SCIENTIFIC INQUIRY AS A TEACHING AND LEARNING TOOL

INVESTIGATING THE FACTORS THAT INFLUENCE EXPERIENCES WITH AND PERCEPTIONS OF SCIENCE

A THESIS

Presented to

The Faculty of the Department of Education

Colorado College

Under the supervision of Professor Mike Taber

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Arts

By

Stefani Messick

May 2017

Abstract

Due to resounding evidence that the quality and frequency of science instruction in public schools has decreased over the past several decades, this study sought to investigate the factors that teacher preparation programs can emphasize in order to effectively prepare teachers to create positive experiences with science for their students. A case study of one two-week experience during a teacher preparation program that emphasizes the practice of inquiry-based instruction was used to investigate the factors that make a difference for teachers and students. The research revealed that training teachers in an environment that underlines an awareness of teacher beliefs about science, inquiry, and teaching practices is important. Cultivating an awareness of pre-existing beliefs and assisting pre-licensure teachers through the process of refining their approaches in combination with their beliefs will help teachers create positive classroom environments and experiences with science. Specifically, inquiry-based practices are important in the classroom and should be reinforced in teacher preparation programs via experience.

Keywords: inquiry, teacher preparation programs, disciplinary literacy, and science instruction

Introduction

Research has shown a decrease in the quality and frequency of science instruction for elementary students (Banilower, Smith, Weiss, Malzahn, Campbell, & Weiss, 2013; Weiss, Banilower, McMahon, & Smith, 2001; Tilgner, 1990). Research reveals that although the total time devoted to teaching core subjects has increased by 4% over the past 20 years, the total time devoted to science instruction has decreased by 24% to an average of 2.3 hours per week, the lowest level since national data tracking began in 1988 (Blank, 2013). The decrease is attributed to three main areas: policy, teacher training, and teacher dispositions (Nadelson, Siefert, Hendricks, 2015; Campbell, Abd-Hamid, & Chapman, 2010; Bleicher, 2006; Crawford, 2000; Anderson, 1996). Factors attributing to the decline include inadequate teacher training, lack of equipment, time constraints, and over-reliance on textbooks contributes to gaps in science instruction (Tilgner, 1990). Teacher attitudes about science can impact student attitudes as well (Scrivner, C. M., 2009; Gourneau, 2005; Pryor & Pryor, 2005; Tilgner, 1990; Rosenshine, 1970). If teachers feel less positive or confident about teaching science, their students will be less likely to develop an appreciation of science. Science education reform requires not only a different way of thinking about science, but also different ways of training teachers to appropriately teach science.

A potential solution lies in how teacher preparation programs actually prepare teachers and the content and practice requirements they set. In 2013, only 40% of aspiring science teachers met the American College Test college readiness benchmark for science (White, 2013). A shortage of science, technology, engineering, and math (STEM) teachers could spell trouble for the economy, considering the projected growth of occupations that require skills in science, technology, engineering, and math. By making improvements to teacher preparation programs, both by changing the content of courses required for entry and the science teaching practices these students are exposed to, the landscape for science education could look vastly different and be more effective.

With so many factors for student achievement tied directly to the teacher, it is imperative to examine how well teachers are prepared to teach science in the classroom. Many studies note that new teachers leave the profession at high rates (Hanushek, Kain, & Rivkin, 2004; Luekens, Lyter, Fox, & Chandler, 2004; Ingersoll, 2001), and according to one such study, 40% of teachers will leave the field within the first five years of teaching (Ingersoll, 2002). The teacher attrition rate is disproportionately higher in urban schools (Allensworth, Ponisciak, & Mazzeo, 2009; Boyd, Grossman, Ing, Lankford, Loeb, & Wyckoff, 2009; Planty, Hussar, Syndaer, Kena, KewalRamani, Kemp, Bianco, 2008). Humphrey and Wechsler (2007) noted that the high attrition in urban schools is commonly attributed to the presence of alternative teacher certification programs such as Teach for America (as cited in Gottfried & Straubhaar, 2015). Net teacher turnover adversely affects the quality of instruction in lower-achievement schools due to a general loss of experience (Hanushek, Rivikin, & Schiman, 2016). Since alternative certification methods lead to higher rates of teacher attrition and subsequently negatively affects student achievement, the *quality* of a teacher’s preparation matters.

Therefore, we must provide learners with more opportunities to engage with science topics and learn from well-qualified teachers. One such opportunity, Whiz Bang Science, is a summer program designed to give local Colorado Springs K-10 students an opportunity to do science in a less restrictive environment than in schools. The two-week program, positioned in the second month of a 14-month graduate program, pairs experienced local teachers with graduate students, or pre licensure teachers (PLTs) to mentor them, specifically in science instruction. The vision is to foster an inquiry-based environment for elementary through high school-aged students to experience and grow as critical and creative thinkers, as well as to provide opportunities for teacher training in developing and implementing lessons.

The original goal of this research was to investigate the factors that influence students' experiences with and perceptions of science. Research began with the hypothesis that overall, Whiz Bang would contribute to an increase in student excitement about science. Further research began to reveal that a student's experience in the classroom is tied most strongly to the teacher, so the factors that influence student experiences are futile if a teacher is unprepared or apprehensive about teaching science. Thus, this research seeks to describe the ways that student experiences with content are shaped by teachers and the corresponding methods that are most appropriate for training PLTs to enter the classroom.

For this study, three questions guided the investigation:

- What role do teacher preparation programs play in shaping PLTs' beliefs about teaching and learning science?
- In what ways does Whiz Bang Science support the development of teacher beliefs and instructional practices for PLTs as related to teaching science?
- What is the relationship between teacher beliefs, instructional practices, and student experiences with and perceptions of science?

Literature Review

Research indicates that teachers have the most significant influence on student achievement (Marzano, 2007; Marzano, 2003; Rice, 2003) and that effective teachers have four times the positive impact on student achievement than the least effective teachers (Marzano, 2003). Unfortunately, many K-12 science educators don't feel well prepared to teach science. In a questionnaire of elementary teachers conducted by Banilower et al. (2013), 81% reported feeling "very well prepared" to teach reading and language arts while 39% felt the same about science. Regardless of how many previous science classes PLTs have had, many enter student teaching programs with limited conceptual understandings of scientific ideas (Riggs, 1991), which can lead to apprehension about their ability to teach science. The amount of science, STEM education required in most elementary teacher certification programs is minimal (Fulp, 2002), which may explain why many K-8 teachers convey perceptions of being unprepared and lacking confidence and efficacy for teaching STEM content (Bleicher, 2006). The lack of exposure and engagement with core STEM practice standards combined with constrained teacher preparation have left many educators without models, motivation, and knowledge of how to teach STEM content (Nadelson, Siefert, Hendricks, 2015). Logically, if a teacher feels less confident or well prepared to teach science, the teacher will be less effective at teaching science.

Affective states, such as enjoyment or anxiety, also influence a teacher's beliefs about teaching and learning. Liang and Gabel (2005) found that most elementary PLTs in their study reported science had never been enjoyable for them, which led them to take the only science courses that were required for their degree programs. Several other studies provide evidence that regarding teaching science, elementary PLTs report relatively high levels of anxiety (Cady & Rearden, 2007; Westerback & Long, 1990). Personal experience plays a role in shaping a teacher's affective attitudes about science. Lee Plourde (2003) asserted after studying PLTs that their attitudes about science appeared to originate from one or more of the following: "a lack of practical work and hands-on manipulation in science related activities; a dependence of science courses on textbooks and lectures; the dispassionate association with science teachers; a focus on formalized tests with no performance assessments; and the lethargical attitude towards the teaching of science by in-service/mentor teachers" (p. 257). Likewise, cognitive beliefs regarding the relevance of science play a role in a teacher's beliefs about teaching science (Riegle-Crumb, Morton, Moore, Chimonidou, Labrake, & Kopp, 2015).

Teachers develop their beliefs about content, teaching itself, and the learning process from personal experience in school themselves and in teacher education programs. A study by Hancock and Gallard (2004) revealed that student teaching field experiences both reinforce and challenge the beliefs of PLTs. Teacher awareness of the beliefs they hold about science is critical, because research indicates negative attitudes toward science are likely to lead to less content coverage as well as less engaging and effective instruction (Riegle et al., 2015). Teacher attitudes, in connection with instructional activities, commitment to student learning, and personal learning, are also connected to student achievement (Scrivner, C. M., 2009; Gourneau, 2005; Pryor & Pryor, 2005).

Rosenshine (1970) not only found positive associations between teacher enthusiasm and student achievement, but also that behavioral descriptors like stimulating, energetic, mobile, and animated are also related to student achievement. His findings suggested that enthusiasm specifically facilitates student achievement "because animated behavior arouses the attending behavior of pupils" (p. 510). Researchers have also studied specific behaviors that teachers perform that enhance the educational environment for students. Hudson (2007) found that elements of "high-impact" teaching for science included a teacher's enthusiasm, targeting misconceptions through content coverage, field excursions, teaching relevant and practical science, group work, and hands-on experiences. The more a teacher engages students in activities that engage both the bodies and the minds and is enthusiastic about the subject, the more students will feel prepared to study science in the future (Hutchinson-Anderson, Johnson, Craig, 2015). In effect, if teachers feel less confident or excited about teaching science, their teaching will reflect this discomfort, and their students will be less likely to develop an appreciation for science as well.

Within the classroom, instruction varies by teacher, and a teacher's beliefs shape instructional patterns. Accordingly, there are three dimensions of a teacher's beliefs that contribute to a teacher's attitude about teaching science, including perceived control, affective states, and cognitive beliefs (Riegle et al., 2015). Factors that contribute to a teacher's perceived control include content knowledge and self-efficacy, both of which help determine whether or not a teacher feels well prepared to teach a subject. Albert Bandura's (1977) theory of self-efficacy refers to an individual's belief in her capacity to perform the necessary actions to produce specific objectives. Self-efficacy reflects confidence in the ability to wield control over one's own motivation, behavior, and social environment. In a study that sought to examine the factors that influence a teacher's confidence for teaching math and science, Bursal and Paznokas (2006) found that teachers with lower self-efficacy also had higher levels of anxiety about the subjects themselves.

Each of these co-occurring factors – negative teacher beliefs, poor self-efficacy, and attitude or apprehension about teaching science - lead teachers to spend less time teaching science content during the school day. A questionnaire funded by the National Science Foundation (2001) that sampled approximately 6,000 elementary teachers throughout the United States found that in the year 2000, teachers spent an average of about a half an hour per day on science instruction compared to nearly an hour each day on mathematics instruction and over 105 minutes on reading and language arts instruction (Weiss et al., 2001). In 2012, those distributions remained similar, with teachers spending an average of 22 minutes on science instruction, 58 minutes on math instruction, and 86 minutes on reading and language arts instruction each day (Banilower et al., 2013). Due to the disproportionate instructional times spent teaching various content areas, teachers implicitly devalue science as a content area and further limit opportunities for students to receive quality science instruction. This disproportionate focus is likely a product of standards-based assessment and accountability measures in the wake of legislation like No Child Left Behind (2001) and Every Student Succeeds Act (2015). As a result, schools with less funding and more students eligible for free/reduced lunch may focus more on reading, language arts, and mathematics instruction to raise test scores and receive more federal funding.

Thus, the amount and quality of science instruction a student receives varies by location. According to the Report of the 2012 National Questionnaire of Science and Mathematics Education, classes in schools with high proportions of students eligible for free/reduced-price lunch are more likely than classes in schools with few such students to be taught by relatively inexperienced teachers (Banilower et al., 2013). Additionally, math and science classes that are categorized as having mostly "high achievers" are more likely to have teachers who feel well prepared to teach those subjects than classes containing mostly "low achievers" (Banilower et al., 2013).

A yearlong study by Jean Anyon (1980) of five elementary schools concluded that public schools prepare students differently based on social class through the types and quality of schoolwork that is assigned, or as Anyon calls it, through the “hidden curriculum of work.” For example, in the working-class schools she observed, schoolwork was strictly procedural, rote, and mechanical, and the class had a science period only several times a week, each of which was void of experiments and explanations (Anyon, 1980). In stark contrast, students in the affluent professional school produced creative, independent work that involved "individual thought and expressiveness, expansion and illustration of ideas, and choice of appropriate method and material" (Anyon, 1980 p. 8). In effect, the poorer schools were preparing students to follow orders and procedures while the schoolwork in the more affluent schools sought to prepare students for a life of achievement, independence, and inventiveness. A student's location, then, both geographic and socioeconomic, may determine the quality and type of education she receives.

Everything discussed so far, including teacher beliefs, self-efficacy, attitude, and physical location, contribute to a teacher's pedagogy. One way to address the disproportionate amount of class time spent on science and reading instruction is through an emphasis of disciplinary literacy. Following a revision of the Common Core State Standards, literacy began to take on a new identity – one of an iterative process that involves strategies such as critical thinking and metacognition, as well as interdisciplinary skills. The shift moved from content area instruction and an emphasis on strategy use to a greater focus on the actual content of the disciplines and the ways that literacy can be used to foster disciplinary understandings (Brock, Goatley, Raphael, Trost-Shahata, & Weber, 2014). Emphasizing disciplinary literacy involves utilizing writing, reading, and classroom talk to support learning and connections across disciplines.

A multi-year study by Romance and Vitale (2012) that focused on the integration of an interdisciplinary model for integrating science and reading had positive results. The interventions were school-wide: in grades K-2 the model called for 45 minutes of *daily* science instruction in addition to regular reading instruction; in grades 3-5 there were *daily* 90-120 minute blocks of integrated science instruction that *replaced* traditional, isolated reading/language arts instruction.

