The scores of the treatment group increased from M = 41.03 in December to M = 67.31 in late Spring; the scores of the comparison group increased from $M = 51.67$ to $M = 76.67$; and the scores of the non-participants increased from $M = 46.93$ to $M = 63.05$.

Although the results between groups were not found to be statistically significant, the increases in mean scores of the participating students show that 24 hours of additional high-quality science instruction positively affected academic achievement in the regular classroom, with the treatment group gaining slightly more than the comparison group on the life processes/living systems objectives. The treatment group's growth was interesting in that the group scored the lowest initially and gained the most in content learning on the district assessments by the end of the year. There were no other significant findings. Table 5 illustrates the increases in mean scores by group and measure.

Table 5

Mean Differences in Gains on Grade Two Science Life Processes, Living Systems Objectives Assessments by Group and Measure

Objective Measure	Pre-test		Post-test		Difference
	M	*SD*	*M*	*SD*	M_D
	Treatment Group				
Life Processes, Living Systems	41.03	22.43	67.31	19.97	26.28
	Comparison Group				
Life Processes, Living Systems	51.67	28.81	76.67	23.83	25.00
	Non-participant Group				
Life Processes, Living Systems	46.93	25.67	63.05	28.46	16.41

Persistence of Saturday Enrichment Benefit

Two months elapsed between the end of the enrichment program and the administration of the Spring district assessment, suggesting that benefit from participation in the Saturday Enrichment Program persisted over the two month time lapse.

Research Question Two

Research question two asks: What differences occurred in student learning gains related to understanding of an overarching concept, science investigation process skills, and science content in a Saturday Enrichment Program when one group learned through a WM Life Sciences unit and a second group learned through the same high-quality unit enhanced for students who score high on nonverbal reasoning tests? To answer the research question, program teachers administered the unit pre-assessments for concept attainment, scientific reasoning process skills, and science content prior to teaching the unit and they administered the post-assessments for concept attainment, scientific reasoning process skills, and science content at the conclusion of the unit.

The researcher scored the pre- and post-assessments according to unit rubrics. When needed, a program teacher collaborated in the scoring of assessments; inter-rater reliability was high at approximately .90 and the researcher and teacher reached consensus on questionable responses.

The researcher obtained descriptive statistics and conducted a repeated measures analysis of variance (ANOVA) on the pre- and post-assessments data to determine if significant growth occurred in student learning for the treatment and comparison groups.

Concept Attainment

The students in the treatment and comparison groups learned to apply the overarching concept of systems to various science topics, such as seeds and plants, as well as to topics of their own choosing. With BB-R unit enhancements (Appendix A) to build on nonverbal reasoning strength, the treatment group concept attainment scores increased from a mean of 13.92 (SD = 3.121) to a mean of 19.46 (SD = .967). The smaller standard deviation in the post-assessment results suggested that more uniform learning occurred in concept attainment within the treatment group than in any other category of assessment or within the comparison group.

Comparison group learning increased from a mean of 11.30 (*SD* = 3.121) on the pre-assessment to a mean of 16.40 (*SD* = 3.836) on the post-assessment.

Results from the repeated-measures ANOVA indicated significant differences in learning over time in concept attainment, $F_{(1, 21)} = 49.73, p < .001$. Analysis of treatment effects indicated that the treatment group had statistically significant higher posttest mean scores than the comparison group, $F_{(1, 21)} = 5.647, p < .05$.

Scientific Investigation Reasoning Skills

Students learned to reason like scientists through learning experiences in BB (Center for Gifted Education, 2007a) and BB-R (Appendix A). An analysis of the descriptive statistics displayed initial pre-assessment differences between the scores of the treatment group and the comparison group; therefore, a univariate analysis of covariance (ANCOVA) was conducted to determine if the pre-assessment scores were a significant covariate, affecting the post-assessment scores. Results indicated that initial differences in mean pre-assessment scores were not significant, $F_{(1, 20\ corrected)} = .977, p = .335$. The treatment over the six Saturdays from pre-assessment to post-assessment did not result in statistically significant growth overall for either group. However, the treatment group had significantly higher post-assessment scores than the comparison group in scientific reasoning, $F_{(1, 21)} = 13.289, p < .01$. Treatment group scores increased from a mean of 10.08 (*SD* = 1.754) on the pre-assessment to a mean of 11.31 (*SD* = 2.213) on the post-assessment. Comparison group scores increased from a mean of 7.60 (*SD* = 3.534) to a mean of 8.30 (*SD* = 3.057).

Content Knowledge

All students learned science content through hands-on activities such as dissecting seeds and organizing knowledge with Need to Know charts and concept maps. Students in the treatment group were prompted to visualize as they listened to auditory descriptions and to incorporate descriptions into their writing rather than explanations. They learned to use scientific symbols for system features and to conclude their science reports. Students were encouraged to engage in informal discussions with their peers and teachers about experiments in class and their findings both at home and in class.

In content learning, a repeated-measures ANOVA indicated that significant content learning occurred for the treatment and comparison groups, $F_{(1, 21)} = 6.417$, $p < .05$. A further examination of the effects of the treatment and time interaction indicated that the treatment group made significant gains over time relative to the comparison group, $F_{(1, 21)} = 5.669$, $p < .05$. The interaction between time and treatment is illustrated in Figure 1.

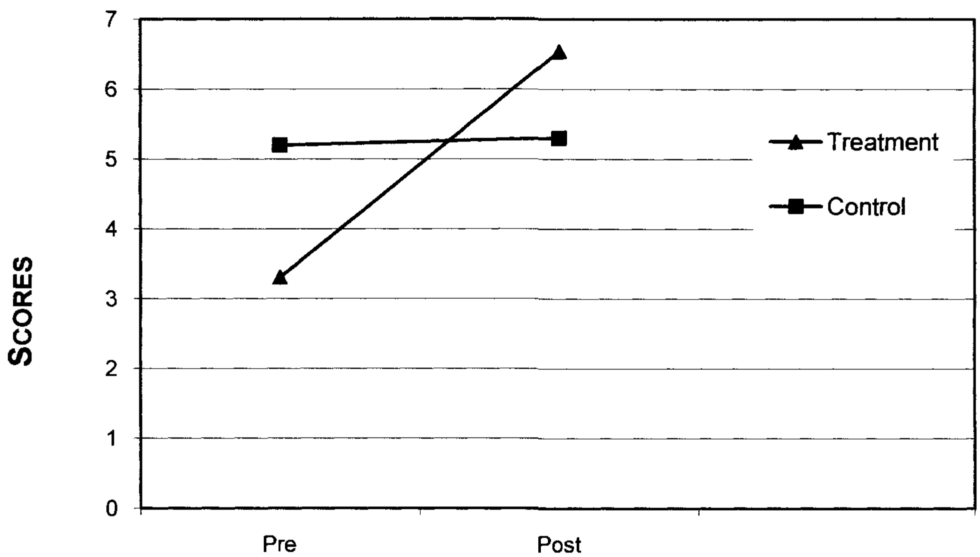

Figure 1. Time and treatment interaction showing scores for treatment group and comparison group on pre-assessment and post-assessment of unit content learning.

Effect Size Findings

Effect sizes of pre- post-assessment of concept attainment, scientific reasoning, and content gains over time. Effect sizes were calculated for each of the findings using Cohen's *d* to measure growth in terms of standard deviation units. This measure provides an indication of the practical significance of statistical findings and allows one to determine how much growth in standard terms occurred due to the effects of a treatment (Cohen, 1990; Gravetter & Wallnau, 2008).

For the treatment group, Cohen's *d* indicated that the use of BB-R (Appendix A) resulted in a large effect on student gains in concept attainment, and a large effect on student gains in content knowledge, $d = 2.72$ and $d = 1.50$, respectively. The effect size of the gains for scientific reasoning indicate a medium to large effect of the treatment ($d = .62$).

For the comparison group, Cohen's *d* shows a large effect of the use of BB for concept attainment, $d = 1.17$. Cohen's *d* shows a small effect size for the gains in scientific reasoning, $d = .21$ and for growth in content learning in content learning, $d = .03$.

Effect sizes of gains of the treatment over the comparison groups. Effect size calculations suggested a large additional effect of the BB-R (Appendix A) treatment on the scores of the treatment group compared to the comparison group for concept learning and scientific reasoning, $d = 1.28$ and $d = 1.14$ respectively. In content learning, the BB-R treatment added value, with a small to medium effect, $d = .45$.

Table 6 provides descriptive statistics for pre- and post-assessments of concept attainment, scientific investigation skills, and content mastery for the treatment and comparison groups. Table 7 summarizes the findings of the repeated-measures ANOVA for concept attainment, scientific investigation skills, and content mastery for the treatment and comparison groups.

Table 6

Descriptive Statistics for Unit Pre- Post- Assessment Differences

	M	*SD*	*M*	*SD*	$d_{pre-post}$	d_{groups}
			Treatment Group			
Concept	13.92	3.121	19.46	.967	2.72	1.28
Reasoning	10.08	1.754	11.31	2.213	.62	1.14
Content	3.31	2.136	6.54	2.184	1.50	.45
			Comparison Group			
Concept	11.30	4.877	16.40	3.836	1.17	---
Reasoning	7.60	3.534	8.30	3.057	.21	---
Content	5.20	2.936	5.30	3.302	.03	---

Table 7

Repeated-measures Analysis of Variance Results for Concepts, Scientific Reasoning, and Content

Source	Measure	*df*	*SS*	*MS*	*F*	η^2
			Between subjects			
treatment	Concept	1	91.325	91.325	5.647*	.212
	Reasoning	1	94.818	94.818	13.289**	.388
	Content	1	1.208	1.208	.137	.006
			Within subjects			
time	Concept	1	319.848	319.848	49.730**	.703
	Reasoning	1	11.045	11.045	2.393	.102
	Content	1	31.353	31.353	6.417*	.234
time x treatment	Concept	1	.543	.543	.084	.004
	Reasoning	1	.088	.088	.019	.001
	Content	1	27.701	27.701	5.669*	.213

Note. η^2 = partial eta squared; partial effect size.

*$p < .05$ **$p < .01$

Research Question Three

Classroom Observations and Fidelity of Treatment

Research question three asked: To what extent did teachers successfully implement a prepared unit of study or the prepared unit with enhancements? To answer this question, two areas of teaching behaviors were examined: the use of differentiated strategies as recorded through observations on the COS-R (VanTassel-Baska, Avery, et al., 2007; See Appendix F) and the implementation of key instructional models of the unit as recorded on the Treatment Fidelity form (Center for Gifted Education, 2007b; See Appendix G).

Use of the COS-R Instrument

The COS-R is organized into six sub-scales of categories of teacher behaviors found in the research to support educational reform and differentiation of instruction for the gifted (VanTassel-Baska, Quek, & Feng, 2007; Appendix F). The categories each include three to five items. The first sub-scale in the category of curriculum planning and delivery (CPD) rates teacher behaviors related to educational reform practices such as, setting expectations for high student achievement. The remaining categories: accommodations for individual differences (AID), problem solving (PS), critical thinking strategies (CRI), creative thinking strategies (CRE), and research strategies (RS), reflect research-based best practices in differentiating instruction for gifted students (VanTassel-Baska, Quek, & Feng, 2007). Teaching behaviors are rated on a Likert scale indicating 1 = ineffective, 2 = somewhat effective, and 3 = effective.

To obtain frequency counts of each teacher's use of differentiation strategies, teaching behaviors identified in each category of the COS-R (VanTassel-Baska, Avery, et al., 2007; Appendix F) were observed and tallied for three observations of each teacher.

To obtain the effectiveness mean for each differentiation strategy category, effectiveness ratings of each teacher's observed teaching behaviors in three separate observations were averaged. A mean of the treatment teachers' averages and a mean of the comparison teachers' averages were obtained and compared, using an independent samples *t*-test analysis.

Results of Analysis of COS-R (VanTassel-Baska, Avery, et al., 2007; Appendix F)

Findings

Frequency of teaching behaviors related to differentiation strategy categories of COS-R. The data indicated CPD was utilized with the highest frequency by the treatment and comparison teachers (N = 15, 13 for treatment teachers, N = 15, 13, 15 for comparison teachers). Analysis of the employment of differentiation strategies by category and teacher indicated that treatment teachers employed CRE (N = 12 each), CRI (N = 11, 10), and AID (N = 12, 10) with the highest frequency. The categories of strategies used with the lowest frequency by the treatment teachers appeared to be RS (N = 1, 4) and PS (N = 6, 8).

Among the comparison teachers, utilization of AID (N = 11, 12, 12) and CRI (N = 11, 12, 8) were reported with the highest frequency. The category of strategies used with the lowest frequency by the comparison teachers appeared to be RS (N = 2, 2, 5) and PS (N = 8, 5, 7). Table 8 presents the data related to observed teaching behaviors by COS-R categories and by teachers.

Table 8

Frequency Count of Differentiation Strategies Teaching Behaviors Observed in Three Observations as Reported on the Classroom Observation Scale – Revised (COS-R) Sub-scales for Each Teacher

	Treatment		Comparison		
Category	A	B	C	D	E
Curriculum Planning and Delivery	15	13	15	13	15
Accommodations for Individual Differences	12	10	11	12	12
Problem Solving	6	8	8	5	7
Critical Thinking Strategies	11	10	11	12	8
Creative Thinking Strategies	12	12	9	11	8
Research Strategies	4	1	2	2	5
Frequency Totals	60	54	56	55	55

Effectiveness of teacher behaviors related to the use of differentiation strategies. Observation data recorded on the COS-R rated the effectiveness of treatment and comparison teachers' use of differentiated strategies in their implementation of the BB-R (Appendix A) and BB (Center for Gifted Education, 2007a) units of instruction.

