Science in the City:

Meeting the Needs of Urban Gifted Students With Project Clarion

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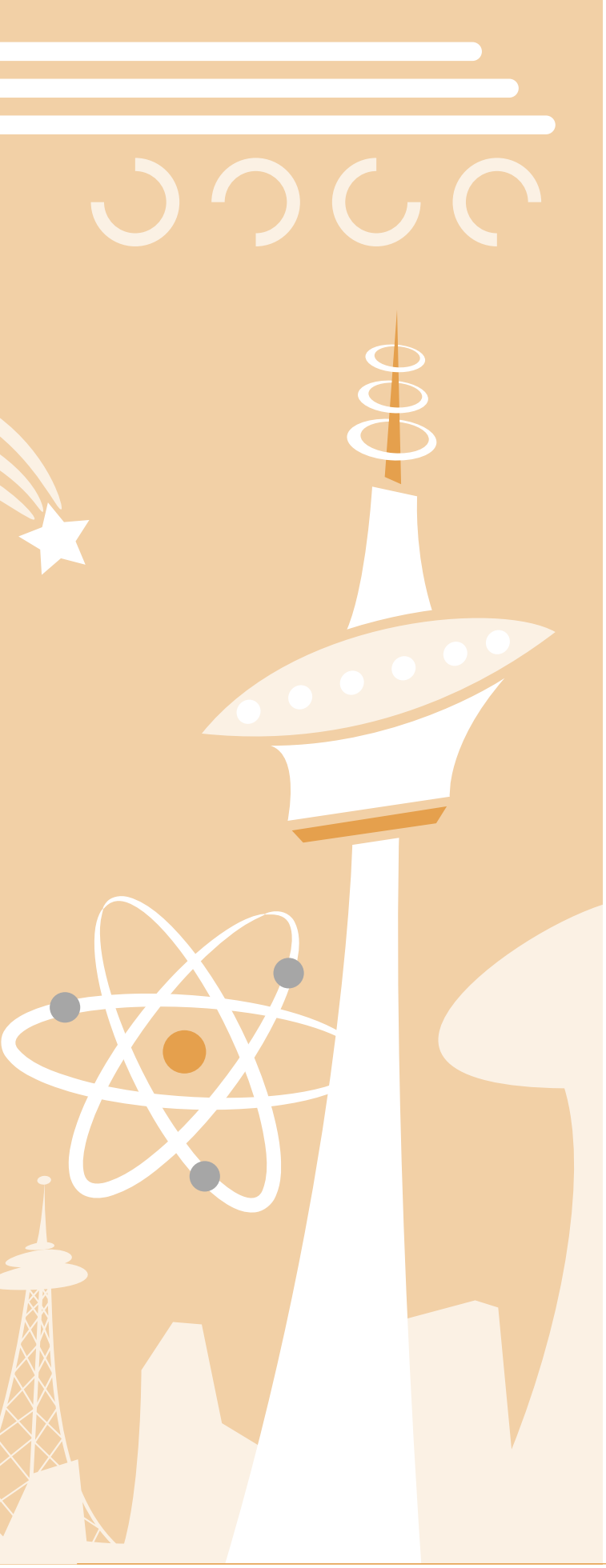

Long before children knock on the kindergarten door . . . forces have already been put in place that encourage some children to "shine" and fulfill their potential in school and life while other forces stunt the growth and development of children who have just as much potential. The cost to the nation in terms of talent unfulfilled and lives of promise wasted is enormous (Hodgkinson, 2007).

Urban gifted children encounter many forces that derail the development of their full potential. A report by the Jack Kent Cooke Foundation and Civic Enterprises found that more than a million children in poverty rank in the top quartile academically, but few of these children will find adequate opportunities to fulfill such potential in urban schools (Wyner, Bridgeland, & DiIulio, 2009). The same report found that only about half of these students will remain high achievers by fifth grade and that they are twice as likely to drop out of school as their middle class, same-ability peers. This is the result of multiple debilitating factors that impinge upon urban gifted children's abilities to develop to their full potential. Although much research suggests that focusing on students' strengths yields higher academic achievement (e.g., Sternberg, 1998), most models focus on the academic deficits that our urban children face and completely ignore their strengths. The National Research Council (2000) has provided convincing evidence that expertise develops over time and through practice. What if we started the expertise development process earlier for urban gifted children by concentrating on their interests and strengths? The focus of this article is on how we can help to ignite a fire of interest in science in urban gifted children and nurture scientific habits of mind beginning in the primary grades while providing specific strategies to mediate gaps in understanding and skills.