Romance and Vitale (2012) found that "increasing time for integrated science instruction in grades K-5 not only results in stronger preparation of students for secondary science, but also concurrently improves student proficiency in reading comprehension (in general) and content-area reading comprehension (more specifically) across grades 3-8" (p. 512-13). In effect, interdisciplinary instruction that integrates science and reading can reinforce literacy skills as well as develop disciplinary comprehension.

Inquiry as it relates to science and its teaching is not a new concept: the necessity for inquiry in the science classroom was established more than 50 years ago (Schwab, 1962) and has resurfaced in the Next Generation Science Standards (NGSS, 2013). Barriers to the use of inquiry in the science classroom are similar to the barriers that keep teachers from spending much time on science in general: limited pedagogical content knowledge, incomplete understanding of the nature of science, or pressure of content coverage (Campbell, Abd-Hamid, & Chapman, 2010; Crawford, 2000; Anderson, 1996). The National Research Council (2012) posits that "students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined" (cited in NGSS, 2013, p. 1). Such necessary practices include asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructive explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information (NGSS, 2013, p. 1). Considering the necessity of inquiry-based instruction for effective science teaching, it is imperative that science teachers at any grade level have a working understanding of these practices.

However, many PLTs have limited exposure to inquiry-based science instruction in their K-12 and college experiences (Riegle et al., 2015). Had they experienced more effective instruction in their past that included inquiry-based practices rather than rote memorization, perhaps PLTs might have better understandings of science content and subsequently more self-efficacy for teaching science. One study found that PLTs significantly changed their opinions toward science after participating in inquiry-based content courses during their teacher prep programs. "They reported more confidence in their skills as science learners, more enjoyment and less anxiety toward science, and perceived it as more relevant" (Riegle et al., 2015, p. 832). By making improvements to teacher preparation programs, both by changing the content of courses required for entry and graduation as well as the science teaching practices PLTs are exposed to, the landscape for science education could look vastly different in the future. While it may seem difficult to undo years of damaging and ineffective science instruction in the educational pasts of our PLTs, perhaps we should look to models of teacher prep programs that will positively influence their attitudes and beliefs about science to create more effective science teachers and create better educational experiences for our students.

Methods

Research Design

This research study is a mixed-methods case study of the summer program Whiz Bang Science that has a sequential equal status design. The study is non-experimental and descriptive. Analysis primarily focused on qualitative content, but quantitative measures helped inform the observations and conclusions. This study sought to investigate the role that teacher preparation programs play in shaping pre licensure teachers' (PLTs') beliefs related to science and the relationship between these beliefs and student experiences and outcomes.

Participants

All participants were gathered through convenience sampling; all participants were involved in the 2016 Whiz Bang Science summer program.

Whiz Bang students. The first group of participants (n=80) consisted of students, aged 5 to 15, who participated in the 2016 Whiz Bang Science Program at Colorado College. The total student participation rate was 39% (N=206). Those who were enrolled in local public schools represented 8 different school districts (Table 1) with an average percent free and reduced lunch of 25.8%, ranging from a minimum of 3% to a maximum of 84% (Figure. 1). This group of students (n=80) was given a questionnaire on the fourth day of Whiz Bang (after all parent consent forms were returned) and another questionnaire in the final two days of Whiz Bang.

A second group of students was selected to take part in a focus group (N=7). These students were determined after looking at the pre-questionnaire data. One student who represented each of the following 7 categories was randomly selected from the participants who reflected the appropriate characteristic:

- Rated science 7 out of 10 or lower and were unsure about/didn’t like science
- Didn’t do any science outside of school
- Do science at home or in clubs
- Rated science 8 out of 10 or higher
- Doesn’t like/was unsure about how science has been taught
- Doesn’t want to do more science at school
- Wanted to do more science at school.

All duplicates were removed before random selection. In one instance, the selection process was run twice to attain a more representative gender balance (3 girls, 4 boys), as 40% of all Whiz

Bang participants were female. Parents and students gave additional informed consent to participate in the focus group interview. The focus group was split into two chunks to best accommodate student and parent schedules. Due to illnesses, 5 participants took part – 4 boys and 1 girl.

Parents. This group of participants (N=206) was gathered through selective, nonrandom sampling. There are three groups of participants within this category: parents who took both the pre- and post-questionnaire (n=40); parents who only took the pre-questionnaire (n=42); and parents who only took the post-questionnaire (n=33). The pre-questionnaire had a 40% response rate (n=82) and the post-questionnaire had a 35% response rate (n=73). Parents were offered the chance to win a $25 Barnes and Noble gift card for their time.

Masters students. The 2016-2017 class of Masters of Arts in Teaching students at Colorado College were also included in my participant pool (N=14). In this study these students will be referenced as pre licensure teachers (PLTs). For the three questionnaires they took part in, participation was as follows: pre-questionnaire (n=11), post-questionnaire, (n=14), post post-questionnaire (n=10). Participants were offered compensation only for the third questionnaire – a $5 gift card. The respondents represented a mixture of educational backgrounds and teaching trajectories. Their Bachelor's degrees represented the areas of the Humanities, the Sciences, Business or Communication, the Arts, and Education; 43% plan to teach at the elementary level and 57% plan to teach middle or high school.

Apparatus

The student questionnaires were generated using Microsoft Word © and the parent and MAT questionnaires were generated using Qualtrics © software.

Student questionnaires.

Pre-questionnaires. Students were given written questions (Appendix A). The youngest students, grades 1-4, answered 12 simple, closed-ended response questions that required mostly yes, no, and maybe responses. Students in grades 5-10 were asked 17-questions. Many of the questions were the same as the younger students with additional questions that required qualitative elaboration. The pre-questionnaire asked students whether they liked science, how they have been taught science in school, their preferred learning style, and the ways they are able to tell whether their teacher likes science.

Post-questionnaires. Students grades 1-4 completed a 9-item questionnaire (Appendix B) that included a mixture of yes-no questions and qualitative responses that sought to gather a description of the students' experience with Whiz Bang in contrast to what they experience in school. Students grades 5-10 completed a 12-item questionnaire comprised mostly of questions that required a qualitative response to gather a comparison between Whiz Bang and school science experiences.

Focus groups. Each focus group lasted for approximately 45 minutes (Appendix C). Students answered questions over lunch and the discussion was recorded on a digital audio recorder. The purpose of the focus group was to gather a more nuanced understanding of student experiences in school and at Whiz Bang as well as to investigate the factors that influence a student's perception about science, whether it be the teaching methods, a teacher's attitude, or the actual content.

Parent questionnaires.

Pre-questionnaire. Parent participants completed a self-reported questionnaire (Appendix D). The questionnaire was comprised of both closed- and open-ended questions. Participants remained anonymous and consented to terms and conditions before answering questions. In total, the questionnaire contained 11 questions. The questions sought to determine some basic demographic information about the parent's child, including how many years the student had participated in Whiz Bang previously, the type of school the student attended, the quality of the school, and similarly, the quality of the science instruction, and the primary reason for enrollment in Whiz Bang Science.

Post-questionnaire. Similar protocols were followed with the post-questionnaire. This self-report questionnaire included 10 items (Appendix E). Parents disclosed any perceived differences they saw in their students since participating in Whiz Bang, differences including increased or decreased interest in science, a change in the frequency that science was a topic of conversation, as well as perceived similarities and differences between Whiz Bang and their student's experiences at school.

PLTs.

Pre-questionnaire. This self-report questionnaire was sent out via email (Appendix F). The instrument contained 15 items and respondents answered questions about their history with science K-12 and throughout college, their perceived level of preparedness to teach certain subjects, their trajectory for future teaching, and their beliefs about which factors might influence a student's perception about science and a teacher's confidence for teaching science. Participants completed the questionnaire prior to the start of Whiz Bang Science.

Post-questionnaire. Respondents completed this questionnaire five months after the conclusion of the Whiz Bang program. The self-report questionnaire (Appendix G) contained 13 items that asked participants about how prepared they felt to teach science and other subjects after participating in Whiz Bang, their perceived level of confidence for teaching science at the elementary level, their beliefs about the environment Whiz Bang provided for practicing specific teaching skills, and their biggest takeaways from the experience.

Post post-questionnaire. Participants completed this questionnaire in the middle of the spring semester, which is near the end of their student-teaching experience (Appendix H). This 12-item self-report questionnaire contained mostly Likert scale questions that asked for levels of agreement on various statements regarding the value of inquiry and discovery, the role Whiz Bang has played in the participants' approach to teaching currently, and the ways that participants' feelings and attitudes about science may or may not be reflected in their teaching.

Procedures

Data from the parent and PLT questionnaires were collected using an online Qualtrics © questionnaire and was emailed to participants during the last week of June. Parents had until the end of the first day of Whiz Bang to complete the pre-questionnaire.

After taking note of which students had consented to participate, the classroom teachers were informed which students in each class had consent to take the questionnaire. The questionnaires were returned at the end of the day. Over the weekend, the student pre-questionnaires were coded and basic descriptive statistics were run in SPSS to determine the categories to draw random samples form to form the focus groups. The appropriate parents were contacted and asked to give additional consent for their students to participate in the focus group.

The focus group interviews were held in the middle of the second week of Whiz Bang. Students received either a free lunch or snacks in return for their participation. All participants signed assent prior to participating and were read a script prior to the start of each interview. The interviews were recorded with a digital audio recorder.

The student post-questionnaires were distributed on the final day of Whiz Bang and returned later that afternoon. The parent post-questionnaires were emailed on the last day of Whiz Bang and remained open for one week following. The MAT post-questionnaires were emailed five months later to allow time for the participants to experience their teaching placement following their Whiz Bang Science experiences. The MAT post post-questionnaire was emailed eight months following to allow more time for participants to experience the teaching placements as a source of comparison to their summer experiences.

Following the close of the parent post-questionnaires, a complete participant email spreadsheet was compiled. The list was randomized in Microsoft Excel®. The number generator at random.org was run to select the winner of the gift card and it was mailed out to the winner by the end of the week.

The student and parent questionnaires were matched based on the unique codes parents provided and using registration data that included some of the demographic information. In some cases, the questionnaires weren't matched successfully due either to errors by the participants in recording their unique codes or to a lack of demographic information with which to match parents to students. Once all questionnaires, pre- and post- and parent-student, were matched, all identifying information was removed.

Each questionnaire was coded via the same process. Each closed-ended response was assigned a numerical value. Each open-ended response was sorted and assigned to categories that emerged after examining the data. Each categorical theme was assigned a numerical value. Once each response had been re-coded, the updated Microsoft Excel®spreadsheet was loaded into SPSS. Each questionnaire was screened for errors before descriptive and inferential tests were run on the data to establish potential relationships and patterns in the responses.

Results

Initial Student Impressions of Science

Prior to participating in Whiz Bang the mean score for liking science on a scale of 0-10 (10 being positive) was 8.24 (n=66) (Figures 2 and 3). Similarly in the focus groups, aside from one adamantly negative student, all other students (N = 5) reported having liked science since elementary school. A lower elementary student said that science was his favorite subject, but later reported that his teacher only taught science two days a week. The student used a science journal, but instead of writing original thoughts or observations, students are asked to write what the teacher says to write. A high school student said, “It’s not that I like [science] less now, it was just more fun in elementary school. It’s a lot more tedious now.” The older students also discussed the value that doing experiments in the classroom has. “Labs ask me to apply what I learned…You’ll probably remember it more if you do it than if you just wrote it down in a journal.” One high schooler described the ideal science class, noting that class should start with 10-15 minutes of lecture then be followed up by an activity that reinforces the content. The older students reported studying personally relevant concepts on their own at home, especially since school science focuses less on engineering and building concepts.

Students Reference the Important Role Teachers Play in School Experiences

In response to the question, “What do you not like about the way you have been taught science?” 100% of students who responded (n=10) referenced elements that had to do with the teacher, whether it be the teacher’s seeming lack of knowledge or experience, a lack of student choice in the classroom, or a teacher’s enthusiasm while teaching (Figure 4). In a focus group, a high school student noted, “My friends complain about the [science] teachers. Some don’t know what they’re doing. Some just don’t interact with the kids as much, like they teach in a way with a lot of lectures and not a lot of interaction." Students who have spent few years in schools are also keen on teachers' attitudes. A lower elementary student said, "Some [teachers] do [like science] and some don't. If they do, they do more fun experiments. My teacher definitely doesn't like science. Also, she's not very kind to me." Whether a student has a positive experience with science is seemingly related to the way a teacher interacts with both the material itself and with the students on a personal level.

When asked how they are able to tell whether a teacher likes science, 47% of the 5^{th}-10^{th} graders noted that a teacher's attitude or disposition is the clearest indicator. In the focus group, students mentioned aspects of interactions and attitudes that some of their best science teachers had: "My last science teacher liked science a lot. He was very enthusiastic." Another student said, "[Good teachers] use humor to make [science] more interesting and they aren't boring and repetitive." However, it also mattered to students the ways a teacher treats the material *and* the students. An upper elementary student said, "Yes, [my teacher] likes science, but I don't, and [my teacher] doesn't like me either!" This same student adamantly objected to the possibility of ever liking science in the future, regardless of whether the teachers or the teaching practices looked different. A high school student connected a teacher's attitude to the classroom environment: "When they get to know you it makes it a more comfortable environment." The student also noted that good teachers also have "high energy" and interact with their students a lot.