Treatment teachers appeared to employ CPD ($M = 2.57$) with the highest effectiveness. Among the categories of differentiation strategies, the treatment group teachers employed AID ($M = 2.54$) and CRE ($M = 2.50$) with the highest effectiveness. The lowest effectiveness means were found in RS ($M = .43$).

Comparison teachers appeared to employ CPD (*M* = 2.56) with the highest effectiveness also. Among the categories of differentiation strategies, they used AID (*M* = 2.50) with the highest effectiveness. They appeared to employ RS (*M* = .44) with the lowest effectiveness.

Differences between the treatment and comparison teachers related to effective use of differentiation strategies.

An independent samples *t*-test analysis yielded no statistically significant differences between the teaching behaviors of the treatment and comparison teachers in the use of differentiation strategies. Further examination of the mean scores indicated higher effectiveness ratings for the treatment teachers in CRE use compared to the comparison teachers (*M* = 2.50 and *M* = 1.92, respectively).

Table 9 presents the findings of an independent samples *t*-test analysis, as well as descriptive statistics related to the COS-R ratings, for the treatment teachers and comparison teachers.

Table 9.

t-Test Analysis of Means of COS-R Category Scores Averaged from Treatment and Comparison Teachers' Individual Effectiveness Means over Three Classroom Observations of Each Teacher

	Treatment			Comparison			
Category	*N*	Mean	*SD*	*N*	Mean	*SD*	*t*
CPD	6	2.57	.57	9	2.56	.70	.032
AID	6	2.54	.49	9	2.50	.57	.146
PS	6	2.00	.92	9	1.74	1.10	.477
CRI	6	2.29	.68	9	2.14	.71	.416
CRE	6	2.50	.42	9	1.92	.99	1.349
RS	6	.43	.51	9	.44	.31	-.053
Effectiveness Mean		2.06	.38		1.88	.52	.669

Results of Observations of Treatment Fidelity in Implementation of Key Instructional Models

Use of the Treatment Fidelity (Center for Gifted Education, 2007b; Appendix G) form. The Treatment Fidelity form consists of a list of eight teaching behaviors which reflect the key instructional models and strategies used in the WM life science units. The teaching models and strategies are recursive within and among the WM curriculum units. They are integral to the Integrated Curriculum Model (ICM) in that they promote the learning of advanced content knowledge of subject disciplines, the development of higher-order critical and creative thinking processes and products, and the application of knowledge to contemporary issues and interdisciplinary themes through real-world experiences (VanTassel-Baska,1986, 2003a). Unit implementation is rated by the observer on a Likert scale in which 3 = effective, 2 = somewhat effective, and 1 = not effective. If use of a model or strategy is not observed, N/A is checked.

To obtain the frequency count of each teacher's implementation of key instructional models, teaching behaviors related to each instructional model were observed and tallied for three observations of each teacher.

To obtain the effectiveness mean for each key instructional model, effectiveness ratings of each teacher's observed teaching behaviors in three separate observations were averaged. A mean of the treatment teachers' averages and a mean of the comparison teachers' averages were obtained and compared using an independent samples *t*-test analysis.

Frequency of use of key instructional models. An examination of the frequency of implementation of key instructional models indicated that the treatment teachers evidenced high frequency use of the following instructional models: "structured questions for scientific inquiry, " "engaged students in journal writing," "enhanced oral communication," and "emphasized relevant concepts, themes, or ideas in instruction and/or activities," ($N = 3$ for both teachers in models cited). The treatment teachers appeared to show the lowest frequency use of "instructed students in the 'Need to Know' board," ($N = 1$ for both teachers).

The comparison teachers evidenced the highest frequency use of "enhanced oral communication" and "emphasized relevant concepts, themes, or ideas in instruction and/or activities," (N = 3 for all teachers in models cited). The lowest frequency uses were recorded for "emphasized 'systems' in instruction and/or activities," (N = 1 for teacher C and D, N = 2 for teacher E). Table 10 presents the data related to frequency use of key instructional models.

Table 10. *Frequency Count of Implementation of Key Instructional Models Observed in Three Observations as Reported on the Treatment Fidelity Form by Teacher*

	Treatment				
Comparison					
Key Instructional Model	A	B	C	D	E
Emphasized "systems" in instruction and/or activities	2	2	1	1	2
Referred to problem statement/scenario in discussion and/or activities	2	1	2	1	3
Instructed students in "Need to Know" board	1	1	2	0	1
Structured questions for science inquiry	3	3	3	2	3
Engaged students in journal writing	3	3	2	1	0
Engaged students in treatment design	3	1	2	3	2
Enhanced oral communication	3	3	3	3	3
Emphasized relevant concepts, themes, or ideas in instruction and/or activities	3	3	3	3	3
Frequency totals	20	17	18	14	17

Effectiveness means of treatment fidelity scores. For treatment teachers, the researcher reported the highest effectiveness means in the implementation of instructional models related to "structured questions for scientific inquiry," (M = 3.00), "engaged students in journal writing," (M = 3.00), and "emphasized relevant concepts, themes, or ideas in instruction and/or activities," (M = 3.00). The lowest effectiveness means for the treatment teachers were reported for "instructed students in the 'Need to Know' board," (M = 1.00) and "referred to problem statement/scenario in discussion and/or activities," (M = 1.50).

Among the comparison teachers, the highest effectiveness means were found in "emphasized relevant concepts, themes, or ideas in instruction and/or activities," (M = 2.78). The researcher reported the lowest effectiveness means in "engaged students in journal writing," (M = .78) and in "emphasized 'systems' in instruction," (M = .89).

An independent samples t-test analysis yielded no significant differences in the effectiveness means for key instructional strategies between the treatment and comparison teachers. Table 11 presents the data on effectiveness of implementation of key instructional models.

Table 11

Mean of Treatment Fidelity Scores of Treatment and Comparison Teachers' Individual Effectiveness Means for Implementation of Key Instructional Models over Three Classroom Observations

	Treatment			Comparison			
Key Instructional Model	N	*M*	*SD*	N	*M*	*SD*	*t*
Emphasized "systems" in instruction and/or activities	2	2.00	.00	3	.89	.51	2.931
Referred to problem statement/scenario in discussion and/or activities	2	1.50	.70	3	1.55	1.07	-.060
Instructed students in "Need to Know" board	2	1.00	.00	3	1.00	1.00	.000
Structured questions for science inquiry	2	3.00	.00	3	2.11	.70	1.714
Engaged students in journal writing	2	3.00	.00	3	.78	1.07	2.782
Engaged students in treatment design	2	2.00	1.41	3	1.89	.51	.135
Enhanced oral communication	2	2.66	.47	3	2.44	.20	.766
Emphasized relevant concepts, themes, or ideas in instruction and/or activities	2	3.00	.00	3	2.78	.39	.775
Effectiveness Mean		2.27	.21		1.68	.51	1.517

The Relationship between Effective Use of Key Instructional Models and Effective Use of Differentiation Strategies

Analysis of the relationship between teacher effectiveness of use of differentiation strategies and teacher effectiveness of implementation of key instructional models was undertaken to gain further insight into teachers' abilities to implement successfully the BB (Center for Gifted Education, 2007a) and BB-R (Appendix A) instructional units. A bivariate correlation was conducted to examine the relationship between treatment fidelity ratings and COS-R scores for the treatment and comparison group teachers as a whole and for the treatment and comparison group teachers separately.

A Pearson correlation was selected to examine the relationship between teacher effectiveness in the use of key instructional models and teacher effectiveness in the use of differentiation strategies, both of which are considered essential to strong instruction for gifted learners. Correlations can be used to test the reliability of separate ratings, to verify theory regarding relationships, or to predict one behavior from the strength of another. To clearly understand the relationship, Gravetter and Wallau (2008) recommend squaring the coefficient to produce r^2, a coefficient of determination, which indicates the degree of variability in one score which can be predicted from another (Gravetter & Wallnau, 2008).

Using the data from observations and ratings of all the teachers instructional behaviors, a correlation of COS-R (VanTassel-Baska, Avery, et al., 2007; Appendix F) and Treatment Fidelity (Center for Gifted Education, 2007b; Appendix G) scores yielded a significant Pearson's product-moment correlation coefficient of .677, $p =$

.006, and r^2 = .46. Thus, one may predict teacher effectiveness from the relationship of the scores with 46% accuracy.

A correlation of COS-R (VanTassel-Baska, Avery, et al., 2007; Appendix F) and Treatment Fidelity (Center for Gifted Education, 2007b; Appendix G) scores for the comparison group teachers yielded a significant Pearson's product-moment correlation coefficient of .698, p = .036, and r^2 = .49. One may predict teacher effectiveness from the relationship of the scores with 49% accuracy. For the treatment group teachers, a correlation of treatment fidelity and COS-R scores yielded a statistically insignificant Pearson's product-moment correlation coefficient of .657. Table 12 presents data related to the correlation between the treatment fidelity ratings and the COS-R scores.

Table 12

Correlation between the Effectiveness Means for Use of Differentiation Strategies, as on the COS-R, and the Effectiveness Means for Implementation of Key Instructional Models, as on the Treatment Fidelity Form

	Rating on the COS-R		
	All Teachers	Treatment Group Teachers	Comparison Group Teachers
Treatment Fidelity	.677**	.657	.698*

*p < .05. **p < .01.

Research Question Four

Research question four asked: What were teachers' perceptions of the learning abilities of students who performed well on nonverbal reasoning tests?

Focus Group Interview Findings

To explore this question and share their views, four of the five teachers of both the treatment and comparison groups met for one hour to reflect upon and discuss responses to structured interview questions which the researcher-moderator presented to them (See Appendix H for the teacher focus group questions). One teacher was unable to join the group due to other commitments. In order to conduct the interview within the week following the end of the enrichment program, the researcher decided to proceed without the full complement of teachers.

The focus group interview took place in a comfortable, informal setting in an elementary school parent center. The researcher provided refreshments as an incentive for teachers to participate in the interview after the school day. The teachers were enthusiastic about sharing their insights and experiences and participated willingly, despite obvious fatigue on the part of one teacher, in particular.

Data Collection and Analysis

Several steps led to the creation of meaning from the data collected. The structured focus group interview questions guide served as the descriptive analytical framework for analysis as recommended by Patton (2002) (Appendix H). Using the method outlined in Feng and Brown (2004), the researcher transcribed the original data collected in flip chart notes and participants' notecard responses. As distinct issues and topics emerged, the transcription was coded by content and, then, re-organized according to categories. Attention to recurring words and phrases contributed to the process. Use of the majority rule determined if more than half the teachers concurred in their conclusions. If so, the conclusions were included in the discussion of the interview findings. The patterns and themes that emerged as a result of the analytical processes of transcription, counting recurring words and phrases, content coding, and applying the majority rule are described below for each interview question (Feng and Brown, 2004; Patton, 2002; Schwandt, 2001).

Description of Teacher Participants

Two treatment teachers and two comparison teachers participated in the focus group interview. Each selected their own pseudonym to protect their identity. The teacher-selected pseudonyms were: Ms. Intense Thinker, Ms. Smith, Ms. Crystal, and Mrs. Outofthebox. The teacher who did not participate in the focus group was included as "Non-participant." The pseudonyms, classes, and years of teacher experience are described in Table 13.

Table 13

Teacher Selected Pseudonyms and Teaching Experience

Treatment Teachers	Teaching Experience	Comparison Teachers	Teaching Experience
Ms. Outofthebox	>15 years	Ms. Intense Thinker	>15 years
Ms. Crystal	>15 years	Mrs. Smith	<5 years
		Non-participant	5-10 years

Focus Group Question One Analysis

Focus group question one. In response to focus group question one: "How would you characterize your experience teaching this group of students?" and the sub-questions: "What was different or unusual about teaching and learning with this population?" and "What particular teaching or coaching skills did you use with this group?" teachers concurred on several key points. The following themes emerged: the importance of raising student confidence, the power of emotional, social, and intellectual scaffolding to increase students' comfort level in the classroom setting, and the effectiveness of incorporating students' love of movement and talking into instructional strategies and activities.

Importance of raising student confidence. Teachers perceived that their students needed extra encouragement and praise to build their emotional confidence. Initially, the students were quiet and reluctant to share. The group concurred, however, that with encouragement, the students were willing to try. Ms. Intense

Thinker pointed out that she "used a great deal of encouragement and this seemed to help" her students. Likewise, Mrs. Outofthebox noted that "most were very willing to try when encouraged verbally." Both treatment and comparison teachers highlighted this student need.

Intellectual scaffolding. In addition to emotional confidence from teachers' provision of personal encouragement and praise, teachers reported that students also gained intellectual confidence from exposure to formal scientific concepts and engagement in conscious thought about them. Teachers found that students talked more freely about the subject matter once they learned the features of the "systems" concept, as presented in the BB (Center for Gifted Educaiton, 2007a) and BB-R (Appendix A) units. The majority of the teachers noted that students' verbal interactions increased after they had gained confidence in their ability to reason about scientific concepts.