Achievement in Urban Schools

A chasm of performance disparity has separated urban children from all other students in other parts of the country in all subject areas, including the STEM fields (National Center for Education Statistics [NCES], 2007). Urban students' achievement scores in math, science, and reading fell far short of the national average (NCES, 2007). Nearly half (46%) of fourth graders in urban areas failed to read or understand science at a basic level on the National Assessment of Educational Progress compared with only 30% of their suburban peers (NCES, 2007). Urban students continued to fall behind in all areas of high school with only 65% of urban high school freshmen graduating as compared to 79% of their suburban peers (NCES, 2007). A multiplicity of debilitating factors has interfered with urban students' talent development in science.

Debilitating Factors in Urban Schools

Urban schools have experienced overwhelming debilitating factors. A paucity of resources plague inner city schools (Burns, Grande, & Marable, 2008). Although resource scarcity is not unique to urban schools, urban schools face it at greater rates. The Education Trust (2005) found that across the United States, $614 less is spent per student per year in school districts with high percentages of minority students compared to districts with high percentages of White students. This disparate allocation of funding has led to a severe lack of resources for urban schools. Typically, urban areas have higher costs of living. Thus, urban districts have had to pay more for teachers, which is a factor contributing to the lack of funding (Roza & Hill, 2004).

Compounding the funding problems, urban districts also have suffered from a shortage of qualified teachers (Burns et al., 2008). Too few well-prepared teachers have been employed by urban school systems (Levin & Quinn, 2003). One reason has been that teachers have avoided working in urban settings (Ladson-Billings, 2005). Those teachers who have chosen to teach in urban schools move to schools with more advantaged populations as they have gained seniority. Thus, the flight of experienced teachers from urban schools has created a vacuum of inexperience in the schools of greatest need, and has reduced the stability of programs and the quality of instruction (Roza & Hill, 2004).

Cumbersome and inefficient urban bureaucracies have further compounded the teacher shortage, creating a broader human resources concern. A study by the New Teacher Project found that many teachers interested in working in urban schools have been forced to take jobs in other school districts because increased bureaucracy in urban districts has delayed job offers by several months more than in smaller districts (Levin & Quinn, 2003). The lack of monetary and human resources, especially qualified teachers, in urban schools has intensified the difficulties in overcoming the debilitating factors that affect urban students' achievement, especially in science.

Table 1
Project Clarion Science Units

Grade(s)	Macro-Concept	Science Domain	Unit Title
K–1	Change	Earth and space	*How the Sun Makes Our Day*
		Life	*Survive and Thrive*
		Physical	*Water Works*[a]
1–2	Systems	Life	*Budding Botanists*[b]
2	Change	Earth and space	*Weather Reporter*
2–3		Physical	*What's the Matter?*
3		Earth and space	*Dig It!*
3–4	Systems	Physical	*Invitation to Invent*

[a]2009 Winner of a National Association for Gifted Children Curriculum Award. [b]2008 Winner of a National Association for Gifted Children Curriculum Award.

Project Clarion

Project Clarion was a 5-year Javits project funded by the U.S. Department of Education, and was initiated by the Center for Gifted Education (CFGE) at The College of William and Mary (VanTassel-Baska & Bracken, 2004). Project Clarion's purpose was to "scale up" rigorous science curriculum with broad populations of K–3 students. Project Clarion has been implemented and researched in Title I schools.