Students Comment About the Important Practices of Whiz Bang Teachers

While 90% of students reported liking how they have been taught science in school, 96% reported liking how they were taught during Whiz Bang. While only 7% of students specifically referenced a teacher's disposition as a contributing factor to having had positive experiences with science in school (Figure 5), 31% reported that their Whiz Bang Science teacher's disposition was the *main factor* that contributed to having a positive experience (Figure 6). Additionally, 100% of students reported thinking that their Whiz Bang teacher liked science and was excited about the subject. Further, 54% attributed this perceived connection between a positive opinion and enthusiasm to the teachers' attitudes/dispositions and 27% attributed the connection to the teachers' level of knowledge and experience. In a focus group, a high school student noted, "[A teacher's attitude] determines whether or not you have fun learning what you're learning and whether you're looking forward to that class." Following this comment, a middle school student said, "Yeah, if a teacher gets excited about a subject, you know it's probably going to be a good or fun subject." Therefore, students make a connection between a teacher's affective mood and attitude, a teacher's level of experience, and the resulting quality of the learning experiences in the classroom.

Student Whiz Bang Experiences

Overall, most students who participated in Whiz Bang Science began the experience with a favorable opinion of science. For elementary students grades 1-6, the mean rating of science on a scale of 0-10, 10 being most positive, prior to Whiz Bang was 8.17 (N=49). The upper level students, grades 7-10, entered Whiz Bang with a mean rating of 8.24 (N=17). A paired-samples t-test was conducted to evaluate the impact of the Whiz Bang Science experience on students' attitude ratings of science. In the upper grades (5-10), there was a statistically significant increase in student science ratings from before Whiz Bang ($M = 8.27$, $SD = 1.07$) compared to after Whiz Bang ($M = 8.64$, $SD = 1.08$), $t\ (2.30) = 21$, $p < 0.032$, two-tailed. The mean increase in scores was 0.36 and the eta squared statistic (0.17) indicated a large effect size (Table 2).

The results were similar for the parents' perceptions of their students' science opinion. The results of a paired-sample t-test indicated a significant increase in perceived student science opinions from before Whiz Bang ($M = 8.69$, $SD = 1.37$) compared to after Whiz Bang ($M = 9.10$, $SD = 1.29$), $t(2.19) = 28$, $p < 0.037$, two-tailed. The mean increase in perceived student science opinions was .41 and the eta-squared statistic (0.15) indicated a large effect size.

Parent and Student Comparisons Between Whiz Bang and School

While most parents believed that their children's schools were either good or excellent (92%) and 80% were at least "somewhat satisfied" with the experiences their students have with science in school, most parents reported enrolling their children in Whiz Bang specifically for science enrichment (80%). Following the conclusion of Whiz Bang, 87% of parents reported thinking that the quality of experience at Whiz Bang was greater than those their students have in school and 63% agreed that Whiz Bang contributed to a positive shift in their students' perception of science.

Ninety-six percent of students reported that the Whiz Bang experience differed from school in some way. The parents reported similar perceptions: 77% thought that Whiz Bang was more different than similar to their child's experiences with science in school. As such, Whiz Bang provides unique opportunities for students to experience science with fewer limitations than exist in schools (e.g., absence of grading, extended class time).

A lower elementary student said, "I like science at Whiz Bang but not the science at school. It's a lot of reading and there aren't any projects. We do one experiment a year [at school]. And even though I usually enjoy reading, I do not enjoy the reading [we do in science]." When asked what the ideal setup for learning science in school would be, the same student said, "If we got to make rockets the same way it is here…*out of our own mind*. The rocket thing was so fun because *we* got to make it. I like learning [when the teachers] don't put it together [for us]. They only tell us and show us and we put it together on our own." Personal choice and autonomy was evidently important to this student in shaping the learning experience. Another student echoed this sentiment, referring to learning experiences at school: "Science is miserable. It's a waste of time. It's really boring and I know all the answers. I just read, write, answer questions. How I like to do [science]: I try it first, then I read what to do." This student referenced several aspects of inquiry that involve planning and carrying out investigations and asking questions, both of which are necessary for creating meaningful experiences with science.

The relevance of science content also mattered to students. One student reported thinking science is a "waste of time" because his future plans don't involve science whatsoever (he wants to be a Youtuber). This student mentioned the problem that a lack of originality and variation in the content posed for his experiences with science. "None of the science we're learning is new…I've learned about the solar system *every single year!"* Another student reported similar feelings, lamenting, "The things we do at Whiz Bang are a bit better, but at school we just make baking soda volcanoes. I've done that so many times it's unreal! ... [Whiz Bang] is different. It's better. We do more experiments. It's more fun than sitting in a dark room, reading books, and drawing complicated pictures."

PLT Experiences During Whiz Bang

Overall, participating in Whiz Bang Science led the PLTs to feel more qualified to teach elementary science. However, the results of a paired-sample t-test did not indicate a significant increase in perceived qualification to teach elementary science on a scale of 1-10 from before Whiz Bang ($M = 4.14$, $SD = 3.16$) compared to after Whiz Bang ($M = 5.56$, $SD = 3.71$), $t(1.82)$

= 6, $p < 0.118$; two-tailed). Even when the data was stratified between those who will be teaching elementary and those who will be teaching secondary, the mean increases (0.47 and 1.77, respectively) the differences were not significant. This could be due in part to the small sample size. The differences may also indicate that the two-week Whiz Bang Science experience is not long enough to significantly increase a teacher's perceived qualification to teach a specific subject.

Overall, however, the MAT students who will teach elementary felt least qualified to teach science relative to other subjects prior to experiencing Whiz Bang, but felt more qualified to teach science relative to other subjects after experiencing Whiz Bang.

PLT's Previous Experiences and Pre-Whiz Bang Beliefs

Three MAT students reported having had terrible experiences with science during K-12 schooling. Of these, PLT 1 went on to major in science and will teach the elementary grades. Content knowledge was the most important factor contributing to PLT 1's confidence teaching science, with curriculum having the next largest influence, and personal opinion and the teacher preparation program having only a "moderate" influence. Furthermore, PLT 1 believed that teaching practices and the curriculum influence a student's experience, but a teacher's attitude and extracurricular activities involving science cannot.

PLT 2 has a degree in Business and Communication and will teach the elementary grades. A "terrible" personal experience with science led this participant to have a somewhat negative opinion about the subject. Prior to participating in Whiz Bang, this participant thought that content knowledge, personal opinion, and teacher preparation all had "a lot" of influence on perceived confidence teaching the subject, and following Whiz Bang, this participant reported that content knowledge and teacher preparation had a lot while personal opinion and curriculum had moderate influence. Prior to Whiz Bang, this participant reported thinking that teaching practices do not influence a student's perception of science. After participating in Whiz Bang, PLT 2 felt more confident teaching science and reported finding value in learning and practicing inquiry-based teaching practices. Participant Two reflected that Whiz Bang helped students see that science is fun and similarly, Whiz Bang helped Participant Two see that excitement in a classroom is contagious.

PLT 3 developed a "somewhat positive" opinion about science despite having had a "terrible" personal experience with K-12 science. With a degree in the Humanities and a trajectory to teach secondary education, the Whiz Bang experience was less personally relevant for Participant Three. Nonetheless, PLT 3 reported increases in the perceived amount a teacher's opinion about science and the teacher preparation program influences confidence to teach. Following Whiz Bang, PLT 3 noted feeling increased confidence to teach science in direct relation to the realization that science is interdisciplinary.

In response to the statement: "I have a deep science content understanding," six PLTs noted that they either "somewhat" or "strongly" agreed with the statement. Of these, three had degrees in science. Of these science majors, two reported having had excellent experiences with science during K-12 while one reported having had a poor experience. The other three respondents had degrees in the arts, business and communications, and the humanities, and reported having excellent, good, and average experiences with science, respectively.

The PLTs noted upon reflection that their perception of a teacher's content knowledge had the greatest impact on their resulting perceptions of science after K-12 schooling. A teacher's attitude closely followed as having had the next greatest impact.

On average, the PLTs reported that content knowledge had the greatest influence on their confidence to teach science, followed by an average tie between the teacher preparation program and personal opinion about the subject. In terms of which factors hold weight in forming a student's perception of science, 100% of PLTs reported thinking that curriculum plays a role; 80% thought teacher attitude plays a role; and 60% thought that extracurricular activities related to science play a role.

PLTs' Post-Whiz Bang Beliefs

After participating in Whiz Bang Science, PLTs reported on average that content knowledge still plays the most important role in determining their confidence to teach science, but at a greater amount than before (pre, 3.9, post, 4.5, on a scale of 5). The difference was not significant when a paired samples t-test was run, $t(-1.549) = 6$, $p<0.172$ (two-tailed). The mean for personal opinion, as related to confidence teaching science went up while the means for teacher preparation program and curriculum went down. The differences were not significant.

PLTs' Inquiry Beliefs

Participants (n=10) were assessed on their levels of value and implementation of inquiry in their classrooms. Participants were asked to rate their levels of agreement (on a scale from 0-10) with the following statements:

- I learned about designing for inquiry during Whiz Bang;
- I *use* what I learned about designing for inquiry in my placement;
- Inquiry is important in my discipline;
- Autonomy is important in my classroom;
- Discovery is important in my classroom; and,

- When I don't know enough about the content I am supposed to teach, I research it on my own.

For each of these assessment scales, four participants scored high (8-10) in every category, including one PLT in a high school art placement, one PLT in a high school geography/history placement, and two PLTs in elementary placement. The remaining two participants in elementary placements scored in the medium ranges for having learned inquiry during Whiz Bang and using that knowledge in their placements but high in all other categories. All other participants had placements throughout the humanities and scored with mixed results; no science placement PLTs took the post-post questionnaire. The only participant to score in the low ranges had a placement in a high school Latin classroom. This participant reported low levels of incorporating inquiry in the classroom and did not think inquiry is important in the discipline.

One hundred percent of participants scored in the high range, indicating that autonomy was important in their classrooms, and 80% indicated that discovery was important in their classrooms, excluding the PLT in the Latin placement and a PLT in a high school English classroom.

There was a positive correlation between the two variables: "Discovery is important in my classroom" and "Inquiry is important in my discipline," $r = 0.894$, $n = 10$, $p = 0.000$. This could either indicate that the PLTs believe that discovery in the classroom goes hand-in-hand with the practices of inquiry, or that the PLTs most likely conflate inquiry with discovery.

According to those in elementary classroom placements ($N = 4$), reading was taught more often than any other subject, on average. In a one-sample t-test, the number of minutes spent teaching reading was almost significantly different than the number of minutes spent teaching math, $t(3.169) = 3$, $p < 0.051$ (two-tailed), with a mean difference of 33.25. The results were similar on the one-sample t-test run between the number of minutes spent teaching reading and the number of minutes spent teaching science, $t(0.811) = 3$, $p < 0.061$, with a mean difference of 30.75. These four participants also scored above average with their responses to the Likert scale statement: "Standardized test expectations influence the content I teach," ($M=4.97$, Mean difference = 1.956, scale of 10, 10 being "strongly agree"). In effect, those teaching elementary grades are influenced more by standardized testing expectations when designing lessons than do the entire pool of MATs.

Discussion

While researchers have argued that teachers have the most significant impact on student achievement (Marzano, 2003; Rice, 2003), this study reveals that teachers also have significant impacts on student experiences, and thus perceptions, via their teaching attitudes and pedagogy. In forming approaches to pedagogy in Whiz Bang and beyond, the PLTs in this study drew from several areas: their personal experiences with science and schooling, their experience in Whiz Bang learning to teach with a curriculum that values inquiry, their beliefs about science and teaching, and their resulting attitudes and affective moods. As a model of teacher preparation, Whiz Bang Science provides significant exposure to an inquiry-focused science curriculum that includes scaffolded opportunities to practice teaching. Whiz Bang is an example of an environment in which PLTs are able to reflect on and reform their beliefs about science and teaching in general, and furthermore, to learn to act on those beliefs appropriately to maximize student experiences. Learning to teach in an environment like Whiz Bang that emphasizes an awareness of teacher attitude and enthusiasm, as a component of student experience and achievement is valuable. For a teacher to engage an awareness of attitude or enthusiasm while teaching, in conjunction with a multidisciplinary approach to science, will encourage more positive interactions with the subject overall.

The Next Generation Science Standards (NGSS) have replaced the term "inquiry" with what they outline and define as "science and engineering practices" in order to emphasize that "engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice" (NRC, 2012, p. 30). For the purpose of simple and clear analysis, this paper will continue to reference this set of skills and knowledge as "inquiry." Inquiry involves: asking questions, defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations, designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information (NRC, 2012, p. 49). Both students and PLTs alluded to the value of interdisciplinary learning as related to science. The PLTs, especially after participating in Whiz Bang, noted the perceived importance of making efforts to teach in interdisciplinary ways and some specifically noted coming away believing that science lends itself much more to this than they previously thought.

