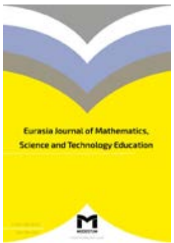

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“Doing Science” in Elementary School: Using Digital Technology to Foster the Development of Elementary Students’ Understandings of Scientific Inquiry

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ABSTRACT

National efforts have described the need for students to develop scientific proficiency and have identified informal learning environments, interactive technologies, and an understanding of inquiry as ways to support this development. The Habitat Tracker project was developed in response to this need by developing a digitally-supported, inquiry-oriented curriculum focused on engaging elementary students in science practices in formal and informal settings. This study employed a mixed methods approach to explore how engagement in the project affected 125 fourth and fifth grade elementary students’ views of scientific inquiry and if certain aspects of scientific inquiry were shaped by student participation. The Views of Scientific Inquiry – Elementary School Version (VOSI-E), was administered before and after students had engaged with a three week Habitat Tracker curriculum and assessed aspects including the role of questions, diversity of methods, experiments and investigations, developing scientific explanations, supporting scientific explanations, predictions and hypotheses, role of subjectivity, role of creativity, and goal of science. VOSI-E responses were analyzed using a mixed methods approach. Chi-squared test results suggest that classroom learning coupled with visits to a wildlife center can help improve student understanding of scientific inquiry when integrated with technology-enhanced, field-based inquiries that emphasize the practices of science.

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State of the literature

- To become scientifically proficient students must engage in the *doing* of science.
- Learning that occurs across formal and informal settings through authentic experiences can engage student with real-world phenomena; however, learning opportunities across settings must be connected.
- Interactive and mobile technology have been assessed for the learning opportunities they afford learners. Less is known about how technology can help students engage in the practices of science.

Contribution of this paper to the literature

- Involving elementary students in digitally supported scientific inquiries to collect data in novel, informal contexts has an intuitive appeal. Yet, there is a clear need for research that examines learning in these contexts.
- This study examines elementary students' views of scientific inquiry and the specific aspects that are most challenging when they engage in a digitally-supported scientific inquiry-oriented curriculum inside and outside the classroom.
- Study findings suggest elementary students' understanding of scientific inquiry are largely naïve and difficult to shape, but can be developed when curriculum is structured around technology-rich supports in formal and informal settings.

Keywords: practices of science, scientific inquiry, informal science education, elementary students, digital technology

INTRODUCTION

It has long been recognized that to understand science and to be able to apply it requires students to master the process of science and be able to conduct scientific investigations (Duschl, Schweingruber, & Shouse, 2007). The *Framework for K-12 Science Education* (National Research Council [NRC], 2012) and the *Next Generation Science Standards* (Next Generation Science Standards [NGSS] Lead States, 2013) that followed have established a three-dimensional perspective to science education, which encompass a set of core ideas, crosscutting concepts, and scientific practices. These dimensions support student development across four strands of science proficiency: a) knowing, using, and interpreting scientific explanations; b) generating and evaluating scientific evidence and explanations; c) understanding the nature and development of scientific knowledge; and d) participating productively in scientific practices and discourse (Duschl et al., 2007). Two additional strands of proficiency, specific to informal settings, provide opportunities to foster affective dimensions of learning through: e) engagement and motivation of students to study about natural phenomena by providing them with experiences in the physical world; and f) the development of science learning identities as students are put in the position of scientists allowing them to practice the processes of science (Bell, Lewenstein, Shouse, & Feder, 2009).

One of the more direct ways of engaging students in three-dimensional "knowledge-building processes that are the core of science" (Duschl, 2008, p. 269) to develop their proficiency in science is to engage them in inquiry. According to Abrams, Southerland, and Evans (2008), inquiry is "any cognitively appropriate activity that echoes some subset of the practices of authentic science in which students are expected to engage with resources (literature, people, environments) around the generation or answering of questions or the solving of problems" (p. xxxiv). Inquiry, however, has not been prominent in K-12 instruction and it is not frequently employed as a strategy for teachers to engage students in science and science learning (Capps, Crawford, & Constas, 2012), particularly at the elementary level (Lee, Lewis, Adamson, Maerten-Rivera, & Secada, 2008). Some of the reasons for this absence include the difficulties teachers have in incorporating scientific inquiries into their curricula due to time constraints, accountability pressures to meet national and state standards, lack of resources and support, and limited in-service training (Abrams et al., 2008; Anderson, 2002).