Project Clarion Goals

Project Clarion's goals were to:

- Use instrumentation sensitive to low-socioeconomic learners for identification and assessment of learning.
- Implement, refine, and extend research-based science concept curriculum in grades K–3.
- Develop and implement professional training models for teachers, administrators, and broader school communities.
- Conduct research on short-term and longitudinal student learning gains as well as the mechanisms that

promote the institutionalization of innovation through scaling up.

Project Clarion's products included eight science curriculum units for K–3 learners, pre-post curriculum-embedded performance-based assessments, a professional development program, and research results. Table 1 lists each of the units.

The Project Clarion Curriculum

The Project Clarion curriculum was developed based on the Integrated Curriculum Model (ICM), which provides for equal emphases on the teaching of rigorous content, process/product development, and concept development (VanTassel-Baska & Stambaugh, 2006). Project Clarion curriculum develops multiple levels of conceptual understanding. Macro-concepts, such as systems or change, provide a framework for teaching key science concepts (National Research Council, 2002, 2007; Sher, 2004). In the unit *Budding Botanists* (Center for Gifted Education, 2010a), the macro-concept of systems is explored with a terrarium. For example, students learn that systems have elements, inputs, and boundaries; they also learn that the elements interact with inputs to create outputs. Understanding a terrarium as a system allows students to integrate key science concepts, such as:

- Plants have basic needs, including air, water, nutrients, and light.
- Plants produce oxygen and food.

Project Clarion also cultivates scientific habits of mind, including skills in scientific inquiry, reasoning and investigation, and creativity. Units present problem-based scenarios to help students understand that real scientists conduct experiments to solve a problem. In the unit *Weather Reporter* (Center for Gifted Education, 2010f), students are asked to become meteorologists. Students learn specific science content as they make observations or conduct experiments to help address the problem-based scenario presented at the beginning of the unit. For example, students build their own barometers and measure air pressure over the course of several days. In another unit, *Dig It!* (Center for Gifted Education, 2010b), students are asked to plan a "Preservation Park." In *Dig It!*, the students conduct an experiment to learn the best method to clean birds affected by an oil spill. Units culminate with a final project and a concluding lesson that unify the solution to the problem with the science investigations, key science concepts, and the macro-concept. Figure 1 shows a sample lesson from *Budding Botanists*.

Project Clarion Teaching and Learning Models

Each unit includes multiple teaching and learning models that provide the instructional scaffolding to integrate concept development, content attainment, and process/product development. Problem-based learning acts as the foundation for helping students to understand how science is conducted by scientists (VanTassel-Baska, 1998). The Frayer Model of Vocabulary

Sample Instructional Objectives From "Planning the Lesson"

Instructional Purpose

- To investigate and understand basic plant life processes.
- To demonstrate an understanding of plant system interactions.

Sample Systems Concept Generalizations

- Systems have parts (elements).

Sample Key Science Concepts

- Plants have basic needs, including air, water, nutrients, and light.

Sample Scientific Investigation Skills and Processes

- Make observations.
- Ask questions.
- Learn more.
- Design and conduct experiments.
- Create meaning.
- Tell others what was found.

Sample Teacher Directions From "Implementing the Lesson"

- Tell students that they are going to investigate the question, "What do plants need to survive?" . . . Ask students to state their hypotheses about what plants need. . . . "I think plants need . . . (water, soil, food/nutrients, light)." . . . Ask students how they could test each hypothesis.
- Create groups. . . . Give students Handout 10B (Examining Features of Experiments). Remind students that when doing an experiment it is important to control all of the variables that are not being tested. Have each group identify which components they will control.
- Challenge each group to complete Handout 9B to plan an experiment that will test the hypothesis . . . As groups work, circulate . . . assist students in planning their experiments.
- Students will record plant observations . . . for 2 weeks (i.e., count the leaves, measure the height, note the color of the plants, etc.).

An Example of a Plant Experiment for Light

1. Label the plants A, B, and C.
2. All three plants should be planted in the same kind of soil.
3. Plant A will be covered with a brown paper bag and placed in a dark place (closet) . . .
4. Plant B will be placed in the classroom near the window.
5. Plant C will be placed in a dark corner of the room, . . . where it will receive limited light.
6. Check and record findings for all three plants . . . daily . . ., watering the plants as necessary.