While the NGSS do outline inquiry within the context of science specifically, this research recommends that the processes of inquiry in general be considered *interdisciplinary* to create more meaningful and positive learning experiences for students across the board. Additionally, reinforcing the processes of inquiry through teaching disciplinary literacy strengthens the quality of engagement and reinforces content-specific skills and literacy-based skills. Specifically, teaching science and reading *together* reinforces subject-specific skills and addresses the problem of disproportionate time spent on each subject. Additionally, if students learn science and practice comprehension and literacy skills simultaneously, this instructional approach implicitly values the subject of science and validates it within the academic spectrum. Early experiences with science are important: students' desires to study or not study science at the college level is linked to their perceptions of engagement, relevance with content, creativity, and exposure to science in elementary and secondary grades (Hutchinson-Anderson et al., 2015). If teachers can emphasize science and make it more relevant by weaving its content and processes within interdisciplinary instruction, students will have more experiences with the subject overall, and hopefully these experiences will be more thorough and encouraging than the past has led them to be.

In order to effectively implement inquiry-based instruction, it is imperative that teacher preparation programs include a methods-based course that exposes PLTs to the processes of inquiry via experience, not just through passive discourse. The acquisition and subsequent implementation of inquiry-based practices in the classroom varied widely among PLTs in this study. Participating in inquiry-based methods courses during teacher preparation results in higher self-efficacy for teaching with inquiry, less anxiety about teaching science with inquiry specifically, and more confidence for teaching in general (Riegle et al., 2015). While it may be too much to ask of Whiz Bang, which falls within the second month of a 14-month graduate program, to completely tackle the transmission of pedagogical inquiry skills, it is recommended that teacher preparation programs in general dedicate a sizeable portion of the curriculum to reinforcing inquiry skills.

Because teacher beliefs shape and inform pedagogy, the insight as to where the PLTs' beliefs about science originated. The questionnaires were helpful in determining the factors that have helped form the PLTs' beliefs about science and teaching in general. The PLT students represented a wide range of personal experiences with science in school, which in some ways was reflected with their trajectory for teaching specific grades and subjects. The PLTs also reflected a wide range in personal content knowledge and confidence for teaching science at the elementary level, but on the whole, the PLT students left Whiz Bang feeling more comfortable with the subject and with many of the basic aspects of teaching (lesson planning, e.g.) Many PLTs expressed a shift in perspective following their experience in Whiz Bang, generally related to either the importance of inquiry or the innate interdisciplinary nature of science itself. Because the directors of Whiz Bang do emphasize inquiry-based instruction in the training of the PLTs during this experience, I feel confident in saying that Whiz Bang contributed to these shifts in perspectives and additionally may have helped bring awareness to their beliefs in general. While Whiz Bang as an isolated program may not directly change the beliefs of PLTs, whether due to the short duration or other factors, it *does* contribute to pedagogical awareness, which has important ramifications in the classroom.

This study was limited in its investigation in that it only studied one two-week instance of a larger teacher preparation program. Further study of teacher preparation programs that emphasize inquiry as related to teaching in general, or teaching science specifically, is necessary to confirm the most effective way of transmitting the skills necessary for effective implementation. Many of the findings related to PLTs were not significant due to the small sample size and further research that includes a larger pool and range of experiences is necessary to confirm the factors that influence PLTs' approaches to pedagogy in the classroom. Additionally, the population of student participants was not representative of the general school-age population in Colorado Springs in terms of both qualifications for free and reduced lunch and dispositions about science. Remember that a large majority of students attending the program had overwhelmingly positive opinions about the subject beforehand. Thus, further research that accounts for a more diverse school-age population is necessary to truly investigate the factors of teaching that are important for students in forming their experiences with science.

References

Allensworth, E., Ponisciak, S., & Mazzeo, C. (2009). The schools teachers leave: Teacher mobility in Chicago public schools. Chicago: Consortium on Chicago School Research. Retrieved from http://consortium.uchicago.edu/publications/schools-teachers-leave-teacher-mobility-chicago-public-schools.

Anderson, R. D. (1996). *Study of curriculum reform*. Retrieved from http://files.eric.ed.gov/fulltext/ED397535.pdf.

Anyon, J. (1980). Social class and the hidden curriculum of work. *Journal of Education, 162*(1). Retrieved from http://www.jstor.org/stable/42741976.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis A. M. (2013). Report of the 2012 national questionnaire of science and mathematics education. Chapel Hill, NC: Horizon Research, Inc.

Bleicher, R. E. (2006). Nurturing confidence in preservice elementary science teachers. *Journal of Science Teacher Education*, *17*, 165-187.

Boyd, D., Grossman, P., Ing, M., Lankford, H., Loeb, S., & Wyckoff, J. (2011). The influence of school administrators on teacher retention decisions. *American Education Research Journal, 48*(2), 303-33.

Brock, C. H., Goatley, V. J., Raphael, T. E., Trost-Shahata, E., & Weber, C. M. (2014). *Engaging students in disciplinary literacy, k-6: Reading, writing, and teaching tools for the classroom*. New York, NY: Teachers College Press.

Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 106*(4), 173-80.

Cady, J. A., & Rearden, K. (2007). Pre-service teachers' beliefs about knowledge, mathematics, and science. *School Science and Mathematics, 107*(6), 237-45.

Campbell, T., Abd-Hamid, N. H., & Chapman, H. (2010). Development of instruments to assess teacher and student perceptions of inquiry experiences in science classrooms. *Journal of Science Teacher Education, 21*(1), 13-30.

Clan, H., Dsouza, N., Lyons, R., & Cook, M. (2017). Influences on the development of inquiry-based practices among preservice teachers. *Journal of Science Teacher Education, 28*(2), 186-204.

Crawford, B. A. (2000). Embracing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching, 37,* 916-37.

Fidler, C. (2012). College science for preservice elementary teachers: What is the best approach? *Journal of College Science Teaching, 42*(2), 16-17.

Fulp, S. L. (2002). *The status of elementary school science teaching*. Chapel Hill, NC: Horizon Research.

Gourneau, B. (2005). Five attitudes of effective teachers: Implications for teacher training. *Essays in Education, 13,* 1-8. Retrieved March 31, 2017, from University of South Carolina, Department of Education Web site: http://www.usca.edu/essays/voll32005/gourneau.pdf.

Gottfried, M. A., & Straubhaar, R. (20015). The perceived role of the Teacher for America program on teachers' long-term career aspirations. *Educational Studies, 41*(5), 481-98.

Hancock, E. S. and Gallard, A. J. (2004). Preservice science teachers' beliefs about teaching and learning: The influence of k-12 field experiences. *Journal of Science Teacher Education, 15*(4), 281-91.

Hanushek, E. A., Kain, J. F., Rivkin, S. G. (2004). Why public schools lose teachers. *The Journal of Human Resources, 39*(2), 326-54.

Hanushek, E. A., Rivkin, S. G., & SChiman, J. C. (2016). Dynamic effects of teacher turnover on the quality of instruction. *Economics of Education Review 55,* 132-48.

Hudson, P. (2007). High-impact teaching for science. *Teaching Science, 53*(4), 18-22.

Hudson, P., Usak, M., Fancovicova, J., Erdogan, M., & Prokop, P. (2010). Preservice teachers' memories of their secondary science education experiences. *Journal of Science Education & Technology, 19*, 546-52.

Hutchinson-Anderson, K., Johnson, K., & Craig, P. A. (2015). Students' perceptions of factor influencing their desire to major or not major in science. *Journal of College Science Teaching(45),* 2, 78-85.

Ingersoll, R. M. (2001). Teacher turnover and teacher shortages: An organizational analysis. *American Education Research Journal, 38*(3), 499-530.

Ingersoll, R. M. (2002). The teacher shortage: A case of wrong diagnosis and wrong prescription. *NASSP Bulletin 86*(631), 16-31.

Lewis, E., Harshbarger, D., & Dema, O. (2014). Preparation for practice: Elementary preservice teachers learning using scientific classroom discourse community instructional strategies. *School Science and Mathematics, 114*(4), 154-65.

Liang, L. L., & Gabel, D. L. (2005). Effectiveness of a constructivist approach to science instruction for prospective elementary teachers. *International Journal of Science Education, 27*(10), 1143-62.

Luekens, M. T., Lyter, D. M., Fox, E. E., & Chandler, K. (2004). Teacher attrition and mobility: results from the Teacher Follow-up Questionnaire. *2000-01*. Washington, DC: National Center for Education Statistics.

Marzano, R. J. (2003). *What works in schools: Translating research into action*. Alexandria, VA: Association for Supervision and Curriculum Development.

Marzano, R. J. (2007). *The art and science of teaching: A comprehensive framework for effective instruction*. Alexandria, VA: Association for Supervision and Curriculum Development.

Nadelson, L. Siefert, A., Hendricks, J.K. (2015). Are We Preparing the Next Generation? K-12 Teacher Knowledge and Engagement in Teaching Core STEM Practices. ASEE Annual Conference and Exposition, Conference Proceedings, 122nd ASEE Annual Conference and Exposition.

National Research Council (NRC). (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. The National Academies Press: Washington, D. C.

Next Generation Science Standards. (2013). Appendix F – Science and Engineering Practices in the NGSS. Retrieved April 2, 2017 from http://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf.

Planty, M., Hussar, W., Snyder, T., Kena, G., KewalRamani, A., Kemp, J., Bianco, et al. (2008). The condition of Education 2008. *(NCES 2008-031)*. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U. S. Department of Education.

Plourde, L. A. (2003). Elementary science teaching education: The influence of student teaching – where it all begins. *Education, 123*(2), 253-59.

Pryor, B. W., & Pryor, C. R. (2005) *The school leader's guide to understanding attitude and influencing behavior: Working with teachers, parents, students, and the community*. Thousand Oaks, CA: Corwin Press.

Rice, J. K. (2003). *Teacher quality: Understanding the effectiveness of teacher attributes*. Washington, DC: Economic Policy Institute.

Riegle-Crumb, C., Morton, K., Moore, C., Chimonidou, A., Labrake, C., & Kopp, S. (2015). Do inquiring minds have positive attitudes? *Science Education 99*(5), 819-36.

Riggs, I. M. (1991). Gender differences in elementary science teacher self-efficacy. Paper presented at the annual meeting of the American Educational Research Association: Chicago, IL.

Romance, N. R., & Vitale, M. R. (2012). Expanding the role of K-5 science instruction in educational reform: Implications of an interdisciplinary model for integrating science and reading. *School Science and Mathematics 112*(8), 506-15.

Rosenshine, B. (1970). Enthusiastic Teaching: A Research Review. *The School Review,78*(4), 499-514.

Scrivner, C. M. (2009). The relationship between student achievement and teacher attitude: A correlational study (Doctoral dissertation). UMI Microform, 3351416.

Tilgner, P. J. (1990). Avoiding Science in the Elementary School. *Science Education 74*(4): 421-31.

Weiss, I. R., Banilower, E. R., McMahon, K. C., & Smith, P. S. (2001). Report of the 2000 national questionnaire of science and mathematics education. Chapel Hill, NC: Horizon Research.

Westerbacck, M. E., & Long, M. J. (1990). Science knowledge and the reduction of anxiety about teaching Earth science in exemplary teachers as measured by the science teaching state-trait anxiety inventory. *School Science and Mathematics, 90*(5), 361-74.

White, M. (2013, July 4). Report notes shortage of high-quality STEM teachers. *Deseret News National Edition*. Web.

Appendix A – Student Pre Questionnaires

Research Study: Investigating the Factors That Influence Experiences with, Perceptions of, and Engagement with Science

Investigator: Stefani Messick
Student Assent Form – **Written Questionnaire (Grades 1-4)**

I am doing a research study about *what students think about science and why*. A research study is a way to learn more about people. If you decide that you want to be part of this study, you will be asked to *take a questionnaire*.

There are some things about this study you should know. The written questionnaire should take no longer than five or ten minutes to complete.

Not everyone who takes part in this study will benefit. A benefit means that something good happens to you. Participating in this study might help you think more about how you feel about science, what you like about how science is taught in school, and what you might want to be different. This might benefit you because this new knowledge might help you improve your experience with science.

When I am finished with this study I will write a report about what I learned. This report will not include your name or that you were in the study.
You do not have to be in this study if you do not want to be. If you decide to stop after we start, that's okay too. Your parents know about the study, too.

If you decide you want to be in this study, please sign your name.

I, _________________________________, want to be in this research study.

_______________________________________ ________________
(Sign your name here) (Date)

What is your birthday? Please write it here. _________________________
(month) (date) (year)

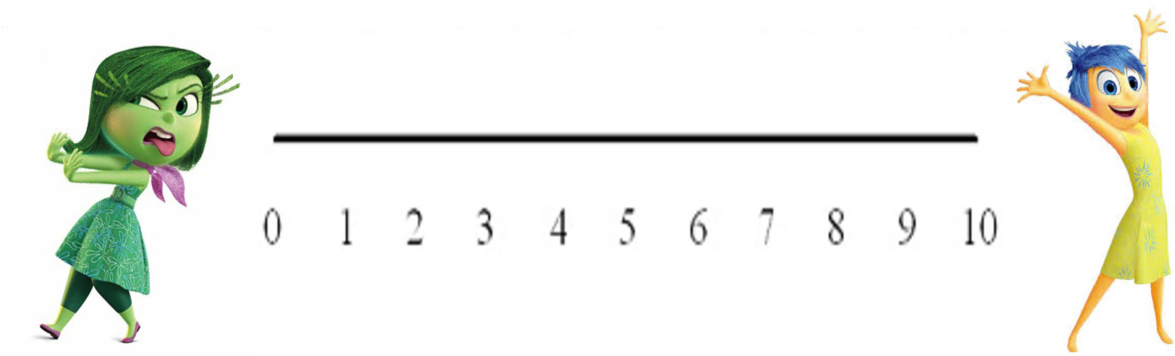
What are your initials? My name is **S**tefani **M**essick, so my initials are **SM**.