Scientific Inquiry and Informal Environments

Bell, Smetana, and Binns (2005) describe four types of inquiry that provide varying opportunities for students to engage in the practices of science: a) *confirmation inquiry* – students corroborate a principle by completing an activity where the results of the inquiry are already known; b) *structured inquiry* – the teacher provides a question or problem to the students along with a set of prescribed procedures to follow in order to answer the question or solve the problem; c) *guided inquiry* – the teacher presents a question or problem and the student designs or selects the procedures to answer the question or solve the problem; and d) *open inquiry* – the student formulates questions or problems and designs or selects the procedures to answer the question or solve the problem. Regardless of the type of inquiry, there has been a move to provide students with multiple learning opportunities (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003; Eshach, 2007; Hofstein & Rosenfeld, 1996; Marty et al., 2013) across formal classroom and informal settings, such as museums and wildlife parks (Griffin, 2004; Hwang, Tsai, Chu, Kinshuk, & Chen, 2012; Kisiel, 2007; Knapp & Barrie, 2001; Rennie & McClafferty, 1995) to develop "habits of mind" (American Association for the Advancement of Science, 1993, p. 281) associated with inquiry.

Informal environments can be described as settings where scientific inquiries can be practiced through authentic experiences with real-world phenomena (Bitgood, Serrell, & Thompson, 1994; Bell et al., 2009; Looi et al., 2016; Vitone et al., 2016). Learning that occurs in these environments can fuse affective and cognitive learning, meld education and recreation, and engage students in inquiry activities including "identification, observation, imagination… and discovery" (Bitgood et al., 1994, p. 63) without the pressure of classroom norms. The connections that occur in informal settings bridge prior and new knowledge and experiences together more quickly, resulting in stronger and new associations (Bitgood et al., 1994; Falk & Storksdieck, 2005). These connections, however, are stymied when visits are not tightly interwoven with classroom activities (Avraamidou & Roth, 2016; Bell et al., 2009; Zimmerman & Land, 2017). If students are not familiar with at least some aspects of scientific inquiry prior to their informal learning experiences, they will be unable to make the connections associated with these environments (Bitgood et al., 1994), thereby reducing the benefit of classroom curriculum and field trip activities.

It is not clear, however, if teachers recognize the potential to leverage informal settings. Cox-Petersen and Pfaffinger (1998), for example, found teachers who brought their classes to the Discovery Center of the Natural History Museum of Los Angeles County had little preparation for their visits. Anecdotal explanations include two teachers who said that they did not want to influence the children's experience, and others reported that they did not have enough information or the time to prepare students. Although this is a dated reference, more recent work suggests that things have not changed. In 2012, Morag and Tal interviewed participants from 22 schools and found that only 27% of schools had prepared their fourth through sixth grade students in advance for their trip to a nature park, and that only 5% had connected the trip to the school curriculum.

It is important to note that even when teachers attempt to create a direct connection between field trips and their curricula, the result is not always engaging. In a study of teacher-guided field trips to a natural history museum in Los Angeles, Kisiel (2003) found that only 7% of groups arrived with preplanned student projects. Similarly, Holmes (2012) used pre- and post-reports to assess the activities teachers had conducted before, during, and after a visit to a children's museum for math and science. Although more than half of the teachers had students complete reading assignments, watch videos, or undertake experiments before their trip to the museum, less than 20% had students do an activity while at the museum. In both the Kisiel and Holmes studies, when teachers gave students assignments to complete at the museum they often used task-oriented activities (e.g., label-reading to develop general vocabulary and language use) that distracted or impeded student learning from the exhibit or museum activity (Griffin & Symington, 1997; Price & Hein, 1991). Moreover, a majority of teachers do not have specific follow-up lesson plans to connect museum field trip learning with curriculum or post visit activities (Anderson & Zhang, 2003; Griffin & Symington, 1997).

Technology and Engagement in Informal Environments

It is common for students to perceive museums as austere environments in which to passively view objects (Hall & Bannon, 2006; Soloway, 1991). Incorporating technology into field trip experiences to focus students and scaffold their science learning may be the first step in providing immediate stimuli to a technologically advanced generation (Csikszentmihalyi & Hermanson, 1995). Many researchers have investigated the use of interactive technologies and mobile computers for improving educational experiences in informal learning environments (Economou & Meintani, 2011; Proctor, 2011; Rogers & Price, 2009; Tallon & Walker, 2008). Although some progress has been made in assessing the learning opportunities these technologies can afford the informal learner (Filippini-Fantoni & Bowen, 2007; Schaller & Allison-Bunnell, 2005; Wakkary & Evernden, 2005; Woodruff, Rosenholtz, Morrison, Faulring, & Pirolli, 2002), few researchers have examined the ability of these contributions to encourage students to play an active role in their own learning (cf. Alexander, 2006), or the degree to which these technologies can support students' engagement in the practices of science (Vogel, Spikol, Kurti, & Milrad, 2010).