Sample Items From "Concluding and Extending the Lesson"

Discussion Questions

- How do plants change under different conditions? Why?

Log Prompts

- Describe how conducting an experiment is like a system.

Figure 1. Excerpted lesson: "Plant Experimentation on Basic Needs." From *Budding Botanists* (pp. 95–98), by Center for Gifted Education, The College of William and Mary, 2010, Waco, TX: Prufrock Press Inc. Copyright 2010 by Prufrock Press Inc. (http://www.prufrock.com). Reprinted with permission.

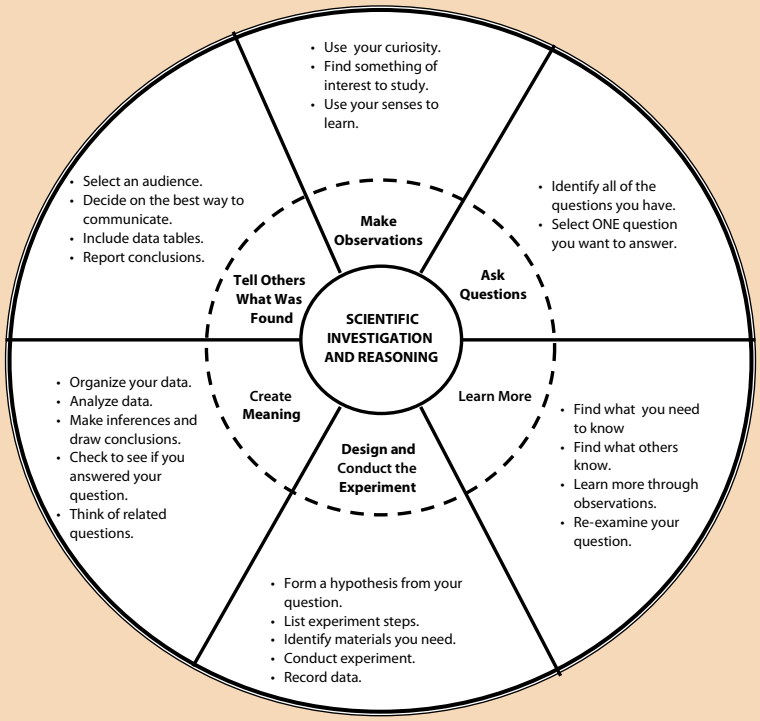

Figure 2. Wheel of Scientific Investigation and Reasoning. From *Budding Botanists* (p. 55), by Center for Gifted Education, The College of William and Mary, 2010, Waco, TX: Prufrock Press Inc. Copyright 2010 by Prufrock Press Inc. (http://www.prufrock.com). Reprinted with permission.

Development helps children build scientific vocabulary (Frayer, Frederick, & Klausmeier, 1969). Teachers use the Taba Model of Concept Formation to build understanding of the macro-concepts (Taba, 1962). Students use concept maps to develop their understanding of key science concepts (Novak, 1998). Finally, students learn that science is an iterative and integrated process using the Wheel of Scientific Investigation and Reasoning (Center for Gifted Education, 2008a, 2008b, 2010a, 2010b, 2010c, 2010d, 2010e, 2010f; Kramer, 1987; Paul & Binker, 1992). (See Figure 2 for the Wheel of Scientific Investigation and Reasoning.)

Performance-Based Assessment in Project Clarion

Pre and post performance-based assessments were developed to measure students' understanding of the macro-concept, key science concepts, and scientific investigation and reasoning skills. Students complete open-ended questions about the features of, examples of, and generalizations about the macro-concept. Key science concepts are assessed using a concept map. The Diet Cola Test was adapted for use with primary age students to assess application of scientific investigation and reasoning skills (Fowler, 1990). Rubrics were developed for each performance-based assessment. Rubrics and exemplar papers are provided for high, midrange, and low scores.

