

It's Hard, but I Can Do It: How an Independent Engineering Fair Project Can Affect Student Perceptions Of Science

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Abstract

Incorporating authentic engineering practices into educative experiences in elementary school has the potential to positively impact student consideration of STEM careers and increase student self-efficacy in later engineering study. Additionally, as students move from primary to secondary grades, their interest in STEM topics tends to decline. To that end, teachers and researchers at Chaparral Elementary facilitated an independent engineering fair project to engage students in authentic practices of engineering to solve a self-identified problem with a designed or improved solution. We investigated how students' perceptions of science and engineering were affected by their engagement in the practices of engineering through a two-week long independent engineering fair project. Data sources for the study include student surveys, researcher qualitative memos, informal student interviews, and student presentations. Our findings indicate that as students engaged with their independent engineering projects, their understanding of science as a tool for explaining the natural world improved and their perceptions of science and engineering and themselves as scientists and engineers was positively impacted.

Keywords:

Elementary Science, Elementary Engineering, Engineering Fair, Student Perceptions

Introduction

The introduction of engineering practices in elementary school has the potential to positively impact student consideration of careers across science, technology, engineering, and mathematics (STEM) fields (National Academy of Engineering and National Research Council, 2009; Ritz & Fan, 2015). Engineering design is an iterative process that introduces students to the notion that there are likely multiple solutions to a problem through a context requiring relevant content knowledge across STEM domains (National Research Council, 2009). In addition to supporting 21st century skills such as problem solving through a reflective, collaborative process using higher-order thinking



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(Fan & Yu, 2017; Marulcu & Barnett, 2015; Wendell et al., 2017), engineering processes have been shown to support student content understandings in science (Atman et al., 2007; Capobianco et al., 2015; English & King, 2015; Guzey et al., 2017; Marulcu & Barnett, 2015; Wendell & Rogers, 2013).

As students move from elementary school to secondary school, their interest in science tends to decline (Christidou, 2011; Kang & Keinonen, 2018; Potvin & Hasni, 2014b). However, introducing engineering practices to students in the early grades has been shown to increase their self-efficacy in engineering in the college years (Fantz et al., 2011). To this end, additional research is needed to understand in what ways engineering can be implemented into elementary school curriculum and how it impacts students' perceptions of STEM practices and career fields (McCormick & Hammer, 2016; McFadden & Roehrig, 2019).

Background

Traditionally, elementary teachers have attempted to engage students in authentic science through the inclusion of science fair projects. Some argue that science fairs serve as a source of anxiety for teachers, parents, and students (Carrier, 2006) and that the common step-by-step formulaic processes do not connect students to authentic science (Magee & Flessner, 2012). However, science-fair projects that promote student-guided inquiry have the potential to increase student self-efficacy in science (Dionne et al., 2012) and increase student attitudes towards and understanding of inquiry (Schmidt, 2014). Additionally, engaging in student-centered inquiry experiences in science can aid students as they approach more complex scientific concepts (Bellipanni & Lilly, 1999).

Combining an approach towards elementary science education that values the inclusion of engineering processes and student-centered, autonomous, inquiry experiences we worked with three fifth-grade teachers at a local elementary school to design and implement an independent engineering fair. We used the engineering fair experience to investigate how students approach the process of engineering design and how completing an individual project impacted their perceptions of science.

Science Project Fairs

Science fairs have traditionally been used to engage students in authentic science and researchers have concluded that engaging students earlier with hands-on experiences in science eases the transition to complex scientific concepts (Bellipanni & Lilly, 1999) Dionne and colleagues studied students'

motivational factors for participating in science fairs and the influence on their interest in STEM careers. Factors included an interest in science, self-efficacy, assurance of achievement, social aspect, and working on strategies to gain scientific knowledge. The authors stated, "for teachers who strive to make science more appealing to a larger audience of students, science fairs are considered to be promising pedagogical activities because they promote inquiry-based learning" (Dionne et al., 2012, p. 672). Schmidt (2014) confirmed participation in science fairs increased students' attitudes and understanding of inquiry. The study revealed students who have more autonomy over their projects gained the most positive attitudes towards science (Schmidt, 2014).

