Interactive Science Notebooks: Exploring the Extent Which Integrating a New Learning Tool Supports Self-Efficacy in Expressing Science Content Knowledge and Interest in Pursuing a STEM Related Career

Jessica Tanya Krachenfels

Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Curriculum and Instruction
(Integrative STEM Education)

Bradley Bowen, Chair
Jeremy Ernst
David Kniola
Thomas Williams
Cherie Edwards

May 13, 2019
Blacksburg, Virginia

Keywords: interactive science notebooks (ISN), science, technology, engineering, and mathematics (STEM)

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ABSTRACT
(Academic)

Interactive science notebooks, used as a learning tool during science instruction, was found to have a positive influence on student self-efficacy in expressing science content knowledge and interest in pursuing a STEM-related career. This study, involving 25 participants, discusses the integration of interactive notebooks into two elementary school classrooms in a rural Kentucky community over 55 instructional days. Through an explanatory sequential multiple-method research design, a quantitative survey given at two intervals, pre and post study, and qualitative student interviews, data found that 76% of the sample had an increase in their overall attitude toward science and 10 out of 12 STEM careers had an increase in overall interest at the conclusion of the study. The qualitative data, three oral interviews, revealed that 22 participants referenced an increase in science interest, two participants stayed the same, and one participant noted a decrease in interest. Nine participants felt that their interest in pursuing a STEM career remained about the same or had no significant changes since their initial survey and 16 participants referenced an increase in pursuing a STEM career in their final interview. This study aims to engage educators and administration in conversation about an explanatory sequential multiple-methods research design involving a unique population of transient students and the influence of a new learning tool used in the classroom.

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Dedication

With all of my heart, I would like to dedicate this journey to my brother P.J. Krachenfels. Your support has never wavered. You inspire me to be a better person. You are the calm to my impulsive spirit and I keep you in mind whenever I take leaps. At the end of every day and when I wake up in the morning to begin my next adventure, I know you are right there with me as my biggest cheerleader.

I would also like to thank Dr. Elizabeth Miller and Jessica Chavez Daugherty. You are my sisters through and through. There is something so fierce about your spirits that has drawn me from the moment I met you. Thank you for supporting me each and every day. My life is so much more meaningful because of you.

Acknowledgements

I would like to express my sincerest gratitude to my advisor, Dr. Bradley Bowen, for his guidance, feedback, support, and regular Zoom chats to help reign in my wild ideas and calm my worries. My PhD journey has been one of the toughest challenges I have conquered and I appreciate your significant presence. I would also like to thank my committee members Dr. Jeremy Ernst, Dr. Cherie Edwards, Dr. David Kniola, and Dr. Thomas Williams for your willingness to answer my questions, foster my growth as a researcher, and provide valuable insight which has allowed me to become a better student and educator.

Thank you Dr. Christine Sherretz, Laura Gibson, Denise Stevens, Angie Bragg, Debbie Bluestone, Rick Thompson, and Rachael O'Donnell for being my EduFam. You have been a part of my daily world for many years and bring such a positive light to our profession. You make a difference and I am thankful that our professional and personal lives have intertwined.

I would also like to acknowledge West Point Elementary and Ray Flores for welcoming me with open arms. Thank you, Lena Ross and Angela Chenault, two phenomenal educators that inspire everyone around them. Your willingness to integrate Interactive Science Notebooks into your classroom, your support, collaboration, and openness to help me has given my PhD journey a greater meaning now that I have had the privilege of working with you.

Finally, I would like to acknowledge my parents. I am strong-willed, independent, determined, and fierce. All characteristics make for a difficult child, yet you still have my back. I have always been one to pave my own way and even more determined to make my own decisions and I thank you for acknowledging my desire to do so.

My PhD journey is not one that I can claim solo credit for because of the people I've met and the experiences I've had have all greatly contributed to my success. Thank you.

