Constructivism and the Effects of Teaching Gifted Middle School Science Students

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Abstract
The No Child Left Behind Act (NCLB) of 2002 was enacted to address the declining proficiencies of students in the United States, particularly in the areas of math, reading, and science. An unintended consequence of promoting equality in education for all children is that gifted or advanced learners are often forced to slow their pace to match their lower level peers, resulting in boredom, frustration and disinterest in subjects in which they may have otherwise excelled. Professional development programs have emphasized teaching techniques that have been demonstrated to help gifted students absorb and apply content material through constructivist and inquiry-based models.

The effectiveness of constructivist teaching methods was tested in an embedded, descriptive multiple case study of six middle school teachers who attended professional development training in order to offer their gifted students an extracurricular after-school science class. The findings of the research indicated that science teachers viewed the program as valuable for advanced and gifted learners. The program was also valuable for the teachers who developed new peer groups of contacts and resources that supported them. However, when presented with the notion of including constructivist practices in their general education classrooms, study participants expressed doubt that these methods would be successful in attaining NCLB goals while simultaneously addressing the needs of gifted middle school students.

Introduction
Over a decade ago, the National Science Education Standards (NSES, 1996) were published to guide the nation towards a more scientifically literate society. It was obvious that the nation was in danger of falling behind other technological powerhouses in the world, posing a threat to its way of life. Primarily, a nation’s prosperity depends on its ability to recognize, nurture and use its diverse gifted population for future progress (Watters & Diezmann, 2003).

When the Soviets launched Sputnik in 1957, the United States reacted, in part, by emphasizing the study of mathematics and science in American schools. This scientific achievement by the Soviet Union caused the United States to allocate large sums of money to identify gifted and talented students who had the ability to advance science and technology for this country. Subsequently, spending on the development of scientific curricula increased, and science education curricula like the Chemical Education Materials Study (ChemStudy), Chemical Bond Approach (CBA), Project Physics, Physical Science Study Committee (PSSC), Biological Science Curriculum (BSCS) resulted. The goal of science education during that era was to produce scientists and innovators for the nation. These efforts yielded results, and in 1969 the first American stepped on the moon.

Following that era, however, many problems arose in the 1970’s, and the focus on scientific innovation was lost. Both internal and external factors including wars, depletion of natural resources, and unstable international political fronts, led to reduction in funding from the National Science Foundation. Science education lost its earlier support, and students started to lose interest in science. Lower scores in
mathematics and science resulted (NAEP, 1977). Very few students were interested in science, stating instead that they were bored by the subject area (NAEP, 1979; Hueftle, Rakow, & Welch, 1983).

This disappointment concerning science education continued in the 1990’s and beyond 2000. Many noted reports emphasized that science education was lacking purpose, scope, quality of teaching, and science graduates (Adler, 1982; Boyer, 1983; Goodlad, 1983). International reports noted that the students of other industrial nations outperformed American students (Husen, 1983).

The White House April (2004) fact sheet reported that America's growing economy is continuously changing and a response to these changes is to help more Americans gain the skills to find good jobs in the 21st Century economy. Many of the fastest-growing occupations require strong math and science preparation, and training beyond the high school level. Unfortunately, not many high school students are receiving the skills they need to compete in these fields and in higher education. Only 24 states require at least three years of math, and only 21 states require at least three years of science. Because their math and science education is lacking, young Americans stand to miss out on job opportunities, lack the necessary skills for post-secondary study, or will not complete post-secondary study in a timely manner.

Among many measures being taken to encourage reform in science education that will improve student outcomes are to increase funding for Mathematics and Science Partnership programs which can be formal, informal or extracurricular in nature. They are designed to provide extra help to middle and high school students and to expand Science Technology Engineering and Mathematics (STEM) knowledge. They also provide professional development for science teachers so that students are better qualified for college education in science and math content areas. Effective teaching is at the heart of the vision for science education that is described in the National Science Education Standards. What the standards say to the teacher is well supported in education research and many teachers have become successful at adapting and incorporating the standards into their daily routines in the classroom.

Statement of the Problem

Gallagher (2006, p. 432) indicates that theoretically gifted students have a “natural appeal” for science. However, a study on 600 middle school students by Lupart, Cannon & Telfer (2004) reveals that by middle school the gifted science students have mixed feelings about science. National Assessment of Educational Progress (NAEP, 2000) reports that only 4% of 8th graders and 2% of 12 graders scored in the advanced section (USDOE, 2001). As well, a study by O’Sullivan & Grigg, (2001) reveals that students in advanced sciences scored a mere 174 of 300, which is just above 150 on the scaled scores. And, the Trends in Math and Science Study (TIMSS) indicates that US students who were in AP Physics scored the lowest in the test from 16 nations. These studies reveal that the situation for gifted students does not seem favorable. There needs to be more efforts channeled to support and serve gifted students in science.

Currently, gifted education suffers from a lack of national support. Many gifted science students are not being identified or appropriately challenged. This lack of support for gifted students is reflected in diminishing federal funding, from $11.25 million in 2002 to $9.6 million in 2006 with no allocation in the education bill for the Javits Gifted and Talented Students Education Act in 2007. In 2002, the No Child Left behind Act (NCLB) was signed into law, which focuses on developing “proficient” science abilities for all students. The development of the gifted science student’s “advanced” talent is not a priority. This is a major flaw in the No Child Left Behind provisions. The students who could be science leaders in this nation are denied the opportunity to learn advanced science content and develop talent based on their scientific understandings. Science teachers need to use special strategies to facilitate the learning of science by gifted middle school science students.

One obvious intervention is to provide special services to students gifted in science by offering challenging courses appropriate for the highly proficient and advanced science students. Also, we need
highly qualified science teachers equipped with the essential tools to teach the gifted science students beginning at least in the middle school. “In the life of any child, a teacher is crucial. But for a gifted child, one teacher can open the door to an entirely new educational pathway by making sure that child is set on an appropriate challenging course” (Colangelo, Assouline, & Gross, 2005). These students need sufficient, nurturing environments that will allow them to become creators of knowledge (Watters & Diezmann, 2003).

By providing challenging and interesting lessons, the science teacher may be the only catalyst that a gifted science student will have to develop his/her potential. Popular wisdom says that gifted children can teach themselves and learn by do-it-yourself trips to the library; experts say the truth is that academically talented students need qualified, informed teachers” (Colangelo et al., 2005).

The science teacher, through the appropriate identification of students gifted in the field of science, can provide new challenges and positive science learning experiences that can help gifted science students develop their abilities as talented young scientists.

The Middle School Student Gifted in Science
In the NSES (1996) there is less emphasis on treating all students alike and treating the whole class as a whole to envision change. This encompasses the gifted science student, as a major provision made for the teacher to nurture the student who is gifted in science.

Yager (1989) has identified the student gifted in science as possessing a variety of characteristics and abilities:

1. Strong curiosity about objects and environment;
2. High interest in investigating scientific phenomena;
3. Tendency to make observations and ask questions;
4. Ability to make connections between scientific concepts and observed phenomena;
5. Unusual ability to generate creative and valid explanations;
6. Interest in collecting, sorting, and classifying objects.

The middle school ages (13 years to 15 years), including grades six, seven, and eight are a period of student turmoil connected with a critical developmental period. This period represents a time of maturation, including the establishment of self within the teenage culture. This culture becomes a dominant consideration. This age demands recognition of the right to individuality and uniqueness, as well as respect for the process of “being who they are” (Assouline & Colangelo, 2005). Silverman (1993) observed “The children’s experience of school is completely colored by the presence or absence of relationships with peers” (p. 72).