Engineering as a Tool to Learn Science

The Nebraska Project was a collaboration of the College of Engineering and Technology and the College of Education and Human Sciences at the University of Nebraska-Lincoln and designed for middle and high school math and science teachers. The program focused on increasing teacher awareness of engineering and increasing their self-efficacy in teaching engineering. Teachers participating in the programs reported an increase student interest in math, science, and engineering. In the second year of the program, researchers specifically asked students if their interests towards STEM were increased. Eighty-six percent of the students said they "strongly agreed" or "agreed" they learned something from their lessons and 75% stated the lessons increased their interest in STEM. The concluding impact on students also showed increased awareness and interest in engineering (Nugent et al., 2010). These findings suggest a positive influence on students' attitudes and interest in STEM.

Engineering poses real-world solutions to problems and students are given the autonomy to solve them (Cunningham & Lachapelle, 2014). It is not surprising that studies show an increase in students' interest in STEM careers when engineering design is incorporated in curriculum (Benenson, 2001; Cunningham & Lachapelle, 2014; Fortus et al., 2004; Silk et al., 2009). Engineering challenges situated in the real world are often attractive to and motivating for students, particularly those who are otherwise underserved or underrepresented in the discipline (Cunningham & Lachapelle, 2014). Fortus and colleagues (2004) supported using design-based science (DBS) to increase student knowledge and interest in science. Current curriculum, they argued, is not based in real-world problems where students struggle through decisions that are not easy to make (Fortus et al., 2004). In addition to solving real-world problems of relevance to students, including engineering design in the classroom allows students

to question their data when it is contrary to what they believe to be right (Benenson, 2001) and students can represent their ideas with concrete artifacts (Fortus et al., 2004).

Silk, Schunn, and Cary (2009) conducted a study of the pre-post gains of scientific reasoning of eighth-grade students located in a high-needs urban setting. The methods of instruction consisted of an emphasis on DBS, inquiry, and textbook curriculum supporting science methods used in the DBS project. Results concluded significant gains in science reasoning using all three methods of teaching, with DBS curriculum showing the most gains. The study concluded "student's knowledge of science reasoning improves if it is taught explicitly in a rich context" (Silk et al., 2009, p. 219).

Ganesh and Fulton (2011) also supported using engineering-design projects to increase students' knowledge in science and technology when they are involved in the learning process. Using engineering design over a two-year period, the authors wanted to determine the characteristics of a successful learning experience for middle school students. Characteristics included: hands-on experiences using engineering design, using the instructional sequence of the 5E's (engage, explore, explain, elaborate, and evaluate), access to technology and tools, and an apprenticeship with university students and engineers. Students became empowered and gained knowledge in technology (Ganesh & Fulton, 2011).

Engineering and Student Self-Efficacy, Interest, and Attitude Towards STEM

A study of college students determined those who were exposed to engineering practices at a younger age tended to be more interested and have higher self-efficacy in engineering (Fantz et al., 2011). Inspired by this research, Zhou and colleagues (2017) studied the influence of engineering at the middle-school level. Their study investigated how toy-design activities increased students' self-efficacy in and knowledge of engineering design. Students with limited experience in engineering design may have lower self-efficacy and thus not enroll in engineering programs later in their schooling career. Fostering self-efficacy as early as elementary could help increase interest in engineering. The study included 24 middle school students between the ages of 13-14 who were engaged in building relatable objects they could play with, such as a Marshmallow Challenge and Nerf Blaster Dissection, capitalizing on relevance and students' prior knowledge and skills. The results of the study showed an increase in self-efficacy in engineering as well as increased knowledge of engineering design (Zhou et al., 2017).

Engineering in Elementary

While there is little present research investigating how exposure to the processes of engineering design affects elementary students, researchers have suggested exposure to science and engineering as early as elementary school may have a positive effect on students' self-efficacy, attitude, and interest in science (Cunningham & Lachapelle, 2014; Samuels & Seymour, 2015; Zhou et al., 2017). The current literature is centered on middle and high school students, suggesting more research is needed at the elementary levels (Cunningham & Lachapelle, 2014; Dionne et al., 2012; Hirsch et al., 2007; McFadden & Roehrig, 2019; Nadelson et al., 2015).

Student Perceptions of Science and their Possible Selves

Student perceptions of their possible future selves are influenced by their current identity and experiences and represent specific, personalized conceptions of who one could become in a given social context (Markus & Nurius, 1986). For students to imagine their future possible selves engaging in science coursework or careers, they need to feel as though there is a place for them in science and that they possess the competencies required. Engaging students in authentic, relevant, problem-driven science experiences has the potential to positively affect student perceptions of and motivation for science learning (Hellgren & Lindberg, 2017; Kang & Keinonen, 2018; Potvin & Hasni, 2014a).