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CHAPTER 1 INTRODUCTION

The transient lifestyle of a migrant farm worker or single parent seeking employment all has one goal in mind, provide for the family. From construction jobs in Florida, the cotton fields in Texas, to the horse stables of Kentucky, the transient child learns how to adapt to a new environment, transition into a new classroom in the middle of a school year, adjust within the parameters of new social circles, and sometimes learn a new language depending on where their new home is located. According to the Statewide Comprehensive Needs Assessment and Service Delivery Plan (2016), there were 4,563 K-12 students eligible to receive support from the Kentucky Migrant Education Program. That number had risen by seven hundred students from the previous year. Migrant students are present in four hundred sixty-two schools across the state and the communities that surround these schools recognize the unique atmosphere that must be provided in order to support the children that walk through the doors each and every morning. Teachers and staff are trained by school counselors and non-profit organizations about the effects of migrant families and the impact of moving seasonally based upon crop harvests or every few years seeking employment and its effects on academics and behavior. Migrant students may have added challenges compared to their peers, but over the past several years teachers, parents, and community partners have voiced their concerns and needs in order to support this unique population. The state is responding through funds, professional development, and providing supplemental academic support for students that qualify during summer months and after school programs (ESCORT State University of New York at Oneonta, 2016).

In 2011, Kentucky was considered a state leader in the development of the Next Generation Science Standards (NGSS) with Achieve, Inc. (KY Department of Education, 2018) and developed a STEM initiative in an effort to provide students with opportunities to thrive in the fields of science, technology, engineering, and mathematics. Not only was this the direction of many other districts and states, but this was also in response to the White House's call to stimulate the pursuit of continued education and careers in STEM disciplines. Schools all across Kentucky began to organize school-wide events promoting their efforts in developing 21st Century learners and K-12 teachers began short-term projects within their classrooms to better integrate disciplines, increase their collaborative efforts, and reignite the love of learning within their students. In the study's rural setting along the Ohio River, the STEM initiative was a direct need. Teachers had noticed a decline in student participation and science was not a regular component of daily classroom life due to a demand in increasing reading and mathematics test scores. Pedagogical practices needed updating, professional development needed to foster growth in sciences, and standards needed to be revamped. With the adoption of Next Generation Science Standards in June 2013 (KY Department of Education, 2018) there was a new light shed on science yet the nature of the school's funding has continued to plague their growth and development even in 2019. As schools slowly began to acknowledge the 21st Century learner there was a common conversation among stakeholders that the content existed and there were improvements in how science content was being presented, but it was still evident that students struggled to comprehend concepts. There was something missing.

Science became a new buzzword as a result of the state's adoption of Next Generation Science Standards (NGSS). Teachers were bringing in toy cars and racetracks for a demonstration on force and motion, kindergarten teachers were dropping a variety of balls at the top of playground equipment to demonstrate gravity, third grade teachers had purchased rock kits, fourth grade teachers used Oreos to demonstrate the phases of the moon, and both parents and students were saying how *fun* science had become. There was *still* something missing. Despite an increased effort in hands-on learning, teachers recognized that there was limited transfer of knowledge as students were recording or explaining the phenomena of study. Primary teachers began using pictures or cut and paste activities and upper elementary teachers were using more traditional methods of written response to teacher generated questions. This eventually led to the use of using a science notebook to have a regular record of learning during science lessons. The use of science notebooks in the classroom is not an uncommon practice across grade levels. There are multiple versions and uses of notebooks or journals in a learning environment and appear differently across grade levels, but Fulton (2012) states that if writing is not a common practice within science lessons then science notebooks tend to be prescribed or dictated. On the opposite end of the spectrum they can also be too open-ended or ill-structured that they do not serve a true purpose for students as a learning tool. Jaladenki and Bhattacharya's study of a high school physics teacher's use of journals as a learning tool were used to increase interest in subject matter and generate academic achievement success. The researchers explain that interactive journals increase student output through a two-column format which helps students to categorize and process information in an engaging and creative way that turns into a reference tool of information through student selected representations such as Venn diagrams, concept maps, graphic organizers, diagrams, poems, and songs (Young, 2006). Through this framework, students are better able to interact with the content and represent their understandings in a differentiated and meaningful way. Therefore, interactive science notebooks provide an opportunity to influence interest and success in a content area which may have been previously out of reach.