The Project Clarion Professional Development Model

A systematic professional development program was key to the successful implementation of the units and assessments. A training model was developed for Project Clarion that includes an emphasis on these elements:

- guided review of units,
- practice with the teaching strategies,
- planning time embedded within training,
- modeling strategies with students,
- observing teacher implementation of strategies and coaching,
- teacher and administrator reflection, and
- advanced training for teachers who have implemented the model.

Project Clarion professional development has been provided to teachers and administrators across the country, as well as internationally. Participants have included teachers of students in gifted programs, general education teachers, science teachers, science coordinators, gifted education coordinators, school and district administrators, and policy-makers.

Content of the Project Clarion professional development. Individual modules were developed to help teachers "unpack" and successfully implement Project Clarion units. Each module provides information about research-based best practice, a description of the teaching strategy, modeling the strategy with teachers, teacher practice with the strategy, and teacher reflections. Ambassadors were assigned to each school division to provide in-class modeling, coaching, and general implementation support. Classroom observations for Project Clarion teachers also were conducted during the implementation years as a measure of implementation fidelity. Figure 3 lists the professional development modules that CFGE offers on Project Clarion (Bland, 2009).

Project Clarion Research

The units were rigorously field-tested in heterogeneous classrooms to ascertain whether the curriculum and assessments could be used to benefit all learners, including learners in Title I settings and from backgrounds that

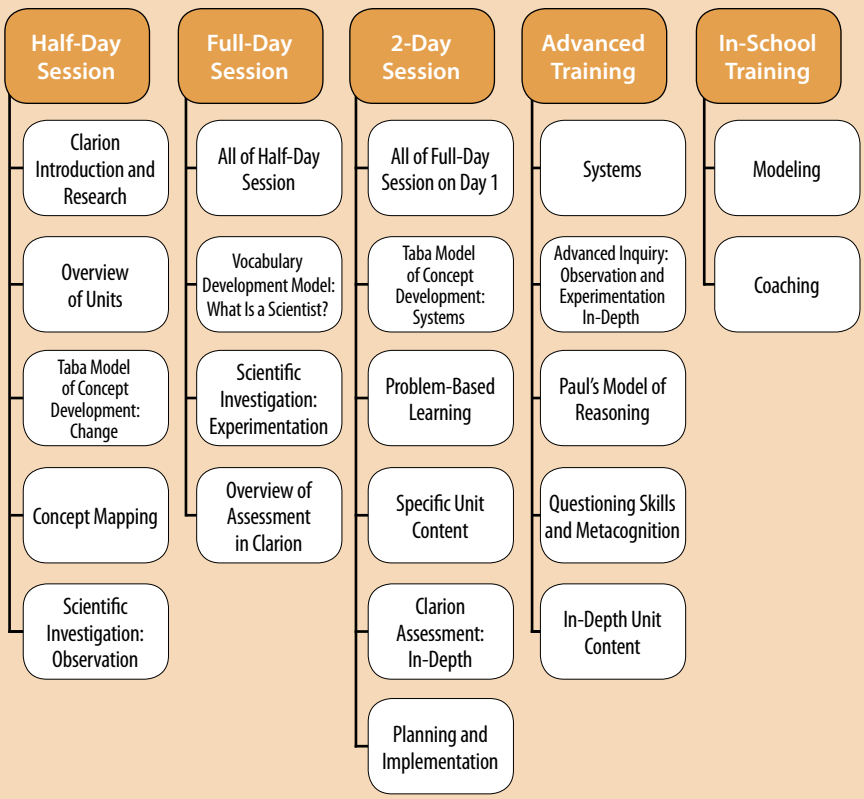

Figure 3. List of Project Clarion professional development modules.

potentially "stunt growth and development" (Hodgkinson, 2007). The units were intricately designed to develop deep understanding by focusing on mutually supportive skills and concepts. Therefore, multiple measures of performance were necessary to obtain accurate results about what students knew and were able to do as a result of the units. Because valid and reliable inferences can be drawn from performance-based assessments used with gifted children and with young children (Moon, Brighton, Callahan, & Robinson, 2005; Schappe, 2005; VanTassel-Baska, Johnson, & Avery, 2002), three performance-based assessments were developed to measure knowledge and skill attainment in the units. Further control and experimental group comparisons were made on science content attainment using a norm-referenced standardized measure of achievement, The Metropolitan Achievement Test (Harcourt Educational Measurement, 2000). Critical thinking skills were assessed using the Test of Critical Thinking, or TCT (Bracken et al., 2004).