Context

This study was conducted at Chaparral Elementary (a pseudonym). Chaparral Elementary includes grades pre-k through fifth and is in a suburban setting in the central United States. Upon enrollment, a majority (55.8%) of the 513 students were identified as Caucasian, 12.7% Hispanic, 7% Black, 5.1% Native American, 1.4% Asian, and 18.1% two or more races. Over half of the students (56.3%) are eligible for Free/Reduced Lunch. On state readiness testing, 47% of all fifth-grade students scored proficient and above (Office of Educational Quality & Accountability, 2017). Fifth-grade classes at Chaparral Elementary are 1:1, meaning for each student in the class there is a laptop computer available for use. In addition, at the time of the study the district utilized Google Classroom for student-teacher communication and assignments that require the use of technology.

The independent engineering fair took place over a two-week period near the end of the academic year, after state testing (see Feille et al., 2021a). Students were asked to identify a real-world problem they were interested in, research possible solutions, use research

findings and content knowledge to design or improve a solution, communicate their proposed solution through the use of drawn prototypes, and present their process at the close of the fair. The design portion of the project focused students on an iterative process using drawn sketches for generation and communication of student ideas, an important step prior to constructing physical prototypes (McFadden & Roehrig, 2019).

This qualitative, single case study investigates the effect of individual engineering fair projects as authentic science teaching and learning experiences. Participants in the larger study include fifth grade students across three classes and their classroom teachers. This manuscript includes only student-focused data and investigates the question, how does participation in an individual engineering fair project affect student perceptions of science?

Participants

The participants in this study include 29 of 90 fifth grade students in three classes. Although all 90 fifth grade students completed the engineering fair projects, the students included in the study provided both parent permission and student assent to contribute data to the study. All identifying information was immediately removed from student data and each assenting student was assigned a unique numerical identifier and later a pseudonym. To avoid the identification of any participants, only the student's gender and assigned class remain as an identifying feature in the reporting of data (see Table 1).

Table 1
Consenting student participants

Class	Male	Female
Ms. Powers*	5	5
Ms. Myer*	5	7
Ms. Ferguson*	2	5

Note: Teacher names are pseudonyms

Data

The data sources used in this study include a student survey (Elementary Student Perceptions of Science Instrument [ESPOSi]), researchers' observations and field notes collected throughout student work and presentation of individual engineering fair projects, as well as recorded and transcribed informal interviews conducted at student presentations.

The ESPOSi student survey seeks to provide a baseline of student understandings of science as an explanation of the natural world, view and value of science, and view and value of formal science learning (Nettles et al., 2018). The survey utilizes multiple modes of questioning including single-choice and multiple-choice as well as open-response questions. Student

responses are then coded as Low-Mid-High for each question utilizing a rubric (see Appendix). Finally, students are described as Low-Mid-High for each of the three focus areas (science as an explanation of the natural world, view and value of science, and view and value of formal science learning).

The research team moved among classes while students worked on their individual engineering fair projects and for student final presentations of their projects acting as participant observers. During this time, the research team interacted with students inviting them to describe their ideas and thoughts about the process. Detailed field notes and post-experience reflections were recorded to describe observations of student work, student-teacher/student-student interactions, and any notable questions or descriptions.

Finally, consenting student presentations were audio recorded and prototype drawings and diagrams were photographed. At the close of their presentation, each student was asked if their ideas about science and engineering had changed throughout the project as well as how they now thought of themselves as scientists and engineers. Responses were audio recorded and hand transcribed.

Method

Prior to beginning their individual engineering fair projects, each student completed the ESPOSi online using Qualtrics (Qualtrics, 2018) and their assigned laptop computer. For nine school days, the students spent approximately one hour each day on their engineering fair projects. Table 2 outlines the timeline of the study.

Table 2
Study outline

Study Day	Event	Data Collected
Prior to project	Obtain parent permission ESPOSi	ESPOSi Survey Data
Day 1	Topic Brainstorm	Observational Memos
Day 2	Purpose	Observational Memos
Day 3	Background Research	Observational Memos
Days 4 - 6	Prototype Plan	Observational Memos
Days 7 - 8	Improve Prototype Design	Observational Memos
Day 9	Present project and final prototype design.	Audio recorded Student Presentations & Informal Interviews

ESPOSi results were analyzed according to the survey rubric (See Appendix). Field notes and informal student interviews were transcribed and coded using MAXQDA 2018 (VERBI Software, 2017) for data analysis. Using constant comparative analysis (Glaser, 1965), data segments were coded primarily with themes

taken from the ESPOSi student survey (science as explanation of natural world, view and value of science, and view and value of formal science learning) and secondarily with themes that emerged throughout data collection and analysis (Stake, 2010). Regular research team meetings were used to identify researcher agreement and discuss instances of conflicting coding to come to consensus.

