

"You Don't Have to Be Sighted to Be a Scientist, Do You?"

Issues and Outcomes in Science Education

Elizabeth J. Erwin, Tiffany S. Perkins, Jennifer Ayala, Michelle Fine, and Ellen Rubin

Abstract: This qualitative study explored the issues and outcomes associated with implementing Playtime Is Science for Students with Disabilities, a curriculum and materials that were modified for students who were visually impaired. It found several student-related outcomes, such as persistence, positive peer-related skills, risk taking, and making meaningful connections about the world, and themes regarding implementation of the curriculum, such as teachers' interest level, issues associated with power, and how teachers supported students' learning.

Interviewer (who is sighted): If you were teaching a class about this activity, what would you tell the kids?

Adaline (fourth grader who is blind): I would tell them that this is Oobleck, and this is how you make it with two cups of cornstarch, a cup of water, and two drops of food coloring; mix it up with a popsicle stick, and see what happens. I would like to be a scientist. That would be fun. You don't need to be sighted to be a scientist do you?

Interviewer: No. Absolutely not. Everything you've done today and last time is science, and you've done it, right?

Adaline: And Ellen (an observer who is blind) isn't sighted. If I become a scientist, maybe we [Ellen and I] can work together. You [the interviewer] can be the assistant scientist.

Science is an exciting process that involves observation, discovery, critical thinking, and reflection about the environment. Science education represents the opportunity to forge an interactive relationship between children and the world around them. If the primary focus of science education is to help children make sense of their world, then teachers have an enormous responsibility to design learning opportunities and experiences that foster children's natural inquisitiveness and thirst for knowledge. One of the most important questions that teachers can ask is, How can I support students' inquiry about the world? This question is particularly important for teachers who work with children who are visually impaired (that is, those who are

This study was supported by a grant from the National Science Foundation. The material does not necessarily reflect the position or policies of the National Science Foundation, and no official endorsement should be inferred.

Accepted July 25, 2000.

blind or have low vision). Children can and should have positive, frequent, and successful experiences in science that will allow them to explore, discover, and ask questions about the world in which they live, so they can develop a deep respect not only for the environment in which they live, but for all living things. In schools in which there is a preponderance of children with disabilities, a critical examination of the science curriculum and its accessibility for all students has yet to be conducted, however. It is just such an inquiry that was undertaken for this research. Given the opportunity to study a hands-on science curriculum developed by Educational Equity Concepts and implemented with children who are visually impaired, this study posed some important questions to educators and curriculum specialists who are interested in science education for all students.

Although the literature on the pedagogy of science and children with disabilities is growing (Cawley & Cawley, 1994; Mastropieri & Scruggs, 1992, 1995; Parmar & Cawley, 1993), there is a dearth of knowledge specifically about science and children with visual impairments. Most of the information on science curricula and adaptations for students who are visually impaired was written over 20 years ago (Franks & Butterfield, 1977; Linn, 1977; Linn & Thier, 1975; SAVI/SELPH, 1975).

According to Huebner (1986), teaching science to students with visual impairments must be firmly grounded in a multi-sensory approach if students are to receive positive benefits, such as activities related to tactile and auditory interactions, and ample opportunity to manipulate and explore equipment and materials must be

provided. Davidson and Simmons (1984) contended that it is necessary to provide access to new content within the environment, guide exploration and discovery, and encourage interpretation.

This article describes a qualitative study of the impact and implementation of a science curriculum, *Playtime Is Science for Children with Disabilities (PSCD)*. The study examined the PSCD adaptations and modifications for children who are visually impaired to gain a better understanding of the issues, challenges, and outcomes associated with teaching and learning about science and visual impairment. Because the documentation sought to understand how PSCD is taught to children across a range of visual disabilities, the researchers relied upon qualitative methods to document the micropractices of teaching and learning (Bogdan & Biklen, 1998; Denzin & Lincoln, 2000; Fine, Weis, Weseen, & Wong, 2000). The study was designed to include participant observations of two classrooms for seven months, structured interviews with nine students and two teachers, and a focus group of teachers. Two research questions drove the design:

1. What outcomes emerged from PSCD for students with visual impairments, such as science vocabulary, independent inquiry, and knowledge of scientific methods or concepts?
2. What pedagogical decisions and practices do teachers use in implementing this curriculum?

Method

SETTING

Initially the curriculum developers and researchers sought a school with a sufficient

number of students who were visually impaired and were mainstreamed into traditional classrooms. This search yielded no such school in the urban Northeast. Therefore, the study was conducted in a large state-funded residential school in the northern United States that serves children who are visually impaired. Although the students leave the classroom for specialty classes, such as gym and individual counseling, they spend most of their day with each other, a teacher's aide, and one teacher.

PARTICIPANTS

Students. A multiracial sample of five boys and four girls from two classrooms (a fourth-grade and a first-grade classroom) participated (see Table 1 for demographic information on these students). Parental consent was obtained for each student before the observations began.

Teachers. The two teachers of the classrooms studied—Mr. Pearson and Ms.