And, it is realized that the importance of an educational environment that sustains the growth of friendships through the attainment of excellence is an essential learning environment for these gifted middle school students. The need to challenge these talented adolescents to continue developing their talent and potential in science is too often ignored.

The Science Teacher for the Gifted Student
A survey conducted in which experts in the field of the education of the gifted were asked to rank “key features of programs for the gifted in order of importance (Renzulli, 1981). The teacher: “selection and training” was accorded the highest priority (Borland, 1989). Research suggests that curriculum, class size, district funding, family and community involvement and many other school related factors all contribute to school improvement and student achievement (Cawelti, 1999). But the single most influential school-based factor is the teacher (Stronge & Tucker, 2000). Recent research also suggests focusing on value added connection between teaching and learning has found that teachers produce a strong cumulative effect on
student achievement. For example, students placed with highly effective teachers for three years in a row, beginning 3rd grade, scored 52 percentile points higher (96th versus 44th percentile) on Tennessee’s state mathematics assessment than did students with comparable achievement histories that had three low performing teachers in a row (Wright, Horn & Sanders, 1997). It is evident that the significance of a teacher is central to education and education of the gifted. Research reveals that gifted science students need special attention in content and strategies of teaching (Gross, 2000; Watters & Diezmann, 2003), but what do we know about teachers who teach the gifted science middle school students?

Effective science teaching is the key vision for science education and is described in the NSES (1996). The Standards are supported by research and many science teachers are using them in their classrooms. The National Science Education Professional development Standards (NSES, 1996) envision change throughout the system. The focus for increased emphasis for the professional development science education standards is indicated in Table 1. It provides the vision for all science education programs to inculcate and promote for better science teaching.

**Table 1**

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<tr>
<th>Changing Emphases of Teaching</th>
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<td><strong>Less Emphasis on</strong></td>
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<td>1 Transmission of teaching knowledge by lectures</td>
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<td>2 Learning science by lecture and reading.</td>
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<td>3 Separation of science and teaching knowledge</td>
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<td>4 Separation of theory and practice</td>
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<td>5 Individual learning</td>
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<td>6 Fragmented, one shot sessions</td>
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<td>7 Courses and workshops</td>
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<td>8 Reliance on external expertise</td>
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<td>9 Staff developers as educators</td>
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<td>10 Teacher as technician</td>
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<td>11 Teacher as consumer of knowledge about teaching</td>
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<td>12 Teacher as follower</td>
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<td>13 Teacher as individual based in a classroom</td>
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<td>14 Teacher as a target of change</td>
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Source: National Science Education Standards, 1996, p.27-5

**Significance of this Study**

The National Assessment of Education Progress (NAEP 2000) science assessment report reveals better scores for middle school science students are found if taught by teachers majoring in science education. It is of utmost importance to ensure that the science teachers teaching the highly proficient and advanced students have knowledge of and access to the conceptual tools needed to teach the gifted science students.
This area lacks research; therefore the purpose of this study was to investigate how science teachers who teach science in an extracurricular science program describe their conceptual understandings, beliefs about constructivist teaching practices, and understanding of the nature of science. And, how do they change with professional development. This study demonstrates the importance of professional development for science teachers who facilitate the learning process for gifted science students at the middle school level.

Identifying the need for inspiring middle school interested and gifted science students, The University of Iowa’s Belin-Blank Center piloted “The Extracurricular Enrichment Science Program (EESP), an extracurricular mathematics and science enrichment program for interested high-ability rural middle-school students in Iowa in 2003. Six science teachers from EESP participated in this study. The goals of the EESP are to provide advanced mathematics and science curriculum for high-ability middle school students in an effort to increase the academic aspirations of these gifted students, as well as to prepare these students for Advanced Placement and other high-level mathematics and science opportunities. These goals have been achieved by providing professional development to EESP teachers through the Belin-Blank Center’s Dynamic Model of Professional Development.

**Extracurricular Science Programs for Middle School Gifted Science Students**

Extracurricular are those activities which are sponsored or approved by the board but are not offered for credit toward graduation. Such activities are generally conducted outside the regular school day available to students who voluntarily elect to participate, marked by student participation in the processes of initiation, planning, organizing and execution and shall ordinarily include band, clubs, dramatic or musical presentations, and intramural and interscholastic sports.

The Excellence Program is categorized as an “Extracurricular Enrichment Science Program” and follows a curriculum outside the normal academic day in science and mathematics. The program provides acceleration through enrichment (Assouline, Blando, Croft, Baldus & Colangelo, 2008).

The necessity of extracurricular programs seems to be essential as students have 80% of time open to them when they are not in school (Zaff, Moore, Papillo, & Williams, 2003). The National Research Council and Institute of Medicine, 2000 and Nadel 2000 reports that five million students are not supervised by an adult after school. The Council also reports that the maximum crime involvement of juveniles is conducted between 2 p.m. and 8 p.m. As well, it is reported that 66% of the Nation’s children live in single parent home. Structure-less time for adolescents may have a negative impact on them (Mahoney, 2000). Productive structured activities for children and adolescents provides benefits and is considered to be safe and prevents delinquent activities like playing a video game or watching television (The National Research Council and Institute of Medicine, 2000). Extracurricular, after school programs are assumed to have a positive short as well as long term effects, although there is not enough research to support this claim (Pittman & Cahill, 1991).

Many summer camps, competitions, and retreat programs for science have emerged for gifted students in various universities and schools, but there are very few extracurricular science programs being run for gifted learners during the academic year.

A study on extracurricular science activities as an after school program conducted for girls in grades 3-6 by Wood (2002) indicated that there was limited opportunity for students to use hands-on or inquiry science in their regular science classes. Wood suggested science teachers should increase their efficacy for science teaching by providing them with subject specific professional development. Another study by Melber, (2003) concerning an extracurricular science program showed positive results on students liking the inquiry science activities and would like such activities in their regular science classes.

Research conducted by Cross and Coleman (1992) reveals student frustration at being held back in content courses. In another study by Lynch, (1992) on a 3 week summer science program conducted for 6
years for middle school gifted learners in science revealed that these middle school gifted science students performed better than the high school students who participated in yearlong courses.

There are not many research examples to cite that demonstrate the positive impact of extracurricular programs on gifted students in middle school with regard to their academic achievement, however, it seems a significant step forward to accelerate the gifted science students in the middle school through enrichment programs like the Iowa Excellence Program.

**Elementary Science**

Literature and resources for gifted science learners in the elementary area is very scarce. There is evidence that there is a lack of attention to the students who are gifted in science at the elementary level. Elementary science curricula for gifted elementary learners were reviewed by Adams & Pierce, 2007 over the past 25 years; they reported one book as a resource containing 139 articles. Of the 139 articles, 53 articles did not cater to elementary science for gifted or high ability learners. Research by Rogers (1992) also revealed that there have been 21 investigations for subject acceleration in grades 2-12; however, only 2 of the 21 studies focused on science acceleration in these grades.

There is research that delineates the effectiveness of some elementary science curricula in use. College of William and Mary developed and implemented 7 science units; of them 3 (Acid, Acid Everywhere; Electricity City; What a Find) were studies reporting their effectiveness. The units are for grades 2-6 for 45 classes in 15 school districts in 7 states. The evaluation for some units reported significant gains in the experimental group (Van-Tassel Baska, Bass, Ries, Poland & Avery, 1988).

Research conducted on Individual Progress Program (IPP) by Norsen & Wick (1983) was begun in 1978 in Seattle, WA elementary school in grades 1-5. Students were identified as gifted students. The science part of the curriculum targeted higher order science process skills, laboratory activities, critical thinking, and complex problem solving. California’s Achievement test was used for above level testing. However, science achievement was not measured.