Rationale

Through the use of interactive notebooks for inquiry-based science, Chesbro (2006) details how they serve as an opportunity to promote constructivist pedagogical practices which represent a differentiated record of learning throughout an entire school year. Interactive science notebooks, as described by Chesbro (2006), are an engaging method of tracking content which promotes higher-order thinking skills and allows for students to personally connect with their grade level content. Teachers view notebooks as a differentiated learning tool that documents student thinking according to their own conceptual understanding of content (Gilbert & Kotelman, 2005) and fosters the opportunity for students to become an active learner. Through this increased engagement with the curriculum and grade-level standards, there is a need to research the extent at which the use of an interactive notebook impacts student self-efficacy in expressing science content. At the elementary school level, students are typically given explicit directions in how to represent learned content as dictated by the classroom teacher. This may be due to assumptions that students don't yet have the skill to represent their understanding in a variety of ways or have not been taught alternate methods. The method by which a teacher chooses for all students to demonstrate the learned content is not differentiated by need or may not be a method of interest for students, thus hindering students in truly representing their understanding of the content standard. The ability for a student to choose and interact with their own learning may provide a new lease on how they view their own success in science. Integrating interactive science notebooks allow students to visualize science content which is often viewed as abstract information. Visualization, as a means of data collection, discovery, exploring phenomena, and critical thinking has a profound impact on the world around us. The genres of visualization: scientific and simulations, historical, infographics, and interactive are used to inform, influence, explain, and conceptualize ideas. Ferster and Shneiderman (2014) found that in a problem-based learning environment, visualization allows students to comprehend content in an authentic and constructive way which promotes the learning styles of

21st Century learners. It is through visualization that sets apart an interactive science notebook from a traditional notebook or journal.

A student with high self-efficacy believes that they will be able to achieve or surpass their performance expectations in future tasks allowing them to overcome obstacles and challenges in their learning process. Therefore, if you believe in yourself then you are more prone to pursue a pathway in which you have demonstrated success. The results of one study indicated that under-confident students were less-likely to choose courses or a pathway linked with science as opposed to their counterparts that verbalized success in previous coursework (Sheldrake, 2016). Interactive science notebooks can be a way to motivate those that are under-confident and provide an opportunity for those that are over-confident to represent their content knowledge in a way that meets their needs because they are given the opportunity to choose a method that supports their style of learning. Elevated levels of anxiety during instructional tasks can negatively impact student performance and reduce their ability to break down their cognitive load as seen in one study. If a teacher mandates that content is expressed by writing a summary and writing is a weak skill for a student, then their approach to the content is already threatened because they are anxious about the outcome. Confidence was further reduced when student interest levels in the content were minimal. The opposite achieved a positive correlation between interest level, anxiety levels, and ability to break apart the work load into manageable parts in order to complete a task (Hong, Hwang, Tai, Tsai, 2017). Hence, when combined, self-efficacy and student interest play significant roles in academic achievement and pursuance of future career pathways.

“Learning interest is a personality trait or inspirational and motivational characteristic in a human being that can result in a long-lasting preference for a certain learning area or study topic" (Krapp, 1999). As students age they begin to align themselves with specific content areas based upon their previous academic achievement and interests. A student's interest yields a more concentrated effort in the content thus leading to better results. From my experience in education working with K-12 students, teaching science content has been a teacher-driven environment. Teachers explicitly state how students are to express or demonstrate their understanding of content. Students are often given a series of questions to answer related to the latest lesson or represent their findings to an experiment using a formatted lab report. If interest is a key component in success, then what are the methods that students prefer to utilize to help them with demonstrating science content? The method which they are told to use may not necessarily be one that helps transfer knowledge and may create a barrier in interest. There is a direct need for students to be given a voice in how they can prove they meet their grade level standards in science.

In 2017, about 6.1% of all workers represent STEM occupations according to the Unites States Department of Commerce. Even though the Economics and Statistics Administration projects a growth of 8.9% in STEM occupations between 2014 to 2024, the Department of Labor maintains that K-12 education has a vital role in building the gateway to STEM careers and there is a direct need for more interest in science, technology, engineering, and mathematics in order to boost our economy in a fast pace and competitive global environment. At the elementary school level, a shift in pedagogical practice through the integration of interactive science notebooks may positively impact a renewed awareness of connecting content with self-efficacy and interests in related career pathways.