Caruso (the names are pseudonyms)—were selected based on their interest in participating and received training in the PSCD activities. Mr. Pearson, the fourth-grade teacher, had taught children with mental retardation and severe cognitive impairments for 11 years and had a degree in special education. Ms. Caruso, the first-grade teacher, had been a teacher for five years and had recently earned a master's degree in the education of students with visual impairments; this was her first year teaching at this school.

PSCD

Funded by the National Science Foundation Program for Persons with Disabilities, PSCD is a model project that builds and expands on Playtime Is Science: An Equity-Based Parent/Child Science Program, developed by Educational Equity Concepts, a national nonprofit organization founded in 1982 to foster equal educational opportunities for all children, regardless of

Table 1
Demographic data on the student-participants.

Participants' names	Gender	Age	Ethnicity	Status of vision and hearing
Teddy	M	12	African American	20/200 in both eyes, hearing impaired
Candice	F	12	African American	Totally blind, no hearing impairment
Adaline	F	12	Caucasian	Totally blind, no hearing impairment
Dale	M	12	African American	20/200 in the left eye, 20/20 in the right eye; no hearing impairment
Josh	M	11	Latino	20/200 in both eyes, no hearing impairment
Roy	M	6	African American	20/200 in the left eye, blind in the right eye; no hearing impairment
Pilar	F	8	Latina	Totally blind, no hearing impairment
Julie	F	7	Caucasian	20/200 in both eyes, no hearing impairment
Carlos	M	8	Latino	20/200 in both eyes, no hearing impairment

gender, race, ethnicity, disability, or family income, and equal access to the study of science.

PSCD incorporates science and scientific thinking into the daily routines of children who have a variety of disabilities to reinforce the connection between children's play and science learning. The PSCD curriculum focuses specifically on the priorities and capabilities of children with disabilities. Its goals are to

- increase the ability of teachers, staff, and parents to motivate and empower children with disabilities in kindergarten through the fourth grade to develop their science skills in a supportive environment;
- help children with disabilities build on their strengths and develop confidence and skills in science that will persist beyond school and will inform later career options; and
- provide opportunities for parents of children with disabilities to become involved in their children's early science learning and to convey positive messages and expectations to their children about science.

Hands-on staff development was conducted for all the elementary-level teachers, paraprofessionals, and parents. The physical science activities were implemented in various inclusive and special education classrooms. Modifications were developed to meet the needs of students who are blind or have low vision, deaf or hard of hearing, physically disabled, learning disabled, speech and language impaired, or emotionally disabled. Classroom observations and feedback from teachers were used to design the modifications for the activities.

The administrator selected the teachers who participated in the study. The teachers chose five activities, including these:

1. *Building with Wonderful Junk*: problem solving, mathematics, physical science, gross motor and cooperative learning skills (fourth grade).
2. *Sink and Float*: first-hand experience in understanding why some objects stay on top of water and others sink to the bottom (fourth grade).
3. *Bubble Science*: students creating their own bubble makers and exploring cohesion (first grade).

The two teachers taught the same lessons, as determined by an age-appropriate match of tasks and students.

DATA COLLECTION

To determine how the curriculum was implemented and what outcomes were achieved, the researchers (who were trained in the PSCD activities and curriculum-specific interview techniques) used three methods: systematic participant observations in each classroom (three times: at the beginning, middle, and end of the semester), individual interviews with nine students and the two teachers, and a focus group of teachers.

Participant observations. Each researcher directly observed the students in one class (in the classroom or related settings, such as the gym and lunchroom) in early March, late April, and early June for approximately 3 1/2 hours each session. The PSCD project coordinator, who was actively involved in the development of the PSCD curriculum and staff training, was also present during each session. A common coding scheme was deployed throughout to collect and analyze teacher-student interac-

tions, interactions among peers, and the students' engagement in the activity. The data were recorded in the form of detailed field notes, and the two primary observational data collectors met weekly (during the period of intensive observation) to ensure interrater agreement on the coding categories.

Interviews with the students and teachers. Each on-site researcher conducted two to three individual interviews of about 10 minutes each with each of the nine students who participated in the study. The design called for three interviews with each student, but for some students, time or absences did not permit three interviews. All the interviews were audiotaped.

During the interviews, the students were asked the following questions:

1. What did you learn today?
2. What observations did you make?
3. Do you know what a solid and liquid, balance, gravity, sink, float [whatever was relevant to activity] are?
4. What questions would you like to ask the other students about the science lesson?
5. If you were teaching this class, what would you tell the kids?
6. What would you like to tell the people who are running the science program about what works and what doesn't work?

The students' responses were analyzed for content and evidence of science vocabulary and presentation of scientific concepts.

During the first and third participant observations, the two teachers and a paraprofessional were also interviewed about the curriculum and the students' experiences. The interviews, which lasted approx-

imately 30 minutes each, followed a predetermined set of questions to ensure consistency across the interviews.

Focus group. The focus group, conducted at the school in June, involved the two classroom teachers; a school administrator; the PSCD project coordinator; and the research team, which included the authors of this article, as well as two of the developers of the PSCD curriculum. The focus group was conceptualized as an informal two-hour meeting to share ideas and information about the curriculum and its implementation; to check for accurate or reliable impressions and observations; and to discuss challenges, questions, or issues that emerged from this project. The preliminary findings were presented, and the staff was invited to give feedback.