Some states report special programs for gifted learners in science at the elementary level. Indiana, Illinois, and Ohio use Project “Spring” for gifted science learners. “Spring II” (Spicker, 1996) serves African American, Mexican American, Mescalero Apache and Appalachian populations in Indiana, South Carolina and New Mexico.

**Secondary Science**

Gifted students in science at the secondary level receive more attention than the elementary students gifted in science. They are provided with opportunity to participate in college level course work offered by the College Board in the form of advanced placement or another option is the International Baccalaureate offered by many high schools in the nation. There are several colleges and universities that waive course work completed by students in high school when they enter undergraduate education dependent on student achievement in these external exams. Even then, the Third International Math and Science study (TIMSS;Mullis et al,1998) reports that grade 12 students in the US did better than only 2 nations of the 21 participating nations in math and science.

There are several studies indicating the focus on gifted or high ability science students at the secondary level. Research by Simonton, 1988; Subotnick & Steiner, 1994; Zuckermann, 1996 reported qualities like scientific inquiry, intelligence and persistence as three reasons for success in science in individuals who are members of the National Academy of Science (NAS). A study by the Westinghouse finalists conducted by Feist (2006b) on gifted science students of the age range of 11-22 reported that 79% of the students continued to do science because they had a “motivation to do science”.
Reis and Park (2001) found males achieving higher than females in the National Longitudinal Study of 1988. Family and teachers influences were found to be the reasons for girls achieving higher in science in a study by Olszewski-Kubilius & Yasumoto (1995). Joyce and Farengo, (2000) concluded from their study of 9-13 year old science high ability girls that special programs for science in residence are helpful in their science achievement.

**Teachers of Gifted Students**

Teachers need to teach gifted learners in a manner that encourages them to practice thinking like experts in more depth (Ericson, Krampe & Tesch-Rome, 1993).

Teaching that includes cognitive flexibility (Spiro, Coulson, Feltrovich & Anderson, 1988) is especially appropriate. Teaching that has instruction that has cognitive apprenticeship (Brown, Collins & Duguid, 1989) is appropriate instruction for gifted science students is essential. Lack and depth of content may be the problem with science instruction in the nation for gifted science students. Japanese 8th do not do better because of better prepared teachers, smaller classes, a longer school year, less TV, and more homework. The differences trace right to the classroom, where the learning goals are clear, the topics per year are few but treated in depth, and where students learn to apply through real-world problem solving and verbalizing for meaning. In US schools, by contrast, learning goals are defuse, coverage is “Key” (30-35 topics a year vs, 6-10 in Japan), textbooks are larger each year, and everything has to be taught and re-taught again… (Marchese, 1998, p.3)

The National Research Council (NRC) supports inquiry as an appropriate instruction approach for gifted science students. NRC advocates that this instruction so much that a book was published was published authored by (Olson & Louck-Horsley, 2000). It supports the inquiry instruction for teachers to support gifted science learners through modeling scientific thinking and attitudes.

Inquiry teaching requires that students combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science. Engaging students in activities of and discussion about scientific inquiry should help them to develop an understanding of scientific concepts; an appreciation of “how we know” what we know in science; understanding of the nature of science; skills necessary to become independent inquirers about the natural world; and the disposition to use skills, abilities, and attitudes associated with science. (NRC 1996, p.6)

To evaluate the type of inquiry instruction, NRC set standards for inquiry instruction which include:

1. Learners are engaged by scientifically oriented questions;
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions;
3. Learners formulate explanations from evidence to address scientifically oriented questions;
4. Learners evaluate their explanations in light of alternate explanations, particularly those reflecting scientific understanding; and
5. Learners communicate and justify their proposed explanations (NRC, 1996, p.14)

Mentorship and Internships offer opportunities for gifted science learners that have proved very helpful to gifted science students to pursue their interest and potential in science (Subotnik & Steiner, 1993; VanTassel-Baska & Subotnik, 2004). Csikszentmihalyi (1996) found that creative individuals who have made major contributions in their fields owe it to their mentor and mentorship. Feng, 2007, Subotnik et al., 2001, Van Tassel-Baska, 1998 and Quek, 2005 indicate the significance of a good mentor for gifted science students.
Curriculum for Middle and High School Gifted Science Students

There is scarce numbers of curricula available for middle school gifted science students. Some examples of curricula that can be used for gifted science students include: Knowledge Integrated Environments framework (KIE) by Linn, Davis and Eyl on (2004). This curriculum uses a combination approach of inquiry through science activities. The curriculum projects that are developed using the KIE framework are – Project Web Based Inquiry Science Environment (WISE); Project Science Controversies Online Partnership for Education (SCOPE); Computer Supported Intentional Learning Environments (CSILE); Computer as Learning Partner: House Design (CLP).

Other attempts to better serve gifted students include:

1. Science /Technology /Society (S/T/S; Yager, 1993) Many science teachers of gifted learners use the STS model for teaching science as it can be adapted to the level of challenge, complexity and abstraction can be molded to need (Gallagher, 2005)
2. Problem Based Learning (PBL; Barrows & Tamlyn, 1980). This can also be used for other subjects than science and can be used for middle and high school science students.
3. The Illinois Mathematics and Science Academy (IMSA) integrates the three areas in science to develop strong epistemological grounding in students.
4. Specialized online schools for the gifted in science for high school – National Consortium of Specialized Secondary Schools of Mathematics, Science and Technology (NCSSMST) provide advanced course work to gifted science students in high school.
5. Subotnik (2003) supports individualized instruction to gifted science learners based on their level and speed, comparing the instruction delivery and format to how musicians and sports men and women gain support.
6. Science and Technology Industries sponsor and support science competitions in many areas to provide the desired advanced science experience (Gallagher, 2006) Extracurricular Science: Institute of Educational Advancement (IEA) – conducts academic competitions. Summer Opportunities are provided in any area. Talent searches are conducted by University of Iowa’s Belin-Blank Center, John Hopkins University Center for Talented youth, Duke University’s Talent Identification program are some locations for resources on camps, extracurricular science programs for advanced science learners. NASA operates camps and space programs for interested and able science students.

Methodology

The purpose of this study was to investigate how six teachers who teach science in the Excellence Extracurricular Science Program (EESP) describe their conceptual understandings, beliefs about constructivist teaching practices, and understandings of the nature of science.

Another focus was on how the science teachers change over the course of their involvement in professional development programs prior to the start of the Excellence program and to find out what the six teachers found most useful for improving their teaching for the benefit of the students enrolled in the program.

This project is a descriptive embedded multiple case study (Isaac & Michael, 1995; Merriam, 1998; Yin, 2003) designed to document what six science teachers who participated in the program brought to the enrichment course regarding their knowledge of science, constructivism, and teaching methodology, as well as what they took away from the professional development.
Additionally, this study documents the groups understanding about gifted middle school science students. A description of the Iowa Excellence Program’s history is included elaborating on its current status as an important and vital educational project and increasing opportunities for the advanced learner. It is of outmost importance to have programs that are able to draw student interest in science during their elementary and middle school years.

Theoretical Basis

The National Science Education Professional Development Standard indicates that: “The challenge of professional development...is to create optimal collaborative learning situations in which the best sources of expertise are linked with the experiences and current needs of the teachers” (National Science Education Professional Development Standards, 1996, p.58). In addition, the second basis for this study lies in the general belief that investment in teachers is highly correlated with improvements in student achievement than are any other use of educational resources. Science students whose teachers participate in professional development which focus on laboratory skills and/or facilitate hands on learning outperform their peers are best. (Cohen & Hill, 2000; Darling-Hammond, 2000; Weglinsky, 2000). Both these bases provide ample reason for providing need based professional development to impact student achievement by identifying what the science teachers bring to the professional development program and what they take away from it while using it in the extracurricular science program for gifted middle school science students.