____

1. Do you like science?

Yes No

2. On a scale of 1-10, rate how much you like science.



3. Do you do science every day at school?

Yes No

4. Do you like the way your teacher teaches science?

Yes No

5. Is science your favorite subject?

Yes No

6. Do you wish you learned science more often?

Yes No

7. Do you do science experiments in school?

Yes No

8. Do you think your teacher likes science?

Yes No

9. Do you think your teacher is excited about science?

Yes No

10. Do you take notes or learn science from a book at school?

Yes No

11. Do you spend the same amount of time on science in school as you do other subjects?

Yes No

12. Do you do science at home?

Yes No

Research Study: Investigating the Factors That Influence Experiences with, Perceptions of, and Engagement with Science
Student Assent Form (Grades 5-10) – Written Questionnaire

Researcher – Stefani Messick
Supervisor – Mike Taber
Colorado College Department of Education
719-389-6146
Stefani.Messick@ColoradoCollege.edu

You are invited to take part in a research study of factors that influence student perceptions of science.

What the study is about: I am investigating the factors that influence student experiences with science, their perceptions of science, and the reasons why they may continue to engage with science.

What you will be asked to do: *You will complete a written questionnaire that should take no longer than 5-10 minutes*.

Risks and benefits: There are no anticipated risks to you if you participate in this study, beyond those encountered in everyday life.

Participation in my study may help you reflect more critically on your experiences in order to discern the factors that have made the experience beneficial and the factors that need improvement. The data may help you outline your priorities for future opportunities to engage in science.

Taking part is voluntary: Your participation in this study is completely voluntary. You can withdraw from the study at any time without consequences of any kind, and you can withdraw. You may choose to skip any question and participate in only some tasks. Participating in this study does not mean that you are giving up any legal rights.

Your answers will be kept confidential: The records of this study will be kept private, and individual data will only be accessible by the researcher. Data will be kept on a personal computer and will be destroyed at the culmination of the thesis project. Any report of this research that is made available to the public will not include your name or any other individual information by which you could be identified.

If you have questions or want a copy or summary of the study results: Contact the researcher at the email address or phone number above. You will be given a copy of this form to keep for your records. If you have any questions about whether your child has been treated in an illegal or unethical way, contact the Colorado College Institutional Research Board chair, Amanda Udis-Kessler at 719-227-8177 or audiskessler@coloradocollege.edu.

Statement of Consent: I have read the above information, and have received answers to any questions. I consent to take part in the research study of science procedures and resulting attitudes.

______________________________	______________________________	______________________________
;tudent Signature	Student's Name (Please Print)	Date

What is your birthday? Please write it here. __________________________
(month) (date) (year)

What are your initials? ___________________

1 Do you like science?

Yes No

2 What is it about science that you like/don't like?

3 On a scale from 1-10, rate how much you like science.

0 1 2 3 4 5 6 7 8 9 10

4 How many science classes do you think you will take (in both middle and high school) by the time you graduate high school?

a 5 or fewer
b 6
c 7
d 8 or more

5 Do you like the way you have been taught science?

Yes No

6 What do you like/not like about how you have been taught science?

7 Is science your favorite subject?

Yes No

8 Do you wish you had more opportunities to explore science topics?

Yes No

9 Think back on one science teacher in particular. Do you think this teacher likes science?

Yes No

10 How can you tell if your teacher likes or doesn't like science?

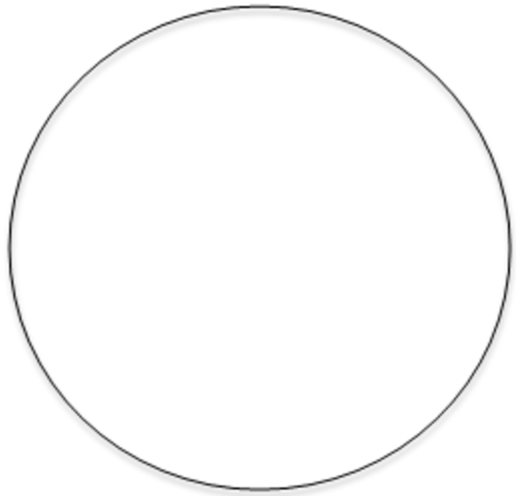
11 Do you think this teacher is excited about science?

Yes No

12 What method of learning science do you feel you get the most out of?
a Notes/textbook
b Class discussion
c Experiments or activities

13 Draw a pie chart to show how much time you spend in science classes learning using these instructional methods. Please label the percents or fractions:

a Notes/textbook
b Class discussion
c Experiments/Labs



14 Do you spend the same amount of time on science in school as you do other subjects?

Yes No

15 Do you participate in clubs that focus on science topics?

Yes No

16 Do you do science at home that is unrelated to science at school?

Yes No

17 How are your experiences with science in clubs or at home different from your experiences with science in the classroom?

Appendix B – Post Student Questionnaires

Research Study: Investigating the Factors That Influence Experiences with, Perceptions of, and Engagement with Science
Investigator: Stefani Messick
Student Assent Form – **Written Questionnaire (Grades 1-4)**

I am doing a research study about *what students think about science and why*. A research study is a way to learn more about people. If you decide that you want to be part of this study, you will be asked to *take a questionnaire*.

There are some things about this study you should know. The written questionnaire should take no longer than five or ten minutes to complete.

Not everyone who takes part in this study will benefit. A benefit means that something good happens to you. Participating in this study might help you think more about how you feel about science, what you like about how science is taught in school, and what you might want to be different. This might benefit you because this new knowledge might help you improve your experience with science.

When I am finished with this study I will write a report about what I learned. This report will not include your name or that you were in the study.
You do not have to be in this study if you do not want to be. If you decide to stop after we start, that's okay too. Your parents know about the study, too.

If you decide you want to be in this study, please sign your name.

I, ________________________________, want to be in this research study.

______________________________________ ________________ (Sign your name here) (Date)
What is your birthday? Please write it here. ________________________
(month) (date) (year)

What are your initials? My name is **S**tefani **M**essick, so my initials are **SM**.

____

1. Did you enjoy Whiz Bang Science?

Yes No

2. What did you like best about participating in Whiz Bang Science?

3. Was learning science during Whiz Bang *different* than how you learn at school?

Yes No

4. Do you think your teacher during Whiz Bang Science likes science?

Yes No

5. Do you think your teacher during Whiz Bang Science is excited about science?

Yes No

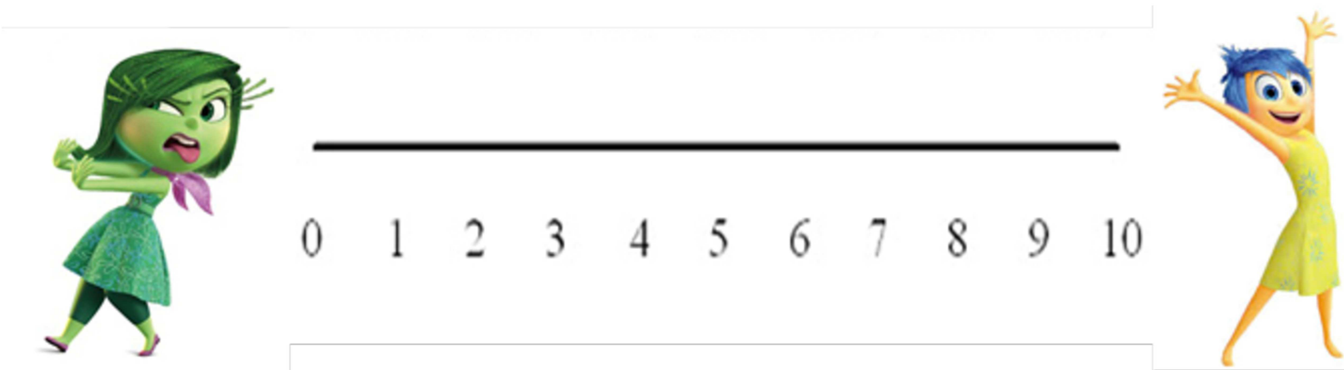
6. Do you think your teacher during Whiz Bang Science would make a good science teacher at school?

Yes No

7. If you could change anything about Whiz Bang Science, what would you change?

8. If you could change anything about how you learn science *at school*, what would you change?

9. On a scale of 1-10, rate how much you like science.



Research Study: Investigating the Factors That Influence Experiences with, Perceptions of, and Engagement with Science
Student Assent Form (Grades 5-10) – Written Questionnaire

Researcher – Stefani Messick
Supervisor – Mike Taber
Colorado College Department of Education
719-389-6146
Stefani.Messick@ColoradoCollege.edu

You are invited to take part in a research study of factors that influence student perceptions of science.

What the study is about: I am investigating the factors that influence student experiences with science, their perceptions of science, and the reasons why they may continue to engage with science.

What you will be asked to do: *You will complete a written questionnaire that should take no longer than 5-10 minutes*.

Risks and benefits: There are no anticipated risks to you if you participate in this study, beyond those encountered in everyday life.

Participation in my study may help you reflect more critically on your experiences in order to discern the factors that have made the experience beneficial and the factors that need improvement. The data may help you outline your priorities for future opportunities to engage in science.

Taking part is voluntary: Your participation in this study is completely voluntary. You can withdraw from the study at any time without consequences of any kind, and you can withdraw. You may choose to skip any question and participate in only some tasks. Participating in this study does not mean that you are giving up any legal rights.

Your answers will be kept confidential: The records of this study will be kept private, and individual data will only be accessible by the researcher. Data will be kept on a personal computer and will be destroyed at the culmination of the thesis project. Any report of this research that is made available to the public will not include your name or any other individual information by which you could be identified.

If you have questions or want a copy or summary of the study results: Contact the researcher at the email address or phone number above. You will be given a copy of this form to keep for your records. If you have any questions about whether your child has been treated in an illegal or unethical way, contact the Colorado College Institutional Research Board chair, Amanda Udis-Kessler at 719-227-8177 or audiskessler@coloradocollege.edu.

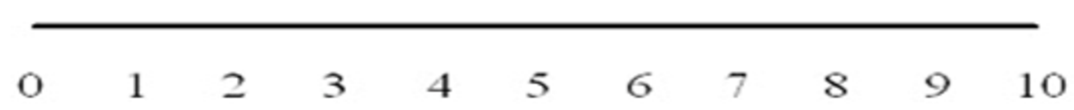
Statement of Consent: I have read the above information, and have received answers to any questions. I consent to take part in the research study of science procedures and resulting attitudes.

______________________________	____________________________	____________
Student Signature	Student's Name (Please Print)	Date

What is your birthday? Please write it here. _________________________
(month) (date) (year)

What are your initials? ___________________

1. On a scale of 1-10 how much did you enjoy Whiz Bang Science?



2. Was learning science during Whiz Bang different than how you learn at school?

Yes No

3. What similarities between learning at Whiz Bang and learning science at school did you notice?

4. What differences between learning at Whiz Bang and learning science at school did you notice?

5. Did you like the way your teacher taught science during Whiz Bang?

Yes No

6. What did you like about how your teacher taught science during Whiz Bang?

7. What did you not like about how your teacher taught science during Whiz Bang?

8. Do you think your teacher during Whiz Bang likes science?

Yes No

9. How can you tell?

10. Do you think your teacher during Whiz Bang is excited about science?

Yes No

11. Do you think your teacher during Whiz Bang would make a good science teacher in a school?

Yes No

12. If you could change anything about Whiz Bang, what would you change?

13. If you could change anything about how you learn science *at school*, what would you change?

14. On a scale of 1-10, rate how much you like science.

0 1 2 3 4 5 6 7 8 9 10

Appendix C - Student Focus Group Script and Questions

Hello, and thank you for electing to participate in this focus group. My name is Stefani and I will conduct this discussion. I invited you to discuss the experiences you've had with science in school and during your time at Whiz Bang so far. In order to determine what you think about science and why you might feel that way, I will ask you several questions. Your personal opinions and views are very important to me. There are no right or wrong answers. Please feel welcome to express yourself freely during this discussion. The conversation will be recorded on tape. This is only for the purpose of the research. Only I will listen to the tape and it will be destroyed once my research is complete. No names or personal information will be used in the report.

The discussion should last about 60 minutes, but we may go shorter depending on how the conversation flows. I ask you to please switch off your cell phone. Please give everyone the chance to express his or her opinion. If, after hearing anything I just said, you have changed your mind about wanting to participate, you are free to leave. This will not impact you in any way.

Is everyone clear about how this discussion will go? (Answer any questions.)

Great, let's begin. (share some results from the pre-questionnaires. How many people like/don't like science, share that students reported differences in how often and the methods by which they are learning science at school, just to get students thinking that not everyone's experience with science is the same.)

1. Let's start just by asking, do you like science?
    a. What do you like about science?
    b. What do you not like about science?

2. What do you think influences your opinion about science?
    a. What do you know about ___________(insert hot topic, e.g. global warming).
        i. Parents?
        ii. Teachers?
        iii. TV?

3. Tell me a little about what your experience with science at school is like. How many days each week do you learn science, and what methods does your teacher use to teach science?
    a. Do you do science every day?
    b. Do you read from a textbook?
    c. Do you do experiments?
    d. Do you have class discussions?

e. How do you *prefer* to learn science?

4. What do you like about the way your teacher teaches science?

5. Do you wish your teacher taught science differently? What do you wish was different?

6. Do you think your teacher likes science?
    a. How can you tell?
    b. Does this make a difference for you in learning science or your opinion about science?

