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How Does Science Learning Occur in the Classroom? Students' Perceptions of Science Instruction During the Implementation of the REAPS Model

Maria P. Gomez-Arizaga
Universidad de los Andes, CHILE
A. Kadir Bahar
Bahçeşehir University, TURKEY
C. June Maker, Robert Zimmerman &Randal Pease
The University of Arizona, USA

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In this qualitative study the researchers explored children's perceptions of their participation in a science class in which an elementary science curriculum, the Full Option Science System (FOSS), was combined with an innovative teaching model, Real Engagement in Active Problem Solving (REAPS). The children were capable of articulating views about their learning experiences during science classes. Meaningful experiences with deep levels of engagement were those that involved hands-on activities, such as experiments, provided by the FOSS curriculum; and problem-solving and model building, which were components of the REAPS model. Students' perceptions demonstrated in their drawings were similar to their interviews, which were evidence of their meaningful science learning experiences. Incorporating students' voices, as a type of feedback for teaching and learning, is important for teachers and practitioners; innovative pedagogical models contribute to meaningful and long-lasting science learning.

Keywords: REAPS model, students' voices, science learning, science teaching, teaching models, creative problem solving

INTRODUCTION

Students' perceptions of science learning and teaching have been listened to by only few educators and researchers. Children's interests and attitudes have had little general impact on pedagogy, assessment or science curriculum reform, perhaps

Correspondence: Maria P. Gomez-Arizaga,
Universidad de los Andes, Álvaro del Portillo 12.455, Santiago, Chile.
Phone: 56-2-6182031
E-mail: mpgomez@uandes.cl
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because the implications of the findings for the science curriculum and for the way in which science was taught, learned and assessed were by no means straightforward (Jenkins, 2006). However, researchers reported that consulting students about their perceptions of science and their school science education can enhance their learning and contribute to the development of a wider range of teaching strategies and, thereby, to raising the levels of student attainment in science (Flutter & Rudduck, 2004).

Students' interest in science has been conceptualized as a complex and diverse construct that includes perceptions of teachers, value of science as a discipline, enjoyment, and achievement (Osborne, Simon, & Collins, 2003). Researchers have found that instructional and conceptual approaches to science education could have an effect on students' attitudes, motivation, and perceptions of science as a discipline. For example, in Mason and Kahle's study (1988) on students' attitudes about science, students who participated in hands-on activities and had an active involvement in their lessons showed more positive attitudes about science.

In a qualitative approach to study students´ insights, Braund and Driver (2005) studied 14 primary and secondary students in the United Kingdom and they found that all the students thought that practical work was an important factor for learning science, which contributed to making science more fun, enjoyable, and motivating.

In addition to teaching methods and instructional strategies, teachers' approaches to science education were found to play an important role in students' perception of science. In a qualitative study with 144 students using focus groups to investigate students' experiences in science classes, Osborne and Collins (2001) found that students gave a high instrumental value to science education because science was related to their everyday lives. Students complained about science teachers being focused solely on content and their lack of application of this content to life in general. Another factor mentioned by the students was the excessive speed through which science content was addressed by teachers, a situation that led to an incomplete understanding of crucial concepts (i.e. little time left for reflection). Copying, repetition, and the use of a traditional (i.e. teacher centered) pedagogy were the least enjoyable activities of a science lesson. Teachers who encouraged students' active involvement in science content were highly valued by the students participating in the research (Osborne & Collins, 2001).

State of the literature

- Teaching methods and instructional strategies were found to play an important role in students' learning experiences and perceptions of science.
- Making science more appealing to children and helping them achieve deeper levels of understanding and engagement has been a challenge for teachers and practitioners involved in the field. However, students' voices have not been always included in this discussion.
- Students need to be provided with opportunities to discover, explore, and think as if they were scientists.

Contribution of this paper to the literature

- The purpose of this study was to investigate students' perceptions of their science classes through the analysis of in-depth interviews and drawings. This approach provides a deep understanding of how students learn and get involved in science activities.
- The model used, Real Engagement in Active Problem Solving, provides an opportunity for students to achieve long-lasting learning through meaningful problem-solving experiences as a complement to the curriculum.
- Students´ articulated perceptions help to understand about how science should be learned as a process, in which teachers and students are actively involved and where the role of the teacher as a mediator is crucial.

CHANGES IN SCIENCE EDUCATION

Science education has evolved as progress has been made in scientific fields. For example, at the beginning of the 20th century, teachers were instructing their students about botany and physiology; however, when discoveries were made about phenomena such as the DNA structures and atom particles, designers had to change science curricula to include new findings and concepts in the field (O'Brien & Thompson, 2009). Because of the nature of science knowledge, science education has evolved progressively, especially in the early 1960s, to include innovations as they were occurring in science (Fensham, Gunstone, & White, 1994). The goal of evolution in science education was to increase students' interest and motivation to study science.

In the 1980s and early 1990s, professionals in scientific organizations such as the American Association for the Advancement of Science and the National Center for Improving Science Education promoted additional changes in the national science curricula. The main goal of this movement was to develop scientific literacy, which included science, mathematics, and technology (Bybee & Champagne, 1995). During this period, the Science Education Standards were created by the National Research Council with the goal of providing a framework for evaluating science programs.

Researchers, investigating new educational approaches, have stated that students should be provided opportunities to discover, explore, and think as if they were scientists (Pozuelos, Trave, & Canal de Leon, 2010; Rehorek, 2004). These approaches were named inquiry-based, and the main goal was for students to develop several skills such as (a) asking questions that are scientific in nature, (b) gathering evidence from different investigations, (c) explaining scientific phenomena, and (d) being able to communicate their results to their peers and teachers (National Research Council, 2001). Under the inquiry-based approach, science has been understood by teachers and students as a process, a continuum in which teachers and students have been involved actively and in which the role of the teacher is crucial. Regarding the effectiveness of inquiry-based teaching, Furtak, Seidel, Iverson, and Briggs (2012) conducted a meta-analysis of 36 studies over a decade and found that the studies had a mean effect size of .50, which was indicative of students´ learning of science through inquiry.