Because this particular study focuses on an extracurricular academic program, it did not test students to determine a change in science achievement scores to measure success of the teachers’ professional development. The pilot study conducted from 2003 to 2006, however did conduct above-level testing at the beginning and at the end of each year of the Excellence program during the three years when the study was being funded by a grant from the federal government.

The average science results for the three years showed an increase in achievement by the students who participated in the program. The mean science pretest score over 3 years was16.90 while the mean posttest score over 3 years was 18.04. An increase in test score 1.14 was evidenced (Gifted Education Center, 2006)

This study involves using three pretests before and three posttests after the professional development provided to all the teachers participating in the program. Triangulation was implemented with face to face interviews as well as observations of the teachers while they taught in EESP.

Excellence Program

The Excellence Program’s history dates back to the late 1990’s when The University of Iowa’s Belin-Blank Center partnered with Israel’s Arts and Science Academy (IASA) in Jerusalem. The purpose of the Excellence Program was to increase aspirations and to provide a more challenging math and science curriculum for rural Iowa, gifted middle-school students. The idea was simple: initiating rural school children for more advanced math and science studies at high school and college levels. A unique aspect of the program was that, although the University of Iowa implemented it, it was Federal funding that financed the pilot phase. Science and math experts from the University provided the professional development for the teachers participating in this program. A key element of this additional academic opportunity was that it was extracurricular in nature with no assignments or tests; the “work” was seen as fun and free from traditional classroom constraints.

Soon after the exploration phase, the Gifted Education Center initiated affiliation with the Mitchell Excellence Program (Curriculum) at the Israel Arts and Sciences Academy (IASA), in Jerusalem, Israel. In 1988 IASA founded a residential public high school for gifted and talented students in Israel. The Academy discovered that mainly urban students applied for admission and achieved academic success at the academy, while rural students were not prepared for IASA’s program. To rectify this inequity IASA developed the
Mitchell curriculum. This specialized curriculum targeted only rural middle schools in Israel; its single goal was to support and prepare students in the middle school to be more successful at IASA, if they were accepted. It was believed that if the rural students in Israel benefited from the Mitchell curriculum, there was no reason why students in rural Iowa could not also benefit from an identical extra curriculum science and math opportunity. (Assouline, Blando, Croft, Baldus, & Colangelo, 2008).

The pilot phase of the Excellence Program was implemented from the fall semester of the 2003 school year to 2006, supported with federal funding. The project began in five rural school districts; these selected schools included 22 teachers for science and math, coordinators, administrators, and 67 students in grade 6. In one year the students received 96 classroom hours of science and math instruction each year with 4 hours of after- or before-school instruction each week. Prior to the implementation of the Excellence program, the science and math teachers participated in a weeklong professional summer workshop at the University of Iowa.

The independent phase of the Excellence program began in 2006 with 7 school districts, 155 students, and 21 teachers and coordinators. Four school districts were new to the program while 3 school districts continued from the pilot phase of the program.

The Excellence Program revolves around the following 7 elements:
1. Middle School Students
2. Talent Development
3. Extracurricular Science
4. Student Identification
5. Excellence Teachers and Professional Development
6. Program Implementation
7. Evaluation

**Middle School Students**
The Excellence Program is for rural middle school students who are interested in math and science and who have proven to be highly competent. Normally, and unfortunately, these children have limited opportunities due to their school district size and/or location. Most advanced programs are targeted for high school students but not for middle school children.

The middle years, however, have been identified as the most crucial years for school children; at this age, boys and girls still have a sense of wonder about the world around them, they are still curious and open to experimentation, and they invest time in thinking about what they would like to be when they grow up.

These are also the years in which young people begin to develop special interests and define individual strengths. It is especially critical that young gifted students have opportunities, separate from the classroom experience, to explore new and/or more advanced academic realms. For middle school children who are interested in science, the Excellence Program provides not only a productive use of after school time but also an environment in which they can explore more independently their special areas of interest.

The middle school ages - 13 years to 15 years - include grades 6, 7, and 8. These years represent a critical developmental period; it is a time of maturation and individuation – separating from family and home life – and includes that difficult stage of life, the establishment and/or identification of “the self” within teenage culture. This culture becomes a dominant consideration, as all parents know this particular stage of life demands recognition of the right to individuality, as well as respect from others for the process of “being who they are” (Assouline & Colangelo, 2005).

Historically, tension has existed between gifted education and regular middle school curricula (Tomlinson, 1992), leaving advocates of each educational practice suspicious of the other. Unfortunately,
this leaves middle school youngsters who are advanced in one or more areas of learning in an educational no-man’s land.

A major problem for these gifted young adolescents is that middle school educators are trained and advised to promote academic environments in which teenagers can feel they belong to a nurturing peer group. School decision-makers understandably desire classrooms that provide children with consistent access to adults who know and care about their social needs. Regrettably, the result can be a minimizing of the students’ intellectual needs (George & Shewey, 1994). It is therefore essential for school districts to incorporate curriculum and services that meets the needs of the students intellectually as well as academically in the content areas.

**Talent Development**

Bloom (1985) suggests that the first phase of talent development allows for “informality and playfulness”, which means catching the gifted child’s attention (hopefully even before school age). The second phase focuses on the individual student’s specific areas of talent, including participation in varied activities and invitations to explore subject matter with more advanced teachers in more disciplined and sophisticated ways. The focus of the Excellence Program is with the first phase; students gifted in math and science must be provided with opportunities to fully enjoy their chosen areas of specialization, and with extra time allotted for developing their individual talents in science.

The first and most important aspect of this academic approach involves the excitement of discovery, “hooking” youngsters into math and science for the first time. Each discipline (like physics or history) “…exhibits its own particular practices and approaches…. One cannot begin to master a [discipline] or to understand it, unless one is willing to enter into its world and to accept the**disciplinary and epistemological constraints that have come to operate within it over the years” Gardner, (1991).

**Extracurricular Science**

Extra-curricular programs traditionally offer music, sports, arts and crafts, but rarely science. However, the assumption is that there are, indeed, many students who enjoy science more when it is being offered to them as an after school activity. It is a unique idea: the offering of an extracurricular science program for middle school students that is completely hands on and non-competitive. Exploring science just for the fun of it is much more appealing to most youngsters, especially when there is no academic follow-up in the form of tests or assignments.

The most important component of the Excellence Program is to have fun with science while also increasing knowledge in preparation for high school level work. Unfortunately, in many of the Midwest’s rural school districts, including Iowa, the size of the school impacts the number of Advanced Placement courses offered.

The smaller the school the fewer AP courses are available for the gifted student(s). This dilemma, in fact, led to the introduction of Iowa’s Online Advanced Placement Academy (IOAPA), which now offers college based course work to the many small sized Iowa high schools. Similar thinking by the Gifted Education Center led to the inception of the Excellence Program.

It was designed to remedy the lack of challenging and much more advanced subject matter to interested middle school students. This is especially true in regards to advanced science and math. The obvious additional benefit is that the participating students would be better prepared for more difficult high school math and science studies.
**Student Identification**

The first method of identifying students who qualify for participation in the Excellence Program is through teacher nomination; obviously, instructors are best able to assess their own students’ abilities and strengths. Test scores from the Iowa Test of Basic Skills (ITBS) and teacher observation(s) are considered prior to nomination.