Participants. Participants included 3,462 students in 48 experimental classrooms and 43 comparison classrooms in six Title I schools in three school districts during the 3 years of implementation. Racial/ethnic distribution across the multiple years of the study included about 13% African American students, 17% Asian students, 33% White students, 26% Hispanic American students, less than 1% Native Americans, and about 10% students whose racial/ethnic identity was not provided. Students who participated also included a range of ability levels as measured by the Naglieri Nonverbal Ability Test (Naglieri, 1991).

Research findings: Project Clarion works. Research highlights about the curriculum implementation include:

- *Project Clarion produces positive gains.* Project Clarion students made gains in conceptual understanding, science content attainment, and the scientific process on the curriculum-embedded performance-based assessments (Bland et al., 2009).
- *Project Clarion improves critical thinking.* Project Clarion students had more statistically significant and educationally important gains on the Test of Critical Thinking (Bracken et al., 2004) than did the comparison group of students who had higher ability scores (Kim et al., 2010).
- *More Project Clarion is better.* Project Clarion students who received initial instruction on the units in kindergarten and first grade and continued to receive instruction for multiple years scored higher on standardized measures of science content than students who received Project Clarion instruction for one year or less (Kim et al., 2010).
- *The sky's the limit with Project Clarion.* The performance-based measures and rubrics are effective with more advanced students as no ceiling effects were observed (Bland et al., 2009).
- *Project Clarion acts as an equalizer.* Traditionally underserved and underidentified students in science performed well on standardized measures of science content after receiving instruction on Project Clarion units in multiple years (Kim et al., 2010).
- *Project Clarion is "more than the sum of its parts."* Project Clarion units are most effective when implemented fully. Science achievement is supported with the teaching of macroconcepts (like change and systems), problem-based learning, and the scientific investigative process, which work together to help students construct and organize their understandings of science concepts in order to show long-term gains (Bland et al., 2009; Bland, VanTassel-Baska, Stambaugh, & Chandler, 2010; Kim et al., in press).

- *The Project Clarion innovation improves teachers' science instruction.* With professional development and support from building and district administrators, teaching Project Clarion units provided the structure for teachers to make significant changes to their science instruction, which they believed and the administrators in their districts believed were positive improvements in their growth as professionals (Bland et al., 2010).

Discussion

Project Clarion units work with students from a variety of backgrounds. The Project Clarion teaching models and strategies are integrated such that they are mutually supportive of students achieving multiple goals, including language acquisition, concept development, scientific habits of mind, and development of social skills and independence. Thus, the Project Clarion model simultaneously builds upon students' abilities and interests, provides instructional scaffolding to address knowledge and skill gaps typically found with urban students, and nurtures the talent development process in science.

Project Clarion provides multiple opportunities for students to "think like a scientist." Using this model, teachers act as facilitators and questioners. Project Clarion employs multiple questioning strategies. For example, problem-based learning questions help students with executive function skills, including planning and organizing their thinking about the problem. Questions focusing on higher level thinking provide scaffolding to encourage students to explain their reasoning based on scientific evidence. Using the Wheel of Scientific Investigation, students learn that a scientific argument begins by asking a question and that a full scientific argument is developed by progressing through multiple stages of observation, learning more, designing and conducting experiments, making meaning of data, and telling others about the results (Kim, Bland, & Chandler, 2009). Concluding questions at the end of each lesson and the "Wrap It Up" Lesson at the end of the units include metacognitive questions, which allow students to reflect on their learning. Over time, students "take the wheel" and ask questions of each other. Such questioning strategies and student ownership of the process allow students to build the habits of mind necessary to engage in critical and creative thinking. Most importantly, many disadvantaged urban students come to school lacking the structure, organizational skills, and personal habits to plan and do school work. The processes taught to, modeled for, and reinforced with students allow disadvantaged students to practice not only the habits of mind of science, but also the working habits and personal infrastructure to do advanced coursework.