Along with efforts to reform the content of science education, methods used in the teaching of science have become a matter of concern. Researchers investigating cognitive processes and the social nature of learning called for new methods to be used by teachers to achieve meaningful learning in their students. Particularly, science teaching has been influenced by teaching models focused on effectiveness (Cochran-Smith, 2003), in which teachers provide opportunities for learners to engage in the subject matter, taking into consideration students' needs and previous experiences (Omotayo & Olaleye, 2008).

Even though many efforts have been made to achieve a paradigmatic shift in science teaching, researchers have found that teachers' knowledge about effective teaching methods was limited, and that traditional lectures and report writing were the most commonly used teaching strategies during science lessons (Appleton, 2003; Ranade, 2006). Teachers tended to focus on facts and scientific procedures (e.g. observing and measuring) in an isolated manner when teaching science, without connecting scientific phenomena with the actual context (Schauble, Glaser, Duschl, Schulze, & John, 1995). This traditional approach was noted as being teacher-centered, in which teaching and learning were conceptualized as having a knowledgeable educator who usually stood in front of the class and transmitted the content in a unidirectional way (Ruben, 1999).

Another element of science teaching that was emphasized by researchers using the inquiry-based approach was "hands-on" activities, in which children were allowed to manipulate different scientific objects and materials so they could have an interaction with science. Students could observe how science learning *occurred* through "hands-on" activities (e.g. children not only knew the properties of water, but also saw the different changes in water states, such as solid to liquid). A common belief held by many educators has been that hands-on activities were not as effective to teach content—assessed through standardized tests—as was direct instruction (Pine et al., 1987). However, Stohr-Hunt (1996) found that children who had frequent hands-on experiences on a weekly or daily basis had the same or better results on achievement tests than their peers who were taught science through textbook-based curricula.

Meaningful and long-lasting learning has been a critical component of any type of content teaching. In the case of science learning, comprehending scientific concepts, linking previous concepts to new ones, and internalizing scientific knowledge in a comprehensive way has been important to students. Students have been criticized for their lack of interest in "hard" sciences such as mathematics and science. However, one of the reasons for students' lack of interest in science was traditional science instruction, which significantly reduced children's interest and caused students to select career paths in their academic future that were different from science (Mathews, 1994).

Over the last decade, several calls have been made worldwide to make a profound shift in how science is taught, to move from the mere acquisition of scientific concepts toward a "culture of scientific literacy by engaging students in the language and ways of scientific inquiry" (Barab & Luehman, 2003, p. 454). Also, the need for change has been sustained by the premise of equity: all students need to have access to science regardless of their background (Riedinger, Marbach-Ad, McGinnis, Hestness, & Pease, 2010). To respond to these calls, several inquiry-based constructivist models and curricula have been created to improve science teaching and increase students' learning. Teaching models have been useful to teachers because they provide clear methods for implementing the school curriculum. A model has several components: (a) a theoretical base, (b) sequenced learning activities, (c) teachers' recognition of the content knowledge to be taught, (d) expectations for student and teacher behaviors, (e) task structures, (f) meaningful assessment of student learning, and (g) ways of verifying that the model was being implemented successfully (Metzler, 2000).

CONTEMPORARY METHODS FOR SCIENCE TEACHING

The FOSS curriculum

An example of an inquiry-based type of curriculum is the Full Option Science System (FOSS), a research-based science curriculum for grades K-8 developed at the University of California, Berkeley. The goal of the FOSS curriculum is to provide meaningful science instruction for diverse students in U.S. classrooms. One of the main characteristics of the FOSS curriculum was building scientific knowledge in a meaningful context. Knowledge gained in an activity was applied in subsequent learning activities because building on previous knowledge promoted long-lasting learning (Glaserfeld, 1984; Resnick, 1983).

Researchers have investigated the implementation of the FOSS curriculum, particularly with middle school students, and found that it was effective for enhancing achievement in science, reading, and writing, and for narrowing the achievement gap among racial/ethnic groups in science education (Powell & Wells, 2002). Also, the FOSS curriculum emphasizes the acquisition of process skills that are critical to understand the underlying scientific concepts, such as asking questions, defining problems, planning, conducting investigations, analyzing and interpreting data, using models, using mathematics, constructing explanations, applying scientific knowledge, and communicating the information to others (Vélez, 2015). Franklin (1992) found that students had higher scores on science process skills after the implementation of the FOSS curriculum and both females and males had better attitudes toward science and scientists.

Throughout our study, the classroom teacher was implementing the FOSS curriculum for elementary (3rd grade), which includes units such as *Earth, Ecosystems,* and *Water*. The FOSS curriculum has an organization and structure that includes materials for the teacher (e.g. Investigations Guide, Teacher Resources), the student (e.g. Student Book), and a FOSS kit that includes all the materials that are needed for the investigations (www.fossweb.com).

The REAPS Model

The model Real Engagement in Active Problem Solving (REAPS) was created by Maker and colleagues (Maker & Zimmerman, 2008; Maker, Zimmerman, Gomez-Arizaga, Pease, & Burke, 2015) and has been implemented both for teacher professional development and with elementary, middle, and high school students. The goal of this student-centered approach was, through the incorporation of different problem-solving strategies, to complement traditional science curricula to achieve meaningful and long-lasting learning. The REAPS Model included Discovering Intellectual Strengths and Capabilities (DISCOVER), Thinking Actively in a Social Context (TASC) and Problem-Based Learning (PBL) models to help students in their learning process while they engaged in meaningful and real-life problem solving science activities (Figure 1). The DISCOVER strategies were based on a continuum of problem-solving experiences that ranged from problems that were closed (Type I) to problems that were open in nature and therefore had multiple appropriate methods and solutions (Type VI). TASC was incorporated into REAPS Model for the processes and structure to follow when solving a problem, especially problems in the open-ended range of DISCOVER. The TASC problem solving steps have been designed to help students to guide and structure their problem-solving process (Wallace, 2008): (a) gather and organize, (b) identify, (c) generate, (d) decide, (e) implement, (f) evaluate, (g) communicate, and (h) learn from experience. The role of PBL in the REAPS Model was to provide teachers the opportunity to integrate theory and practice, and to develop analytical and practical skills in their students (Gallagher, 1997). Problem-based learning experiences "provided a context in which knowledge and skills deemed important in a discipline were applied in a real-life situation—thus integrating the traditional analytic and synthetic abilities with practical ones" (p.13). One important goal of a PBL experience was that students could become independent learners.