Social and emotional scaffolding from peers. The treatment teachers reported that another source of students' increased confidence came from their association with each other. The focus group data suggested that a major commonality among the students was a dislike for and reluctance to use writing to communicate their ideas. Ms. Crystal noted that "the students seemed to feed off of each other. They knew their peers didn't know what to write so that provided a comfort zone for them." Both treatment teachers reported that students' experience of "fitting in (Ms. Crystal)" with each other increased their social confidence. As their emotional, social, and intellectual confidence increased, the teachers perceived that the students' comfort level in the classroom grew as well.

Students' love of movement and talking. All the teachers mentioned the students' love of movement and talking. Ms. Smith reported that the use of a "small group worked well with them because they were active and talkative." The treatment teachers reported that the students liked to act and pantomime and that such opportunities for movement focused students' attention on connecting their love of activity with learning formal knowledge. As Ms. Crystal conveyed, these students seemed "more energetic and more talkative" than most gifted students that she had taught and "using movement helped a great deal" to focus their energy on science learning.

Focus Group Question Two Analysis

Focus group question two. Teachers were asked to consider the following question and two sub-questions: "What have you learned from the experience of teaching this group of students? How did students learn from you? How did the students learn from each other?" They reported that students learned particularly well from reality-based, hands on activities, from engagement with the BB (Center for Gifted Education, 2007a) and BB-R (Appendix A) fictional character, Professor Blackwell, who provided routine updates to the students on a real-world problem, and from exposure to advanced curriculum. In addition, the teachers of the treatment group reported that the students learned from discussions with each other.

Learning from reality-based, hands-on activities. Teachers maintained that conducting plant experiments in order to solve a real-world problem built students' knowledge base and led them to think more abstractly. The teachers described the transformation of students' thinking from the concrete to the abstract as they worked through the treatment process. They found that students were able to generalize their learning about experiments, for example, and use their learning again in creating experiments at home. Ms. Smith posited that she "learned that having students do experiments really improved their knowledge."

Learning in the context of a real world problem. The unit-long connection with Professor Blackwell captured students' interest and attention. "They really looked forward to Professor Blackwell's journals. They thought they were going to be famous. It was very motivating" (Ms. Smith).

Learning from advanced curriculum. As the unit unfolded, teachers realized that the students were capable of handling curriculum that they at first thought might be too advanced for them. "I learned that students are capable of learning complex ideas and are able to make connections if exposed to advanced curriculum." (Ms. Intense Thinker) "I didn't think the students could do this but I found out they could," noted Ms. Crystal in a discussion about the ability of the students to distinguish among plant cells they viewed on slides through a microscope.

Learning from each other. Treatment teachers noticed that their students functioned differently from other gifted students they had taught. "Students weren't threatened by other students as usually happens with gifted students." (Ms. Crystal) "They were kind to each other and encouraged each other, even regarding their behavior." (Mrs. Outofthebox) "Students learned from each other. They built their knowledge and self-confidence from discussing with each other and building on each others' ideas. They were not competitive." (Mrs. Outofthebox)

The teachers' responses to focus group question two reflected upon what students learned from BB unit activities (Center for Gifted Education, 2007a) such as plant and seed experiments, Professor Blackwell's journal entries, and BB-R enhancements (Appendix A) such as, increased opportunities for discussions with each other. The teachers focused primarily on ways in which students learned content through the curriculum unit. Efforts on the part of the researcher/moderator to elicit examples of personally developed teaching practices related to how students with high nonverbal reasoning abilities learn were not productive.

Focus Group Question Three Analysis

Focus group question three. Focus group question three asked teachers to consider the following: "What did you find was most interesting to most of your students? Which activities easily engaged students' attention and effort? Which activities did students talk about with you? With each other?" Three themes emerged from the analysis of teachers' responses. The immediate emphasis was on students' enjoyment and success with graphic organizers. Yet teachers provided the most information about students' high interest in hands-on activities. Finally, the treatment group teachers noted that the students engaged in scientific conversations with each other. All the teachers reported that students engaged them in discussions about how their experiments were progressing at home and about their progress as scientists and students in the Saturday Enrichment Program. Students also engaged their teachers in conversations about Professor Blackwell and the college.

Interest in graphic organizers. A key point noted by the teachers was that graphic organizers supported the development of student knowledge. They provided a springboard for high level thinking and discussions about concepts. Ms. Intense Thinker noted that:

> Students enjoyed discussing the graphic organizers (i.e., the Wheel of Scientific Investigation and Reasoning, the Need to Know chart, and the Systems Model). At first, they didn't know what to write in the graphic organizer but after awhile, they gained confidence and enjoyed them.

Ms. Outofthebox added, "The students really did well with the concept maps. Teachers should start using them sooner with students. Young students can learn from the use of concept maps." Ms. Smith thought the Wheel of Scientific Investigation and Reasoning was particularly effective and commented that she thought the students would "remember the Wheel of Scientific Investigation through their school years." And, finally, Ms. Crystal concluded that students "used the graphic organizers and concept maps to make the concept connections."

Interest in hands-on activities. Teachers noted high interest among the students for hands-on activities. "The hands-on aspect engaged the students the most" (Ms. Intense Thinker). Comparison and treatment teachers mentioned a myriad of activities from the unit which included using microscopes, working with specimens, creating and taking care of personal greenhouses, and conducting experiments. Treatment teachers noted the interest students had in the BB-R unit activities (Appendix A) such as observing terrariums from various perspectives, and acting out the Wheel of Scientific Reasoning. They thought the activities build on the students' natural penchant for learning nonverbally through visual spatial reasoning as well as physical activity and problem solving.

All the teachers reported that the students connected hands-on learning with real learning. The students also expressed satisfaction in learning at an advanced level and engaging in scientific activities that represented professional scientific endeavors. Teachers noted that students' reasoning improved with their engagement in the activities. Ms. Crystal summarized:

> Their reasoning was way above what you would expect from second graders and they reasoned because they were handling the plants and dissecting and looking through the microscopes. They loved the experiment with the plants and used hypotheses in their answers that demonstrated that they actually understood what a hypothesis is. For example, one student offered, 'In my hypothesis, I knew my plants would not grow well in sand and soil.'

Another teacher noted: "They loved the greenhouses and the quick growth, change, conducting observations; they drew conclusions." (Mrs. Outofthebox)

Differences between treatment and comparison students in involvement in scientific conversations with peers. Treatment group teachers reported that the students talked with each other about their scientific observations and the application of scientific concepts. They engaged each other in productive, focused discussions based on their findings from their observations. "They really called on each other to look at their specimen and described what they saw, using specific scientific vocabulary and saying things like, 'No, that is the nucleus, the brain – that is the biggest part'" (Ms. Crystal). "Students talked well together and made high level connections . . . they built upon each other's ideas" (Mrs. Outofthebox).

In contrast, the comparison group teachers found that the students worked independently more than cooperatively. Mrs. Intense Thinker remarked that, "They didn't always share ideas with one another when working as a team, though. Most of the time, they simply worked independently and recorded their data. I had to encourage the exchange of ideas among members."

Interest in conversations with teachers. In conversations with their teachers however, the students in both treatment and comparison groups discussed the progress of the seedlings and plants they were caring for at home. Ms. Crystal reported that "they thought they were really doing and thinking more than they usually do." They looked to teachers for more information about Professor Blackwell. "Every week," according to Ms. Smith, "they asked if there was another journal entry from Professor Blackwell. They wanted to find out as much about him and William and Mary as possible." They seemed to regard the teacher as a resource and sounding board rather than the keeper of the right answers.

In sum, the interview response data to question three indicated that teachers found students had a strong interest in the use of graphic organizers, in the conduct of scientific explorations and experiments, and in the case of the treatment students, in participating in discussions with the teachers and with each other. Teachers reported that the students also were interested in the tools of scientific research and most engaged when they were observing, making connections, recording data, and, in the case of the treatment group students, discussing their findings with each other.

Focus Group Question Four Analysis

Focus group question four. Teachers responded to the following: "What do you think motivated your students to learn? Were they interested in grades? Helping others? Leading a group? What were your students' attitudes towards learning when it was difficult?" Their responses revealed several themes, two of which have been noted in other responses. Hands-on activities again were identified as important and, in the context of this question, as motivating students to learn. They also reported that students were motivated to work together as a team; they enjoyed playing the role of experts; and they were interested in the content.

Team motivation. The students enjoyed working as a team. In the discussion about the importance to these students of belonging to a team, Ms. Outofthebox said that "a few were sullen the first day but they bonded and became a team of scientists." Ms. Smith noted that when the work was difficult "if another student said it was easy, then they would think more about it and they would get it."

Roles of experts and motivation. The students enjoyed showing their intelligence by taking on the roles of experts. They shared their journals with their parents, wore lab coats in class, and had opportunities "to share how smart they are" (Mrs. Outofthebox). "Taking on the role of the expert captured their attention" (Ms. Intense Thinker).

Intellectual motivation. Each teacher noted that students were interested in the topic of plant life and biofuels. Ms. Intense Thinker reported that "they were highly engaged and interested in the unit. The experience of proving a hypothesis stimulated their interest." Mrs. Outofthebox also noted that students loved "the hands-on activities, and were motivated by interest" in the topic of plant life.

Focus Group Question Five Analysis

Focus group question five. "How do you think elementary school teachers can support the academic success of students with high nonverbal reasoning scores?" Responses to this question yielded six major suggestions related to the value of real world problems, graphic organizers, higher level thinking questions, scaffolding, visual aids for students with high nonverbal reasoning skills, and the need to create time for students to respond and assimilate learning.

Relate instruction to the real world. Teachers reported that students built knowledge of content and concepts and developed high level thinking about the content by grappling with real-world problems, open-ended scenarios, and real-world experiences. Ms. Intense Thinker suggested that "many open-ended scenarios should guide the teachers' planning and instruction. Offer more open-ended activities that have no right or wrong answer. Allow students to show you the process, to show their thinking." Ms. Smith further noted that "these students should be given opportunities to learn through real-life scenarios." Ms. Crystal found that "repetition in the use of concepts where they can make the connections in a real-world setting" increased students' abilities to apply knowledge.

Support mental and intellectual reasoning through visual organizational tools. Both treatment and comparison teachers found that students benefitted from visual organizers. They reported that students saw the value of organizing their thinking and gained confidence, according to the teachers, in their ability to organize knowledge over time through the repeated use of graphic organizers, such as the Wheel of Scientific Investigation and the diagram for the concept of Systems. Ms. Intense Thinker suggested that "elementary school teachers can support students with high nonverbal skills in their learning/academic growth by presenting a variety of graphic organizers." Ms. Crystal further stated that teachers should "use more graphic organizers that help students with organizational skills."

Use higher level questioning to probe students' thinking. Teachers found that there were multiple benefits in using higher level questioning with the students. They routinely responded to students' observations with open-ended questions that challenged students to think more deeply and with more complexity. For example, students created greenhouses using plastic bags, paper towels, and seeds one Saturday and took them home to observe for the week. When students returned the following Saturday with their personal greenhouses, some of them noted odors and the presence of mold. Ms. Crystal scaffolded students' discovery of the reasons for the odor by asking students why they thought the odor occurred and leading students to think about the conditions within the plastic bag greenhouses. Other open-ended questions such as "Do scientists always agree?" (Mrs.Outofthebox) and "How can we find out?" (Mrs. Outofthebox) in response to a student's question about how plants protect themselves gave students permission to think for themselves. "What if?" questions such as, "What if you don't know what to do next?" (Ms. Smith) further challenged students to consider novel situations and to problem solve.

Teachers' thought the incorporation of higher level questioning uncovered students' deeper thinking, stimulated discussions, and prepared students to write about their ideas. The group suggested that teachers should "use high level questions and re-phrase them to get at students' deeper thinking." One teacher said: "Present the question in an interesting manner that actively engages these students" (Ms. Crystal). Another further explained the value of extended discussions to students' academic growth and advised teachers to "pose questions related to topics and have students practice sharing verbally before they write" (Mrs. Outofthebox).

Provide visual scaffolding for the acquisition of verbal fluency in speaking and writing. Teachers thought that visual scaffolding worked. This finding emerged from observations of student change that the treatment teachers shared in the discussion of this question. "The discussion and the symbols and the graphic organizers led to their writing more" (Ms. Outofthebox). "They were not using pictures as much in the end" (Ms. Outofthebox). Ms. Crystal advised teachers to "use the concrete picture or symbol to lead students to the abstract knowledge."

The value of time. In the discussion of recommended instructional strategies for high nonverbal reasoning students, the issue of time wove through the treatment teachers' ideas. They thought that strategies that were effective required a sense of open time and that student development and learning warranted the time spent. In discussing the use of real-world problems, Ms. Crystal recommended that teachers "have a problem that allows the students to work through it in a hands-on manner." Mrs. Outofthebox counseled, "Present big ideas and allow students time to discuss and make the connections." Also, she advised, "Allow time for movement, song, pantomime."

Teachers also noted the effects of the use of strategies over time. They remarked that, during the last two weeks of the Saturday Enrichment Program, students became more confident in their use of graphic organizers for organizing in-depth knowledge about plant life. They reported that students did not rely on the use of symbols and pictures instead of writing by the end of the program, and instead wrote more. Thus, the provision of time for students to work with content and strategies appeared to be a critical aspect of successful implementation.