The next step in the process was student assessment from the results of above-level test(s). This means that grade 6 students take a science and math test, which is meant, for grade 8 students. The above-level test used is the American College areas of (a) English, (b) Mathematics, (c) Reading, and (d) Science Reasoning. Information from the above-level test can help plan appropriate curriculum for students in any of the above areas. As well, students interested in participating in the program were given the opportunity to join the Excellence program. It was discovered as the program was implemented, however, that the students who had lower scores on ITBS or the Explore tests decided to drop out of the Excellence program. The students who achieved a high score on these tests continued to participate in the program.

The Explore test was given to students as a pretest before the start of the Excellence Program and then as a post-test at the end of the school year. This method of identifying gifted students proved to be effective.

**Excellence Teachers and Professional Development**

Understanding the need to empower the teacher to strengthen the student in science and math, the middle school science teachers who teach the gifted middle school science students in the Excellence program were provided with a professional development before the start of the academic year. The professional development provides training to these excellence teachers to practice:

1. Facilitating independent study, where the teacher is a guide and/or coach.
2. Encouraging depth of learning within a fast pace (discovery)
3. Emphasizing complex and challenging work by the student
4. Freedom of choice [for the student] in content, process, product, and environment

The teachers in the Excellence Program were chosen by the school district based on various factors, including possessing an Iowa teaching license for middle school; endorsements and certification at the secondary level in biological science, chemistry, physics, general science, earth science, physical science and/or mathematics. Attendance at professional development every summer at the Gifted Education Center is also a requirement for the teachers participating in the Excellence Program.

Other factors that contribute to teacher selection are enthusiasm, expertise in middle school education, a willingness to learn and collaborate with others, unique teaching methods, and perhaps most importantly, creativity in teaching above-average middle school science and math students.

The teachers who are selected for the Excellence Program have many responsibilities that require vigorous practice. The instructors begin their leadership “practice” by participating in mandatory professional development during the summer. Once the teacher has successfully completed this requirement he or she is provided with the curriculum units for the middle school semester and is then assisted with resources and mentoring by experts in the fields from the University.

The teacher helps identify students from their schools by nominating children for talent discovery. They must also familiarize themselves with equipment and technology recommended for inclusion in the Mitchell Curriculum. During this intensive work period, teachers are collaborating with other Excellence teachers from other participating school districts while also partnering with coordinators of the program. The teachers learn to work directly with the district Excellence coordinator; who is assigned to communicate with families, school administration and the Gifted Education Center during the school year.

The teachers complete their summer project with an evaluation of the procedures set by school districts and the Gifted Education Center in order to help improve the program for the following summer.
Last but not least the teachers provide feedback to the Iowa Excellence coordinator, school district, and the Gifted Education Center about progress in their own Excellence classes.

Professional development of science and math teachers is a major component of the Excellence Program. The model used by the Excellence professional development was created by the Gifted Education Center in 1980 and is called the Dynamic Model of Professional Development.

This instructors’ summer course begins with general housekeeping matters and moves onto an explanation of the history of the Excellence Program. Data regarding the previous year’s evaluation are also shared at this time. The participants are then split up into math and science sections with teachers attending sessions led by master instructors from the University of Iowa. These experts outline the content of each academic unit and offer teaching strategies, which includes use of University laboratories.

Each unit takes two to three hours; these presentations and “labs” comprise most of the first few days of professional development. At the end of the week the Excellence middle school curriculum is given to the teachers for peer coaching followed by group discussions. The teachers are encouraged to communicate with each other throughout the school year by using their Excellence teacher’s list-serve where current science information and/or math news is posted. Figure 5 demonstrates the facets of input and output for the science instructors teaching in the Excellence Science Program for Middle School Students.

**Program Implementation**

The need for more challenging math and science curricula for the middle-school grades in rural districts in the Midwest was met primarily by the Partners in Excellence Program. In 2000, on a National indicator of academic success the number of Advanced Placement (AP) exams taken per thousand students), Midwestern public schools ranked 45th out of 50 states in the nation. Just as students cannot succeed in the college classroom without appropriate preparation, they cannot succeed in the challenging AP classroom without extraordinary preparation; the Excellence Program serves to enhance analytical thinking, communication skills and enthusiasm.

The Excellence Program was formally launched during the fall semester of 2003. Using the Israel Arts and Science Academy in Jerusalem as a “template”, a middle school curriculum was adapted by University of Iowa’s math and science professors for use in Iowa’s rural public schools. The academic topics covered during the pilot phase are listed below in Table 2. The science units completed during the first year in 96 hours of class time are also included.

**Table 2**

<table>
<thead>
<tr>
<th>Topics Covered by the Iowa Excellence Program in Three Years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year 1 Science</strong></td>
</tr>
<tr>
<td>Grade 6</td>
</tr>
<tr>
<td>Flight into Space</td>
</tr>
<tr>
<td>The Unseen World</td>
</tr>
<tr>
<td>Grade 7</td>
</tr>
<tr>
<td>Chromatography</td>
</tr>
<tr>
<td>The Chicken and the Egg</td>
</tr>
</tbody>
</table>

Sixty-seven schools are currently using this curriculum across Illinois in the Illinois Math and Science Academy (IMSA hub). This includes five districts in three pilot years and seven school districts in 2006-07 are using it in Iowa.
There are forty-five schools in the Jewish Day school system that are using it in New York, the Gruss Foundation in the United States. Twelve units were translated into English and the units were purchased annually from IASA. Currently, about 130 schools around Israel operate the programs, with the involvement of approximately 7,000 students, guided and taught by approximately 400 teachers.

Each participating school district has an on-site Excellence coordinator, a science teacher, and a math teacher. There is collaboration among the three in setting up the classes, guiding and assisting the students, encouraging active and lively debate among the students, as well as providing appropriate materials and resources. “Quality control” includes on-site visits by the Administrator from The Gifted Education Center, while newsletters and dissemination of enrichment materials are ongoing.

The Federal grant and allotment of funds during the pilot phase of the Excellence Program is provided in Table 3.

**Table 3**

**Financial Support Provided to the Participating Schools**

<table>
<thead>
<tr>
<th>Provision/Support</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Salary for Instructor</td>
<td>100 per hour &amp; $10000 year</td>
</tr>
<tr>
<td>2 Resources and Supplies for Schools</td>
<td>$1200 per year</td>
</tr>
<tr>
<td>3 Salary for Excellence Coordinators</td>
<td>$1000</td>
</tr>
<tr>
<td>4 Tuition for one graduate credit for professional development</td>
<td>$ 285</td>
</tr>
<tr>
<td>5 Travel/ Food and Lodging for professional development.</td>
<td>Varies</td>
</tr>
<tr>
<td>6 Talent Search Fees $25 per student for 25 students per site</td>
<td>Gifted Education Center</td>
</tr>
</tbody>
</table>

In August 2006, the financial support changed and the school districts had to find funding for the Iowa Excellence Program from other sources; the Federal funding was provided only during the pilot phase, 2003 to 2006. Middle schools were able to apply for affiliation with the Excellence Program at the Gifted Education Center, at a University in the Midwest. Although there is no fee for affiliation, a minimum of three years commitment is required.

Table 4 shows the list of provisions and support provided to the Iowa Excellence Program by the Gifted Education Center and Independent School Districts. There were many costs associated with the continuation of the Program.

Each district was provided with a recommended salary for the teachers, but they were allowed considerable flexibility in locating their funding and establishing individual budgets.