The main reason why the REAPS Model was selected for this study was because REAPS model not only was a framework for teachers to guide students throughout

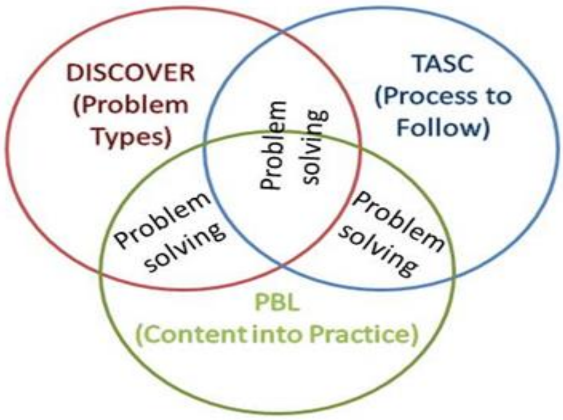


Figure 1. The Model REAPS

their learning, but it was also an opportunity for students to achieve long-lasting learning through meaningful problem-solving experiences as a complement to the curriculum and was related to students' lives and interests. Researchers have found that the integration of three widely researched models into REAPS makes the model applicable to enhance students' learning by letting them express their abilities in different ways through problem solving (Reinoso 2011; Gomez-Arizaga & Maker, 2011).

For this research, the activities of the REAPS model were designed to complement the FOSS curriculum, to provide the students with open-ended problems to solve at the end of each unit (by doing so the DISCOVER strategies were applied), so they would be able to integrate and apply the main concepts of the module. As an example, at the end of the *Water* unit, students were invited to solve the problem of water conservation at their school. For this purpose, students were divided into groups to create small-scale projects to solve this problem. The students guided their problem-solving process through the steps given in the TASC wheel. Problem-based learning (PBL) was used structure the presentation of the real-life problem of water scarcity in the desert. The research team included a scientist, who was in charge of the main problem-solving idea, and the rest of the team who helped with the design, implementation, evaluation, and communication of the students´ projects.

The implementation of science teaching methods has been discussed widely by researchers and teachers. Making science more appealing to children and helping them achieve deeper levels of understanding has been a challenge for practitioners involved in the field. However, students' voices have seldom been brought into this discussion. Students often have been viewed as beneficiaries of the educational services that were provided to them (Fullan, 1991), and researchers have given little consideration to the students' perceptions of schooling (Wilson & Corbett, 2007). Research involving students' perceptions of teaching has been scarce (Shultz & Cook-Sather, 2001).

The purpose of this study was to explore third grade students' perceptions of their science classes throughout the implementation of the model REAPS. The following research questions guided the study:

1. What concepts did third grade students use to define science?
2. What were students' perceptions of their science learning experiences?
3. How did third grade students depict themselves as participants in the science classroom?

METHODS

Setting

This study was conducted as part of a larger research project in an elementary school in the Southwestern United States. The school was located in an upper-middle class neighborhood near a public university. Many of the parents worked as professors at the local university or were owners of local businesses and they represented a variety of nationalities. Due to the location, the school population had more high ability students than other schools in the district. For example, over twenty percent of the students participating in the study were identified as gifted. However, comparing the implementation of the model on gifted and non-gifted students was not a focus of the study. The research project was implemented in three third grade classrooms. The research was part of an ongoing project conducted for three years; however, the purpose of the present study was to analyze data on students´ perceptions for the first two years.

Implementation of the REAPS Model

The REAPS Model was put into practice throughout each academic year and was implemented during students' science instruction using the Full Option Science System (FOSS) curriculum.

Students' participation included pre and post assessments for each of the FOSS units using concept maps (Novak, 1990; Ruiz-Primo, 2004) and standardized assessments. At the end of each unit, students were involved in group projects that included model construction, which had different characteristics according to the unit and content that was taught. Besides the pedagogical activities implemented in the classroom, teachers, parents, and students were invited to participate in interviews with the purpose of evaluating the implementation of the teaching model. Only students' interviews were considered for the present study.

Participants

Twenty four third grade students were selected to participate in the study. The sampling procedure was purposive and implemented in an attempt to find students who were representative of the gender, sex, and ethnicity from the school population. The final group was comprised of eleven girls and twelve boys, and the mean age of the students was nine years old. Twelve students who participated in this study had citizenship in countries other than the United States, which was a sign of the diversity of the participants.

Data collection

Consent and assent forms were provided both to parents and children prior to the beginning of the investigation. Upon approval of guardians and students, each child participated in an in-depth interview with one researcher that lasted from 15 to 30 minutes. After each interview the student was invited to draw a picture of him or herself in the science classroom. The interviewers established rapport with the interviewees, clearly explained to them the purpose of the interview, and guaranteed the confidentiality of the process. Interviews were audio-recorded and transcribed verbatim after they were conducted.

In-depth interviews

Interview has been one method commonly used in qualitative research. Researcher are able to learn about the individual's opinions, feelings, and comments about a situation through this method (Wengraf, 2001). Children have been found to be valuable sources of information and reliable informants about their experiences, and capable of reporting about their own feelings and beliefs (Reynolds, 1993). Interviews with children have constituted a special case, and have to be carried out carefully, taking into consideration the child's age and language. Children's interviews should be done sensitively and responsibly, because sometimes having adults asking about their opinions might be unusual for children (Swiers & Morrissette, 1999). Because children could respond poorly in extremely rigid settings, the researchers chose a flexible type of interview using Barker's (1990) guidelines for interviewing children: (a) acknowledging children's different cognitive and linguistic abilities, (b) stressing the voluntary nature of the interview, (c) informing the child about the purpose of the interview, and (d) telling the child about the role of the interviewer.

The semi-structured interviews included eight open-ended questions. The construction of questions was based on the following criteria: (a) research questions of the present study, (b) population, and (c) appropriateness of language. The interview questions are shown in Table 1.