Summary of Findings

Research Question #1

To what extent did participation in a Saturday Enrichment Program contribute to academic achievement in the regular science classroom?

1) The treatment group, the comparison group, and the group of invited students who did not participate in the Saturday Enrichment Program, showed gains between the pre- and post-assessments on the district second grade science tests. Students with high nonverbal reasoning skills who attended the Saturday Enrichment Program made greater gains from December to Spring on the life processes, living systems district assessment objectives related to the BB (Center for Gifted Education, 2007a) and BB-R (Appendix A) units than students with high nonverbal reasoning skills who did not attend the program;

2) On the December district pre-assessment, students in the treatment group initially had the lowest scores on the district assessment objectives related to the BB-R units (Appendix A) and subsequently made the greatest gains on the Spring district post-assessment and had the least variation in scores;

3) The treatment and comparison students' gains appeared to persist over the two month lapse between the end of the Saturday Enrichment Program and the Spring district assessment.

Research Question #2

What differences occurred in student learning gains related to understanding an overarching concept, science investigation process skills, and science content in a Saturday Enrichment Program when one group learned through a WM Life Sciences unit (BB, Center for Gifted Education, 2007a) and a second group learned through the same high-quality unit enhanced for students who score high on nonverbal reasoning tests (BB-R, Appendix A)?

1) Both treatment and comparison students showed a statistically significant increase ($p < .001$) in their level of concept attainment with only 24 hours of instruction based on the curriculum unit;

2) The treatment group students' mean concept attainment scores were significantly higher ($p < .05$) than the comparison group students' mean scores;

3) Treatment students had significantly higher ($p < .01$) post-assessment scores than the comparison group in scientific investigation process skills, although the data did not indicate statistically significant growth for either group overall;

4) Both treatment and comparison students' knowledge of content material significantly increased ($p < .05$) from exposure to the curriculum units;

5) The treatment group showed significantly more ($p < .05$) content knowledge learning over time on the post-assessments than comparison students who were not exposed to the enhanced strategies;

6) Treatment group use of BB-R enhancements (Appendix A) yielded a large effect on student gains in concept attainment and content knowledge (*d* = 2.72 and 1.50 respectively) and a medium effect on scientific investigation skills (*d* = .62). Comparison group learning with BB (Center for Gifted Education, 2007a) yielded a large effect for concept attainment (*d* = 1.17).

Research Question #3

To what extent did teachers successfully implement a prepared unit of study and enhancements to the unit?

1) As measured on the COS-R (VanTassel-Baska, Avery, et al., 2007; Appendix F), treatment and comparison teachers differed in their frequency of use of differentiation strategies only in their use of CRE, favoring treatment teachers. Both groups of teachers evidenced low frequency use of PS and RS.

2) There were no significant differences between the treatment and comparison teachers in the effectiveness means of teacher use of differentiation strategies.

3) As measured on the Treatment Fidelity form (Center for Gifted Education, 2007b; Appendix G), frequency totals indicated that treatment teachers employed key instructional models more than comparison teachers.

4) Although the differences between effectiveness means for use of key instructional models were not found to be statistically significant, the treatment teachers evidenced high effectiveness means in the use of four key instructional models, "structuring questions for scientific inquiry," "engaging students in journal writing," and "emphasizing relevant concepts, themes, or ideas in instruction and/or

activities." The control teachers evidenced a high effectiveness mean in the use of only one instructional model, "emphasizing relevant concepts, themes, or ideas in instruction and/or activities."

5) A significant Pearson correlation was found between the effectiveness means for use of differentiation strategies and for implementation of key instructional strategies for the group as a whole, ($p < .01$).

Research Question #4

What were teachers' perceptions of the learning abilities of students who performed well on nonverbal reasoning tests?

1) In response to focus group interview questions (Appendix H), treatment and comparison teachers reported their observations that students with high nonverbal reasoning skills needed teacher encouragement to succeed in the classroom;

2) In the treatment group classes, through extensive discussion, as called for in BB-R (Appendix A), students got to know their peers quickly, and engaged with them in scientific conversations related to graphic organizers and experiments;

3) All teachers reported that hands-on activities, like using a microscope or magnifying glass, as included in the BB (Center for Gifted Education, 2007a) and BB-R units, and movement activities, like creating a pantomime of the Scientific Wheel of Reasoning, as included in the BB-R unit, led students to advance in their thinking by generalizing from the concrete to the abstract;

4) Treatment teachers seemed to value characteristics of high nonverbal reasoning ability students such as a love of movement and discussion and found that

students learned when the movement and discussion were incorporated into instruction.

5) Treatment and comparison teachers recommended the increased use of concept maps in the primary grades. They also recommended higher level questioning strategies to uncover students' thinking, to stimulate discussion, and to prepare students for writing about scientific topics. Treatment teachers also recommended more use of visualization, visual mental models, and symbols to scaffold acquisition and expression of knowledge.

6) Treatment and comparison teachers recommended consistent use of key instructional models over time so that students would have opportunities to master their use of models such as the Scientific Wheel of Investigation and would be able to apply their skill to other science units.

Chapter 5 Discussion, Conclusion and Implications

In this chapter, a discussion of the findings of the study in relation to the relevant research literature is presented. The discussion includes a consideration of the potential added value of enhanced instructional strategies for learners with high nonverbal reasoning skills, and the importance of professional development in the provision of gifted education to students in the gifted cluster model currently used for the provision of services in ABC Public Schools. Following this, the conclusion of the study and a summary of possible implications for instructional practice and program planning practice are provided. A brief consideration of future research related to the findings of the study concludes this chapter.

Relationship of the Research Literature to Study Findings

Research on young gifted children, high quality curriculum, culturally diverse young gifted children, reasoning strengths as measured by nonverbal tests, and responses to the needs of gifted students identified through nonverbal testing informed the development of this intervention study and the instructional enhancements of BB-R (Appendix A). Relevant research is now discussed in relation to the study findings.

Intervention Effects

The core intervention of this study, BB-R (Appendix A) incorporated strategies through which classroom teachers also could provide instruction to support the academic progress of students with high nonverbal reasoning skills. In this study, students were recognized as possessing high nonverbal reasoning skills through their performance on the CogAT. Their gains in this study support the crafting of instructional enhancements to match the cognitive strength of this particular group of students in academic subjects. Instructional provision for this group of gifted students from culturally diverse, low income backgrounds, who show their intelligence in myriad ways, appears to be possible and effective.

Students' immersion into scientific study during a Saturday Enrichment Program appeared to benefit students' science achievement in the regular classroom over the following two month period. As noted in the literature (Olszewski-Kubilius, 2007), after school, Saturday, and summer programs for gifted low income students provide needed scaffolding for these students. Likewise, the provision of a Saturday Enrichment Program for in-depth study of a topic related to the regular curriculum and the use of corresponding research-based instructional units, BB (Center for Gifted Education, 2007a) and BB-R (Appendix A), for young gifted students may have contributed to students' academic advancement.

Several researchers have noted the mismatch between students' reasoning skills and the demands of formal schooling (Bittker, 1991; Clasen, 2006; Sarouphim, 1999; VanTassel-Baska, 2006; VanTassel-Baska et al., 2002; VanTassel-Baska, Feng et al., 2007). In this study, the significance and large effect sizes of the treatment group gains in concept attainment and content mastery and higher mean scores in scientific reasoning suggested that the instructional strategies included in the enhanced unit (BB-R, Appendix A) scaffolded treatment students' learning and boosted their mastery of advanced science knowledge. This outcome illustrated the underlying framework of the study, and provided an example of Vygotsky's (1978, 1986, 1994) conception of student learning in the zone of proximal development with the support of adult and more capable peers in action.

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The study findings are consistent with the research literature on effects of science instruction through Project Clarion units (VanTassel-Baska, 2008a) and other WM science units (Feng et al., 2005; VanTassel-Baska and Brown, 2007; VanTassel-

Baska et al., 1998). For the Project Clarion units, VanTassel-Baska (2008a) reported strong student gains, demonstrated by performance-based assessments in concept attainment, scientific reasoning, and content mastery. As noted in this literature, the open-ended, generative nature of performance-based assessments allows students to show the extent of their knowledge. In this study, the treatment and comparison groups with high nonverbal reasoning skills and less developed verbal skills also seemed to demonstrate knowledge well due to the open-ended, generative nature of these performance assessments, particularly in concept attainment.

Treatment students' moderate gains in scientific reasoning are consistent with the findings of Feng et al. (2005). Their longitudinal study of the effects of utilization of the ICM found stronger gains in scientific research skills over a two to three year period, illustrating the importance of cumulative exposure to instructional models and consistent practice over time, as also noted by Bransford, Brown, and Cocking (2000). Treatment student gains over a brief period of time suggest that they experienced a good start in this regard, but needed much more time to master the needed skills.

Research also indicated that problem-based scenarios in the WM units historically have enhanced learning and student motivation (VanTassel-Baska et al., 1998; VanTassel-Baska & Brown, 2007). Positive growth gains of the treatment group and teacher feedback in this study suggested that this outcome was enhanced by strategies applied to the problem-based scenario which specifically addressed students' visual, spatial reasoning strength.

The findings of this study are consistent also with the studies of instructional adaptations of Corno et al. (2002) and Snow (1992) on which Lohman and Hagen (2003) based their recommendations related to specific learning profiles. In that research, instructional strategies adapted to specific learner strengths and cognitive make-up led to improved academic performances. The incorporation in BB-R enhancements designed to meet Lohman and Hagen's recommendations for students with high nonverbal reasoning strengths, such as the use of formal symbol systems, visual thinking, and spatial reasoning, may have contributed to treatment students' positive growth overall.

The content gains of the treatment group may be related to BB-R (Appendix A) activities designed to correct and expand background knowledge. Bransford, Brown, and Cocking (2000) and Lohman and Hagen (2003) noted the importance of clarifying misconceptions and pre-conceptions when introducing new topics, particularly for students with nonverbal reasoning strengths from culturally diverse, low income backgrounds. The visual aspect of the enhancements designed to correct misconception may have boosted the positive effects of the activities, as well as lessened the effects of lack of exposure to literature, technology resources, and educational materials, noted in the literature on students from low income backgrounds (Ford, 2007; Hodgkinson, 2007).

Treatment student gains may be related also to increased externalization of thinking through students' discussions of science concepts, demonstrations, and experiments with peers and teachers, as recommended in the research (Bransford, Brown, and Cocking, 2000; Lohman and Hagen, 2003). The BB-R enhancements incorporated this research recommendation, and encouraged discussion among the treatments students as they engaged in activities that supported their natural interests in hands-on, creative activities (Benbow & Minor, 1990; Gohm et al., 1998; Shea et al., 2001). Further, the research of Hedegaard (1996) and Vygotsky (1994) indicated that social relationships supported young students as they attempted to transform their inner thinking into verbal communication. This cycle of externalization of thinking, refinement of thinking through reflective discussion with peers, and, perhaps, greater internalization of knowledge may have led to slightly better retention of learning among the treatment students.

Teachers' Use of Differentiated Strategies

Overall, in this study, teachers were moderately proficient in the use of differentiated teaching behaviors. Teachers' incorporation of a variety of strategies into their teaching, such as accommodating individual differences, and engaging students in critical thinking strategies, demonstrated that teachers in this study differentiated instruction for gifted students when provided with high-quality curriculum units, a finding consistent with the research (Bransford, Brown, & Cocking, 2000; Swanson, 2006; Tieso, 2002, 2003; VanTassel-Baska, 2008a; VanTassel-Baska et al., 1998; Van Tassel-Baska et al., 2005).

As was also found in the research on WM curriculum units (VanTassel-Baska, 2008b; VanTassel-Baska, Feng, Brown et al., 2008), both treatment and comparison teachers were observed instructing students effectively through the use of themes, concepts, or ideas. However, observations of comparison teachers making less effective use of the key instructional models in the BB unit (Center for Gifted

Education, 2007a) suggested that teacher differences in the implementation of key instructional models may have affected student learning as evidenced by lower comparison group gains on the unit assessments.

The role of professional development in the delivery of research-based curriculum is undisputed in the literature (Feng et al., 2005; Swanson, 2006; VanTassel-Baska, 2008a; VanTassel-Baska & Brown, 2007; VanTassel-Baska et al., 1998). In this study, it appeared from examination of frequency and effectiveness means derived from three classroom observations of each teacher that treatment teachers who engaged in professional development related to instructional strategies designed for students with high nonverbal reasoning abilities were equipped to implement key instructional models of the unit. Professional development focused on the target sample population's strengths may have supported the development of teachers' proficiency in delivery of instruction in ways that encouraged academic growth among these culturally diverse, low income students.

Conclusion

The incidence of gifted students with high nonverbal reasoning skills in schools adds urgency to the need for curriculum units and instructional materials to build on their strengths (Bracken et al., 2008 Lohman & Hagen, 2003; Naglieri and Ford, 2003). The discussion of the study findings suggests that the utilization of the Project Clarion BB unit (Center for Gifted Education, 2007a), and the development of instructional enhancements (BB-R, Appendix A) to meet the needs of culturally diverse, low income students with strong nonverbal reasoning abilities, led to significant learning gains for the treatment and comparison groups.