7. Do you think your teacher knows a lot about science?
    a. How can you tell?
    b. Does this make a difference for you in learning science or your opinion about science?

8. Do you do science at home?
    a. What does this look like?
    b. Does doing science at home contribute to whether you like or don't like science?

9. Think about what you've experienced so far at Whiz Bang. How is your teacher teaching science?
    a. Are you taking notes or learning from a book?
    b. Are you doing experiments?
    c. Are you having class discussions?

10. What do you like about the way you are learning science at Whiz Bang?

11. Do you wish Whiz Bang would teach science differently? What do you wish was different?

12. Do you think your Whiz Bang teacher likes science?
    a. How can you tell?
    b. Does this make a difference for you in learning science or your opinion about science?

13. Do you think your Whiz Bang teacher knows a lot about science?
    a. How can you tell?
    b. Does this make a difference for you in learning science or your opinion about science?

Appendix D – Pre Parent Questionnaire

Stefani Messick
Colorado College Department of Education
719-389-6146
Stefani.Messick@ColoradoCollege.edu

Investigating the Factors That Influence Experiences with, Perceptions of, and Engagement with Science

Pre-WBS Consent Form

You are invited to take part in a research questionnaire about factors that influence student perceptions of science. Your participation will require approximately 15 minutes. There are no known risks or discomforts associated with this questionnaire. Participation in this questionnaire may help participants reflect more critically on their experiences with science in order to discern the factors that have made the experience beneficial and the factors that need improvement. The process and final data may help parents or students outline their priorities for future opportunities to engage in science.

Taking part in this study is completely voluntary. If you choose to be in the study you can withdraw at any time without adversely affecting your relationship with anyone at Colorado College. Your responses will be kept strictly confidential, and digital data will be stored in secure computer files. Any report of this research that is made available to the public will not include your name or any other individual information by which you could be identified. If you have questions or want a copy or summary of this study's results, you can contact the researcher at the email address above. If you have any questions about whether you have been treated in an illegal or unethical way, contact the Colorado College Institutional Research Board chair, Amanda Udis-Kessler at 719-227-8177 or audiskessler@coloradocollege.edu. Please feel free to print a copy of this consent page to keep for your records.

Clicking the "Next" button below indicates that you are 18 years of age or older, and indicates your consent to participate in this questionnaire.

Page Break
If you have more than one student participating in WBS, please indicate which student you have in mind while answering these questions. The student's identity will only be used to match the student data with the appropriate parent's data, at which point, I will remove the identifying information and the data will be anonymous.

Student's name: ______________________________

1. How many years have you had a student who participated in Whiz Bang Science?
    a. This is our first year
    b. 1 year
    c. 2 years

d. 3 years
e. 4 years or more

2. I perceive my student to be ___________ interested in science compared to other subjects.
    a. More
    b. No more or less
    c. Less

3. I perceive my student's current opinion about science to be:
    a. (Sliding scale from negative – neutral – positive)
    b. (0-4.9 = negative; 5 = neutral; 5.1-10=positive)

4. How much do you feel the following factors influence your student's perception of science?
    a. School
        i. A great deal
        ii. A lot
        iii. A moderate amount
        iv. A little
        v. Not at all
    b. Home
        i. A great deal
        ii. A lot
        iii. A moderate amount
        iv. A little
        v. Not at all
    c. Extra programs like WBS
        i. A great deal
        ii. A lot
        iii. A moderate amount
        iv. A little
        v. Not at all
    d. Other ____________
        i. A great deal
        ii. A lot
        iii. A moderate amount
        iv. A little
        v. Not at all

5. What kind of school does your student attend?
    a. Public school
    b. Private school
    c. Home school
    d. Magnet school
    e. Other ___________

6. What school district is your student's school a part of?

7. What is your **primary** reason for enrolling your student in WBS?
    a. Science enrichment
    b. Convenience of having a summer activity
    c. Personal affiliation with CC
    d. Other ________________________________

8. What do you perceive to be the *quality of the educational experience* your student is receiving at school?
    a. Excellent
    b. Good
    c. Average
    d. Poor
    e. Terrible

9. Based on what you've seen or heard, how satisfied is your student with the *in-school science experience?*
    a. Extremely satisfied
    b. Somewhat satisfied
    c. Neither satisfied nor dissatisfied
    d. Somewhat dissatisfied
    e. Extremely dissatisfied

10. What factors of this program do you anticipate to contribute to a positive experience for your student?

11. What factors of this program do you anticipate to contribute to a positive experience for you as a parent?

Appendix E – Post Parent Questionnaire

Stefani Messick
Colorado College Department of Education
719-389-6146
Stefani.Messick@ColoradoCollege.edu

Investigating the Factors That Influence Experiences with, Perceptions of, and Engagement with Science

Post-WBS Consent Form

You are invited to take part in a research questionnaire about factors that influence student perceptions of science. Your participation will require approximately 15 minutes. There are no known risks or discomforts associated with this questionnaire. Participation in this questionnaire may help participants reflect more critically on their experiences with science in order to discern the factors that have made the experience beneficial and the factors that need improvement. The process and final data may help parents or students outline their priorities for future opportunities to engage in science.

Taking part in this study is completely voluntary. If you choose to be in the study you can withdraw at any time without adversely affecting your relationship with anyone at Colorado College. Your responses will be kept strictly confidential, and digital data will be stored in secure computer files. Any report of this research that is made available to the public will not include your name or any other individual information by which you could be identified. If you have questions or want a copy or summary of this study's results, you can contact the researcher at the email address above. If you have any questions about whether you have been treated in an illegal or unethical way, contact the Colorado College Institutional Research Board chair, Amanda Udis-Kessler at 719-227-8177 or audiskessler@coloradocollege.edu. Please feel free to print a copy of this consent page to keep for your records.

Clicking the "Next" button below indicates that you are 18 years of age or older, and indicates your consent to participate in this questionnaire.

Page Break

If you have more than one student participating in WBS, please indicate which student you have in mind while answering these questions. The student's identity will only be used to match the student data with the appropriate parent's data, at which point, I will remove the identifying information and the data will be anonymous.

Student's name: ______________________________

1. I perceive my student's current opinion about science to be:
    a. (Sliding scale from negative – neutral – positive)
    b. (0-4.9 = negative; 5 = neutral; 5.1-10=positive)

2. My student talks about science ______________ since participating in Whiz Bang.
    a. Less often
    b. With the same frequency
    c. More often

3. My student seems _______________ about science since participating in Whiz Bang.
    a. More excited
    b. Less excited
    c. To have the same opinion

4. My student's overall experience with Whiz Bang was:
    a. Excellent
    b. Good
    c. Average
    d. Poor
    e. Terrible

5. My overall experience with Whiz Bang was:
    a. Excellent
    b. Good
    c. Average
    d. Poor
    e. Terrible

6. To what extent do you agree with this statement: "I feel that WBS contributed to a positive shift in my student's attitude about science."
    a. Strongly agree
    b. Agree
    c. Neither agree nor disagree
    d. Disagree
    e. Strongly disagree

7. Complete this statement: "I feel that the quality of my student's experience during WBS was ______________ than the quality of the my student's in-school science experience."
    a. Much better
    b. Better
    c. Neither better nor worse
    d. Worse
    e. Much worse

8. Complete this statement: "I feel that my student's experience in WBS was _______________ to/from my student's in-school science experience."
    a. Very similar
    b. Similar
    c. Different
    d. Very different

9. What factors of the program do you feel contributed to any shift, either positive or negative, or lack thereof, in your student's attitude about science? Circle all that apply.
    a. Teaching practices
    b. Activities/curriculum
    c. Teacher disposition or attitude
    d. At-home experience or enrichment
    e. Other ____
    f. None of the above

10. Please expand on how you feel the factors from above impacted your student's experience and resulting attitude about science, if applicable.

Appendix F – PLT Pre Questionnaire

Stefani Messick
Colorado College Department of Education
719-389-6146
Stefani.Messick@ColoradoCollege.edu

Investigating the Factors That Influence Experience with, Perceptions of, and Engagement with Science

Pre-WBS Online Consent Form

You are invited to take part in a research questionnaire about factors that influence student perceptions of science. Your participation will require approximately 10 minutes and is completed online at your computer. There are no known risks or discomforts associated with this questionnaire.

Participation in this questionnaire may help participants reflect more critically on their experiences with science in order to discern the factors that have made the experience beneficial and the factors that need improvement. The process and final data may help current or future teachers outline their priorities for engaging with science in the classroom and their best practices for doing so. Taking part in this study is completely voluntary.

If you choose to be in the study you can withdraw at any time without adversely affecting your relationship with anyone at Colorado College. Your responses will be kept strictly confidential, and digital data will be stored in secure computer files. Any report of this research that is made available to the public will not include your name or any other individual information by which you could be identified. If you have questions or want a copy or summary of this study's results, you can contact the researcher at the email address above. If you have any questions about whether you have been treated in an illegal or unethical way, contact the Colorado College Institutional Research Board chair, Amanda Udis-Kessler at 719-227-8177 or audiskessler@coloradocollege.edu. Please feel free to print a copy of this consent page to keep for your records.

Clicking the "Next" button below indicates that you are 18 years of age or older, and indicates your consent to participate in this questionnaire.

1. Page BreakWhat subject is your Bachelor's degree in?

2. What grade do you intend on teaching after you complete the MAT program at CC?

a. K-5
b. 6-8
c. 9-12

3. How many science courses did you take from the following categories during your undergraduate experience?
a. Physical science ____________________
b. Earth science________________________
c. Life science__________________________

4. How many science courses did your institution require to graduate?

5. (For elementary teachers only) Complete this statement: " I think elementary educators should have a _______________ of science topics.
a. General understanding
b. Deep understanding

6. (For secondary teachers only) To what degree do you agree with this statement: "Only science teachers should have science content knowledge."
a. Strongly agree
b. Agree
c. Neither agree nor disagree
d. Disagree
e. Strongly disagree

7. To what extent do you agree with this statement: "I have a deep science content understanding."

a. Strongly agree
b. Agree
c. Neither agree nor disagree
d. Disagree
e. Strongly disagree

8. Drag the bars to depict how well qualified you feel to teach the following subjects at your prospective grade level:
a. Reading
b. Mathematics
c. Science
d. Social Studies/History
e. Writing
    i. Very unqualified

ii. Somewhat unqualified
iii. Somewhat qualified
iv. Very qualified

9. How would you describe your experience with science throughout primary and secondary school?
   a. Poor
   b. Fair
   c. Good
   d. Very good
   e. Excellent

10. Given your K-12 experience with the subject, what perception of science do you remember having after graduating high school?
   a. Negative
   b. Somewhat negative
   c. Neither positive nor negative
   d. Somewhat positive
   e. Positive

11. How much did the following factors influence your perception of science during your K-12 experience?
   a. Science teacher content knowledge
      i. A great deal
      ii. A lot
      iii. A moderate amount
      iv. A little
      v. Not at all
   b. Perceived science teacher opinion of science (e.g. excitement for the subject, disinterest in the subject)
      i. A great deal
      ii. A lot
      iii. A moderate amount
      iv. A little
      v. Not at all

12. How much do the following factors influence your confidence about teaching science:
   a. Level of understanding/content knowledge
      i. A great deal
      ii. A lot
      iii. A moderate amount
      iv. A little
      v. Not at all
   b. Personal opinion/attitude about science
      i. A great deal
      ii. A lot

iii. A moderate amount
iv. A little
v. Not at all

c. Teacher preparation program
i. A great deal
ii. A lot
iii. A moderate amount
iv. A little
v. Not at all

d. Curriculum provided by school
i. A great deal
ii. A lot
iii. A moderate amount
iv. A little
v. Not at all

e. Other ______________________________
i. A great deal
ii. A lot
iii. A moderate amount
iv. A little
v. Not at all

13. To what degree do you agree with this statement: "My undergraduate experience has prepared me to adequately teach science."

a. Strongly disagree
b. Disagree
c. Neither agree nor disagree
d. Agree Strongly agree

14. To what degree do you agree with this statement: "I feel confident about teaching science."

a. Strongly disagree
b. Disagree
c. Neither agree nor disagree
d. Agree
e. Strongly agree

15. What factors do you think influence student perceptions of science as a subject in school? Circle all that apply.

a. Teaching practices
b. Activities/curriculum
c. Teacher disposition or attitude about science
d. At-home experience or enrichment
e. Other ____
f. None of the above

Appendix G – PLT Post Questionnaire

Stefani Messick
Colorado College Department of Education
719-389-6146
Stefani.Messick@ColoradoCollege.edu

Investigating the Factors That Influence Experience with, Perceptions of, and Engagement with Science

Post-WBS Online Consent Form

You are invited to take part in a research questionnaire about factors that influence student perceptions of science. Your participation will require approximately 10 minutes and is completed online at your computer. There are no known risks or discomforts associated with this questionnaire.

Participation in this questionnaire may help participants reflect more critically on their experiences with science in order to discern the factors that have made the experience beneficial and the factors that need improvement. The process and final data may help current or future teachers outline their priorities for engaging with science in the classroom and their best practices for doing so. Taking part in this study is completely voluntary.

If you choose to be in the study you can withdraw at any time without adversely affecting your relationship with anyone at Colorado College. Your responses will be kept strictly confidential, and digital data will be stored in secure computer files. Any report of this research that is made available to the public will not include your name or any other individual information by which you could be identified. If you have questions or want a copy or summary of this study's results, you can contact the researcher at the email address above. If you have any questions about whether you have been treated in an illegal or unethical way, contact the Colorado College Institutional Research Board chair, Amanda Udis-Kessler at 719-227-8177 or audiskessler@coloradocollege.edu. Please feel free to print a copy of this consent page to keep for your records.