**Table 4**

**Provision and Support during the Independent Phase from Fall 2006**

<table>
<thead>
<tr>
<th>Provision/Support</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Salary for Instructor</td>
<td>School district determine</td>
</tr>
<tr>
<td>2 Excellence Curriculum &amp; Resources and Supplies for Schools</td>
<td>Gifted Education Center</td>
</tr>
<tr>
<td>3 Salary for Excellence Coordinators</td>
<td>School district determines</td>
</tr>
<tr>
<td>4 Tuition for one graduate credit for professional development</td>
<td>$ 285 by Gifted Education Center</td>
</tr>
<tr>
<td>5 Professional development/Registration and Meals</td>
<td>Gifted Education Center</td>
</tr>
<tr>
<td>6 Talent Search Fees</td>
<td>Discounted by Gifted Education Center</td>
</tr>
</tbody>
</table>
The school districts’ responsibilities increased when the Excellence Program began its independent phase during the fall of 2006. The participating schools signed a three-year commitment contract with the Gifted Education Center, as required, while the Gifted Education Center provided administrators, professional development training during the summer, mentoring, and graduate credit to teachers (for participating in professional development and leading the Excellence curriculum units at selected middle schools). School districts are responsible for paying their teachers and the Program coordinators. Collaboration with the Belen-Blank Center and the International partners is ongoing in order to ensure adherence to the Mitchell Curriculum.

There were many methods used to measure the impact of the Excellence Program. Surveys to determine satisfaction were completed by both students and teachers. For the most part, students and teachers agreed that they thoroughly enjoyed the activities associated with the curriculum. During the pilot study American College Testing (ACT) administered an above level test in order to determine student progress. The results from the pilot phase of the Excellence Program are outlined below.

A mean science score of the pretest, for the three years is 16.90 and the mean science score of the posttest is 18.04. A total improvement of 1.14 in the area of science reasoning (Explore Above level test) is noted (Gifted Education Center, Excellence program 2006). One science teacher, who has been with the Excellence Program since its inception, remarked that all but one student in her school district has chosen to study science in high school. This instructor has been teaching since 2003 and has taught many students in the Excellence Program. It is assumed that many other teacher/participants have experienced identical achievements by their own math and science middle school students.

**Excellence Workshop Description**

The Excellence Professional Development Program follows the Dynamic Model of Professional Development (DMPD). This is a model developed in 1980 and includes the following components: an in-residence immersion experience at the University of Iowa, interaction with master instructors in the areas of mathematics and science, exposure to principles of gifted education, and opportunities to discuss relevant issues associated with promotion of excellence at the middle-school level. The workshop at the University of Iowa campus is supplemented with individual science teacher support throughout the school year. The administrator keeps continuous contact with the Excellence program coordinators of the participating schools. Immediate teaching and resource help is provided to the Excellence program coordinator for the sites. The administrator makes site visits at least twice a semester to view the ongoing program and provides any additional individual needs based professional development to support the teachers.

During the pilot phase from 2003 to 2006, the Excellence program was funded by the Federal grant that funded the program execution and it paid for the teachers teaching time. During its independent phase from 2006 onwards, the parents whose children participated and the school district paid the teachers a smaller amount as compared to what they were paid when the federal grant was being used.

The formal part of the Excellence professional development occurs over three days during the summer when the units are distributed to the teachers. Workshops are taught by experts from the fields with hands-on
experience at the University of Iowa laboratories. The teachers are provided with a small stipend to teach the Excellence science program.

Table 5 demonstrates the DMPD. This model features an analysis of content, a review of curriculum, an examination of actual practice and collaborative efforts.

**Table 5**
The Belin-Blank Dynamic Model for Professional Development and Curriculum Improvement

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Immersion</td>
<td>Provide the time and place for teachers of the Excellence program to focus on learning Science in depth related to the curriculum.</td>
</tr>
<tr>
<td>Focus on Curriculum</td>
<td>Review Existing Curriculum and learn to develop new materials to allow students to analyze the science curriculum content.</td>
</tr>
<tr>
<td>Examination of Practice</td>
<td>Explore and apply best practices.</td>
</tr>
<tr>
<td>Participation in Collaborative Work</td>
<td>Develop small groups and teams to reinforce best practices and ongoing learning.</td>
</tr>
</tbody>
</table>

Source: Belin-Blank Center, 2005

The participating population consisted of the above-mentioned six science teachers from four rural junior high schools in the mid-west. All six instructors were certified science teachers, with expertise in biology, chemistry, physics or general science for elementary or secondary areas. The Excellence Program is currently active in five rural school districts in Iowa.

**Instrumentation**
In addition to the open-ended interview, three validated instruments were used for this study with each participant. The six science teachers prior to professional development answered the instruments and then
the same instruments were used after the professional development. The pretest and posttest were used to investigate changes in the science teacher’s views regarding constructivist teaching practices, specifically, in regards to the nature of science. The investigator also conducted individual interviews, lasting no more than two hours.

The first instrument is titled “A Scale for Constructivist Teaching Practices” (Enger & Yager, 2001). The second instrument assess how familiar each science teacher was with constructivism (Yager, R. E. 2005). The third research instrument use is titled “The Views of Nature of Science Questionnaire – Form C (VNOS – Form C) (Lederman, Abd-El-Khalick., Bell, Schwartz, 2002).

A private, unstructured interview was conducted with each science teacher. As pointed out earlier, these individuals were observed teaching the Excellence middle school extracurricular class on two separate occasions during the academic year. The interviews’ objective was to identify the key features of the professional development summer workshops that were actually employed during extracurricular science teaching. The observations validated their perceptions of teaching gifted students using the Excellence curriculum. A rubric, Expert Science Teaching Educational Evaluation Model (ESTEEM) for a Science Classroom Observation (Burry-Stock, 1995) was used to analyze the teachers’ methodology. The instrument was able to identify whether the science teacher was an effective “facilitator”, were the participating students actively engaged in activities like asking questions, initiating exploration of new material(s) and showing a willingness to collaborate with others in the classroom. The instrument helped assess whether individual teachers were engaged in listening to students’ points of view, whether they offered appropriate and informal mentoring and/or whether they encouraged the extracurricular students to apply newly gained knowledge to further their own exploration(s). Finally, the instruments helped determine whether the science teacher encouraged students to apply and extend knowledge and to use various sources to gain information and insight other than the text book.

Data Sources

Pretests and Posttests

During the summer professional development workshop data were collected on the science teachers’ knowledge in the area of constructivist teaching practices. The science teachers completed their pretests and posttests in the same building where the professional development occurred. Identical questions were used for the pretests and posttests, although numbering was different.

Interview Procedures

Interviews with the science teachers were conducted during the summer, when the participating teachers were given break times. Additional interviews took place during the 2006/2007 academic year. Interviews, which were conducted in person, were audio taped and later transcribed.(Each of the six science teachers was initially asked to describe their educational background and professional experiences.) The investigator chose open-ended questions for the interviews. The content of these questions related to 1) why the teachers were interested in gifted middle school students, 2) what were their observations about a need for additional instructional opportunities, and 3) whether they had ever pursued any professional development specifically targeted for gifted science students. Additionally, the interviews allowed the teachers to describe their experience(s) in the Excellence summer workshops and their familiarity with the National Science Education Standards and Project 2061.

In addition, information about what would they suggest as additions to any science teacher pre-service education or in-service workshops for science teachers who teach at the middle school level with regard to teaching gifted science students was retrieved from them; what sorts of classes or preparation in teaching the
gifted middle school science students have they themselves received and what they felt were their persistent needs; how they filled these needs over time and if these needs were indeed addressed over time.

Also, questions related to whether or not they have gained new understandings or strategies to teach the gifted middle school science students in the Excellence professional development program for science teachers; and whether or not their teaching style differed when teaching the gifted science students as compared to the science students in the regular science at the middle school.