The current practice, in many school districts, of relying on teachers to develop curricular materials while they are engaged in full-time teaching, may reflect an unrealistic assessment of what teachers can accomplish during a school day or week. Teachers in this study appeared to make good use of the curriculum unit materials and resources provided to them. They also expressed satisfaction with the units' (BB, Center for Gifted Education, 2007a and BB-R, Appendix A) effects on students' motivation and engagement.

Teachers also appeared to benefit from professional development closely aligned with the BB instructional unit (Center for Gifted Education, 2007a) and its enhancements (BB-R, Appendix A). This type of professional development in which teachers have opportunities to practice differentiation strategies and instructional models embedded in a specific instructional unit has been shown to lead to effective implementation of key instructional models of curriculum units (VanTassel-Baska, Feng, Brown et al., 2008). The results of this present study related to professional development and the Project Clarion key instructional models suggests that increased utilization of this professional development model, in ABC Public Schools, may add value to students' science learning.

Implications for Practice

The findings of the study are limited in their applicability to other programs and populations due to two important aspects of this study. Results based on the small sample size of 23 students are tentative and should not be generalized to other student populations. In addition, the volunteer nature of the students whose parents selected the program and the non-random administrative assignment of students to treatment and comparison groups limits the validity of the study. With these caveats in mind, implications for practice and future research are presented here.

In this study, many of the participating students had their first taste of instruction based on high-quality, advanced materials designed for gifted learners in the Saturday Enrichment Program. This was due in part to the fact that cluster grouping of small numbers of gifted students in regular classes serves as the structure for delivery of instruction to all gifted elementary age students in ABC Public Schools during the regular school day. The selection of elementary science curriculum materials in this district is limited to the provision of the adopted textbook (Frank et al., 2002) and materials provided in individual schools. To accommodate gifted students in science instruction, gifted cluster classroom teachers are expected to differentiate instruction in the content areas in collaboration with a gifted resource teacher who typically serves teachers at all grade levels in two elementary schools. The results of this study suggest that, given these circumstances, the selection of research-based curriculum units and the development of enhancements that build on students' high nonverbal strengths may contribute to learning gains of gifted students in cluster classes.

Extension of the Saturday Enrichment Program to students as they progress through the elementary grades into the middle school grades and more advanced content learning may support the continued development of the students in this study with substantial nonverbal reasoning abilities. The research literature indicates the benefit of academic support to gifted students with high nonverbal reasoning abilities and the concurrent benefits to society of development of nonverbal reasoning talents in the critical areas of science, engineering, computer sciences, music, and the visual arts (Benbow & Minor, 1990; Bracken, 2008; Feng & VanTassel-Baska, 2008a; Ford, 2003, 2007, 2008; Lohman et al., 2008; Maker, 1996; Naglieri, 2008; Park et al., 2007; VanTassel-Baska, 2003b). Given student gains in this study from a brief program and their vulnerability to lesser outcomes, it appears that continuous and reliable academic support through recurring Saturday Enrichment Program opportunities is justified.

District assessments measured the learning gains in the regular classroom of the study participants. Similarly, over time, monitoring gifted students' growth on district tests, following the implementation of specific curriculum materials, could provide useful information to teachers and administrators about the positive learning of gifted students and effective resources that support such learning.

Implications for Future Research

This study was designed to determine whether specific instructional strategies enhanced to serve the nonverbal reasoning strengths of a group of second grade gifted students would lead to learning gains. The results indicated some significant gains; however, the study findings are limited by sample size and non-random assignment of students. These tentative positive results do suggest that replication of the study with larger samples, randomly assigned to yield more reliable results for practitioners and researchers would be useful in determining appropriate approaches to instruction of students with high nonverbal reasoning skills.

While studies of Saturday programs may suggest good practices related to student growth and support, the extent to which these studies apply to regular classroom instruction is limited. Future research to replicate results in regular classroom settings with more realistic class sizes may be helpful to planners of gifted education programs. Other areas of future research may include the study of improvement in writing skills through the use of strategies tailored for students with high nonverbal reasoning ability, as suggested by students' improved writing on unit post-assessments and remarks of the treatment group teachers.

Further study of the effects of professional development focused on the instructional needs of gifted students with high nonverbal reasoning abilities may serve districts with diverse populations well. Too often districts are tempted to look for quick fixes for complex instructional problems, and fail to provide focused, on-going professional development in district selected interventions. Even in this study, time for professional development was abbreviated and did not meet the standard two full days of professional development or more which WM Center for Gifted Education staff typically offer (VanTassel-Baska, 2009; VanTassel-Baska, Feng, Brown et al., 2008). Investment in well-conceived professional development related to high-quality, research-based curriculum materials may be justified by the positive student gains in this study, as well as the moderate effectiveness of the teacher groups.

This study represents a small effort to build upon what is known about the strengths and the instructional needs of culturally diverse, low income students with strong nonverbal reasoning skills. The results of the study are tentative but encouraging. They suggest that the employment of a more rigorous research design to study effects in other academic settings would contribute further to practical and theoretical insights for students and their teachers. For the betterment of educational outcomes for these students with high nonverbal reasoning skills from culturally diverse, low income backgrounds, it is hoped that scholars and researchers will find such research important and worthwhile.

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Appendix A

Samples of Enhancements for Budding Botanists at Work, Second Grade, Life Science Unit, Center for Gifted Education (Revised) (BB-R), The College of William and Mary

Lesson #1: Introduction to the Unit

<table>
<tr><td>Instructional Purpose
To review the concept pre-assessment with the class and apply ideas to a new system.</td><td>Instructional Time
45 minutes</td></tr>
<tr><td colspan="2">Criteria for adaptations for students with high nonverbal reasoning skills:

1. Make students' thinking visible and external to themselves (Bransford, Brown, & Cocking, 2000);
2. Use students' natural strengths and interests in hands-on, creative activities (Gohm, Humphreys, and Yao, 1998; Root-Bernstein & Root-Bernstein, 1999);
3. Use adaptations that support frequent visual thinking, spatial reasoning, nonverbal symbol systems (Lohman & Hagen, 2003);
4. Emphasize vocabulary development, background knowledge, language use through probing of preconceptions and misconceptions (Bransford, Brown, & Cocking, 2000; Lohman & Hagen, 2003);
5. Provide affective support to relieve undue burden experienced by high ability students with weak verbal and mathematical skills (Lohman & Hagen, 2003; VanTassel-Baska, 2003b).</td></tr>
<tr><td colspan="2">IMPLEMENT THE LESSON</td></tr>
<tr><td>As written</td><td>Enhancements</td></tr>
<tr><td>1. Ask students to share their examples of systems from the pre-assessment activity. Write down all examples.</td><td>None</td></tr>
<tr><td>2. Now ask them to <u>categorize</u> their examples. What systems go together and why? Proceed until all systems</td><td>(Criterion 3)
As students categorize examples, use a symbol or simple drawing to label the</td></tr>
</table>

have a category.	category in addition to a written label. Use the label in verbal discussion of categories.
3. Now ask students: "What would be examples of things that are not systems?" (Examples: a broken-off limb from a tree, a withered leaf, a stem)	*(Criterion 3)* Draw a large X and list the non-examples.
4. Share the basic systems diagram model (Blackline 1.1) with the students and ask them to analyze their school as a system. • What are the elements? (e.g. students, teachers, desks, books) • What are the boundaries? (e.g. school yard, building, property lines) • What are inputs? (e.g. rules from the School Board, parent and community ideas, state mandates) • What are outputs? (e.g. students who have learned important understandings) • What are interactions in the system? (e.g. student-teacher, book-student, desk-student, teacher-teacher, student-student) • What are interactions outside the system? (e.g. school-school, school-district, school-state, student-other students, teachers-other teachers)	*(Criterion 1)* Share the basic systems diagram model (Blackline 1.1) with the students and ask them to analyze their school as a system. Before asking the shaded questions, ask students: *What do you see when you look at the diagram of a system? *(Criterion 3)* *How would the diagram look if you built it on the table (or in the middle of this room)? As students answer the remaining shaded questions, refer to Blackline 1.1 on large chart paper, and draw the following symbols for each part of the system: **Elements**  *(tetractys)* **Boundaries ( )** **Inputs →** **Outputs ←** **Interaction ↔** *(Criterion 1)*

• Can you think of other examples of systems?	As students share other examples of systems, create a diagram or drawing of each one.
5. Distribute Blackline 1.2. Discuss generalizations about systems, "What do all systems have?" Ask the group to look at the model of their school as a system. Which generalizations apply to all systems? (This may be done as whole-group discussion or in small groups).	*(Criterion 3)* Point out the corresponding symbols on the school diagram as the students discuss the generalizations.
CONCLUDE AND EXTEND THE LESSON	
Concluding questions and/or actions Generate and discuss ideas and share unit generalizations with the class. Indicate that they will be studying plants and seeing them as living systems in this unit of study. *What new ideas about the idea of systems did you learn today?*	None
What to do at home Ask students to discuss the school system with their parents. How does it work? How do the elements fit together? Come prepared next Saturday to share ideas.	None

Budding Botanists at Work (Revised) (BB-R), Second Grade, Life Science Unit, Center for Gifted Education, The College of William and Mary.

Lesson #2: Terrariums as Systems

Instructional Purpose	***Instructional Time***
To apply the concept of systems to a terrarium including its generalizations	45 minutes

Criteria for adaptations for students with high nonverbal reasoning skills:

1. Make students' thinking visible and external to themselves (Bransford, Brown, & Cocking, 2000);
2. Use students' natural strengths and interests in hands-on, creative activities (Gohm, Humphreys, and Yao, 1998; Root-Bernstein & Root-Bernstein, 1999);
3. Use adaptations that support frequent visual thinking, spatial reasoning, nonverbal symbol systems (Lohman & Hagen, 2003);
4. Emphasize vocabulary development, background knowledge, language use through probing of preconceptions and misconceptions (Bransford, Brown, & Cocking, 2000; Lohman & Hagen, 2003);
5. Provide affective support to relieve undue burden experienced by high ability students with weak verbal and mathematical skills (Lohman & Hagen, 2003; VanTassel-Baska, 2003b).

IMPLEMENT THE LESSON

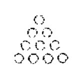
As written	***Enhancements***
1. Tell students that they are going to be learning about plants during *Budding Botanists*. Explain to students that as they work through this unit, they will be exploring the concept of systems. Divide the students into small groups. Explain that a plant is an example of a system.* Allow students to examine a terrarium. As students to look at Blackline 2.1b of the terrarium. Have	*(Criteria 2, 3, 4)* (**Follow Step 1 until after you explain that a plant is an example of a system. Then, do the following*): In the middle of a table, display a plant, leaf, stem and leaf, root and stem, and flower. Ask students to look at and touch each one and share with a partner which ones are plants. Reinforce that a plant is a system made of parts and that the other items on the

students discuss, draw, and label the parts of the terrarium, what must go into it regularly, and what comes out of it. • *What do you notice about the terrarium?* • *What things are parts of the terrarium?* • *What must go in?* • *What comes out?*	table are plant parts. Continue with Step 1 as written. *(Criteria 1, 3)* Elaborate with: • *What do you see?* • Ask students to look at the terrarium from different perspectives – from above, from the side - and describe what they see.
2. Have each group share what they included on their diagram. Begin grouping the ideas students share on a piece of chart paper to correspond with the categories of things in a system: elements, boundaries, inputs, outputs, and interactions (see Blackline 2.2 for set up). Ask questions to enhance understanding and explain aspects of the system. • *What are the parts of the terrarium?* [the tank, soil, rocks, plants, etc.] • *What lives in a terrarium?* [plants, bacteria, insects, etc.] • *What other things have to be in the terrarium for the plants to live?* [water, food, carbon dioxide] All of the things that are parts of the terrarium and what belongs in it are ELEMENTS.	*(Criterion 3)* Include the symbols for the parts of the system on the chart. **Elements**  *(tetractys)* **Boundaries ( )** **Inputs →** **Outputs ←** **Interaction ↔**

• *What keeps the elements of the terrarium together?* [the sides and bottom of the tank] • *What are the edges or boundaries of the system?* [the top of the tank, the glass boundary] BOUNDARIES help us understand where a system begins and what things are inside a system. • *What things go into the terrarium from the outside?* [food, water, air, sunlight, plants, other objects] What are some things that have to be added to the terrarium regularly to keep the plants alive? [food, clean water, sunlight] The things that are put into the system to keep it going are called INPUTS. • *What things come out of the terrarium and its elements?* [water evaporates into the air, more plants may be produced and taken out for other terrariums, dead plants/leaves] the things that a system produces or lets out are called OUTPUTS. • *What are some of the things that happen in the terrarium to use the INPUTS and produce the OUTPUTS?* [the plants produce oxygen; the plansts use sunligiht to produce food] • *What do the plants do to use the*	

INPUTS and give off OUTPUTS? [photosynthesis, transpiration, reproduction] The things that happen in a system to use the INPUTS and give off the OUTPUTS are called INTERACTIONS. Tell students that there are many different kinds of systems. Some systems are small and their boundaries, elements, inputs, outputs, and interactions are easy to see.	