Table 1. Interview protocol

Questions
1. If I say "science," what words come to your mind? (or what words would you relate to the word science?)
2. What do you think about the science class?
3. What do you like the most about your science class?
4. What do you dislike the most about your science class?
5. What is an example of something very cool you did in this class? Please describe it to me and tell me why you enjoyed it.
6. Please tell me about other science classes you have had in the past. In your opinion, how are these classes different from or similar to the science class you have now?
7. If you were a science teacher, how would you be teaching your class? What things would you do and what things would you not do?
8. Please tell about your drawing. (To be asked to students after they are done with drawing of themselves in the science class.)

Artifacts

One artifact, a drawing of the student in his or her science class, was collected from each child. The use of drawings with children has been a very helpful tool for researchers because drawings are one of the ways that children reveal their inner selves and their inner worlds (Malchiodi, 1998). Through drawings, children provide a visual representation of an idea or feeling, and also can solve a problem posed by an adult. Drawings have been methods through which children could express themselves in a different way from using language; however, a prompt was used with the students after they finished their drawings so they could further explain their creations (e.g. *I would like to know about what you made*). Children's explanations of their drawings also were audio-recorded.

Data analysis

Coding and creation of categories of children's responses was accomplished throughout the research. Similar themes were grouped into larger categories; to compare the themes found, the constant comparison procedure was used. The constant comparison procedure was an inductive method that allowed researchers to constantly evaluate themes that emerged from interviews, field notes, and other sources and compare them with the same or another set of data (Merriam, 1998).

Interviews

After verbatim transcription of children's interviews, the first step of the analysis was to find general themes in children's interviews and code them. Coding responses allowed the researchers to group children's responses that had similar ideas or themes (Rubin & Rubin, 1995). Incidents that were conceptually similar were grouped under a tentative label or theme (Strauss & Corbin, 2007).

The researchers looked for emerging themes in the interviews; however, some initial theory-based codes guided the analysis: (a) perceptions of science in general, (b) evaluation of science activities during the school year, (c) students' appreciation of science when hands-on activities were involved, and (d) assessment and comparison of traditional and innovative teaching models.

Artifacts

Content analysis was chosen as the procedure for the analysis of drawings. Therefore, themes were identified and quantified according to frequency of use. Children's drawings also were analyzed in a way similar to the analysis of the Draw-A-Scientist Test (DAST), an open-ended projective test that allows researchers to analyze a child's perceptions of a scientist (Thomas, Pedersen & Finson, 2001). DAST was developed originally by Chambers (1983); the main purpose was to learn at what age the well known stereotypic image of the scientist first appeared. For the research in this study, the DAST was further modified to create the Draw-Yourself-In-Science-Class Test (DYISC-T). When using the DYISC-T the interviewers requested the participant draw him/herself in a typical classroom situation. The DYISC-T differed from Chambers' DAST in that we asked students to draw themselves instead of a scientist in the picture. By doing so we aimed to find out in what kind of activities students were involved during their science class. For the research in this study, the Draw-A-Science-Teacher-Test Checklist (DASTT-C), which was developed by Thomas, Pedersen, and Finson (2001) was further modified to create the Draw-Yourself-In-Science-Class Test Checklist (DYISC-TC) as shown in Table 2. The DYISC-TC differed from the DASTT-C slightly in the wording of items. To develop a clearer picture of children's perceptions of themselves in a science classroom, the DYISC-TC developers added a short interview component to the instrument. We asked students to explain their drawing in the interview. This component was found to contribute information as well as to confirm the evaluators' understandings of images in drawings.

The DYISC-TC score sheet consisted of three sections: Teacher, Students, and Environment. Each section was scored in a dichotomous fashion with an indication of "present" or "not present" in the picture. The "Teacher" section of the instrument was divided into two subsections: (a) the teacher's activity (demonstrating, lecturing, using visual aids); (b) the teacher's position (location with respect to students, such as at the head of the classroom, and posture). The "Students" section of the instrument was likewise divided into two subsections: (a) the activities of students (passively receiving information, responding to the teacher, and similar behaviors); (b) students' positions (seated within the classroom). The third section, "Environment," had elements typically found inside classrooms, such as desks arranged in rows, symbols of teaching (e.g. chalkboards) and of science (e.g. science equipment). The presence of any of the thirteen attributes within a section was

Table 2. DYISC-TC score sheet for analyzing students' drawings

I. TEACHER	**Activity**		**Score**
		Demonstrating Experiment/Activity	
		Lecturing/Giving Directions (teacher talking)	
		Using Visual Aids (chalkboard, overhead, and charts)	
	Position		
		Centrally located (head of class)	
		Erect Posture (not sitting or bending down)	
II. STUDENTS	**Activity**		
		Watching and Listening (or so suggested by teacher behavior)	
		Responding to Teacher/Text Questions	
	Position		
		Seated (or so suggested by classroom furniture)	
III. ENVIRONMENT		Desks are arranged in rows (more than one row)	
		Teacher desk/table is located at the front of the room	
		Laboratory organization (equipment on teacher desk or table)	
		Symbols of Teaching (ABC's, chalkboard, bulletin boards, etc.)	
		Symbols of Science Knowledge (science equipment, lab instruments, wall charts, etc.)	
TOTAL SCORE (PARTS I + II + III)			

scored with a "1", an
absence with "0". Thus, the total score could fall between 0 and 13 (the higher the score, the more teacher-centered the image). Scores of 0-4 indicated student-centered teaching, while values between 7 and 13 represent teacher-centeredness. For scores of 5 or 6 no decision can be made (Thomas et al., 2001). The drawings were rated by two independent raters according to the checklist; inter-raterreliability was tested by Cohen's Kappa and considered to be moderately high with K = 0.93.

Methodological triangulation was performed to compare and contrast findings between interviews and drawings because more than one method was used for this study. Methodological triangulation was used for this research as an attempt to improve validity by combining various techniques in one study. To provide reliability to the research, investigator triangulation also was performed for the analysis, that was, the use of multiple investigators—three in this case—to interpret the data. The use of different researchers was a way to expand the interpretation of the results and to provide insights about the data that were difficult for just one person to consider (Denzin, 2001).

RESULTS

Words used by third grade students to define science

Words used by children to define science were clear reflections of the activities in which they participated and the content knowledge involved in those activities. The words used by children and the frequency of appearance are shown in Table 3. Children's responses related to science and to scientific constructs were grouped into four categories: (a) science disciplines (9.5%) (e.g. chemistry and geology); (b) scientific activities such as experiments and projects (32.4%); (c) science terminology (50.0%) (e.g. earth, water, ecosystems); and (d) scientific processes (e.g. evaporation, erosion) (8.1%).