Their views on gifted middle school science students being allowed to learn science based in their area of interest or should they follow a challenging science curriculum for the most part or a balance of both was sought and examples were collected.

Information on their understanding of the gifted science students was obtained through questions like how they would describe the gifted middle school science student’s interest in science at the present time during the time the excellence program is occurring; how they describe the needs of the students in this after school extracurricular excellence program; what issues and challenges do these middle school science students face; what differences do they feel these middle school science students experience being in a homogenous group after school learning science and how do these students respond to this after school opportunity when no follow up work is required.

Open-ended questions caused the teachers to reflect on what they knew about science content, the nature of science, constructivism, gifted students and professional development. Opportunities were provided for the instructors to expand on their explanations using personal and professional experiences.

Observational Procedures
Interviews with the science teachers were conducted during the summer, when the participating teachers were given break times. Additional interviews took place during the 2006/2007 academic year. Interviews, which were conducted in person, were audio taped and later transcribed. Each of the six science teachers was initially asked to describe their educational background and professional experiences. The investigator chose open-ended questions for the interviews. The content of these questions related to1) why the teachers were interested in gifted middle school students, 2) what were their observations about a need for additional instructional opportunities, and3) whether they had ever pursued any professional development specifically targeted for gifted science students. Additionally, the interviews allowed the teachers to describe their experience(s) in the Excellence summer workshops and their familiarity with the National Science Education Standards and Project 2061.

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Data Analysis

Qualitative or descriptive research focuses on content rather than on procedures involved in research (Thomas & Nelson, 2001). Some procedures, however, were necessary for this study, as the timing of distributing pre-tests and post-tests was imperative.

Themes were chosen based on the questions asked in the survey for the pre-test and posttest, interview and observation guidelines according to the rubric used for observation. Since each of the areas had different topics of interest, there was no room for merger of themes in the three triangulation techniques used to gather data. Each science teacher’s responses and observations were coded in the number chosen for the participants.

For each of the triangulation measures used to gather data for this study, independent themes were drawn based on the questions asked. Each statement, question or survey item carried a different subject altogether, therefore each item was treated as an independent theme. For each of the themes the responses from the teachers were mentioned collectively to voice the science teachers’ knowledge, understanding and/or perspective on that particular question or survey item.

Pseudonyms were used for each science teacher’s name in the study to maintain anonymity of the subjects. Each new name was provided with a code number that determined individual responses for the pretest and posttests.

Results

Most of the teachers understood constructivism as a theory of learning; some realized that they were practicing constructivist teaching without having a name for it. The teacher responses to the items on the research instruments in the pre-test and post-test confirmed that they were already practicing constructivist teaching practices; most of them reported having been taught by these methods in their own undergraduate science education program. The teachers indicated that they felt that constructivist pedagogy was the best method for teaching gifted science students because it had been shown to increase their learning and their interest in science. The main perceived weaknesses of the constructivist methodology was the workload and time pressures on the teacher for the increased preparation required, and the inability of some learners to generalize knowledge learned from laboratory experiments to real-world settings. The science teachers’ perspectives of nature of science paralleled those advocated by the National Science Education Standards (NRC, 1996) and American Association for the Advancement of Science Project 2061 (AAAS, 2005) concerning the nature of scientific knowledge. The fact that the teachers had positive attitudes and experience using constructivist teaching methods prior to their involvement in the Excellence program demonstrated their suitability for inclusion in the program, and also enabled the researcher to measure progress for improving perceptions and general use of such teaching methods.

The in-service science teachers did not show any change in conceptual understanding of constructivism and the nature of science over the course of the professional development program. However, the teachers did enhance their views about certain aspects of constructivist teaching methods. All the six science teachers documented an increase in awareness about constructivist teaching practices for at least one
factor, most increased in five factors, even though there were no changes in relation to some factors for all the teachers. There was evidence that the teachers were able to think critically and to reflect concerning their teaching practices and compared to ideal constructivist practices. Moreover, the in-service science teachers’ use of higher order questions used in class based on Blooms’ Taxonomy increased from the start of the Excellence program to the end.

These findings provide evidence regarding the value of the professional development program as currently taught, at least to the research participants of this study. The program was observed to have a positive impact by encouraging the teachers to review their own teaching methods and to make relevant changes to improve their use of constructionist techniques. However, the program did not significantly improve knowledge of constructionist techniques nor increase the use of them in teaching practice.

The teachers indicated significant growth over the Excellence Professional Development concerning specific constructivist teaching practices. All mentioned their own meaningful learning in ways they could teach inquiry-based science to middle school students, the content of the Excellence program, use of specific teaching strategies for gifted science students in the middle school, developing a good sense of the process and valuable extensions to the curriculum that could be incorporated with ease. The National Research Council (NRC) supports inquiry as appropriate instruction for gifted science students. NRC advocates for this instruction so much that a book was published authored by (Olson & Louck-Horsley, 2000) which supports the inquiry instruction teachers use for gifted science learners by modeling scientific thinking and attitudes.

Inquiry teaching requires that students combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science. Engaging students in activities of and discussion about scientific inquiry should help them to develop an understanding of scientific concepts; an appreciation of “how we know” what we know in science; understanding of the nature of science; skills necessary to become independent inquirers about the natural world; and the disposition to use skills, abilities, and attitudes associated with science. (NRC 1996, p.6)

To evaluate inquiry instruction, NRC offers essential standards for inquiry instruction to achieve:

1. Learners are engaged by scientifically oriented questions;
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions;
3. Learners formulate explanations from evidence to address scientifically oriented questions;
4. Learners evaluate their explanations in light of alternate explanations, particularly those reflecting scientific understanding; and
5. Learners communicate and justify their proposed explanations (NRC,2000.p.29)

This confirmed that the program was providing benefits to teachers and apparently to students too, at least in terms of teachers’ perceptions. The findings relating to teachers’ preferred aspects of the program, in terms of learning content, can provide useful information for informing the nature of future programs with similar objectives.

As well as the formal learning content of the program, which the teachers were subsequently able to draw on in improving their teaching of gifted students, they also reported finding useful the links that were established with expert scientists and professional development experts at the University. In addition, a useful collaboration circle was formed among the science teachers participating in the program. This meant that the teachers had a range of useful resources to draw on in preparing lessons for their students and when dealing with any questions that they had. The resource provided by the inquiry-based standards published by NRC, 2000 is very useful for any science teacher to incorporate inquiry in their lessons. The results demonstrated the value of the professional development program for the teachers not only in terms of the
specific content taught, but also the contacts and access to useful resources that were developed as a result of participation. Such aspects perhaps could be incorporated more formally into the ongoing development of programs.

Mentorship and Internships offer opportunities to gifted science learners that have proved very helpful for gifted science students to pursue their interest and potential in science (Subotnik & Steiner, 1993; VanTassel-Baska & Subotnik, 2004). Csikszentmihalyi (1996) report that creative individuals who had made a major contribution in their field owe it to their mentor and mentorship. Feng, 2007, Subotnik et al., 2001, Van Tassel-Baska, 1998. Quek, 2005 study also delineates significance of a good mentor for gifted science students.

Teachers need to teach gifted learners in a manner that encourages them to practice thinking like experts do, i.e., in more depth (Ericson, Krampe & Tesch-Rome, 1993) and teaching that has instruction that has cognitive flexibility (Spiro, Coulson, Feltrovich & Anderson, 1988) and teaching that has instruction that has cognitive apprenticeship (Brown, Collins & Duguid, 1989).