3. Share the system's definitions (Blackline 2.2) and show how they apply to the terrarium (Blackline 2.3). • Elements – a distinct part of the system • Boundary – something that indicates or fixes a limit on the size or spread of a system • Interaction – the nature of connections made between/among elements and inputs of a system • Input – something that is put in the system • Output – something that is produced by the system; a product of the interactions	
4. Have students plant the lima bean seeds into white paper cups for lesson 9. This can help students to understand the concept of boundaries even further by creating a comparison between the paper cup and the glass terrarium and their differences.	None
5. Discuss the differences between things that are systems and the things that are not. Have students share examples of other things they think are systems and to identify the system parts. Then have students identify things that are not systems. Record	None

students' responses on a chart created from Blackline 1.2.	
6. Explain that generalizations are kind of like definitions but that they go beyond definitions by explaining more about how we understand the concept. Explain that they will be learning some generalizations or descriptions that apply to all different kinds of natural systems. Write each of the generalizations on a separate sentence strip to post in the classroom. They will be using these generalizations in the upcoming lessons, when discussing systems. • *Systems have parts (elements).* • *Systems have boundaries.* • *Systems have inputs and outputs.* • *The interactions and outputs of a system change when its inputs, elements, or boundaries change.*	*(Criterion 3)* Include the corresponding symbols for the parts of a system on the sentence strips. **Elements**  *(tretractys)* **Boundaries** ( ) **Inputs** → **Outputs** ← **Interaction** ↔
CONCLUDE AND EXTEND THE LESSON	
Concluding questions and/or actions • Have students complete a journal entry. Say, "In your journal, draw and label a terrarium. Write the inputs, outputs, parts, and boundaries." This mini-assessment allows teachers to check for student	*(Criterion 1)* As you circulate among the students, ask each to <u>describe</u> how they thought about and drew the terrarium and labeled its parts.

comprehension regarding the terrarium as a system. • Choose one of the generalizations about systems. Write three or more sentences explaining how it applies to another system you know about. Remember to include your reasons or examples to show how the generalization is true. Draw your system example. OR • Distribute handout copies of the blank SYSTEMS Model (Blackline 1.1). Have students choose a system from the class list of examples and show how it fits into the model. Use a piece of chart paper to post the generalizations about systems on one of the walls in the classroom. Remind students to reference these generalizations in the upcoming lessons when discussing systems. Add to the generalizations with examples from corresponding lessons, using it as a record of examples and observations. • For the next lesson, soak lima beans in water overnight.	*(Criterion 3)* Add: <u>Describe</u> the ways a generalization applies to another system you know about. Remember to include your reasons or examples to show how the generalization is true. Draw your system example and label the part you described with words and symbols. *(Criterion 3)* Add: <u>Describe</u> the ways a generalization applies to another system you know about. Remember to include your reasons or examples to show how the generalization is true. Draw your system example and label the part you described with words and symbols.
What to do at home • Share the generalizations about	

systems with someone at home. Ask them to give examples and non-examples of systems, and have them explain why they made that determination. • Have students ask their parents to finish the prompt "To think like a scientist means I will . . . " • Tell students to be prepared to share with the class.	*(Criterion 1)* Change the prompt to: "I see a scientist doing these activities . . ."

Budding Botanists at Work, (Revised) (BB-R) Second Grade, Life Science Unit, Center for Gifted Education, The College of William and Mary.

Lesson #3: What Scientists Do – Observe, Question, Learn More

<table>
<tr><td>Instructional Purpose
To introduce the Wheel of Scientific Investigation and Reasoning</td><td>Instructional Time
45 minutes</td></tr>
<tr><td colspan="2">Criteria for adaptations for students with high nonverbal reasoning skills:
1. Make students' thinking visible and external to themselves (Bransford, Brown, & Cocking, 2000);
2. Use students' natural strengths and interests in hands-on, creative activities (Gohm, Humphreys, & Yao, 1998; Root-Bernstein & Root-Bernstein, 1999);
3. Use adaptations that support frequent visual thinking, spatial reasoning, nonverbal symbol systems (Lohman & Hagen, 2003);
4. Emphasize vocabulary development, background knowledge, language use through probing of preconceptions and misconceptions (Bransford, Brown, & Cocking, 2000; Lohman & Hagen, 2003);
5. Provide affective support to relieve undue burden experienced by high ability students with weak verbal and mathematical skills (Lohman & Hagen, 2003; VanTassel-Baska, 2003b).</td></tr>
<tr><td colspan="2">IMPLEMENT THE LESSON</td></tr>
<tr><td>As written</td><td>Enhancements</td></tr>
<tr><td>1. Have students put on "lab coats" (i.e. white shirts, undershirts, etc.). Explain to students that they are going to learn to "think like a scientist" and learn how to use the science processes.</td><td>(Criteria 1, 4, 5) As students put on their "lab coats" ask them to try to see themselves as scientists in their minds. Ask: What do you see yourself doing as a scientist? Gently correct any misperceptions and invite them to look at the book as you read to them.</td></tr>
<tr><td>2. Read aloud the childrens book: Lehn, B. (1999). What is a scientist? Millbrook Press.</td><td>(Criteria 1, 4)
Pause during the reading and ask students to explain with detail what they</td></tr>
</table>

	see about what a scientist is. When you finish the book, show the last two pages and ask students to stand, select, and act out one thing a scientist does. Then, ask a few students to describe the activity they chose.
3. Ask students to write and share their journal responses, as well as their parent's responses to the prompt: "To think like a scientist means that I will . . ."	*(Criteria 1, 3)* Change the journal prompt to: "I see a scientist doing . . ."
4. Discuss the six processes introduced on the Wheel of Scientific Investigation an Reasoning (Blackline 3.1: 1) make observations, 2) ask questions, 3) learn more about observations and questions, 4) design and conduct experiments, 5) create meaning from experiments, 6) tell others what was found. Tell students that scientists use these processes when learning about their world.	*(Criterion 4)* As you discuss the processes, pause and have students explain each process to you or to a partner.
5. Distribute copies of the Wheel of Scientific Investigation and Reasoning (Blackline 3.1) to all students and describe the six components. Prompt students to see the relationship between the scientific investigation processes and the wheel components. Have them draw or write their idea for each process to help them understand and remember.	*(Criterion 1)* Change to: Distribute copies of the Wheel of Scientific Investigation and Reasoning attached to a larger paper plate. Have students extend the radial lines to the boundary of the plate. Then ask students to draw a symbol or graphic for each process in the extended area to help them understand and remember.

6. Create groups of 3-4 and assign roles for each group member. Review role responsibilities: recorder, reporter, supporter (manages materials, keeps the group on task and encourages), and time keeper. Provide each group with one copy of Blackline 3.2, *Our Observation of Seeds* (NOTE: You may want to recreate the chart on chart paper to facilitate group use.)	None
7. Refer to the *Makes Observations* section of the wheel. Point out concerns about using some senses for some investigations; that is why scientists wear goggles when doing experiments. Also, some things could be poisonous or harmful to the touch so you would not want to taste or touch them. Explain that you know what the substance is so you are going to allow the students to use their senses to make observations. • *When might it be harmful to use some senses during an investigation?* • *How should you decide when it is not safe to use some senses during an investigation?* • *What are some ways that you can protect your senses during an investigation?*	*(Criteria 2, 3)* Add: Refer to *Makes Observations* section of the wheel. <u>Have students point to the section on their Wheel</u>. Ask: *How do goggles affect the boundaries of the scientist's eyes?* Encourage students to think using the metaphor of googles as extensions of the eye. *Which part of the eye system is extended or supported?* [the boundary] *Do the goggles affect any other parts of the eye system?* [the inputs]
8. Show students lima beans that have	None

NOT been soaked and then lima beans that HAVE been soaked in water overnight. Give students magnifying glasses and allow them to observe the seeds closely. Explain that scientists sometimes use tables to record their observations. • *When you make observations, you use your senses to learn. What sense do we/you use most to make observations?* • *Why would it be helpful for scientists to compare observations?* • *How do scientists use observations to study systems?*	
9. Have the students work in their small groups for about 10 minutes and use Blackline 3.2 to write down group observations according to look, smell, and touch. Invite the reporters to share their findings. • *What do you notice about our observations?* • *How are the two seeds alike? How are they different?*	*(Criteron 3)* Add another question: *How does the seed's shape change when it is soaked?*
10. Direct students' attention to the second section on the Wheel – *Ask Questions*. Model this section by writing down one question you have on a sentence strip (do ahead of time).	*(Criterion 2)* Have students find the section on their paper wheels.

• *What are the parts of a seed?*	
11. Ask students to tell you other questions they have about the seeds and write their questions on a large piece of chart paper. Guide the class to pick your question (or one similar to it) as the ONE question they want to answer.	
12. Refer to the third step on the Wheel – *Learn More.* Ask students what can be done to learn more about something (i.e., internet, books, experts).	*(Criterion 2)* Have students find the section on their paper wheels.
13. Point out that one way they can learn more is through additional observations. Demonstrate a seed dissection using a soaked lima bean (See Blackline 4.3 for more information on dissection). Show students the seed coat as you remove it from the seed. Ask students if they think all seeds have seed coats and show sentence strip with the revised question: • *After learning more, I have a new question. Do all seeds have seed coats?*	*(Criteria 1, 2, 3, 4)* Have students mime or rehearse the teacher's actions while dissecting the seed. Ask students to describe what they are seeing as the teacher dissects.
14. Tell students that they are going to complete the remaining steps on the Wheel of Scientific Investigation and Reasoning the next day: *design and conduct the experiment, create meaning, and tell others what you have found.*	None
15. Soak several of three different kinds	None

of seeds in water overnight (at least one of each kind of seed for each group of four students).	
16. Pass out lab books and ask students to predict whether the seeds will have seed coats.	None
CONCLUDE AND EXTEND THE LESSON	
Concluding questions and/or actions • *Which of the system's generalizations do you think applied to our investigation of seeds?* • *What do you think we will do next Saturday to conduct an experiment on our question?*	*(Criteria 1, 4)* Extend the discussion by asking how a seed coat is like a schoolyard fence.
What to do at home • Ask students to work with a parent to identify seeds that are in their homes.	None

Budding Botanists at Work (Revised) (BB-R), Second Grade, Life Science Unit, Center for Gifted Education, The College of William and Mary.

Lesson #4: What Scientists Do – Experiment, Create Meaning, Tell Others

Instructional Purpose	***Instructional Time***
To continue through the Wheel of Scientific Investigation and Reasoning	45 minutes

Criteria for adaptations for students with high nonverbal reasoning skills:

1. Make students' thinking visible and external to themselves (Bransford, Brown, & Cocking, 2000);
2. Use students' natural strengths and interests in hands-on, creative activities (Gohm, Humphreys, & Yao, 1998; Root-Bernstein & Root-Bernstein, 1999);
3. Use adaptations that support frequent visual thinking, spatial reasoning, nonverbal symbol systems (Lohman & Hagen, 2003);
4. Emphasize vocabulary development, background knowledge, language use through probing of preconceptions and misconceptions (Bransford, Brown, & Cocking, 2000; Lohman & Hagen, 2003);
5. Provide affective support to relieve undue burden experienced by high ability students with weak verbal and mathematical skills (Lohman & Hagen, 2003; VanTassel-Baska, 2003b).

IMPLEMENT THE LESSON

As written	***Enhancements***
1. Put on lab coats and remind students of the problem they have been asked to solve: *"Do all seeds have a seed coat?"* Explain that it might be helpful to learn something about seeds and so they are going to continue to investigate seeds.	*(Criterion 4)* Draw attention to the sentence strip with the question on it, *"Do all seeds have seed coats?"* as you remind students of the problem they have been asked to solve.

2. Review what the class has done so far when investigating plants during the previous lesson (lesson #3) and refer to the Wheel (Blackline 3.1). • *What did we start investigating the other day?* • *How did we begin our investigation and what scientific processes did we apply?* • *What did we observe about the seed?* • *What question did we identify?*	*(Criterion 1, 3, 4, 5)* Refer to the large class poster of the Wheel during the review.
3. Move to the fourth process – *design and conduct the experiment* (Blackline 3.1). Note that the first thing scientists do to conduct an experiment is to form a hypothesis from their question. Use Blackline 4.1 to define hypothesis as, "a prediction that can be tested about how a scientific investigation or experiment will turn out." Use Blackline 4.2 to model your thinking process in turning your original question into a hypothesis.	*(Criterion 1, 3, 4, 5)* Refer to the section called *Design and Conduct the Experiment* on the large class poster of the Wheel.