Research Problem

Much of the research in the last decade related to pedagogical practices in science is connected with interactive science discourse, teaching strategies to improve student memory, and note-taking strategies within problem-based learning environments. Although there is a niche for studying the use of interactive journals in science courses, not much research is targeted at the elementary school level. The justification for utilizing interactive notebooks in the classroom usually pertains to academic achievement and subject matter content retention whereas this study is viewing them through the lens of student comfort in expressing their understanding of science content. The problem explored in this study is the extent which integrating interactive science notebooks as a new learning tool influences self-efficacy in expressing science content knowledge and interest in pursuing a STEM related career in elementary school students.

Research Purpose

The purpose of this study is to investigate the influence of interactive science notebooks on self-efficacy in expressing science content knowledge and to explore its impact on student interest in pursuing a STEM related career. The study aims to promote discourse among administration, educators, and students regarding pedagogical practices linked with student self-efficacy in expressing science content and the learning tools influence on student interest in pursuing a STEM related career. Analyzing the impact of interactive journals on self-efficacy in expressing science content knowledge has implications for shifts in pedagogical practices in elementary school classrooms nationwide. If found to positively influence student self-confidence in their performance of science content, interactive journals could be implemented on a consistent basis and specific professional development could be tailored to the integration process. With the growing need for STEM professionals, an increased interest in STEM related career fields as a result of integrating interactive science notebooks in elementary classrooms could have a positive impact on their future success in a competitive, global market.

Research Questions

Research Question 1: To what extent do interactive science notebooks influence student self-efficacy in expressing science content knowledge?

Research Question 2: To what extent do interactive science notebooks foster an interest in pursuing a STEM related career?

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CHAPTER 2 LITERATURE REVIEW

Student Interest and Development of Career Choice

Reflecting upon my own experiences as a learner, confidence has always played a role in the outcome. If I felt a task was beyond my reach or previous attempts resulted in failures, I would try hard to finish, but my journey along the way was full of doubt and concern. The likelihood that I would pursue the same or similar task was unlikely because repeating behaviors causing self-doubt and unworthiness was not desirable. As a child, my favorite subject was language arts because I was a strong reader as supported by local assessments, teacher input, and parent feedback. For a period of time, I wanted to be a high school English teacher because an inspirational teacher of mine mentioned it to me and because my parents encouraged my creative play of school during my free time thus reflecting two of Bandura's (1977) learned self-efficacy expectations, performance accomplishments and verbal persuasion. I also felt that I would be successful according to my continued achievements as a learner. During that time I didn't give much thought to other subjects because they didn't yield as strong of positive results or feedback. According to the U.S. Department of Education's *Stats in Brief* (2018), more than 23,000 high school students revealed in a longitudinal study that their family members were the main influence on their thinking about both postsecondary education and career decision-making followed by school staff, either a teacher or counselor. Career theorists acknowledge that career related concepts and attitudes are developed during childhood, yet there is limited emphasis on career development in the early ages in educational research (Super, 1980) rendering a need to further the field of research with an emphasis on elementary school students.

Student Career Choice Development

An elementary school student, as young as kindergarten, begins to understand the concept of work, earning money, having a job, and helping others (Schulthesis, Palma, & Manzi, 2005). Field trips to the local fire department, events involving police officers and community members, and attending classroom gatherings with parents representing a variety of jobs all expose students at a very young age to the possibilities of their future. As an elementary school teacher, having taught third, fourth, and fifth grades, I begin each and every school year with an activity to get to know students. One of the questions that I always ask is, "What do you want to be when you're older?" I ask students at the end of the school year as well to see if their career aspirations have changed as a means to maintain an active conversation about their career development.

Career development is a life-long process. There isn't clear research identifying when children should begin their understanding of careers because there is uncertainty as to specific ages or phases that children go through in the career development process due to influences of internal and external factors. Maree (2017) believes that from birth until the age of ten that children's interactions with their family shapes their personality traits and decision-making. Super (1980) maintains a similar timeframe that from birth to age 15 is a growth phase in which attitudes and interests in career maturity are developed. Maree (2017) continues that during the next phase, between ages ten and sixteen is when a sense of self is developed. Super (1980) also believes that the next phase is exploratory and that between the ages of 15 and 24 that choices are narrowed down, but not necessarily finalized or made permanent. Super (1980) continues that career establishment occurs between the ages of 25 and 44, and from that point career development goes into a maintenance phase before there is a decline in career maturity around the age of 65 due to planning or preparation for retirement. Park and Jun (2017) support Maree (2017) and Super's (1980) career development timeline in that elementary school learning environments can have a positive effect on career preparation behavior and that parents can have a positive influence on career guidance as found in their quantitative study of fifth and sixth grade students. Park and Jun (2017) also found that the relationship between parent and child should be cooperative otherwise results indicated a negative impact on career-related development in children.