The study revealed certain themes that characterize the teaching practices of the six teachers. First, they all exhibited a passion to teach science to the gifted middle school science students. They all tended to use higher level questioning in their teaching practice. Additionally, the teachers were very keen to collaborate with each other, in order to share ideas about teaching practices as well as student resources. A high level of informal interaction with students was a feature of their teaching styles, and all had created a suitable learning environment for ease of learning. In general, these teachers were acting as facilitators of student learning rather than traditional instructors. They paid attention to ensuring that their students successfully made connections between concepts and evidence, and ensured that they tried to clear up student misconceptions as they arose. The study thus provides good practice examples of constructivist learning techniques for gifted students, which can be incorporated into the design of future programs intended to develop and enhance the skills. The in-service teachers described a significant need to be informed about gifted students in their pre-service education at the undergraduate college of education level. There was a unanimous response from the six science teachers to be having at least one course focusing on the gifted learner mandatory for all education majors at the undergraduate level. Many teacher take special courses in gifted education to be able to teach gifted learner. There is a requirement for special needs students but for the exceptional learner there are no provisions for learning at that needed level. Part of the reasons why the science teachers did not face as much trouble understanding these learners was because these science teachers were identified as gifted learners at some point of their K-12 school years and were thus able to associate with gifted learners.

In general, the teachers indicated that their gifted science students were enjoying and benefiting from the extracurricular science program and liked being with students who had similar interests and passion for science. They attributed the students’ progress in this program to their particular learning needs, such as being taught at the similar level, getting relevant, hands-on experiences, and being challenged and accelerated in course work. Feeling confident and enjoying the class and being excited with challenge were among the observations that the Excellence program science teachers observed while teaching.

These findings provided evidence (at least from the perspective of the teachers and of the researcher-observer) indicating that gifted students of middle school do enjoy and respond positively to the constructivist teaching methods being used by these teachers and characterizes teaching in the Excellence program. The students enjoyed being in an environment where they have the flexibility for learning what they wanted to learn, ask the questions they want to ask, and explore ideas that came to their mind in the particular area of content in focus. However, the long term outcomes in terms of learning achievement could not be measured in the context of this study.
Research into professional development has shifted significantly over the last fifty years, as improved teaching methods have evolved. When considering the nature of teaching, one of the most interesting changes in the academic field is the move from process–product perspectives, which focus on teaching as a technical transmission activity, to understandings of teaching as requiring contextualized decision-making. Current research now focuses on teachers’ cognition, their knowledge of their subject, and their personal belief systems with regard to student welfare.

Recent trends focus on teacher professional development; collaborative models like The Belin-Blank Dynamic Model for Professional Development and Curriculum Improvement were designed to engage modern teachers in inquiry-based, longitudinal, and critical examinations of their instructional methods. These initiatives extend professional development activities from formal settings (e.g., teacher workshops) into authentic communities of practice (e.g. classrooms).

The Professional Development model used by the Iowa Excellence Program was built from emerging concepts of teaching and learning that consider teachers’ contextualized decision-making as they attempt to make changes in their practices, then monitor and account for outcomes associated with the changes they made.

The obvious significance of the teacher/student relationships were magnified by several factors when considering the gifted youngster. The teacher is a primary pole for students in an interactive process that is essential for learning. Superior intelligence performs best when interacting with a stimulating teacher. The teacher is inevitably a model. What does an educational system seek, then, in the teacher of the unusually apt learner? Are particular traits and/or personalities desirable in such a teacher? Is special training necessary? If so, are different components of academic knowledge and professional skill needed? Should such training be part of a teacher's general preparation or should it be a specialty added to the basic structure established for all teachers? What should school systems do to prepare teachers for special assignments with gifted students?

To compensate for the dearth of advanced course work for the gifted child, some school systems offer workshops of limited duration, consultant assistance of some kind, in-service courses in cooperation with university graduate schools, conferences, curriculum development projects, visits to other schools, and publications. A template combining pre-service, graduate, and in-service programs has been developed for teachers working with extraordinary youngsters. Currently, however, these opportunities are so limited in number that they should be regarded as pilot programs rather than as a universally available academic entity.

In conclusion, longitudinal research on changes in teaching practices will provide insights into the pathways of in-service teachers’ professional development and hence, ways to support the process.

The teachers in this study came to the professional development workshop with a range of personal epistemologies. They represented different levels of experience in their teaching practices with differing orientations. Marks and Gersten (1998) reported that when teachers perceived differences between their own beliefs and those proposed by the teacher trainer their changes in teaching practices were slow and gradual. The evidence of slow development and/or changes in beliefs points to the importance of continuing professional development after initial training.

The findings provide more evidence that gifted science students in middle school do, in fact, enjoy and respond positively to the constructivist teaching methods used by teachers who have participated in the Excellence Program. The students enjoyed being in a flexible academic environment where they are able to ask the questions they want to ask, and explore on their own initiative. Long-term outcomes in terms of actual achievement, however, could not be measured in the context of this study.

The findings of this study suggest a need for changes in the area of extracurricular math and science courses. In order to keep up the momentum, appropriate induction programs must be developed.
efforts must be made to encourage partnerships between universities and middle schools. Studies about the role of induction programs in science teacher education have been limited (Roehrig & Luft, 2006; Plummer & Barrow, 1998). Further research on the design and implementation of coordinated induction programs, sensitive to personal epistemologies, will allow middle school math and science teachers to provide exciting and interesting challenges for their young charges. Current science education reform speaks directly to this issue.

In summary, teacher qualification, experience, self-analysis and professional development play important roles in middle school science instructor’s teaching. Formal gifted education training during the pre-service stage and professional development workshops later. To best serve society’s most advanced young learners, first school districts must require specialized training by and for their teachers.

Conclusions
The general conclusions arising from this study based on the qualitative results include the following
1. The science teachers demonstrated growth and increased awareness of their perspectives concerning constructivist teaching practices emphasized during the professional development and reflection caused by the pre and post-test administered to them before and after the Professional Development.
2. The science teachers perspectives of the nature of science corresponds to those advocated by the National Science Education Standards (NRC, 1996) and American Association for the Advancement of Science Project 2061 (AAAS, 2005).
3. The in-service science teachers gained new teaching ideas. These include:
a. Use of inquiry-based methods for teaching science to middle school gifted students;
b. Allowing the students to think and develop their own questions while doing science activities;
c. Allowing the student to carry out independent investigations based on the content area in focus.
d. Being a guide and coach to the students instead of using the traditional teaching strategy where the teacher is the only one in control of all learning.
4. The science teachers benefited from the interaction with science experts at the University level by being able to:
a. obtain ideas on the type of resources to use with middle school students;
b. respond to science content questions through interaction with the experts.
5. The in-service science teachers understood constructivism as a theory of learning and felt that it was the best method to teach gifted science students science as it helps students to build new concepts based on their previous experiences.
6. The in-service science teachers’ number of higher order questions open-ended questions used in class increased by 58% from the start of the Excellence program to the end.
7. The observed behaviors of the six science teachers during teaching and the professional development revealed their passion for teaching, their desire to collaborate, their consistent efforts to ask higher order questions, and, their great desire to learn.
8. The in-service teachers described a significant need to be informed about gifted students in their pre-service education.
9. The teachers described the gifted science students benefiting from the extracurricular science program as it initiated interested in science. Some teachers mentioned that students who participated in the Excellence program during the middle school years chose advanced science courses in high school.
10. The Excellence Professional development provided a platform for reflective practices which enabled the teacher to frame and reframe professional activity and to understand and reflect on their teaching. The professional development emphasized that education, professional development and experience are not
the only components that lead to learning, but rather reflection on experience and self assessment is essential for professional growth.

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