PURPOSE OF THE STUDY

Current national efforts have described the need for students to develop science proficiency, a process that must begin in the early grades (Duschl et al., 2007). The NRC (Bell et al., 2009) has identified the need to leverage informal venues to support this learning, and describes the role technology can and should play in supporting student learning (see also Bawden, 2008; Eshet-Alkalai, 2004; Hobbs, 2011). The goal of this study, therefore, was to determine what students learn from participating in a digitally-supported curriculum focused on engaging elementary students in the practices of science in both the classroom and in informal settings. The research questions included:

1. How do elementary students' views of scientific inquiry change when they engage in a digitally-supported scientific inquiry-oriented curriculum in both the classroom and in informal settings?
2. Which aspects of students' understandings of scientific inquiry are the most challenging for students to learn when they participate in a digitally-supported, inquiry-based curriculum in both the classroom and in informal settings?

METHODS

These research questions were explored before and after fourth and fifth grade elementary students had engaged in an educational project. The project, Habitat Tracker (http://tracker.cci.fsu.edu/), was structured to use online and mobile learning technologies while students conducted inquires in the classroom and on a field trip to a local wildlife center as part of a larger curriculum focused on understanding scientific inquiry and nature of science (Marty et al., 2013). Pre- and post-responses to an open-ended questionnaire developed by Schwarz, Lederman, and Lederman (2008) called The Views of Scientific Inquiry - Elementary School Version (VOSI-E) were evaluated using a mixed methods approach. The VOSI-E was analyzed by two of the authors who began by qualitatively categorizing student responses into one of three levels (i.e., naïve, transitional, or informed) across nine aspects related to scientific inquiry (listed below) associated with questionnaire prompts (See Appendix A for a rubric developed by the authors). The number of instances a word or term occurred by level and aspect of scientific inquiry were tallied and analyzed to answer each of the research questions. To answer research question 1, tallies of levels were used to evaluate overall changes in students' views of scientific inquiry before and after engagement in Habitat Tracker. To answer research question 2, tallies of levels by specific aspect of scientific inquiry were used to evaluate changes in students' responses about each aspect.

Participants

One hundred and twenty-five fourth and fifth grade elementary students from four public elementary schools in two school districts in north Florida participated in the study. The participating schools represented a mix of rural, urban, and laboratory schools that serve a diverse group of students with varied scores on Florida's standardized accountability measures. Teachers selected to participate in this study had senior level experience,

Table 1. Habitat Tracker modules

	Lessons	Activities	VOSI-E Constructs
Module 1 5 lessons 4 class periods	• Observation and Inference: "The Burning Candle" (Bell, 2008) • Defining Science & Its Goals (National Academy of Sciences, 1998) • Scientific Knowledge: "Fossil Footprints" (National Academy of Sciences, 1998) • Boundaries of Science—What Science Is Not (Evolution & the Nature of Science Institutes, 1999a) • The Role of Subjectivity and Creativity in Science (Evolution & the Nature of Science Institutes, 1999b).	Students: • explore what science is and is not and establish the goals of science • create their own understanding of how scientists go about developing and answering questions • engage in inquiry activities that help them to understand the empirical nature of science and to develop skills in making observations and inferences	• The Role of Subjectivity • The Role of Creativity • Goal of Science
Module 2 4 lessons 7 class periods	• Learning to Conduct a Scientific Investigation Part 1: Methods of Science & Background • Learning to Conduct a Scientific Investigation Part 2: Developing Scientific questions • Conducting a Scientific investigation Part 1: Collecting Data (Field trip) • Conducting a Scientific Investigation Part 2: Analyzing & Presenting Data	Students: • participate in activities to understand investigations and experiments • conduct background research • generate research questions and determine if they can collect the data during the field trip • collect scientific data during a field trip to the wildlife center • analyze data, provide evidence to support their conclusions, and answer their scientific question(s)	• The Role of Questions • Diversity of Methods • Experiments and Investigations • Developing and Supporting Scientific Explanations • Predictions and Hypotheses
Module 3 2 lessons 2 class periods	• Scientific Experiments Using the Inquiry Activity "Pendulums" • Nature of Science Wrap Up	Students: • explore the characteristics of scientific experiments • engage in activities and discussions that emphasize that not all science involves experimentation	• The Role of Questions • Diversity of Methods • Experiments and Investigations • Developing and Support Scientific Explanations • Predictions and Hypotheses • The Role of Subjectivity • The Role of Creativity • Goal of Science

participated in a training workshop, and faithfully implemented the curriculum during the first year of the project (this research was part of a three-year project). Teachers implemented the curriculum over the course of three weeks. One researcher was in each classroom during project implementation to provide support and ensure faithful implementation. Multiple project staff were available during the field trip at the wildlife center to provide technical and logistical support.