DATA ANALYSIS

A content analysis was conducted for a set of a priori theoretical variables and variables that emerged empirically via grounded theory. Data generated from the participant observations and individual and focus group interviews were reviewed regularly by the two researchers during and following the data collection to extract themes, patterns, and questions that were emerging from the data. In-person and phone meetings were also arranged between the two primary researchers and the first and last authors to examine patterns and themes.

Triangulation of the data sources (the participant observations, individual interviews, and focus group discussion) occurred to ensure the accuracy and consistency of the themes. The following categories served as a framework for initially organizing the data: (1) the students' inter-

actions with the teachers, (2) the students' interactions with their peers, and (3) the students' interactions around the activity. The themes regarding students' outcomes that emerged a priori from the curriculum goals and, in a more grounded form, from the observational and interview data (Glaser & Straus, 1967) included (1) enthusiasm; (2) persistence; (3) the desire to perform as a scientist, use scientific language and concepts, and share observations; (4) risk taking; (5) making meaningful connections; and (6) positive peer-related interactions. The results presented focus next on the themes that were specifically related to the process and outcomes associated with implementing the PSCD curriculum.

Results

OUTCOMES

Enthusiasm

One of the more striking pieces of evidence of the students' engagement with the PSCD activities was the students' enthusiasm, evident in anticipation, during, and after activities. Here are some examples from the field notes:

Adaline was immediately excited upon hearing the observers enter the room, saying, "Yay! This is gonna be fun."

During one activity, the discussion involved writing up what they had done and then sharing it with the class. The students were very excited to do this task, often continuing to write after the teacher had asked them to stop.

Even in subsequent observations, the students vividly remembered the activities in

which they had participated and would refer to them in other contexts. Enthusiasm is an important learning outcome, since children associate science with something that is fun, interesting, and worth doing and, what is most important, something they are or can be fully capable of doing. It also helps children retain what they have learned. As one teacher explained: "I think they get very excited right from the beginning, extremely excited . . . sometimes . . . I worry about them getting overstimulated such that it diminishes comprehension, but usually the opposite happens: They retain what they discover."

Persistence

One behavior that is essential to the scientific process and that the students exhibited often is persistence—continuing to try experiments in spite of unexpected outcomes or wrong turns. Persistence is also evidence of meaningful engagement and active participation.

Ms. Caruso noted that the students tended to be focused for a longer period of time on science than on other activities and that they tended to stay with it. As the field notes indicated:

During the Looking at How Liquids Move activity, Julie initially had trouble measuring the depth of the water. However, Julie did not seem to become frustrated after she positioned the ruler several different ways but did not arrive at the answer. Instead she persisted and tried it again and again until Ms. Caruso acknowledged that she reached the answer.

Learning vocabulary and sharing observations

That the students seemed to have a strong desire to be “scientists” was evident in their desire to show or share with others (their parents, peers, teachers, or visitors) the inquiry skills they had developed. They seemed to have a strong sense of pride in their work and their discoveries. The following is an example from the field notes:

The students often invited the involvement of others and shared their scientific findings and skills with one another. For instance, during the Looking at How Liquids Move activity, Julie, who had just learned how to measure the depth of water in a pan with a ruler, shared her newly acquired skill with her classmate Carlos when she observed that he, too, was struggling with how to position the ruler properly. Specifically, she offered him tips on how to approach measuring the water by demonstrating for him how she had done it: “Like this, Carlos, make it [the ruler] go straight up.”

Taking pride in one’s work as a budding scientist and wanting to share that work with others is a reflection of a child’s self-esteem and interpersonal interactions skills, as well as developing competencies and confidence in the realm of science. When students have the confidence to share their newly acquired knowledge with others, it is also a reflection of how they have mastered new material.

Risk taking

Children who are visually impaired are sometimes discouraged or protected from

taking risks at home or in school. Risk taking involves taking a chance, particularly when there is the threat of not achieving one’s desired goal or there is a real or perceived danger. Every PSCD experiment conducted in this study involved a certain amount of risk. There were also opportunities for students to make predictions about things that were unfamiliar, as in this example from the field notes:

One of the more striking examples was with Carlos, who is tactilely defensive—reluctant to touch things or put his hands in any strange substance. He surprised his teacher by dipping his hands in whatever substance was being used during the various PSCD activities (like the Oobleck, the Bubble solution, and the Liquid mixture) and thoroughly enjoyed it. During the Oobleck activity, Carlos even encouraged his partner, who was at first reluctant to touch the Oobleck, by saying, “Hey Pilar, touch this, come on, it’s not sticky so don’t worry.”

Wanting to take risks and to participate actively in new experiences is an important skill for children to master. Taking risks is not only necessary for the scientific process, but it is a necessary skill that is used throughout a person’s entire life.

Making meaningful connections to the world beyond school

The students made important connections to the world in which they live in many ways. They not only mastered the new vocabulary associated with the activities, but they often generalized new vocabulary and concepts across time and contexts