Students elaborated their responses according to the disciplines, activities, and experiments that were included in their third grade science curriculum.

> Boy: experiments and working, because in science we do experiments (Individual interview, May 3, 2010).
>
> Boy: experiments, a lot of stuff, like science experiences, making models. (Individual interview, May 5, 2011)

They provided answers that reflected what they had learned and used words and concepts that displayed their understanding of science during the academic year.

> Girl: Water conservation, since that's what we've been studying and stones, rocks and minerals…facts. (Individual interview, May 10, 2011)
>
> Boy: We learn a lot about science so a lot pop up on my mind. Everything we learn comes up to my mind, like how we crack the rocks and put them in the water. (Individual interview, May 7, 2010)

Students' perceptions of their third grade science classes

Students' responses were related to four themes: (a) perceptions of their current science class and activities, (b) activities they liked to do in their science classes, (c) elements or activities they disliked about science lessons, and (d) comparative analyses of current and past experiences in science classes.

Perceptions of their current science class

Most of the children (96%) defined their science experiences using the word "fun", and other adjectives that reflected their enjoyment of the science classes, such as "cool," "neat," and "exciting."

Table 3. Words used by students to describe science

Categories	Words	Percentage (%)
Science discipline	Chemistry	2.70
	Biology	1.40
	Geology	4.10
	Archeology	1.40
	Category Subtotal	*9.50*
Scientific activities	Experiments	12.20
	Model Building	8.10
	Projects	5.40
	Observation	2.70
	Creative Thinking	2.70
	Testing	1.40
	Category Subtotal	*32.40*
Scientific terminology	Water / H2O	6.80
	Minerals	6.80
	Rocks	12.20
	Ecosystems	4.10
	Planets	4.10
	Earth	2.70
	Sand	1.40
	Electrodes	1.40
	Lab	1.40
	Space	1.40
	Animals	8.10
	Category Subtotal	*50.00*
Scientific processes	Evaporation	1.40
	Condensation	1.40
	Water Cycle	2.70
	Water conservation	1.40
	Erosion	1.40
	Category Subtotal	*8.10*

> Boy: It’s really fun because I get to learn about the ecosystem and experiments (Individual interview, May 4, 2010).
>
> Girl: It is very fun because you get to learn a whole bunch of stuff. (Individual interview, May 12, 2011)

The words of enjoyment were followed by a reflection of ways the classes helped the children to learn new and exciting things.

> Boy: It’s fun. I think it’s pretty cool; we learn interesting stuff about science. (Individual interview, May 10, 2011)
>
> Girl: It’s fun learning about rocks and minerals and also water and how we could conserve it. (Individual interview, May 6, 2010)

Activities that were enjoyed by students

Many different tasks and activities, such as group projects and experiments, were identified as enjoyable by the students. As shown in Table 4, in addition to the specific characteristics of the task, most of the students (76%) described the opportunity to do things. Projects that involved hands-on activities were described by the students, using words like “building” and “making”.

> Boy: I like building models because you get to think and have a bunch of ideas (Individual interview, May 12, 2010).

Table 4. Activities liked or disliked by students

Activities students liked	Percentage %
Learning new things	21.00
Activities	42.00
Observation	8.00
Modeling / building	42.00
Group activities	8.00
Tests	4.00
Activities students disliked	
Nothing	29.00
Group activities	4.00
Homework	4.00
Interruptive classmates	17.00
Disagreeing with others in group	8.00
Writing	25.00
Some activities	8.00
Tests	4.00
Lack of time to finish activities	4.00
Showing work and steps in the assignments	4.00

> Girl: I like building a model we made, because I love building, and I love using clay and the water. (Individual interview, May 11, 2010)

However, hands-on activities were not all that were mentioned by the children. Learning was also part of the students' descriptions.

> Boy: I like to do experiments like rocks, and water parks. Because with water parks we can do great water stuff and we can learn about the water cycle. (Individual interview, May 13, 2011)

Activities that were disliked by students

As shown in Table 4, some students (29%) did not list any activity they disliked.

> Boy: Probably nothing, I like everything about science. (Individual interview, May 4, 2010)

Some students (25%) mentioned writing as an activity that was least enjoyable (Table 4). Three children described writing as boring and requiring a great deal of effort.

> Girl: That I don't like when I have to write a lot. Because I found it boring, because you have to write about the experiments… I dislike that you have to write a lot. You have to write a whole bunch (Individual interview, May 10, 2011).
>
> Boy: Probably writing, because my writing isn't that good. (Individual interview, May 5, 2010)

A few students (17%) reported that one of the things they did not like about their science classes was the lack of time and cooperation among students (Table 4). Lack of time was described in the context of model building, and because of all the activities involved, students felt they did not have enough time to finish their final projects.

> Boy: What I don't like about it is that we don't get enough time to finish the whole thing. Because the last two we did it, we had a really short amount of time and we didn't get to finish drawing. (Individual interview, May 9, 2011)

> Girl: Because we have to finish it after and we need to have a better schedule to finish it on time. (Individual interview, May 14, 2010)

Lack of cooperation was described by children as the lack of participation of some members of their group in the activity of building their models.

> Boy: I don't really dislike anything, except for people aren't where they are supposed to be. (Individual interview, May 2, 2011)

Comparative analyses of current and past experiences in science classes

Some students (21%), when asked to compare their current science classes to other science classes they have had in the past, expressed differences in the type of activities they had done before and the ones they were asked to do in third grade.

> Girl: Now we are doing a lot more science, because we are doing more things, like actually doing experiments. (Individual interview, May 2, 2011)

Some students (21%) referred to third grade science as being "harder" than other years; however, students seemed to enjoy the complexities and challenges associated with their current science classes.

> Boy: But this year we had a harder experience building models, which I really like, but it's hard. You have to make an idea, choose which idea you're making, do the idea and you have to write what you learn. (Individual interview, May 7, 2010)
>
> Girl: But this one is a little bit "more higher" in level and it's harder to do, and there is a lot more building and ideas. (Individual interview, May 6, 2011)

A few students (9%) felt that this year they were able to do real science, which involved real scientific activities and experiments.