Career interest surveys can be given to children to initiate conversation, interest, and decision-making. Primary students can utilize an online tool such as Paws in Jobland created by the XAP Corporation which has a simple interest survey of 26 questions which then highlights major job clusters linked with a student's answers. There is also an area for students to explore numerous jobs that exist within a community as they are organized into major clusters. For upper grades, Advance CTE and Minnesota State University adapted a version of the guidance division survey created by the Oklahoma Department of Career and Technical Education which asks participants to select activities they like, personal qualities about them, and school subjects they like or excel in resulting in a connection of up to three of the sixteen career clusters. If Maree's theory of supposed layers of career development is true, there is a nation-wide need in our school systems for early programs and interventions related to knowledge about professions and career pathways.

Through career interest surveys, as mentioned above, and Eccles et al.'s (1983) expectancy-value theory of achievement-related behaviors, there are substantial overtones among career aspirations, academic motivation, and career trajectories. Expectancy-value theory is an individual's constant self-assessment of whether or not they are likely to achieve their desired goal and the ability to rate the gained outcomes or losses of completion (Eccles & Wigfield, 2002) therefore complementing self-efficacy theory when associated with career aspirations and career decision-making. Even though Lauermann, Tsai, and Eccles (2017) analyses of their childhood and beyond study focused on math-related expectancy-value beliefs and an adolescent's career aspirations, a part of their discussion includes science as a part of the STEM domain leading to the possible association that if science interest and aptitude was analyzed that there would be a similar outcome. Expectancy-value theory supports self-efficacy theory when exploring career aspirations and interest in career-pathway. Suggesting that adolescents' career aspirations influence their academic motivations impacts the way in which school systems, teachers, community members, and parents become involved in their lives as it pertains to their future success in career decision-making.

There is a reason to believe that student career choice is influenced by environment. A military dependent is a transient student whereby his or her surroundings are often times tied directly to a military installation. The military lifestyle is a form of identity that serves as a catalyst for relationship building and sense making. There is reason to believe that military dependents would be influenced by their immediate environment, thus resulting in an increased interest in pursuing an occupation within the military. This leads to generations of family members enlisting in the military. It is a community that has shared ideals and is a unique mindset and lifestyle that once you are immersed in the lifestyle becomes a part of you and is typically passed on from one generation to the next. In families like Army Specialist Nathanael Griffie, a fourth-generation soldier or the Miller family with seven generations of West Point graduates, military service becomes a tradition for families (Inskeep, 2018; Kellar, 2013). Although Ott, Kelley Morgan, and Akroyd's (2018) study examined the influence of military lifestyle on military spouses' educational and career goals, there might be reason to believe a connection between their child's aspirations as well. Since military service can be viewed as tradition and children are influenced by their parents (Bandura, Barbaranelli, Caprara, &

Pastorelli, 2001; Maree, 2017) their conclusions that military spouses desired careers in portable careers such as healthcare, business, mental health, and education may influence a military dependent's career choice. Military dependents and the transient students involved in this study have parallels in their educational experiences and transitions to new environments. If there are connections between environment and parental influence there are further reasons to explore how other transient student career choices are influenced.

Gaining Knowledge of Career Choices

Gaining knowledge about existing careers can be through word of mouth, parent influence and conversations, peer interactions, individual research, coming across information in text read at school, classroom lessons, watching videos, or attending community events. The response to the age-old question of, "What do you want to be when you're older?" may change several times throughout the course of one school year because a student might be exposed to a new career through experiential learning. While creating water filters for safe drinking water, a student may now want to become an environmental engineer or while making scale drawings during a math lesson he or she develops a new interest in architecture or becoming a city developer. As a student progresses through their education, interests change and they gain a better understanding in a variety of careers. They move away from the notion that they want to be a superhero and make the connection between subject matter that interests them and jobs that will align with what they like. In elementary school, students have opportunities to learn about careers through curricular materials, discussion, classroom lessons, and activities. Sometimes the teacher explicitly makes the connection between content and career and other times students are exposed to a variety of careers along with a basic understanding of the education and skills needed to follow their pursuits through the nature of the learning environment. Schools such as