Curriculum

The Habitat Tracker curriculum (http://tracker.cci.fsu.edu/teacher/) took place over three modules lasting three weeks focusing on understanding scientific inquiry and the nature of science. In Module 1, students engaged in five structured- and guided-type inquiry activities. In Module 2, students develop their scientific inquiry skills over the course of four lessons, which includes a field trip to a wildlife center. Module 3, took place over two lessons in which students explored what a scientific experiment entails and engaged in an activity to help them understand that science can be conducted in multiple ways. See **Table 1** for a description of each module including a list of lessons, the activities the students engaged in, and the VOSI-E constructs that align with each module.

The curriculum was structured to use online and mobile learning technologies to engage students in the practices of science as they conducted scientific inquiries on field trips to a local wildlife center (Marty et al., 2013). Students used a custom-designed mobile learning (iPad) application and integrated website to work with digital journals and online databases to gather, share, and analyze scientific data about wildlife and natural habitats.

Teachers implemented the curriculum in their own classrooms for three weeks with the help of technical and logistical support from Habitat Tracker staff.

Instrumentation and Data Collection

The VOSI-E questionnaire (Schwartz et al., 2008) was used to assess students' understanding of scientific inquiry concepts three days prior to and three days following the Habitat Tracker curriculum. This instrument has been used by other researchers focusing on the learning of elementary students around scientific inquiry (Granger, Bevis, Saka, Southerland, Sampson & Tate, 2012) because its open-ended nature allows students to express their conceptions; it does not impose views on students, as is the case with Likert style or multiple-choice instruments. This survey included two open-ended items and two multi-part, open-ended items focusing on the role of questions, diversity of methods, experiments in comparison to investigations, developing scientific explanations, predictions and hypotheses, role of subjectivity and creativity, and the goals of science. Students were instructed the goal was to know what they think about science and how it is done; that some questions had more than one part; that there were no right or wrong answers; and that they could draw pictures to help explain ideas. Question 1and 2, asked students what kinds of work scientists do and to explain this work. Question 3 and 4 presented a description of a scientific study of beak shape and food preference and asked students whether they thought the work was scientific and experimental. Students were asked to provide explanations for their answers after each of these two questions. Questions 5a, 5b, and 6 presented the idea that "A long time ago all the dinosaurs died. Many scientists are trying to find out why this happened." Students were asked to consider whether the scientists would all come up with the same reason for why dinosaurs died, to explain their answer, and to identify the information that scientists use to explain their reasoning. It took approximately 30 minutes to complete the survey.

Data Analysis

Given the open-ended nature of the VOSI-E responses, data had to be qualitatively interpreted and quantitatively scored. To that end, the researchers employed a three level (naïve, transitional, and informed) scoring rubric (see Appendix A) developed by the researchers in order to guide the process of coding the research data for the use of words or terms given by a student in response to an open-ended question. Each word or term was considered an instance, and the use of a common scoring rubric provided a basis for quantitative analysis and helped ensure consistency across the coding process between the researchers.

Students' responses were coded based on the nature and depth of information provided. Naïve views of scientific inquiry received a score of one and indicated that students held very basic understandings of concepts; transitional views received a two and indicated that students understood concepts at a somewhat moderate level; and informed views were scored as a three and indicated that students held fairly robust understandings of concepts. Two researchers scored the participants' VOSI-E answers separately with a Cohen's kappa inter-rater reliability of the scores of 0.74 (Cohen, 1992). Given that the scoring rubric resulted in categorical data, a 2x3 contingency table chi-squared test was conducted to determine if there were significant differences between pre- and post-survey scores.

FINDINGS

Prior to participating in the Habitat Tracker curriculum, students' VOSI-E scores indicated an overall naïve understanding of scientific inquiry (**Table 2**). The pre-survey identified 945 instances of naïve responses, 173 transitional responses, and only 7 informed responses.