> Boy: Third grade goes more higher up on how to figure up things. (Individual interview, May 9, 2011)

Students as science teachers

When students were asked to imagine that they were the science teachers, a variety of answers were given about how they would teach the science classes. One of the most frequent answers from students (46%) was that as teachers they would do activities similar to the ones they really enjoyed during their science classes.

> Boy: I would do everything we've done so far this year, like the water conserving system, the ecosystem, I would do all that. I'd pretty much do everything. (Individual interview, May 7, 2010)
>
> Girl: I probably would do a lot of stuff we do on this class, such as encouraging kids making models, to let them have fun while they are doing science. (Individual interview, May 13, 2011)

Some students (17%) put themselves in the place of other students and thought about activities other children would enjoy as much as they did.

> Boy: I would teach about the fun thing I did when I was a kid. I would do ecosystems; I would start to teach them ecosystems, water cycles and water parks. (Individual interview, May 5, 2010)

Another activity mentioned by three students as something they would not do with their potential students was the use of complex words or concepts that they would not understand. For this group of students, clarity of language and explanations seemed to be a very important component of teaching.

> Girl: I would make simple questions like, what happened with your experiments. (Individual interview, May 3, 2010)
>
> Boy: Because sometimes when you talk about it gets clearer on everybody's head and everybody gets an idea. I wouldn't really give them a lot of information about the same I would tell them what we are

doing and probably giving them some information so they would figure it out. (Individual interview, May 12, 2011)

Third grade students' depictions as participants in the science classroom

The authors evaluated four aspects of the drawings: (a) teacher-centeredness vs. student centeredness; (b) types of activities; (c) types of interactions; and (d) mood of children in drawings.

Teacher-centeredness vs. student centeredness

When asked to draw a picture of themselves in the science class, children produced a variety of drawings. Children's drawings were scored by using the DYISC-TC. The results of the DYISC-TC distribution are presented on Table 5. Using the categories defined by Thomas et al. (2001) we saw that 81.25% in the drawings were in the student-centered category (a score of 0-4). None of the drawings were in the "neither student-centered nor teacher-centered" category (a score of 5 or 6). Only 18.75% of the drawings were in the teacher-centered category (a score of 7-13).

Types of activities

The children tended to draw pictures that depicted themselves in student-centered activities. As shown in Table 6, the majority (75%) of students drew themselves performing science activities such as experiments, projects, or model building. Through these drawings students depicted themselves without the presence of the teacher, as shown in Figures 2 and 3.

Girl: I'm a student, and the bubbles show the vinegar is being boiled. There is fire. I love drawing…I love science. (Individual interview, May 9, 2011)

Girl: It's me doing a science project. (Individual interview, May 10, 2010)

Table 5. Distribution of student scores on DYISC-TC

DYISC-TC scores	Percentage (%)
0	18.75
1	50.00
2	12.50
3	0
4	0
Subtotal of student-centered scores (0-4)	81.25
5	0
6	0
Subtotal of neither student-centered nor teacher-centered scores (5-6)	0
7	6.25
8	0
9	12.50
10	0
11	0
12	0
13	0
Subtotal of teacher-centered scores (7-13)	18.75
Sum	100.00

I'm a student, and the bubbles show the vinegar is being boiled. There is fire. I love drawing…I love science.

Figure 2. Example of a drawing that depicts a student-centered science classroom

It's me doing a science project

Figure 3. Example of a drawing that depicts a student-centered classroom

Some students (25%) drew themselves in passive actions rather than doing some kind of science activity (Table 6). These passive actions included students sitting down and responding the teacher, writing, or listening to the teacher's instructions. In these drawings, students were sitting down while in some cases the teacher was in front of the class talking. The teacher usually was drawn at some distance from the group of students. An example of this traditional approach to teaching drawn by students is shown in Figure 4.

> Girl: I drew this picture because it is mostly what we do…write and draw. (Individual interview, May 5, 2011)

Types of interactions

Over half of the children (56%) drew themselves alone in the classroom involved in different types of activities (Table 7). No interactions with the teacher were illustrated by the students.

> Boy: Just me writing about science. (Individual interview, May 8, 2011)

Table 6. Frequency of activities in drawings

Types of activities		Percentage (%)
Students who are active in drawings	Doing experiment	25.00
	Doing project	37.50
	Others	12.50
	Subtotal	75.00
Students who are passive in drawings	Responding teacher	6.25
	Listening	0.00
	Writing	18.75
	Subtotal	25.00
No activities	Subtotal	0.00
	Total	100.00

Table 7. Frequency of interactions in drawings

Types of interactions	Percentage (%)
Student-student interaction	25.00
Student-teacher interaction	18.75
No interaction	56.25
Total	100.00

I drew this picture because it is mostly what we do…write and draw.

Figure 4. Example of a drawing that depicts a teacher-centered classroom.

An example of a drawing that showed just one student is presented in Figure 5, whereas a drawing that illustrated interactivity is shown in Figure 6.

As seen in Table 7, almost half, 44%, of the children made drawings of themselves interacting with either the teacher or other students in the science classroom such as talking and/or sharing materials. In one in every four drawings, children showed themselves in an interaction with classmates and in 19% of the drawings children were interacting with their teacher.

> Girl: Me and my group doing a science project. (Individual interview, May 12, 2011)