4. Have students either turn to their partner or talk in small groups about other possible hypotheses that could come from the question and write down the hypotheses on chart paper. • *What other hypothesis could we form from the original question?* • *How did you come up with this hypothesis?*	*(Criterion 2, 4)* Give students a few minutes to practice turning a question into a hypothesis. Write one of the students' questions on a sentence strip. Ask students what they could do to the sentence strip to create a hypothesis .
5. Explain that the hypothesis needs to be tested and to do that we do an experiment. It is important to plan the experiment by listing the steps. Ask students to tell what they think needs to be done to conduct an experiment for the hypothesis. After students share, reveal the list of steps the class is going to follow (see Blackline 4.3). Point out the list of materials that are needed for the	None

experiment.	
6. Explain that scientists have to be careful about how they test a hypothesis or plan an ***experiment.*** They must think of all the different things that could cause something to happen and then make sure that the experiment changes only one of those things. Identify the variables (type of seed, amount of time seeds were soaked, correct dissection of seeds, etc.) NOTE: If you think some students are ready you can talk about variables. • *Let's consider our experiment. What things could happen that might cause problems?*	None
7. Explain that scientists conduct each experiment more than once to make sure that what occurred isn't just a coincidence. The class is going to observe the teacher conduct the experiment once. The teacher will then conduct the experiment a second time with a few student assistants to illustrate	None

group team work to the class. The third experiment will be conducted by students without the teacher and will then be discussed by the whole class. *(For many students, this may be their first exposure to conducting a scientific experiment and the students need to have it modeled for them).* • *Does each group have the same seeds?* • *Have all the seeds been soaked the same amount of time?*	
8. Review how to dissect seeds and guide the group, step-by-step to conduct the experiment at the same time. Ask each group to make observations and to write down what they observed on Blackline 4.4. • *Did each kind of seed have a seed coat?*	None
9. Tell students that they have just conducted a scientific investigation or	None

experiment. They tested their hypothesis and now they need to do the last two processes: 1) *create meaning* from the data and 2) *tell others what was found.*	
10. Explain that scientists use charts to organize their data so they can figure out or analyze what the data sow – *to create meaning* from the data. Ask the reporter from each group to share the group's findings. Use chart paper recreating Blackline 4.5 to record the findings. Tell students that they are to come up with an ***inference*** – a conclusion about whether the prediction or hypothesis was correct: • *Was there a seed coat on each kind of seed?* • *Was our hypothesis correct?* • *Did we answer our original question?* • *What other questions do you have?* • *What other experiments do you think we might do?*	*(Criterion 3)* Write the students' inferences on chart paper, have students discuss the inferences, and ask them to write the inferences in their investigation lab books. At the end of the inference, have students insert a *halmos* symbol - □ (named for the mathematician who used it to show the end of a proof; also called a "tombstone" by typographers).
11. Explain that now the class needs *to*	

tell others what was found. Ask student pairs or small groups to decide who we should tell about our experiment findings and how we should communicate our findings. Allow students to share with the whole class and lead them to see that one way they could communicate the results is by sharing the experiment data chart. • *What was important about what we found?*	
12. Proclaim that the student scientists have just conducted a scientific investigation and give out "badges" saying "I Conducted a Scientific Investigation – Ask Me About It." (Blackline 4.6). Also ask students to date and make one of the following entries in their investigation lab books: • *When it comes to conducting scientific investigations, the most difficult thing is . . .*	

• *The next investigation I would like to conduct on seeds is . . .*	
CONCLUDE AND EXTEND THE LESSON	
Concluding questions and/or actions • Share investigation log entries. • What do you think we could have changed about the way we did our experiment? • Which generalizations about systems did you observe in our experiment?	None
What to do at home • Using your *Wheel of Scientific Investigation* and with an adult's help, conduct an experiment of your own about seeds. Remember to write down the steps to the experiment.	None

Appendix B

Lesson Schedule for Treatment and Comparison Classes

February 21	Pre-teaching and Pre-assessments L. 1: Introduction to the Unit L. 2: Terrariums as Systems + Sketching, building	80 min 45 min 45 min
February 28	L. 3: What Scientists Do – Observe, Question, Learn More L. 4: What Scientists Do – Experiment, Create Meaning, Tell Others + Re-read book, create new sketches	45 min 45 min
March 7	L. 5: A Real World Problem to Solve! Library visit for resources Lesson 6a & 6b: Animal, Vegetable, or Mineral: What is it? + Research Assign Lesson 8 Seed Project	45 min 30 min 1 hr 30 min
March 14	L. 7: Close Up: Using a Microscope L. 8: Just a Little Seed L. 9: Plant Experimentation on Basic Needs + Reading, sketching	45 min 45 min 45 min

March 21	L. 10: Independent and Small Group Investigations Research to answer Professor Blackwell Lesson 11: Wrap Up! + Reading, sketching	45 min 45 min 45 min
March 28	Post-assessments Celebration and Open House	80 min

Appendix C

Professional Development Plan for Comparison Group Teachers and Treatment Group Teachers

Comparison Group Plan	*Treatment Group Plan*
Session One Objectives	*Session One Objectives*
The participants will: • preview and rehearse pre-teaching activity for pre-assessment of overarching concept of *Systems*; • preview and rehearse pre-assessment package for overarching concepts, scientific investigation process skills, & science content; • practice the concept development process for overarching concept of *Systems* as written in *Lesson #1*; • preview the content of *Budding Botanists* curriculum unit using Teacher Content Notes, and select topics from material for further reading and summarization to share with group at the next session; • share questions, concerns, and need for more information.	The participants will: • review and discuss characteristics & case studies of high nonverbal reasoning learners as presented in the *Interpretive Guide* (Lohman & Hagen, 2003); • preview and rehearse pre-teaching activity for pre-assessment of overarching concept of *Systems*; • preview pre-assessment package for overarching concepts, scientific investigation process skills, & science content; • practice the concept development process for overarching concept of *Systems* as written in *Lesson #1*; • preview concept map of *Budding Botanists at Work* (*Budding Botanists*) material; assign study of Teacher Content Notes, and selection of individual topics from material for further reading and summarization to share with group at the next session; • share questions, concerns and need for more information.

Comparison Group Plan	*Treatment Group Plan*
Session Two Objectives	*Session Two Objectives*
The participants will: • practice the application of the overarching concept of *Systems* in a new context; • engage in discussions of content background knowledge using teachers' prepared summaries as discussion prompts; • review the use of teaching models, including the Wheel of Scientific Investigation and Reasoning, concept mapping, and Problem-based Learning (PBL)*; • introduce the problem scenario; • share questions, concerns, and need for more information.	The participants will: • examine and discuss appropriateness of adaptations in first four lessons for high nonverbal reasoning students; • practice the application of the overarching concept of *Systems* in a new context; • engage in discussions of content background knowledge using teachers' prepared summaries as discussion prompts; • review the use of teaching models, including the Wheel of Scientific Investigation and Reasoning and Problem-based Learning (PBL)*; • share questions, concerns, and need for more information.
Session Three Objectives	*Session Three Objectives*
The participants will: • apply the concept of *Systems* to a variety of systems within plants and discuss questions; • rehearse teaching the problem-based scenario; • use Notes for the Teacher: Quick Review of Photosynthesis, Respiration, and Transpiration in Lesson #9 to build content knowledge	The participants will: • examine and discuss appropriateness of adaptations for high nonverbal reasoning students in last five lessons; • apply the concept of *Systems* to a system within plants and discuss questions; • rehearse teaching the problem-based scenario with adaptations related to

Comparison Group Plan	*Treatment Group Plan*
and fluency in the teaching of concepts/content; • share questions, concerns, and need for more information; • arrange follow-up one hour sessions.	speed of speaker and checking accuracy of students' visual mental models; • use Notes for the Teacher: Quick Review of Photosynthesis, Respiration, and Transpiration in Lesson #9 to build content knowledge and fluency in the teaching of concepts/content; • share questions, concerns, and need for more information; • arrange follow-up one hour sessions.

*All comparison and two of three of treatment teachers participated in a two-hour professional development workshop on PBL conducted in the fall of 2008 by Dr. Janice Robbins, Ph.D., Center for Gifted Education, The College of William and Mary

Appendix D

Graphic Organizer of Research Base for Intervention Study

Theoretical Framework

Vygotsky Perspective & Zone of Proximal Development

- Learning is social
- A child's potential is shown by what is possible with the guidance/ support of an adult or more capable peer

Vygotsky, 1978, 1986, 1994

Studies on Young Learners

Young children from low SES backgrounds benefit the most in comparison to more well off peers from preschool and primary school experiences.

Ramey & Ramey, 1998; 2004; Campbell, Pugello, Miller-Johnson, Burchinal, & Ramey, 2001; Ramey et al., 2000

High Nonverbal Scores with Low Verbal and Math Scores

Young children from low SES backgrounds are more likely to demonstrate a learning ability profile of high nonverbal ability and much lower verbal and math ability.

Lohman & Hagen, 2005

Reasons for Development of Nonverbal Strength with Low SES

- Fluid reasoning responds quickly to novel and real problems
- Fluid reasoning develops without investment of scarce family resources of time, materials, or money

Briggs, Reis, & Sullivan, 2008; Olszewdi-Kubilus, 2007; VanTassel-Baska, 2003b

Value of Nonverbal Reasoning Strengths

Studies using the National Talent Search databases indicate that development of nonverbal reasoning strengths lead to creative careers in engineering, science, computer programming, visual arts, & mathematics.

Benbow & Minor, 1990; Gohm, Humphreys, & Yoa, 1998; Park, Lubinski, & Benbow, 2007; Shea, Lubinski, & Benbow, 2001

Using Nonverbal Reasoning Strengths in Instruction, 1

Teachers can build on students' reasoning strengths that are fluid and strong. These children tend to be:

- Open to new ideas
- Independent
- Creative
- Pragmatic

VanTassel-Baska, 2003b

&

Using Nonverbal Reasoning Strengths in Instruction, 2

Students benefit from:

- Frequent visual thinking
- Spatial reasoning,
- Nonverbal symbol systems

They need:

- Vocabulary development
- Background knowledge
- Language usage practice

Bransford, Brown, & Cocking, 2000; Lohmen & Hagen, 2003

Using Adaptations in High- Quality Instruction to Build on Nonverbal Strengths

- *Budding botanists* curriculum unit is a high-quality curriculum unit, as evidenced on the incorporation of research-based effective learning principles
- Adaptations based on nonverbal strengths to a high-quality unit result in a high-impact unit for this particular population
- As evidenced by studies of young children, small increases in well-being allow young children to grow
- As evidenced in Adaptive Treatment Interaction (ATI) research, small decreases on working memory assist high nonverbal reasoning students in their educational development

Bransford, Brown, & Cocking, 2000; Lohman & Hagen, 2003; Ramey & Ramey, 1998; 2004; Campbell, Pugello, Miller-Johnson, Burchinal, & Ramey, 2001; Ramey et al., 2000; VanTassel-Baska, 2003b

Appendix E

Teacher Participant Information Survey

Participant Information - Please check the boxes that describe you.

1. Current contract position:

   □ Classroom Teacher □ Site Administrator □ Gifted Resource Teacher

2. Gender: □ Male □ Female

3. Ethnicity:

   □ Hispanic-American □ African-American □ Native-American

   □ White □ Asian-American/Pacific Islander □ Other

4. Years of teaching experience:

   □ Less than 5 years □ 11-15 years

   □ 5 to 10 years □ More than 15 years

5. Highest degree earned:

   □ BA/BS □ MA/MS □ EdS (6^{th} year/Ed. Specialist)

   □ PhD/EdD □ Other (________________)

6. Training in teaching gifted students: (Check all that apply)

   □ District in-services □ Workshop outside district

   □ Course(s) at college/university □ Educational degree in area

7. School year grade level(s) assignment: □ Elementary □ Middle □ High

8. Endorsement in Gifted Education? □ Yes □ No

9. How did you participate in the Saturday Enrichment Program?

   □ Teacher of treatment group □ Comparison teacher

Appendix F

Observation Instrument

The William and Mary Classroom Observation Scales, Revised
Teacher Observation

Joyce VanTassel-Baska, Ed.D. *Linda Avery, Ph.D.* *Jeanne Struck, Ph.D.* *Annie Feng, Ed.D.*
Bruce Bracken, Ph.D. *Dianne Drummond, M.Ed.* *Tamra Stambaugh, M.Ed.* *Chwee Quek, M. Ed.*

Directions: Please employ the following scale as you rate each of the checklist items. Rate each item according to how well the teacher characteristic or behavior was demonstrated during the observed instructional activity. Each item is judged on an individual, self-contained basis, regardless of its relationship to an overall set of behaviors relevant to the cluster heading.

3=Effective	2=Somewhat Effective	1=Ineffective	N/O = Not Observed
The teacher evidenced careful planning and classroom flexibility in implementation of the behavior, eliciting many appropriate student responses. The teacher was clear, and sustained focus on the purposes of learning.	The teacher evidenced some planning and/or classroom flexibility in implementation of the behavior, eliciting some appropriate student responses. The teacher was sometimes clear and focused on the purposes of learning.	The teacher evidenced little or no planning and/or classroom flexibility in implementation of the behavior, eliciting minimal appropriate student responses. The teacher was unclear and unfocused regarding the purpose of learning.	The listed behavior was not demonstrated during the time of the observation. (NOTE: There must be an obvious attempt made for the certain behavior to be rated "ineffective" instead of "not observed".)