Clicking the "Next" button below indicates that you are 18 years of age or older, and indicates your consent to participate in this questionnaire.

Page Break

1. (For elementary teachers only) Complete this statement: " I think elementary educators should have a _______________ of science topics.
    a. General understanding
    b. Deep understanding

2. (For secondary teachers only) To what degree do you agree with this statement: "Only science teachers should have science content knowledge."
   a. Strongly agree
   b. Agree
   c. Neither agree nor disagree
   d. Disagree
   e. Strongly disagree

3. Drag the bars to depict how well qualified you feel to teach the following subjects at your prospective grade level:
   a. Reading
   b. Mathematics
   c. Science
   d. Social Studies/History
   e. Writing
      i. Very unqualified
      ii. Somewhat unqualified
      iii. Somewhat qualified
      iv. Very qualified

4. How much do the following factors influence your confidence about teaching science:
   a. Level of understanding/content knowledge
      i. A great deal
      ii. A lot
      iii. A moderate amount
      iv. A little
      v. Not at all
   b. Personal opinion/attitude about science
      i. A great deal
      ii. A lot
      iii. A moderate amount
      iv. A little
      v. Not at all
   c. Teacher preparation program
      i. A great deal
      ii. A lot
      iii. A moderate amount
      iv. A little
      v. Not at all
   d. Curriculum provided by school
      i. A great deal
      ii. A lot
      iii. A moderate amount
      iv. A little
      v. Not at all
   e. Other ______________________________

i. A great deal
ii. A lot
iii. A moderate amount
iv. A little
v. Not at all

5. To what degree do you agree with this statement: “My undergraduate experience has prepared me to adequately teach science.”
   a. Strongly disagree
   b. Disagree
   c. Neither agree nor disagree
   d. Agree
   e. Strongly agree

6. Do you feel that your teaching experience in Whiz Bang has helped prepare you for teaching in your MAT placement?
   a. Yes
   b. No

7. (If yes on #7) How has your involvement with WBS affected your approach to teaching?

8. Complete this statement: “After participating in Whiz Bang, I feel _____________ about teaching science at my given grade level.
   a. More confident
   b. A little more confident
   c. No more or less confident
   d. A little less confident
   e. Less confident
   f. Not Applicable – my given grade level does not include science instruction

9. Drag the bars to depict how much you feel your involvement with Whiz Bang Science this summer has impacted your ability as a teacher in the following areas:

   Sliding scale - (Strongly disagree 0-1.9, disagree 2-3.9, neither agree nor disagree 4-5.9, agree 6-7.9, strongly agree 8-10)

   a. Provided a safe space to get a feel for classroom management
   b. Gave me experience planning and implementing lessons
   c. Helped me develop an authoritative “teacher voice”
   d. Provided quality chance to collaborate with colleagues, more experienced and not
   e. Other

10. In what ways did you see WBS influence your students’ perceptions of science?

11. In what ways did WBS influence your perception of science?

12. IN what ways did WBS influence your confidence for teaching science?

13. Complete this statement: "My biggest takeaway from Whiz Bang Science is ____."

Appendix H – Post Post PLT Questionnaire

Post-Post-WBS MAT questionnaire

Q2 Stefani MessickColorado College Department of Education719-389-6146Stefani.Messick@ColoradoCollege.edu Investigating the Factors That Influence Experience with, Perceptions of, and Engagement with Science Post Post-WBS Online Consent Form You are invited to take part in a research questionnaire about factors that influence student perceptions of science. Your participation will require approximately 5 to 10 minutes and is completed online at your computer. There are no known risks or discomforts associated with this questionnaire. Participation in this questionnaire may help participants reflect more critically on their experiences with science in order to discern the factors that have made the experience beneficial and the factors that need improvement. The process and final data may help current or future teachers outline their priorities for engaging with science in the classroom and their best practices for doing so. Taking part in this study is completely voluntary. If you choose to be in the study you can withdraw at any time without adversely affecting your relationship with anyone at Colorado College. Your responses will be kept strictly confidential, and digital data will be stored in secure computer files. Any report of this research that is made available to the public will not include your name or any other individual information by which you could be identified. If you have questions or want a copy or summary of this study's results, you can contact the researcher at the email address above. If you have any questions about whether you have been treated in an illegal or unethical way, contact the Colorado College Institutional Research Board chair, Amanda Udis-Kessler at 719-227-8177 or audiskessler@coloradocollege.edu. Please feel free to print a copy of this consent page to keep for your records. Clicking the "Yes" button below indicates that you are 18 years of age or older, and indicates your consent to participate in this questionnaire.

- ❍ Yes (1)
- ❍ No (2)

Condition: No Is Selected. Skip To: End of Questionnaire.

Q3 What grade level are you teaching in your current placement?

- ❍ K-5 (1)
- ❍ 6-8 (2)
- ❍ 9-12 (3)

Display This Question:

If What grade level are you teaching in your current placement? K-5 Is Not Selected

Q4 What subject(s) are you teaching in your current placement?

Display This Question:
If What grade level are you teaching in your current placement? K-5 Is Selected

Q5 How many minutes each day do you spend teaching each of the following subjects?
______ Math (1)
______ Science (2)
______ Reading/Language Arts (3)
______ Social Studies (4)

Q6 Do you teach science in your placement?
❍ Yes (1)
❍ No (2)

Display This Question:
If Do you teach science in your placement? Yes Is Selected

Q7 Please rate your level of agreement with the following statements, choose a number between 1 and 10.
______ I like science. (1)
______ I am comfortable with the science content I am supposed to teach. (2)
______ I am enthusiastic when I teach science. (3)
______ I am confident about teaching science. (4)
______ I believe the science I teach is relevant to my students. (5)
______ I would say that my experience with science in K-12 was positive. (6)
______ I am anxious about teaching science. (7)

Q8 Please rate your level of agreement with the following statements, choose a number between 1 and 10.
______ I learned about designing lessons for inquiry during my summer experience with Whiz Bang Science. (1)
______ I USE what I learned about designing lessons for inquiry in my teaching placement. (2)
______ The expectations for content on standardized tests influence the content I teach. (3)
______ The expectations for content on standardized tests influence the WAY I teach (planning, instructional methods, etc). (4)

Q9 Please rate your level of agreement with the following statements, choose a number between 1 and 10.
______ I believe my energy and enthusiasm are important for student learning. (1)
______ When I don't know much about the content I am teaching, I try to learn more about the content on my own. (2)
______ Teaching and designing lessons with inquiry in mind is important in my discipline. (3)
______ Participating in Whiz Bang Science helped me form beliefs about teaching. (4)
______ I believe autonomy and choice are important factors in my classroom. (5)

Q10 Please rate your level of agreement with the following statements, choose a number between 1 and 10.
______ I believe discovery is an important part of learning. (1)
______ My opinion about a subject influences the way I teach it. (2)
______ I believe participating in Whiz Bang Science changed my attitude about science as a content area. (3)
______ I believe participating in Whiz Bang Science changed my attitude about teaching and learning science. (4)

Q11 Would you like to be granted a gift card for your time spent completing this questionnaire?
❍ Yes (1)
❍ No (2)

Tables

Student School District			
District Number		Frequency	Valid Percent
Valid	2	3	3.9
	11	27	35.5
	12	10	13.2
	14	1	1.3
	20	23	30.3
	38	1	1.3
	49	1	1.3
	8	1	1.3
	Other	9	11.8
	Total	76	100.0
Missing	System	4	
Total		80	

Table 1. The distribution of Whiz Bang students' school districts. The distribution of students by school district is not representative of students in Colorado Springs schools overall, as students represent a greater percentage of schools with lower free and reduced lunch numbers. "Other" refers to an out-of-district or out-of-state school. The data came from the Parent Pre-Questionnaire.

Pre versus Post Science Ratings			
Grades	Pre Rating (0-10)	Post Rating (0-10)	Valid N (list wise)
1-4	8.39	8.54	29
5-10	8.27	8.64	22
Parents (Perceived Student Rating)	8.69	9.10	29

Table 2. The ratings of science before and after Whiz Bang by both students and parents (who reported their perception of their students' rating of science). For grades 5-10 and the parents overall, the mean differences were statistically significant.

Figures

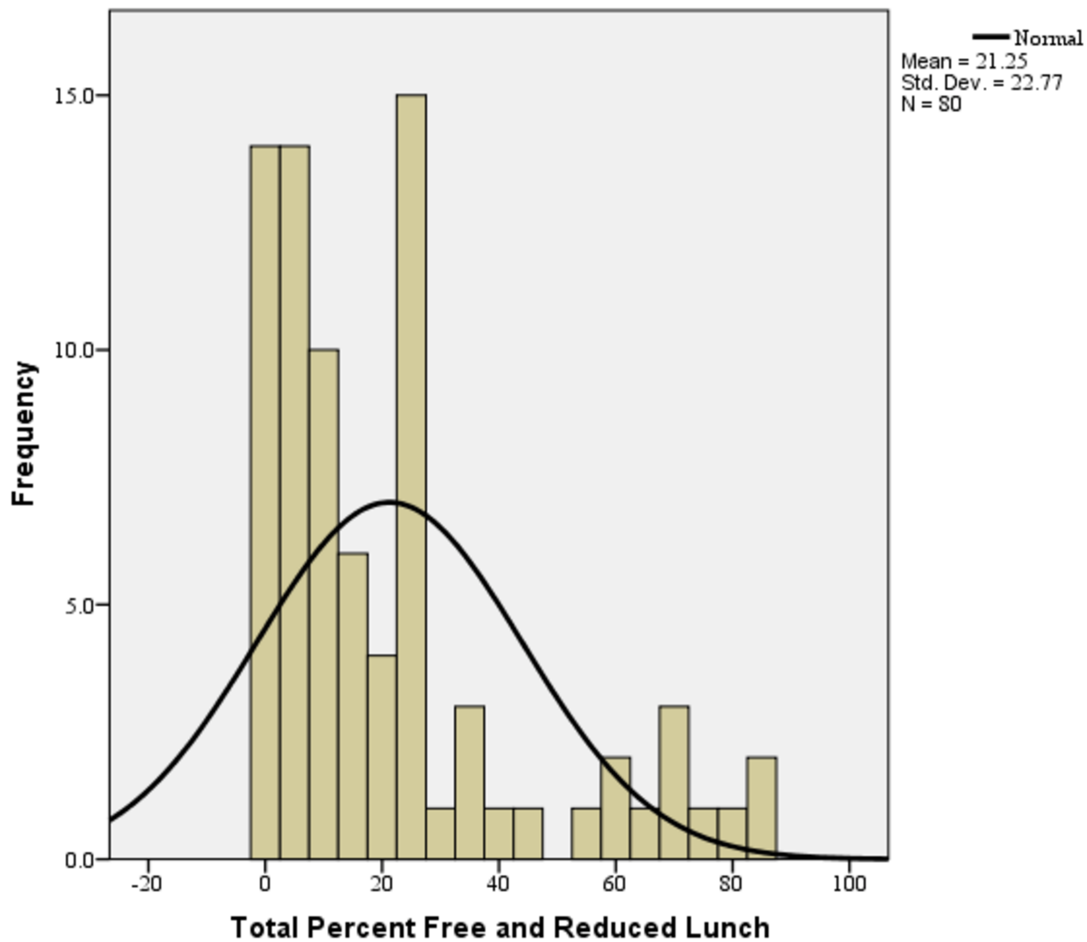


Figure 1. A histogram depicting the distribution of the percent of students who qualify for free and reduced lunch (FRL) at each student's school. A majority of high FRL-qualifying students came from Districts 2 and Districts 11. The mean percent FRL was 21.25% and most students came from more affluent schools. The data came from the Parent Pre-Questionnaires and the student registration data.

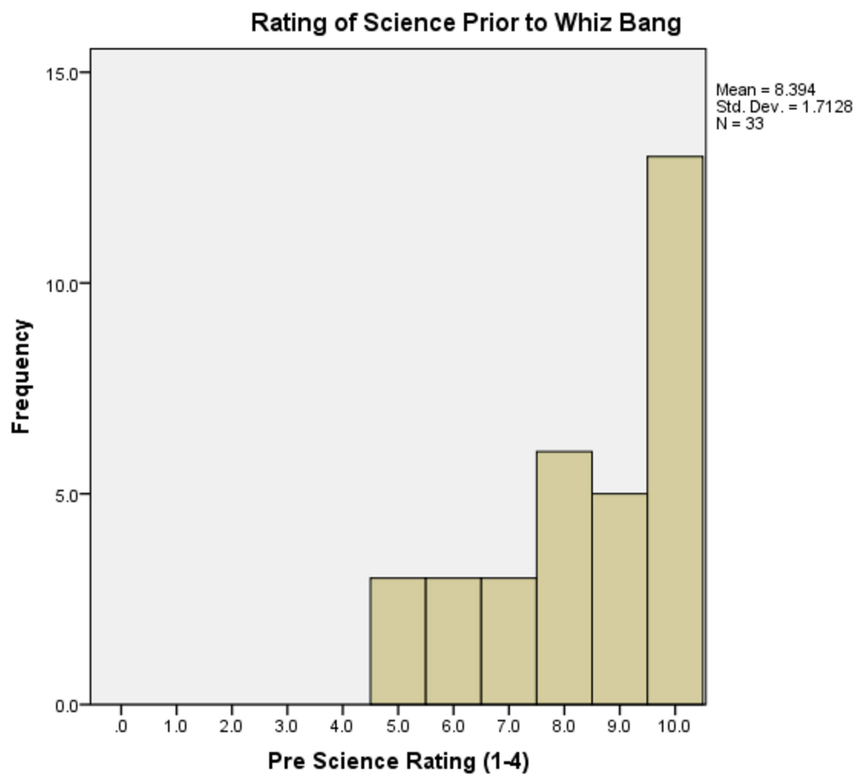


Figure 2. A histogram of the frequency of student responses (grades 1-4) when asked to rate their opinions of science on a scale of 0-10. A majority of the students entered Whiz Bang liking science or having a neutral opinion. The data came from the student pre questionnaires.