Student views of scientific inquiry improved after participating in the Habitat Tracker curriculum. Overall, there was a statistically significant difference in distribution between pre- and post-VOSI-E scores χ^2 (1, N=2250) = 51.10, $p < .001$, with a Cramer's phi effect size of Φ=.15. The effect size, however, suggests a low practical significance. While the majority of students continued to hold naïve views, there was an increase in the number of transitional and informed responses held by students as a result of participation in the program (see **Table 2**). The post-survey identified 814 instances of naïve responses, 278 transitional responses, and 33 informed responses.

Table 2. Changes in students' views of scientific inquiry

VOSI-E	Naïve	Transitional	Informed
Pre-survey	945	173	7
Post-survey	814	278	33

Table 3. Changes in students' responses about specific aspects of scientific inquiry

	χ^2	*df*	*P*	Φ
1. Role of Questions	14.36	2	< .001	.24
2. Diversity of Methods	6.59	2	.04	.16
3. Experiments and Investigations	7.28	2	.03	.17
4. Developing Scientific Explanations	6.22	2	.01	.16
5. Supporting Scientific Explanations	26.08	2	.001	.32
6. Predictions and Hypotheses	*	---	---	---
7. Role of Subjectivity	11.37	2	.003	.21
8. Role of Creativity	1.00	2	.32	---
9. Goal of Science	1.91	2	.17	---

N = 250, *no change between pre- and post-test

Cramer's Φ effect size range: .10 is small, .30 is medium, .50 is large (Volker, 2006)

The VOSI-E instrument measured nine aspects of students' understanding of scientific inquiry (see **Table 3** for a list of the aspects). Significant differences in distribution of the changes of students' understanding before and after instruction were found in six of these aspects including roles of questions, diversity of methods, experiments and investigations, developing scientific explanations, supporting scientific explanations, and role of subjectivity. As shown in **Figure 1**, students originally held largely naïve views for each of these aspects. Only one category, role of subjectivity, had a high number of transitional responses compared with naïve and informed responses before the intervention, of which most responses were from fifth grade students. Predictions and hypotheses, role of creativity, and goal of science saw no shift in student understanding. In fact, predictions and hypotheses and role of creativity were among the aspects that had very few, if any, students holding transitional views before the intervention or after the intervention. Below we provide examples of each of the six aspect for which significant differences occurred between levels before and after the intervention. All quotes are presented exactly as written by the students.

Role of Questions

Much like the aspects of predictions and hypotheses and role of creativity, very few students held transitional or informed views of the role of questions before the intervention. However, unlike the other two aspects, students increased their understanding in this aspect, with more transitional responses occurring after the intervention than before. The VOSI-E includes a question that asks students how "scientists do their work" to assess this aspect. One student responded in the pre-survey with a naïve view, answering the question with a response of "Once they are finished with an experiment the scientist see what others had." This student presented an informed view in the post-survey, writing, "First, scientist ask a question, next the scientist research what their question, then the scientist make a hypothsis to help state their question, after that the scientist will experiment for an answer to their question."

Diversity of Methods

Before the intervention most students held naïve views in term of the diversity of methods employed in science, although some held transitional views on this topic. After the intervention, the number of students holding naïve views decreased and the number of students holding transitional views increased. An example of a student's movement in the understanding of this aspect can be seen when comparing a pre- and post-survey response to a question asking about how scientists do their work, the same question used to assess the role of questions above.