Focusing on Strengths and Interest in Science

Although Project Clarion provides multiple opportunities to help urban gifted students develop understanding and skills to mitigate debilitating factors, the real strength of Project Clarion lies in the excitement and interest in science that Project Clarion builds. Science instruction in a Project Clarion classroom differs dramatically from traditional primary science classrooms (Bland et al., 2010). Project Clarion actively engages primary students. Students "call out" responses to questions; students talk with their peers; students stand and move around tables or desks working within or across groups; and students make their own decisions to get their own materials when needed. The key difference is that children make their own decisions about how to plan and conduct science experiments. At the beginning of the units, teachers provide direct instruction in the scaffolding and strategies that students will need to use to help them become self-directed learners. As the units progress, scaffolding is progressively withdrawn so that students become more self-directed. By the end of the units, students become independent investigators, apply their understandings, use their new skills to solve the problems posed in the units, and share their solutions as practicing professionals in the field. Figures 4, 5, and 6 show a student participating in his own science experiment.

Implications and Recommendations

The multiple Project Clarion studies have implications for effective practice in schools and classrooms serving urban students and other students from disadvantaged backgrounds. They suggest that the use of high-powered curriculum, designed for high-ability learners, can successfully be used with urban students, including learners from impoverished backgrounds, resulting in specific scientific habits of mind and enhanced critical thinking abilities in general. They further suggest that the national tendency to differentiate downward as a result of the educational accountability movement is differentiation in opposition to optimal learning. We must increase rigor for our urban students. Accompanying rigor, we also must provide instructional support for urban students to learn the skills so that they are truly not left behind.

Identification

Project Clarion provides opportunities to observe promising students for scientific talent. The observations can be used, with other data, to support nominations of urban students for gifted programs. Table 2 provides an overview of characteristics as organized by the outcomes of the Project Clarion units: conceptual understanding, science knowledge, science process skills,

Figure 4. Taking notes.

Figure 5. Observing.

Figure 6. Measuring.

and habits of mind: curiosity and critical and creative thinking.

Development of Rigorous Curriculum for All Learners

Early stimulation positively influences children's concept formation and development of perceptual skills. It is most effective when concepts are taught intentionally and systematically, and are practiced and reinforced in an ongoing manner (Kalbfleisch, 2008). Project Clarion represents an important step forward for the field of gifted education in crafting systematic science interventions that provide multiple opportunities for young disadvantaged learners to practice scientific habits of mind yet also serve the gifted learner effectively in the areas of concept development, content attainment, and scientific investigation and reasoning skills. When planning and developing curricula to meet the multiple needs of urban learners, it is important to consider the teaching models and the scaffolding that will be provided to support the learner. The Project Clarion teaching models and scaffolding can serve as useful tools for the curriculum developer.

Teaching models. The teaching models in Project Clarion provide a structure for curriculum development that could be used to develop concepts, content, and skills in science lessons (VanTassel-Baska & Stambaugh, 2006). The teaching models provide scaffolding for disadvantaged students to access rigorous curriculum. The Frayer Model of Vocabulary Development (Frayer et al., 1969) and the Taba Model of Concept Development (Taba, 1962) can be used sequentially to support acquisition of advanced vocabulary and difficult subject matter concepts for urban and other disadvantaged youth who often lack the verbal skills of their more affluent peers. The models systematically differentiate instruction for gifted students (VanTassel-Baska & Stambaugh, 2006). Further, the models have applicability across multiple disciplines and can be used with students at any age level.

Scaffolding. Multiple levels of scaffolding are provided to students to help build independence. Graphic organizers are integrated in the units to support the acquisition of knowledge and skills such as vocabulary development, concept development, content acquisition, and the scientific investigative process. The graphic organizers are initially shared with students in a completed format in order to teach the organizer. As students progress through the unit, the degree to which the graphic organizer is completed diminishes. For upper primary children, students are expected to create independently a graphic organizer for given tasks by the end of the unit.