Student silhouettes were then constructed using individual ESPOSi results paired with coded data segments from research memos and presentation transcriptions. Silhouettes of the participants lack the detail of portraiture (Lawrence-Lightfoot & Hoffmann-Davis, 1997) but can provide an "outline or shadow" of the individual participant and their perceptions of science throughout the independent engineering fair project (Feille et al., 2018, p. 33).

Findings

Researcher memos and field notes were used to investigate student perceptions of science throughout their experience participating in an independent engineering fair. Informal student interviews and student presentation data provide a source of triangulation in conjunction with ESPOSi pre-experience survey results.

ESPOSi

Fifth grade students at Chaparral Elementary generally demonstrated Mid-level perceptions of formal science learning ($N = 25$). This indicates that students generally associate science learning with passive learning practices related to specific content; and when learning is active students refer to general descriptions of practice such as "experiments" or "hands-on." Only three students demonstrated a Low perception of formal science learning while zero demonstrated a High perception of formal science learning. Students can be described as demonstrating Mid ($N = 11$) to High ($N = 14$) perceptions of science indicating that students see science as a meaningful enterprise, applicable to career choice, and necessary at the basic level of knowledge for society. In addition, students may initially turn to scientific practices as methods for problem solving. Very few students ($N = 3$) demonstrated a Low perception of science. Most student participants indicated Low ($N = 20$) to Mid ($N = 8$) conceptions of science as a way of knowing

and understanding the natural world. This reveals that although they are aware of science as a field of study, the application of scientific practices and knowledge may be limited to an academic or content-specific setting. Table 3 describes the ESPOSi rubric coding by question.

Field Observations

Throughout student work on their independent engineering fair projects, researcher field memos revealed that although students frequently struggled with the autonomy of the project (Brophy et al., 2008), they appreciated attending to a topic they had interest in (Brown, 2017; Cunningham & Lachapelle, 2014). Early in the project, a lack of knowing the nature of engineering practices resulted in student frustrations for a few students who shared an intense focus on finding the "right answer" (Memo_Day2). Due to the novelty of the engineering practices, many students also struggled to understand their role related to their self-identified problem (Memo_Day3). The novelty of the process and the lack of a "right" answer required scaffolding and prompting for some students more than others (Lou, 2015; McFadden & Roehrig, 2019). Some of students' struggles seemed to relate to individual teacher's teaching engineering self-efficacy (see Feille et al., 2021b). As the teachers' confidence in facilitating the engineering fair project gained, so did students' comfort. Through teacher scaffolding and reassurance, students eventually came to understand that their purpose was to create or improve upon a solution to their identified problem and that failure along the way was all a part of the process (Memo_Day4).

Over the course of the project, students generally moved away from a more simplistic view of science as a way of knowing where they talked primarily of science topics from the context of an academic setting towards a broadened view of science and engineering in real-world contexts (English & King, 2015). Because the project focused students' attention on identifying a problem and designing their self-conceived solution, students were free to capitalize on their own creativity rather than work within prescribed situations and scenarios (Memo_Day4). By the end of their experience, many students reflected upon the broader application of scientific and engineering practices for problem solving and understanding phenomena of the natural world (Fortus et al., 2004).

Table 3
ESPOSi Results by question

	Perceptions of Formal Science Learning				Perceptions of Science			Science as a way of knowing		
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q1	Q2	Q3
Low	12	11	4	5	8	3	1	18	20	20
Mid	15	16	13	4	8	20	3	10	8	5
High	1	1	11	19	12	5	24	0	0	3

Additionally, several students were forced to recognize how their current scientific understandings could limit their proposed solutions but used the project to support scientific research and investigation on their own (Ganesh & Fulton, 2011). Rather than seeing limited content knowledge as a dead end, students instead identified who might be important design partners or resources as their proposed prototype moved forward (Memo_Day5).

Student Presentations

"I thought like, science, and (pause) technology and stuff like that. I always thought it was circuitries, and circuit boards, and wires, and speakers and batteries. and all that stuff. But really it's like everything. Science is everything" (Lena_presentation). During student presentations, students continued to reflect upon how they think about science differently after the project, "I think science can be a lot more fun than I first thought about it" (Jeremy_presentation). Students talked about science as broader than how they originally conceptualized the subject, more than "just chemicals". "Science is pretty much anything that is man-made and like a helpful, like piece of material that helps us in the world" (Marc_presentation). They continued to describe science as difficult or hard, but their perceived self-efficacy was improved with several students indicating "science is hard, but I can do it" (Memo_presentations).