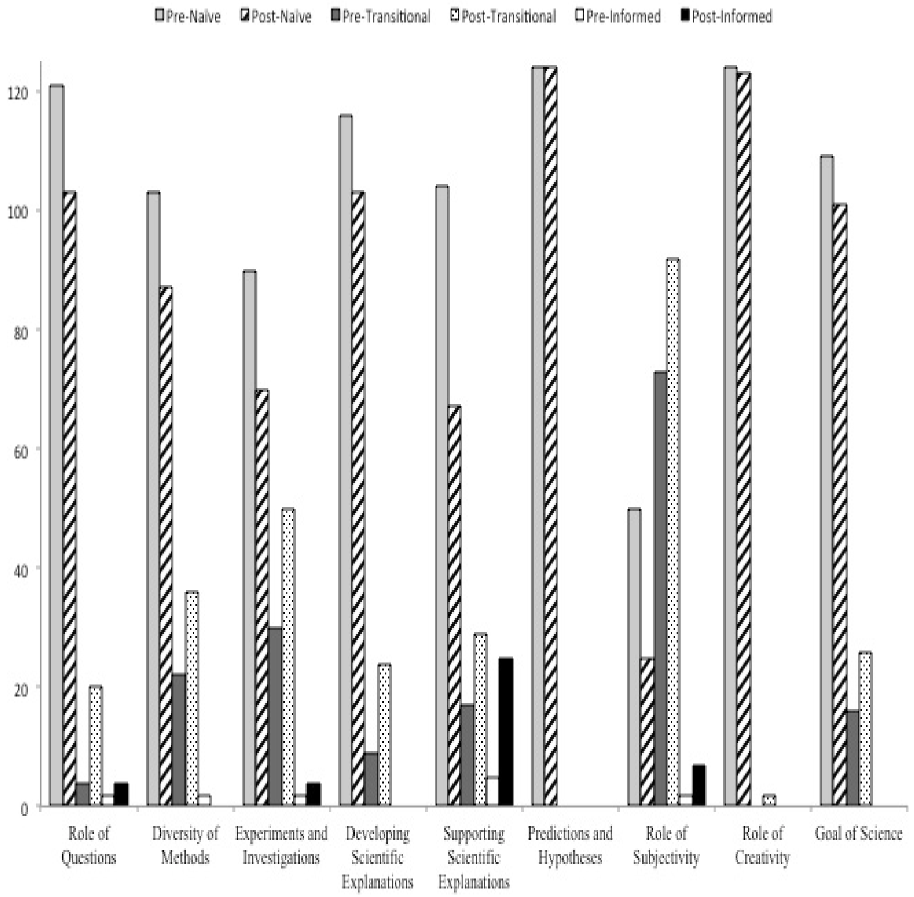

Figure 1. Number of responses before and after intervention at each level of sophistication for each of the concepts related to scientific inquiry (N=125)

Before the intervention this student expressed naïve views by stating, "scientists go to different places and try to uncover things or find things." In the post-survey the student wrote, "scientists do their work by doing experiments and making observations," indicating transitional understanding.

Experiments and Investigations

As was the case for diversity of methods, the aspect of experiments and investigations initially saw students holding largely naïve views complemented by a far smaller number of those holding transitional views. After the intervention, fewer students held naïve views, while transitional and informed views increased. Students' learning in this aspect is demonstrated in a student's response to a question asking if a scientist's work was scientific. A question was asked after students had read a short paragraph about a female scientist who found a connection between beak shape and food preference. One student originally responded that the work was scientific "because she talked about the bird," transitioning in their view upon completion of the intervention with a response of "because she did observation." Another student provided evidence of transformed views by answering that the scientist's work was scientific because "she clearly needed to use science to understand that" and that the work was not an experiment because "an experiment would be a lot more detailed." Originally this student provided a one-word answer of "yes" when asked if the work was scientific and experimental.

Developing Scientific Explanations

Students held largely naïve views about the aspect of developing scientific explanations before the intervention. After the intervention, students' naïve views decreased and their informed views increased. To assess this aspect students were asked about what information scientists use to explain their reasons for why dinosaurs died. One student originally presented a naïve view stating, "They ask the other scientists." In the post-survey response, this student presented a transformed view stating, "They use data from what they got from the evidence." Another student presented a naïve pre-survey answer stating, "They hapend by an astroyd. If that astoryd did not hit earth all the dinosaurs would not be dead." The transitional view this student presented on the post-survey was "A scientists use imfermashon of the data to find out the imformashon." Lastly, one student moved from naïve to transformed when writing in their post-survey answer that scientists use "data, infrence and observations" when they originally only responded with the word "observation."

Supporting Scientific Explanations

The aspect of supporting scientific explanations shows an interesting trend in student understandings before and after the intervention (see **Figure 1**). Before the intervention, students held mostly naïve views, augmented with a small number of those with transitional and informed views. After the intervention, the number of student responses with transitional views increased, while, unlike the other aspects, the number of student responses with informed views also increased. This is the only aspect that saw such a large movement towards informed views. Student learning gains in this aspect are demonstrated by a student's response to the question about how scientists use information to explain why dinosaurs went extinct. In this example, the student responded in the pre-survey with a naïve view that "they use the information that they got from the fossiles." In the post-survey, this same student offered the informed explanation that "they use their evidence." Another student held transitional views, answering the same question in the pre-survey with "observations, inferences, experiments." This student held informed views after the intervention, describing that scientists must use "evidence and facts from the past" to support their explanations.