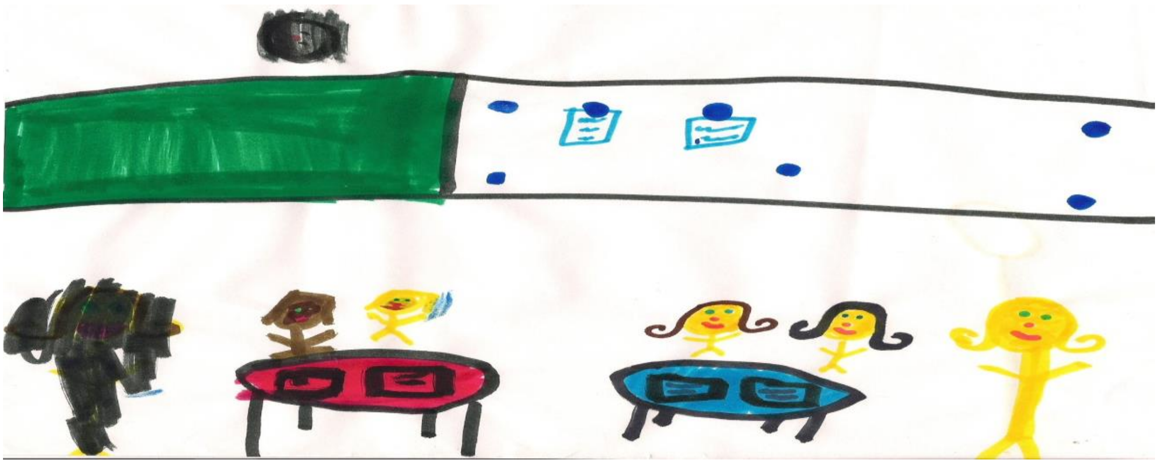
Mood of children in drawings

As shown in Table 8, most of the children (76%) drew themselves with a happy face in the drawings. An example of a drawing that showed students with happy faces is presented in Figure 6.

None of the children drew themselves with an unhappy face (Table 8). Some of the children (24%) drew themselves with a neutral emotion (neither happy nor unhappy) on their faces. An example of a drawing that showed students with a neutral emotion faces is presented in Figure 7.

Just me writing about science

Figure 5. Example of a drawing that shows no interaction

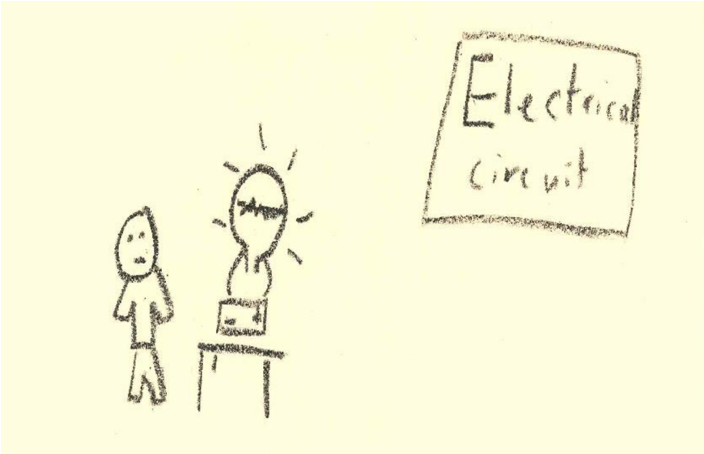


Me and my group doing a science project

Figure 6. Example of a drawing that shows interaction

Table 8. Frequency of students' moods in the drawings

Students' Moods	Percentage (%)
Happy	76.47
Neutral	23.53
Unhappy	0.00
Total	100.00



Me doing a project about electricity

Figure 7. Example of a drawing that shows a neutral face

DISCUSSION

The purpose of this study was to explore third grade students' perceptions of their science classes. Specifically, the aim of the researchers was to evaluate the implementation of a new teaching model during the teaching of science, and how this model could have an influence on children's perceptions of science. Students participating in this study were able to articulate clearly and deeply their views in response to the variety of questions about their learning experiences. These findings are consistent with what authors have stated about the incorporation of students' voices into the educational dialogue based on students' unique perceptions about learning, teachers, and school experiences in general (Cook-Sather, 2007). Although researchers have identified students' perceptions as valid and valuable elements that can inform practitioners about different aspects of education, such as curriculum, instruction, and student-teacher relationships (Shultz & Cook-Sather, 2001; Wilson & Corbett, 2007), students' voices in educational decisions about school reforms, curricula, or teaching practices rarely have been listened to by the researchers (Fullan, 1991).

Students' description of the science lesson

Through their reflections, students described their experiences in their science classes, especially the activities they saw as being meaningful to their interests and learning. According to the students, the most important learning experiences they had in the field of science came from school. For example, when asked to describe science, all of the students used words that were related to their school experiences. When asked why they used these words, some of the students said that those were the things they had learned throughout the academic year. The science terminology was recalled because it was part of students' meaningful learning experiences and therefore had a long-lasting impact on them. Students believed that school was one place where science learning was occurring and where students were experimenting with "real" science. Many students (62%) not only used concepts and scientific terminology to describe science, but also added an "action" component to their definitions, which is one of the important findings of this study. Students defined their scientific experiences practically, referring to science as something that "is done" throughout several activities. They described experiments and model building experiences they had as a result of the implementation of the FOSS and the REAPS Model.

Students' perceptions of their science learning experiences

The students especially enjoyed these activities because they had an opportunity to create, share, and put their ideas into action. Several authors have found that hands-on experiences are superior ways of achieving learning compared to passive or monotonous learning experiences (Powell & Wells, 2002; Stohr-Hunt, 1995). Guenette, Marshall, and Morley (2007) found that students who had intensive hands-on experiences through laboratory activities reported that they had more "complete" learning experiences than when they just used textbooks. Students in this study also mentioned that experiential and interactive activities resulted in an important increase in their knowledge of the subject matter.

One impressive finding of this study is that many students (84%) liked experiments, projects, and modeling the most about their science class. One reason for this result might be due to the use of the Model REAPS, which provides opportunities for students to achieve long-lasting learning through meaningful problem-solving experiences with curriculum concepts related to students' lives and interests.

Students in this study also were able to make comparisons between their current third grade science experiences and the ones they had in the past. They defined this year's science as "harder," which may be attributed to the natural progression in complexity that occurs in the science curriculum or to the addition of model-building which was part of the REAPS Model. However, "hard" was not defined as negative. They conceptualized their current science experiences as being more challenging and as fostering a deeper level of thinking. The most challenging activities mentioned by the students were those that were part of the REAPS Model, such as model building. As students stated, they had to be able to think of the process and problems that might arise, and collaboratively solve, with other students, the scientific problems that were posed to them.