Embracing the value of failure was something several students mentioned in their presentations celebrating that repeated failure usually ends in success, "You might fail 1,000 times. As long as you make it once, it doesn't matter" (Eddie_presentation). The persistence they experienced contributed to their understanding of engineering, "Well, it doesn't always work the first time. You have to go through it multiple times. You have to brainstorm, one idea, your first idea isn't going to work. That's for sure. You have to keep it and add on to it" (Hannah_presentation). Problems in design frustrated some students and had them grappling with how much support or feedback they really wanted, "(I felt) frozen, like I wasn't really sure what to do...and sometimes getting too much help is baddish, then you also want to ask for help when you need it the most" (Elijah_presentation).

Students also described science and engineering as progress, tools to make the world a better place (Lena_presentation). They recognized that their creativity played a role in using the tools and practices of science and engineering to improve their world, "I learned that really science could be anything. Like whether it's a rock or it's a new computer. And that really that, like, if you are creative, you can make an entirely new line of technology" (Jasmine_presentation). For some, being able to showcase their creativity contributed

significantly to their enjoyment of the project, "I had a lot of fun doing this project...(be)cause I saw a lot of creativity in it. And I love doing creative things" (Ella_presentation).

A very small number of consenting students ended up without completed projects. It is possible that a fear of failure contributed to student apathy (Memo_presentations). One student admitted he usually quits on projects like this, but he committed to finishing this project and wished he had done more.

I know I could have had a better problem and a better answer just because I wanted to rush through it. I feel kind of happy about it because I actually did something...Usually I don't get finished with problems and work like this. I wish I could have done a better job (Roman_presentation, Memo_presentations).

The limitations of time and the constraints of the formal classroom environment hindered some students. "To do one project takes a long time" (Justin_presentation) and some struggled with the structure of the slideshow, so many students were not at the point they hoped to be by the time of the presentations.

Silhouettes

When considering science as an explanation of the natural world, students generally described science as broader than they originally thought. Science became for them a tool to understand more about their world through the independent engineering fair project. Students' views and values of science were impacted as they began to consider themselves as ones capable of doing science and engineering. They appreciated the creative aspect associated with solving authentic and relevant problems (Brown, 2017; Cunningham & Lachapelle, 2014; Nugent et al., 2010). For several of the students, the experience shifted their views towards formal science learning as they began to see learning in the science classroom as something they could enjoy and desire to work hard for. A selection of student silhouettes is shared in Table 4.

Concluding Statements

Students entered the engineering design process with an emerging understanding of science as a tool to explain the natural world and did not consider the practices of science and engineering when approaching problems. Students may not have seen themselves as scientists or engineers prior to engaging in the independent engineering fair project and instead considered science primarily in the context of schoolwork rather than a personal endeavor. However, working through their self-identified problem to conceptualize a new or improved

Table 4
Selected Participant Silhouettes

Pseudonym	ESPOSi	Silhouette
Elijah	Low Perceptions of Formal Science Learning Low Perceptions of Science Low Conceptions of Science as a way of knowing	Entering the project with overall low perceptions of science, Elijah struggled with the patience to commit to solving his problem. He encountered several problems with his design that had him feeling "frozen" and unsure with how much help to ask for. Despite persisting through the project, he admitted he doesn't see himself as an engineer because he doesn't have the "patience for things."
Sadie	Low Perceptions of Formal Science Learning Mid Perceptions of Science Low Conceptions of Science as a way of knowing	Sadie entered the project with a low perception of formal science and science as a way of knowing. She acknowledged that the project helped her learn a lot about how things work and thanks to the project she kind of "got into (science) now". The project helped her value the processes of science and engineering, admitting that she can't just "do something random" and expect it to work out.
Jasmine	Mid Perceptions of Formal Science Learning Mid Perceptions of Science Low Conceptions of Science as a way of knowing	Jasmine began the engineering fair project with mid-level views of science and a low conception of science as a way of knowing. But through the project learned that science is broader than her previous conceptions. Coming to understand the role of creativity helped her to engage with the project acknowledging that her desire to be creative could contribute to her future as an engineer.
Roman	Mid Perceptions of Formal Science Learning High Perceptions of Science Low Conceptions of Science as a way of knowing	Roman started the project with a varied perception of science. While he valued science and tolerated the formal classroom, he had low conceptions of science as a way of knowing. He described himself as a student who usually rushes through work. Completing the project gave him a sense of pride, despite admitting he knew he could have done better.
Addie	High Perceptions of Formal Science Learning High Perceptions of Science Mid Conceptions of Science as a way of knowing	Addie began her project with high perceptions of science. She already understood the incredible reach of science knowing that "we could do things that seem completely impossible – but it happens and it is possible." Engineering was new to Addie and understanding that it is more than "just building" but "constantly improving upon other things" allowed her to see herself as an engineer.