Role of Subjectivity

The aspect of the role of subjectivity also presents an interesting trend as students held more transitional views of this aspect than naïve views before the intervention. After the intervention, naïve views decreased, while transitional and informed views increased. The dinosaur extinction question was used to address this aspect. In this question, students were asked if all scientists will come up with the same answer to explain the dinosaurs' extinction. The same question prompts students to give an explanation of why they believe this or why they may not. When asked if all scientists will come up with the same reasons, one student responded in the pre-survey with a naive view, answering "yes, because it seem like a logical reason." After the intervention, the same student answered with a transitional view stating, "different scientists have different theirs and a different way to find things." Another student answered similarly in his post-survey with a transitional view writing, "No, I do not think they will come up with the same answers" because "they all have different theories in life."

DISCUSSION

Of the 125 fourth and fifth grade students taking part in the study, most held limited sophistication levels on understanding of inquiry concepts at the outset, scoring at naïve levels before implementation of the Habitat Tracker curriculum. This naivety may be due to the lack of instructional time in elementary school science (Judson, 2013), the relative paucity of inquiry in the elementary science classrooms (Crawford, 2007), and the tendency to emphasize vocabulary-driven, final form science (Southerland, 2013; Lee et al., 2008). The Habitat Tracker curriculum addressed many of these shortcomings by providing a curriculum that scaffolded students in multiple and varied inquiry opportunities across a three week period. Indeed, engagement in the Habitat Tracker curriculum supported the shaping of some students' views of inquiry, indicating that many aspects of inquiry are not too complex for elementary students and that students are capable of developing knowledge of inquiry.

We focus on two factors particular to the Habitat Tracker curriculum that we posit helped shape students' understanding of specific aspects of scientific inquiry. First, we highlight how student engagement in activities situated in multiple contexts inside and outside the classroom setting provide students with opportunities to make connections between school and real-world science. Second, we discuss the integration of technology as a way to supports students as they engage in a digitally-rich, inquiry-oriented curriculum. We situate these factors in an example drawn from the inquiry activity that occurred around the field trip to the wildlife center, *Conducting a Scientific Investigation Part 1 and 2* (**Table 1**).

Multiple Contexts Inside and Outside the Classroom Setting

Learning that occurs across contexts, inside and outside the classroom, can be particularly salient to student understanding when they are purposefully connected (Behrendt & Franklin, 2014). Informal settings add to students' classroom learning by providing experiential learning opportunities with authentic, real-world phenomena (Bitgood et al., 1994; Bell et al., 2009) that can add relevance (Tal & Morag, 2009), as well as, provide unique opportunities not available in the classroom (Behrendt & Franklin, 2014). These authentic, real-world experiences position students to consider how science is conducted outside the classroom in ways that mirror the work of real scientists. However, these experiences become less useful when they are treated as stand-alone activities with minimal connection to what students are learning in the classroom (Cox-Petersen & Pfaffinger, 1998; Morag & Tal, 2012).

Although the Habitat Tracker curriculum was built to scaffold students through various activities that supported inquiry concepts over three weeks, it is the inquiry activity that occurred around the field trip to the wildlife center, *Conducting a Scientific Investigation Part 1 and 2*, that we draw upon here. The lesson bridged learning in the classroom and at the wildlife center in ways that supported inquiry concepts related to the role of questions, the diversity of methods, developing scientific explanations, and supporting scientific explanations. On the first day of the *Conducting a Scientific Investigation* lesson, before students had visited the wildlife center, they researched the center's animals and habitats and examined existing data. This research and analysis scaffolded students to develop their own research questions and to consider their research methods for collecting data about the question(s). On the day of the field trip, student groups used an iPad loaded with the Habitat Tracker application to collect observational data related to their research question(s) and to craft new research questions that originated from observing animals and their habitats. In this way, students were supported to consider how their experience and the new knowledge they developed at the center influenced the kind of questions that they might ask. After the field trip, back in the classroom, students examined their data and the data of others, which was part of a larger database of observations collected by previous students. They used this analysis to provide evidence to support claims developed to answer their research question(s). Each student group completed the module by creating a poster or PowerPoint presentation to share their findings with their peers.

The experiences students engaged in during the *Conducting a Scientific Investigation* by their very nature supported concepts related to scientific investigations in which students could investigate natural phenomena by making observations of animals. However, the experience did not provide opportunities for experimentation, such that a student could hold a variable constant to measure the reaction of another variables. To provide students with experiences with experimentation, in the last module of the curriculum, they explored characteristics of scientific experimentation. This provided students with opportunities to consider differences between investigations and experiments, which were emphasized in a discussion that wrapped up the Habitat Tracker curriculum.