Performance-Based Assessment

Educationally important strides have been made in Project Clarion by assessing primary age students' science understanding using performance-based assessments of authentic learning. For urban gifted students, open-ended performance-based assessment allows ample room for growth across all lev-

Table 2
Characteristics of Scientifically Talented Students

Conceptual Understanding
- Applies scientific findings from one situation to another
- Understands how scientific events are related

Science Knowledge
- Enjoys investigating and exploring science-related topics

Science Process Skills
- Understands the scientific process
- Observes events closely, notices details
- Formulates sound hypotheses based on evidence

Habits of Mind: Curiosity, Critical and Creative Thinking
- Curious about how the world works
- Asks analytical questions (e.g., questions about the elements or parts of a problem)
- Effective in deductive reasoning (i.e., starts with the large idea and divides it into parts)
- Quickly determines cause-and-effect relationships
- Easily manipulates components to form new relationships
- Initiates science investigations on own
- Persistent in conducting scientific investigations

Note. Adapted from Kwon and Lawson, 2000; National Research Council, 2000; Subotnik, Tai, Rickoff, and Almarode, 2010.

els of skill. Open-ended questions and their scoring rubrics, when appropriately crafted, can be relatively immune to ceiling effects. Therefore, curriculum developers should consider identifying or developing performance-based assessments to measure all of dimensions of learning.

Professional Development and Reform

Professional development alone is not a key to success implementation of Project Clarion. Teacher effectiveness is the primary factor in determining student progress (Sanders & Rivers, 1996). Administrators must select teachers who are comfortable interacting collaboratively with their students, engage students in active inquiry, and employ effective classroom management strategies to support the implementation of curricular reform (Glynn & Winter, 2004). Ineffective teachers can negatively impact achievement for learners regardless of the learners' ability (Sanders & Rivers, 1996). It is difficult to achieve the intended outcomes of a program developed to meet the needs of urban gifted learners if teachers do not have the support, inclination, or skills to effectively implement the Project Clarion curriculum (Bland et al., 2010).

Structured and multi-tiered training must be conducted to support implementation of new and rigorous curriculum and is vital to a program's success (Bland et al., 2010). Teachers also need administrative support in the form of common planning time, materials, and permission to practice implementation of the new curriculum without fear of reprisal. Classroom instruction must be closely monitored, with opportunities for ongoing feedback, teacher reflection, and common planning time for subsequent stages of curriculum implementation and professional development. For behavioral change to occur, it is important that teachers observe lesson implementation by a trained teacher, to practice implementation of lessons, and to receive structured and immediate feedback about their practice (Bland et al., 2010).

Reform takes time, especially when implementing innovative curriculum that is counter to the style of many traditionally trained teachers. Intended outcomes do not begin to be observed until the second year of implementation of curriculum reform emphases (Borko, Mayfield, Marion, Flexer, & Cumbo, 1997; VanTassel-Baska et al., 2008). Reform efforts should, therefore, begin as a pilot process with teachers who represent a best match to the reform. As reform unfolds over time, additional teachers can be trained and supported. Piloting reform efforts also can be an effective strategy in urban schools with scarce resources.

Conclusion

The Project Clarion study employed curriculum, instructional strategies, and assessments that used processes to support students' developing talent in scientific understanding and reasoning. It was based on the assumption that scientific reasoning and deep understanding of science concepts is built through multiple opportunities to learn science content by integrating the development of conceptual and content understanding with student use of the scientific investigative process. The curriculum units weave together targeted strategies successful with primary-age learners including those lacking school readiness skills, low-income learners, students from minority backgrounds, and high-ability learners. This study also provided evidence that valid inferences could be drawn about student understanding and skills in science as measured by the performance-based assessments for the targeted populations.

To employ Project Clarion or other rigorous curricula successfully, urban school districts must focus teacher training on how to address the urban gifted child's strengths, to use scaffolding strategies and teaching models to develop discipline-specific habits of mind, and to foster interest content. When done well, Project Clarion units spark an excitement for science that may potentially last a lifetime, especially for students learning science in the city. GCT

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