General Teaching Behaviors

Curriculum Planning and Delivery	3	2	1	N/O
The teacher…				
1. set high expectations for student performance.				
2. incorporated activities for students to apply new knowledge.				
3. engaged students in planning, monitoring or assessing their learning.				
4. encouraged students to express their thoughts.				
5. had students reflect on what they had learned.				
Comments:				

Differentiated Teaching Behaviors

Accommodations for Individual Differences	3	2	1	N/O
The teacher…				
6. provided opportunities for independent or group learning to promote depth in understanding content.				
7. accommodated individual or subgroup differences (e.g., through individual conferencing, student or teacher choice in material selection and task assignments.)				
8. encouraged multiple interpretations of events and situations.				
9. allowed students to discover key ideas individually through structured activities and/or questions.				
Comments:				

Problem Solving	3	2	1	N/O
The teacher…				
10. employed brainstorming techniques.				
11. engaged students in problem identification and definition				
12. engaged students in solution-finding activities and comprehensive solution articulation.				
Comments:				

Critical Thinking Strategies	3	2	1	N/O
The teacher...				
13. encouraged students to judge or evaluate situations, problems, or issues				
14. engaged students in comparing and contrasting ideas (e.g., analyze generated ideas)				
15. provided opportunities for students to generalize from concrete data or information to the abstract.				
16. encouraged student synthesis or summary of information within or across disciplines.				
Comments:				

Creative Thinking Strategies	3	2	1	N/O
The teacher...				
17. solicited many diverse thoughts about issues or ideas.				
18. engaged students in the exploration of diverse points of view to reframe ideas.				
19. encouraged students to demonstrate open-mindedness and tolerance of imaginative, sometimes playful solutions to problems.				
20. provided opportunities for students to develop and elaborate on their ideas.				
Comments:				

Research Strategies	3	2	1	N/O
(It is atypical for these to be observed in one session. Some teachers, however, may use Items #21-25 within a single period to illustrate the full research process to students. Please note those observations in the comments section.)				
The teacher...				
21. required students to gather evidence from multiple sources through research-based techniques (e.g., print, non-print, internet, self-investigation via surveys, interviews, etc.).				
22. provided opportunities for students to analyze data and represent it in appropriate charts, graphs, or tables.				
23. asked questions to assist students in making inferences from data and drawing conclusions.				
24. encouraged students to determine implications and consequences of findings.				
25. provided time for students to communicate research study findings to relevant audiences in a formal report and/or presentation.				
Comments:				

Additional Comments:

Appendix G

Treatment Fidelity Instrument

The William and Mary Classroom Observation Scales, Revised
Adapted for Project Promise
Treatment Fidelity

Directions: The following observation scale addresses the fidelity of implementation in the Project Promise science units. Please check the relevant category describing the teacher's implementation of key instructional models employed in the units.

Lesson #____________________________ Grade Level____ ______

The teacher...	**Effective**	**Somewhat Effective**	**Ineffective**	**N/A**	**Comments**
Emphasized "systems" in instruction and/or activities.					
Referred to the problem statement/scenario in discussion and/or activities.					
Instructed students in "Need to Know' board.					
Structured questions for science inquiry.					
Engaged students in journal writing.					
Engaged students in experimental design.					
Enhanced oral communication.					
Emphasized relevant concepts, themes, or ideas in instruction and/or activities.					

Additional Comments about Fidelity of Implementation:

Appendix H

Teacher Focus Group Questions

1. How would you characterize your experience teaching this group of students?
    a. What was different or unusual about teaching and learning with this population?
    b. What teaching or coaching skills did you use with this group?
2. What have you learned from this experience of teaching this group of students?
    a. How did the students learn from you?
    b. How did the students learn from each other?
3. What did you find was most interesting to most of your students?
    a. Which activities easily engaged students' attention and effort?
    b. Which activities did students talk about with you? With each other?
4. What do you think motivated your students to learn? (Gohm et al., 1998; Bransford, Brown and Cocking, 2000)
    a. Were they interested in grades? Helping others? Leading a group?
    b. What were your students' attitudes towards learning when it was difficult?
5. How do you think elementary school teachers can support the academic success of students with high nonverbal reasoning scores?

Appendix I

Teacher Intervention Study Information Letter and Consent Form

An Intervention Study of Primary Age Gifted Students with Strong Reasoning Abilities from Low Income and Culturally Diverse Backgrounds

Teacher Participants Information Letter

Dear _______________,

This year teachers for the Saturday Enrichment Program have an opportunity to participate in a study entitled *Intervention Study of Primary Age Culturally Diverse Gifted Students Showing Strong Reasoning Abilities on a Nonverbal Test.* The study will compare student growth between two groups of students, a comparison group and a treatment group. Teachers of both groups will use a high quality William and Mary Life Science unit, *Budding Botanists at Work*, a second grade inquiry based science unit that received one of the 2008 National Association for Gifted Children's Curriculum Division Awards for exemplary curriculum. Teachers of the comparison group will implement the unit as written. Teachers of the treatment group will implement the unit with modifications that build on students' nonverbal reasoning strengths. Unit pre-assessments and post-assessments of learning will measure students' science learning gains from exposure to the curriculum unit. Three second grade teachers will comprise the comparison group teachers and three second grade teachers will comprise the treatment group teachers.

Six hours of professional development related to the science content, the William and Mary teaching models, and concept attainment are planned for the comparison group teachers to prepare you for a successful teaching experience. Six hours of professional development related to the science content, the William and Mary teaching models, concept attainment, and instructional strategies specifically designed for nonverbal reasoning students are planned for the treatment group teachers. Implementation of the curriculum as written or as modified contributes to the reliability of the results. Therefore, your participation in professional development strengthens the study, as well.

The researcher will conduct classroom observations to assess teachers' faithful implementation of the study. The observation results are for the purposes of the study only. Your name will not be attached to any results. No one, other than the researcher, will have access to the observation results.

Participation in the study is anonymous and voluntary; you may withdraw from the study at any time without consequence or question. Results will be reported without individuals or school names. You may indicate your willingness to participate in the study by reading the attached consent form and signing it.

Thank you for your interest, time, and professionalism. This study will help the teachers develop greater understanding of the abilities of students who score high in nonverbal reasoning on a cognitive abilities test. It will also give you an opportunity to explore materials and methods that may be new to you and to increase your capacity as a teacher of culturally diverse primary age gifted students.

If you have any concerns or questions, please contact me at 628-3322 or jrfun2@wm.edu. Again, thank you.

Sincerely,

Joanne R. Funk
Doctoral Candidate Researcher, The College of William and Mary

An Intervention Study of Primary Age Gifted Students with Strong Nonverbal Abilities from Low Income and Culturally Diverse Backgrounds

Consent Form

The College of William and Mary

- The nature of the study entitled "An Intervention Study of Primary Age Gifted Students with Strong Nonverbal Abilities from Low Income and Culturally Diverse Backgrounds" conducted by Joanne R. Funk was explained.

- I agree to participate in six (6) professional development hours to become familiar with the content and pedagogy of the unit, *Budding Botanists* or of the enhanced unit to build on students' nonverbal reasoning strengths.

- I understand that I will be asked to implement the unit, *Budding Botanists* and any additional activities provided by the researcher. I understand the importance of implementing the unit and activities faithfully to ensure the validity of the study.

- I understand that I will be observed teaching three times during the study and that treatment fidelity will be assessed by the investigator using the William and Mary Classroom Observation Scale – Revised (COS-R). References to the observations in the study will be anonymous. All information will be anonymous and specific information attached to my name will not be shared with others, including those in supervisory positions in the school district. Potential risks from participation in this project have been described to me.

- I am aware that I may report dissatisfactions with any aspect of this experiment to the Chair of the Protection of Human Subjects Committee, Dr. Michael Deschenes, 757-221-2778 or mrdesc@wm.edu. I am aware that I must be at least 18 years of age to participate. My signature below signifies my voluntary participation in this project, and that I have received a copy of this consent form.

____

Date Signature

____

Print Name

Appendix J

Parent Intervention Study Information Letter and Consent Form

Intervention Study with Primary Age Students Using High Quality Science Curriculum to Build on Students' Strengths

Dear ___________________,

The Saturday Enrichment Program is an opportunity for your child to learn science through a high quality unit designed for students who are strong in nonverbal reasoning skills. The unit, *Budding Botanists at Work*, is a series of science lessons with learning activities that are engaging, hands-on, and challenging for high-ability second grade students.

In the unit, students take on the role of scientists as they explore new ways to learn about plant life, plan plant experiments, and learn ways to apply their knowledge to real world problems. Botany and plant life materials will create exciting experiences for your child.

This year the second grade students participating in the Saturday Enrichment Program will be part of an educational study conducted by Joanne Funk, a Gifted Teacher Specialist who is a doctoral candidate at the College of William and Mary. The study will examine the learning gains of students with high nonverbal reasoning skills when they are taught using a high-quality science unit. Students will be in a comparison group or a treatment group. The comparison group will learn through the science unit as it is written. The treatment group will learn through the same science unit with added strategies to build on nonverbal reasoning skills.

Your second grade students took the Cognitive Abilities Test in spring of first grade. They scored high in nonverbal reasoning abilities and lower in verbal and quantitative abilities. Your child's participation in this program will help teachers learn more about the ways students who have high nonverbal reasoning skills learn best.

If you are willing to have your child participate in this study, please read and sign the attached Parent/Guardian Consent Form. Participation is voluntary and may be discontinued at any time by contacting Joanne Funk at 628-3322 or jrfun2@wm.edu.

Thank you for your interest in the program. We are looking forward to working with you and your child!

Sincerely,

Joanne R. Funk

Doctoral Candidate Researcher, The College of William and Mary

Parent/Guardian Consent Form

The College of William and Mary

I, ____________________________, parent or guardian, agree to allow ______________, to participate in a study of student learning in science education. I understand that the teacher will use *Budding Botanists at Work, a Life Science Unit*, developed by the Center for Gifted Education at the College of William and Mary, as a curriculum unit guide.

- The purpose of the study is to determine students' progress in learning science when a high quality curriculum unit is used. Activities to build upon my child's strong nonverbal reasoning skills will support my child's academic and intellectual growth.

- Participants in this study were selected based on their high performance on the Nonverbal Reasoning Skills portion of the Cognitive Abilities Test (CogAT).

- My child will be one of about 60 second grade students taught in classes of ten students each. I understand that my child will participate in a four-hour, 6 week long, Saturday Enrichment Program. Teachers for the comparison and treatment classes were assigned randomly.

- My child may be in the control group of classes or the treatment group of classes. Both classes will use the same high-quality science unit but the treatment group will also use specific learning strategies to build upon high nonverbal strength.

- Joanne R. Funk is conducting this study to satisfy requirements for a doctorate in Educational Policy, Planning and Leadership with a focus on Gifted Education Administration at The College of William and Mary.

- I understand that my child's name will not be associated with any results of this study.

- I understand that participation in this study is voluntary and that I may withdraw my consent to participate at any time by notifying the researcher, Joanne R. Funk. My decision to participate or not participate will not affect my relationship or my child's relationship with my child's teacher, principal, school, or the school district.

- If I have any questions or concerns about participation in this study I should contact Ms. Joanne R. Funk, doctoral candidate researcher, at (757) 628-3322 or jrfun2@wm.edu.

I understand that I may report any problems or dissatisfaction to Dr. Thomas Ward, chair of the School of Education Internal Review Committee at (757) 221-2358 or tjward@wm.edu or Dr. Michael Deschenes, chair of the Protection of Human Subjects Committee, The College of William and Mary at (757) 221-2778 or mrdesc@wm.edu.

My signature below signifies that I am at least 18 years old, that I consent to participate in this study, and that I have received a copy of this consent form.

____________________________ _______________
Participant Date

____________________________ _______________
Investigator Date

Appendix K

Teacher Perceptions Focus Group Information Letter and Consent Form

Teacher Perceptions of Students Who Score High on a Nonverbal Reasoning Test

Cover Letter

Dear _________________,

Teacher perceptions of the motivation, interests, and learning habits of students who score high on nonverbal tests provide important insights into effective instruction for these students. As a teacher-participant in the study entitled "Intervention Study of Primary Age Culturally Diverse Gifted Students Showing Strong Nonverbal Reasoning Abilities on a Nonverbal Test," you will have an opportunity to share your experience in a focus group interview.

You will discuss five questions related to your experience and perceptions in working with high nonverbal students. The focus group results will be anonymous. Your name will not be attached to the results. Your participation is voluntary and you have the right to withdraw at any time without question or consequence.

You may indicate your willingness to participate in the focus group by reading and signing the attached consent form.

Thank you for your interest, time, and professionalism.

Sincerely,

Joanne R. Funk

Doctoral Candidate Researcher, The College of William and Mary

Survey of Teacher Perceptions of Students Who Score High on a Nonverbal Reasoning Test

Consent Form

The College of William and Mary

- The general nature of this study entitled "Intervention Study of Primary Age Culturally Diverse Gifted Students Showing Strong Nonverbal Reasoning Abilities on a Nonverbal Test" conducted by Joanne R. Funk has been explained to me.

- I understand that I will be asked to participate in a focus group interview entitled "Focus Group Interview of Teacher Perceptions of Students Who Score High on a Nonverbal Reasoning Test." There are no particular risks involved in my participation. The focus group interview will take one hour. I understand that my responses will be confidential and that my name will not be associated with any results of this study.

- I know that I may refuse to answer any question asked and that I may discontinue participation at any time. Potentials risks resulting from my participation in this project have been described to me.

- I am aware that I may report dissatisfactions with any aspect of this experiment to the chair of the Protection of Human Subjects Committee, Dr. Michael Deschenes, 757-221-2778 or mrdesc@wm.edu. I am aware that I must be at least 18 years of age to participate. My signature below signifies my voluntary participation in this project, and that I have received a copy of the consent form.

__________________ ____________________________________

Date Signature

____

Print Name