Integration of Technology to Support Student Engagement in a Digitally-Rich, Inquiry-Oriented Curriculum

Many of the activities that students engaged in during the three-week Habitat Tracker Curriculum used traditional paper and pencil methods of engagement. However, students were supported through the integration of technology around the *Conducing a Scientific Investigation* lesson. In particular, technology supported students to develop their own research questions and to develop and support scientific explanations, and positioned them to consider the role of subjectivity while conducting a scientific investigation.

The first day of the *Conducting a Scientific Investigation* lesson occurred in the classroom where groups of two to three students conducted background research on animals and their habitats using the Habitat Tracker website. The information provided on the website was relevant to the animals and habitats students would observe at the wildlife center, while still providing students with enough breadth of information that they could choose about particular characteristics that interested them. Students also used the website's analysis tool to explore existing data, to craft their own research question(s), and to determine if they could collect the data needed to answer their question(s) when at the wildlife center. Using the website's digital journaling feature, students presented findings from their research, recorded their research question(s), planned for data collection, and commented on other students' posts.

On the day of the field trip, student groups used an iPad loaded with the Habitat Tracker application to conduct their investigation. Students used the application's data collection and journaling features to record animal, habitat, and weather observations, to record details of their experience, to craft new research questions that originated from observing specific animals and their habitats, and to read and comment on other student entries. When students collected data at the wildlife center they were supported to make observations that drew upon their existing knowledge of animal behaviors and weather conditions using the Habitat Tracker application. These observations positioned students to make choices about how they categorize their observations. For instance, a student making an observation about animal behavior at a bobcat habitat was presented with a screen in which they could choose among multiple predefined activities (e.g., resting, walking, drinking, or marking). The choices students made drew upon the subjective nature of observations such that students had to make judgment calls on what they say the animal doing at any given time, and to make distinctions in those activities. Further, students discussed these observations in the journaling tool, where they could see how other students may have considered similar activities from a different perspective (i.e., subjectivity).

After the field trip, back in the classroom, students completed their investigation using data analyzed from the Habitat Tracker database as evidence to support claims developed to answer their research question(s). The database made use of a dropdown type menu, which allowed students to consider what types of data they wanted to use to answer their questions, and provided them with varies types of tables and figures to support their explanations. This support allowed students to spend time considering the data that they would use to answer their questions and the best ways to communicate their evidence, while eliminating the requirement for students to physically graph their data. At the end of this lesson, student groups developed a poster or PowerPoint presentation using the graphs created through the Habitat Tracker website to communicate their findings.

Results related to the three aspects which saw no shifts in student views suggest that participation in Habitat Tracker did not help students understand the role of predictions and hypotheses in the conduct of investigations and failed to help develop their conceptions of the way in which scientific inquiries are creative (both in the design of investigations and the analysis of data). While these finding echo the results of Granger et al. (2012), who found that elementary students often do not understand how scientists go about their work, what constitutes scientific work, and what information is needed to explain scientific findings, they also point towards limitations in the use of technology to support student understanding. For instance, while the integration of technology supported students to develop scientific questions and to focus the types of data they collected by providing limited observational categories, it may be these very supports that resulted in no changes in student understanding of scientific inquiries as creative. The highly scaffolded nature of the Habitat Tracker website and app may have provided too structured of an inquiry experience, reducing the level of inquiry that a student could engage in (i.e., open inquiry) as described by Bell et al. (2005).

While some growth was identified in students' understanding of scientific inquiry, it is important to note that this growth was minimal at best. The limited nature of these findings speaks to a weakness of the Habitat Tracker curriculum. Although the inquiry activities the students participated in emphasized student engagement in the practices of science, the social practices of engaging in argument from evidence and communicating scientific information fell short as it was employed, even though some of the tools allowed for them. Future efforts must seek a balance among conceptual, epistemic, and social learning and provide scaffolds for the more social aspects of science learning that echo those employed in the data collection and analysis tools constructed for this project.

CONCLUSION

The research presented here suggests that fourth and fifth grade elementary students' understanding of scientific inquiry are 1) initially largely naïve and 2) difficult to shape, but 3) can be developed, even over a very short period of time. These findings also suggest that a curriculum structured around the use of technology and enhanced, field-based inquiries that focuses on developing students' proficiencies in terms of generating and evaluating scientific knowledge and participating productively in scientific practices and discourse, while no panacea, can play an important role in helping elementary students learn to "do science" (Duschl et al., 2007, p. 269). Engagement in such inquiries can put students on a path to becoming proficient in science.

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