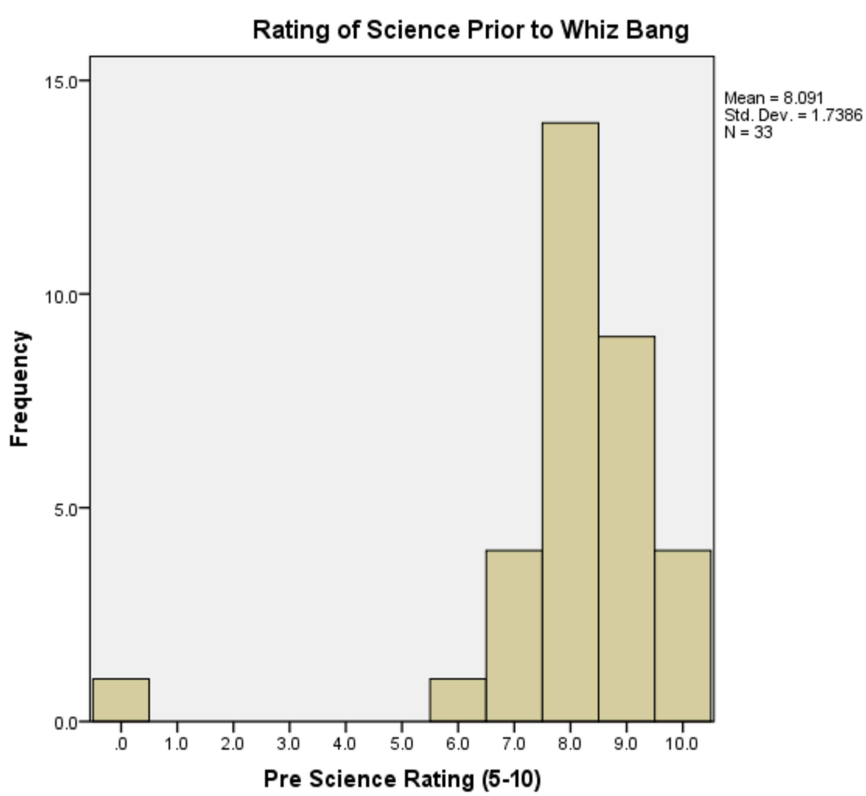


Figure 3. A histogram of the frequency of student responses (grades 5-10) when asked to rate their opinions of science on a scale of 0-10. Most students entered Whiz Bang liking science and only one student who took the survey didn't like science. The date came from the student post questionnaires.

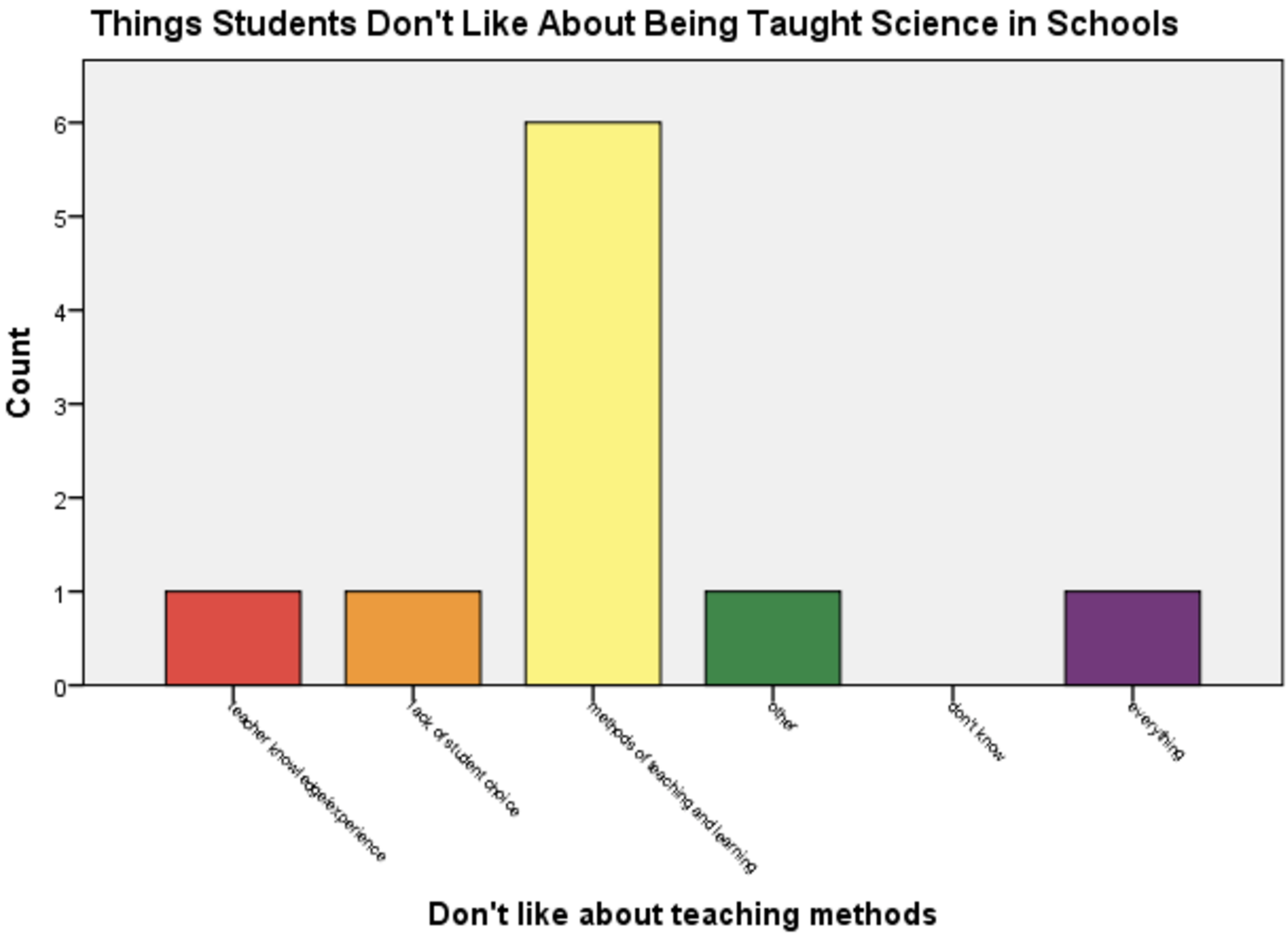


Figure 4. A histogram of student responses (grades 5-10) when asked the question: “What do you not like about the way you have been taught science?” All of these factors are related to the teacher’s disposition or the way the teacher chooses to teach science. The data came from the student pre questionnaires.

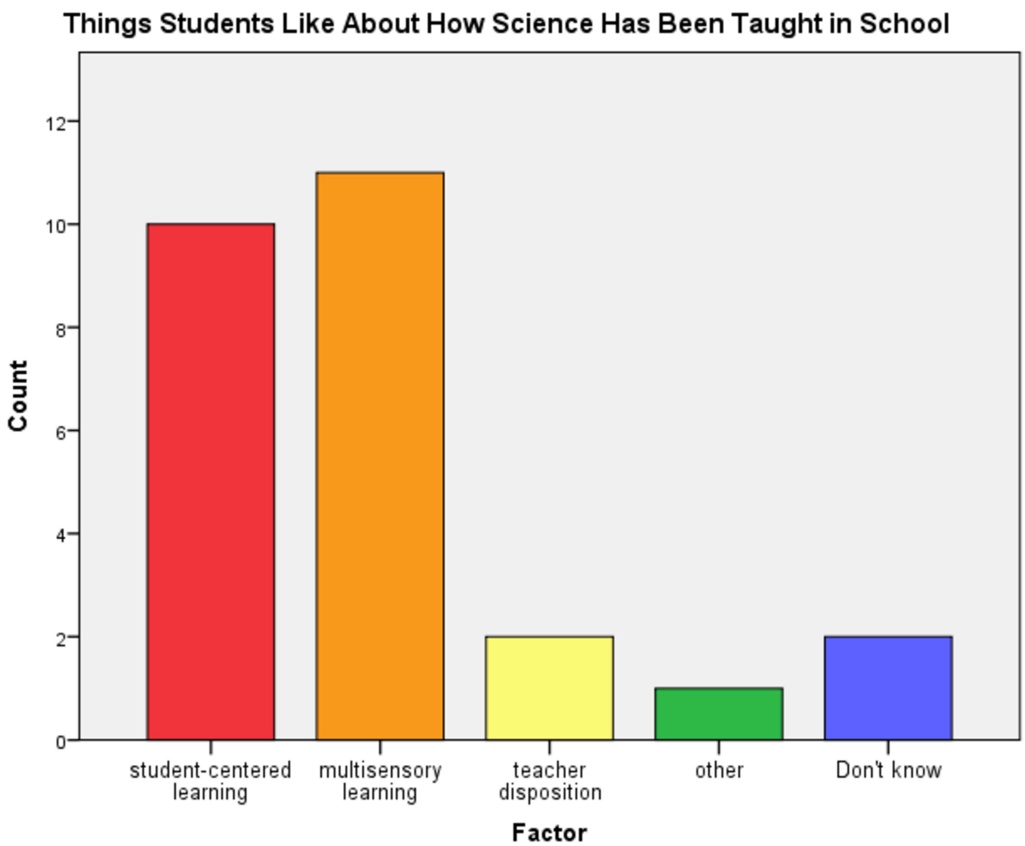


Figure 5. A histogram of student responses (grades 5-10) when asked the question, "What do you like about how science has been taught in school?" Most of these responses were related to "hands-on learning" or "doing projects." The data came from the student pre questionnaires.

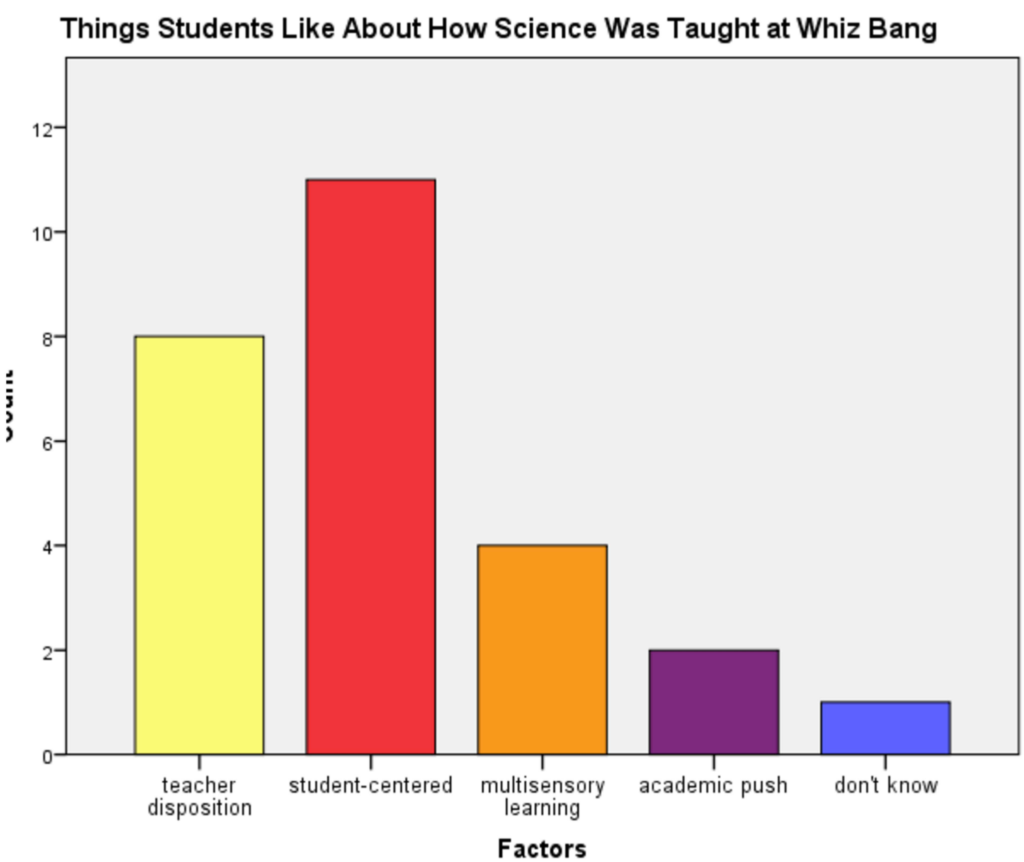


Figure 6. A histogram of student responses (grades 5-10) when asked the question, "What did you like about how you were taught science during Whiz Bang?" More students referenced the Whiz Bang teachers' dispositions than did students responding about school science. The data came from the student post questionnaires.