solution allowed many of them to see the practices of engineering as tools to use for problem solving and the scientific content related to their problem as a means to better understand and explain the world around them. Additionally, engaging in the project helped them understand the nature of engineering and the iterative process of prototype design and improvement resulting in a persistence through and appreciation for the process of failure.

This has significant implications to the field of science education and the endeavor to encourage students from all cultural backgrounds and genders to enter STEM fields, therefore addressing the issues of diversity within STEM careers (National Science Board, 2020). Students must first identify as one capable of doing science or engineering before considering a STEM career (Capobianco et al., 2015). Through the independent engineering fair project, each student worked as an engineer and scientific researcher as they sought to design or improve a solution to their identified problem allowing them to identify as capable of engaging in the practices of science and engineering.

The timing of authentic engagement with the practices of engineering during the fifth-grade year may address the decline in interest in STEM students experience as they move from elementary to

secondary grades (National Academy of Engineering and National Research Council, 2009). If a task such as the independent engineering fair can address students' perceptions of science and formal science learning, it is possible that value of and commitment to STEM course work and endeavors can be positively impacted (Fantz et al., 2011).

This study is limited by scale, with a participant population including only one third of fifth grade students in a single school. Additionally, our participants were not hindered by traditional constraints related to district and state-mandated testing due to the timing of the project. This leaves room for future studies to consider the ways that this process might be integrated throughout the school year and warrants investigation into how the implications may change with a more inclusive, intentional, school-year long focus.

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Appendix

Primary Code	Relevant ESPOSi Questions	Secondary Code		
		Low	Medium	High
Science as a way of knowing Science is both a body of knowledge and the processes and practices used to add to that body of knowledge. Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge. Science is a way of knowing used by many people, not just scientists. (Appendix H NGSS)	What are some things that you know, if you are really good, or an expert at science?	LOW: One-word response that is simplistic or general in nature	MID: Provides simplistic evidence of understanding of the practices of science but is limited to a single facet of science as an explanation of the natural world	HIGH: Detailed response that demonstrates an explicit understanding of science as a process to explain the natural world
	If someone told you they were "doing science", what would you think they were doing?	LOW: General response that is not specific to scientific explanation of the natural world	MID: General response that is related to a scientific process providing explanation of the natural world	HIGH: Detailed response is related to a scientific process providing explanation of the natural world
	Click on each picture that you think of as Science.	0-3	4-6	7+
Perceptions of Science. What are students' understandings and perceptions of and appreciation for science (as a tool, as a way of knowing, and as a potential career)?	If science was not a required subject to study (meaning people did not have to take science classes), how would it impact you? Your friends? Your city? Your country?	LOW: Response that indicates a positive impact	MID: General response that shows limited value of science	HIGH: Specific response that details impact and personal and/or broader value of science
	Click in the box next to each career (job) that you think needs science	0-4	5-8	9+
	You notice that your birdfeeder in your back yard is running out of birdseed faster than usual. What would you do to find out why?	Take down the birdfeeder	Ask an adult who might know OR Look it up on the internet	Collect data and observations and investigate
	Click next to all of the things you expect to do in your next science class at school.	0-3	4-7	8-11
Perceptions of formal science learning What are students' understandings and perceptions of and appreciation for classroom-based science learning?	Which picture best shows what you think of when you think of science at school?	Notes from textbook or website	Teacher demonstration	Formal lab science OR Learning about schoolyard habitat OR Lab with safety equipment
	What do you hope your science class next year will be like? What do you hope will happen in science class?	LOW: Vague response without reference to science processes or content	MID: Passive recipient of scientific knowledge or active participant without specific reference to scientific process or content	HIGH: Active participant in specific scientific processes or content
	Imagine you are at school and your next class is science. What will you be doing?	LOW: Vague response without reference to science processes or content	MID: Passive recipient of scientific knowledge or active participant without specific reference to scientific process or content	HIGH: Active participant in specific scientific processes or content