Russellville Junior High School and Marion Junior High in Arkansas have a career pathway or career cluster option for students to help foster career decision-making through connected educational and technical courses for interests in high demand occupations. At the high school level, school counselors become career or guidance counselors to assist students with course selection, college applications, vocational programs, financial aid, and scholarships. Falco (2017) suggests that the career decision-making process begins at a young age, yet most funding and specific programing is only available to students once they enter high school. The high school counselor assists students in their academic and career choices, but providing services, programs, and information should be embedded into all K-12 settings because career development coincides with student interests and their beliefs about themselves as learners (Falco, 2017). As school districts expand their career development opportunities for students, Santos, Wang, and Lewis (2017) found that having an awareness of student emotional intelligence significantly influences student career decision self-efficacy. On-going support in a student's emotional well-being positively impacts goal achievement, career planning, and problem solving. In other words, it is imperative to invest in the whole child from the early stages of their education. One example of career development across K-12 learning environments is Edmonton Public Schools in Alberta, Canada. In kindergarten to fourth grade, students develop their self-awareness by exploring their likes and dislikes through the concept of work and learn how to set goals. In grades five to nine, students begin to understand the opportunities that are available to them and connect their interests with careers. Grades ten through twelve are readiness years for students to increase their skill set and plan for their transition after graduation. The embedded career planning tool, myBlueprint, used throughout the school district has two main components: all about me and education planner. In grades K-6, students develop their individual portfolio much like a resume with supporting artifacts. In their subsequent years, students conduct research and collect resources connected with their career interests and an educational planner for post-secondary education or workforce information. Through the career pathways framework, Edmonton Public Schools afford students the opportunity to gain knowledge of careers to expose their interests and provide opportunities for exploration, discovery, and experiences long before they enter the workforce.

In a more traditional approach, an urban high school in the Midwest created a nine week career education class for sophomores to study its influence on, “career decision-making self-efficacy, vocational skills self-efficacy, perceived educational barriers, career expectations, and educational plans” (McWhirter, Rasheed, & Crothers, 2000, p.337). The results indicated a rise in short-term gains for their identified target goals, but noted once students were no longer enrolled in the class there was a decline in career development interest.

Parent influence plays a large role in how children gain knowledge of career choices. Bandura, Barbaranelli, Caprara, and Pastorelli (2001) found in their study about socio-cognitive influences on career aspirations and pathways that parents who held academia to a high standard would favor career pathways that would result in their child to pursue a pathway including higher education and would discourage those involving manual labor. In that case, the knowledge that their child would gain would involve careers that required a degree or specialized education. Also noted in their findings was that gender bias from the home environment was present and the parents’ perceived roles of careers projected for specific genders shaped children’s beliefs about academic and career aspirations. A predictive factor in the relationship between a student’s aspiration for STEM careers and having a parent or familial STEM connection was significant in Holmes, Gore, Smith, and Lloyd’s (2017) findings in their longitudinal study gathering surveys from over six thousand students in New South Wales, Australia because students had an increased awareness about STEM occupations thus leading to increased interest. Students with at least one parent that had a post-secondary degree were found to be more likely to pursue the same level of education or higher as compared to their counterparts whose parents did not. Those educational aspirations, in turn, significantly impacted career pathways.