When students asked what they did not like about their science class, they gave a wide range of responses varying from homework to group activities. The largest population (29%) said that they disliked "nothing" about science class. Six of the students said that they did not like "writing" activities. According to Volman, van Schendel and Jongmans (2006), handwriting difficulties are commonly observed in children at primary schools and students have negative attitudes toward writing especially at the early childhood level. Handwriting is a complex perceptual-motor skill that is dependent upon the maturation and integration of a number of cognitive, perceptual and motor skills (Hamstra-Bletz and Blote, 1993; Maeland, 1992). According to McHale and Cermak (1992), thirty to 60% of the elementary school child's class time is spent in fine motor/writing activities, with writing as the predominant task. Although some students might find writing boring and time consuming, researchers consider writing to be a very important tool for learning science (Pollack & Godwin, 1983).

When asked to assume the role of the teacher, students responded empathically to the learning needs of their potential students. Children wanted to replicate the meaningful activities they had in their science classes with other students, so the other children could enjoy them as much as they did. Children also mentioned the activities they would not like to do with their students. When thinking about their "students," children are projecting what they have experienced and the differences between their expectations about science (e.g. hands-on activities) and what the teacher required them to do (e.g. writing). Bjork-Willen (2008) analyzed this phenomenon as a mismatch between the teachers' goals and the children's projections of relevant activities to be conducted in the classroom.

Students' perceptions through their drawings

Students' perceptions expressed in their drawings were similar to the content of their interviews, which showed evidence of their meaningful science learning experiences. Using the DYISC-TC, we found that 81.25% of the drawings were in the student-centered category. None of the drawings were in the "neither student-centered nor teacher-centered" category. Only 18.75% of the drawings were in the teacher-centered category. These findings might be the result of the student-oriented approach of the REAPS Model. Also most of the students (75%) tended to make drawings of themselves in active roles, such as doing experiments, working on projects, speaking to their teacher, and working in a group of students. This result might be explained with the FOSS curriculum's inquiry-based approach and the use of the REAPS Model in which teachers and students are actively involved.

Almost half, 44%, of the children made drawings of themselves interacting with either the teacher or other students in the science classroom doing things such as talking and/or sharing materials. In one in every four drawings, children showed themselves in an interaction with classmates and in 19% of the drawings children were interacting with their teacher. However, in 56% of the drawings, children were not interacting with others. One explanation of this result might be that the REAPS model is a student-centered approach that fosters learners' independence through meaningful problem-solving activities (Maker & Zimmerman, 2008; Maker, Zimmerman, Gomez-Arizaga, Pease, & Burke, 2015).

The children's mood in the drawings was another aspect of evaluation. It is widely acknowledged that children's drawings convey their emotions (Davis, 1997; Golomb, 1994; Rosenblatt and Winner, 1988). In the drawings, most of the children (76%) drew themselves with a happy face and none of the children drew themselves with an unhappy face. Some of the children (24%) drew themselves with a neutral emotion (neither happy nor unhappy) on their faces. One explanation of the children drew themselves happily in their drawings might be that they enjoyed what they have experienced in their science class.

Limitations

The results of this investigation need to be interpreted with caution. We studied the implementation of the REAPS Model in only one school in a medium-sized U.S. southwestern city. We also did not consider how students' characteristics might have affected our results. The results need to be understood in the light of the particular group that was part of the research and the particular characteristics of the students, such as age, grade level, ethnicity, and intellectual strengths.

As indicated before, the school selected for this study had more gifted students than other schools in the district. We did not need to compare the significance of the model for gifted and non-gifted students because it was not the focus of the study. However, through a future quantitative study, we think such a comparison might indicate whether the REAPS Model can engage students who have various intellectual capacities, in learning at different levels. We recommend that future researchers should analyze how gifted and non-gifted students benefit from the implementation of the model.

Theoretical implications

In the current study, we found that the REAPS Model could be successful to engage students into learning. The presence of the FOSS curriculum as a part of the REAPS Model also was able to achieve students' engagement. Although REAPS is a flexible model to use with any kind of curriculum, researchers should evaluate its implementation with other inquiry-based curricula.

Teachers' impact on the implementation of the REAPS Model should also be investigated to understand the teachers' role in the execution of the model. Further studies should include teachers with different levels of experience with the model.

Implications for research

This investigation adds to recent research that incorporates students' voices as informants about educational practices. Future directions for research should be to include comparative analyses between different groups of students such as those who (a) come from different socio-economic status groups; (b) have been exposed to different science curricula and teaching models; and (c) have diverse levels of engagement in school, a variable that has found to be critical when students reflect on their school and learning experiences (Mitra, 2004; Leitch & Mitchell, 2007; Cremin, Mason, & Busher, 2011).

Comparing groups of students who have been exposed to different types of curricula and teaching models and the impact on their learning also can be beneficial to expand research in the field of science education and student learning.

Implications for practice

From students' insights and reflections gathered through this study, some important variables of teaching practice were analyzed. First, the use of hands-on activities resulted in deep student engagement, learning, and involvement-factors that are considered essential for today's classrooms. The use of research-based curricula and teaching strategies can result in positive learning experiences for children from diverse backgrounds. Curricula created using approaches such as the DISCOVER model can eliminate barriers and increase facilitators for culturally and linguistically diverse students. When students' strengths are identified and teaching approaches developed so that strengths are used as vehicles for developing academic and real-life skills, students from all groups, including those considered to be "at-risk" experience greater success in school.

Hands-on activities also can affect students' learning results on standardized tests, a topic of constant analysis and debate in public education. In this study, children worked throughout the year using two approaches that contributed to their learning. The FOSS curriculum provided the scientific experimentation needed to better understand science, and the REAPS Model provided students with the opportunity to work with real-life problems that can have multiple approaches and solutions. The combination of both approaches resulted in active learning reflected through students' perceptions of their science classes.

Making science more appealing to children and helping them achieve deeper levels of understanding has been a challenge for practitioners involved in the field. However, creating and using curricula including concepts related to students' lives and interests will provide opportunities for students to achieve long-lasting learning through meaningful problem-solving experiences.

Student consultation can be a powerful tool to incorporate students' voices into educational discussions and can provide authentic insights about their learning (Flutter, 2007). Students' participation also can help to increase students' engagement and commitment to school, which is critical to student learning and achievement (Yonezawa & Jones, 2007). Actively listening to students' feedback about their learning can be useful in improving teaching practices. This investigation has provided convincing evidence that children know and can articulate their thinking about their learning experiences; educators' wanting to listen to their voices is what really matters.

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