A Discussion about Self-Efficacy

In the examples of the interest surveys mentioned previously, students were asked a series of questions or to select activities they liked to do or learn about. This alignment between interest and what a student likes or prefers has an underlying connection to a student's self-efficacy or confidence level in performance and attitude towards their individual success. The connection being that if a student favors a particular subject in school, then the proposed results will most likely link with a career connected to their preference. Self-efficacy, as found in Taylor and Betz (1983) study about self-efficacy expectations and career indecision, is a predictive factor in levels of career decision and indecision. The college-aged participants in their quantitative study that reported low self-efficacy in decision-making tasks reported higher amounts of career indecision as compared to their counterparts. Taylor and Betz's (1983) implications for practice are therefore connected to interventions needed within high schools to prevent indecision and a growing need to introduce career development in lower grade levels to build a knowledge base and initiate interests in a variety of career pathways. Bandura, Barbaranelli, Caprara, and Pastorelli's (2001) longitudinal study of 272 children with a mean age of 12 years old, found that children with high scientific-technical occupational efficacy selected careers linked with architecture and design and those with high self-efficacy in creative arts would choose artistic or literary careers. Perceived occupational self-efficacy and career choices also provided a predictive factor of what students would not choose. For example, students identified as having self-efficacy in the military-policing category which emphasizes public protection, order, and hierarchical systems of power were less likely to choose a career or viewed themselves as not being a good fit for occupations associated with children and mentoring (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001).

Using social cognitive theory as a framework, Falco (2017) found that the national need for science, technology, engineering and mathematics (STEM)-related jobs could be addressed and influenced through the use of a school counselor at the high school level, but should be integrated at an earlier age to illicit multiple opportunities for career development, especially as it relates to STEM. As early as eight years old, students should begin to develop an awareness of STEM careers in order to foster their career development (Holmes, Gore, Smith, & Lloyd, 2017). Falco (2017) discussed that the earlier students are exposed to STEM-related job opportunities, the earlier students can identify their interests and develop a plan. During middle school years, students navigate through significant changes and developments in their motivation and self-perceptions of achievement impacting their self-efficacy in academic and career trajectories (Falco, 2017).

Social cognitive career theory, as mentioned by Baglama and Uzunboylu, determined through their quantitative study that "self-efficacy and outcome expectations are important determinants of the career choice process" (2017, p. 1). Their study involving 256 preservice special education teachers revealed a relationship between career decision-making self-efficacy and vocational outcome expectancy due to their educational preparedness and awareness of specialized knowledge pertaining to their future students and policies. Their results then have an implication for students to learn about career choices at an early age to increase awareness and preparedness. Self-efficacy, according to Diekman and Fuesting (2018), is not necessarily connected with one's actual ability, but rather one's belief about their perceptions of whether or not one can be successful or achieve the desired outcome and that "choices are shaped by context and constraints, at each level of development" (Diekman & Fuesting, 2018, p.487). Although Pulliam, Ieva, & Burlew (2017) identify a positive relationship between career decision self-efficacy and career choice, very little research is specific to subject or discipline specific content knowledge. Unfried's (2015) article which focuses on the development of the student survey I've selected for my study, student attitudes toward science, technology, engineering, and math (S-STEM), revealed three different measurement instruments which were subject specific. The test of science related attitudes (TOSRA) developed by Fraser (1978) measured seven different scales, but only four of which closely relate to my study: attitude towards scientific inquiry, interest in science lessons, interest in science careers, and attitudes towards science. This survey, given to seventh through tenth grade students in Australia, has yielded good internal consistency reliability, but is not regularly used. Khalili (1987) believes that the TOSRA has low levels of discriminant validity which implies that the correlations between the scales were reasonably low. The affective elements of science learning questionnaire (Williams, Kurtek, & Sampson, 2011) was created to gain insight into students' interests in science as well as gaps in knowledge through a questionnaire that analyzed student self-efficacy in science, interest levels in science, the value of science, and their own identity as it relates to their role as a scientist and in the science classroom. The reason why this particular instrument was not chosen was because it was given to two high school chemistry classrooms and has not been used further for proof of validity, or at least that I was able to find. An instrument that aimed to measure student attitudes towards math, the attitudes toward mathematics survey (Miller, Greene, Montalvo, Ravindran, & Nichols, 1996), is an 83-item survey used with almost three hundred high school students yielded positive relationships between achievement and social behaviors thus furthering a connection between motivation and content-related goals. This survey would have implications for my study, yet was too specific to mathematics to extend proof. Associations can be made between a student's positive self-perception about their ability to perform in a particular content area and their pursuit in a related career, but more evidence is needed to support such a claim, especially in elementary school-aged students.

Summary

Through a comprehensive analysis of research about student interest and development in career choice, both childhood exploration and guidance by family members and other adults that play a significant role in a child's life such as teachers and counselors, enhance knowledge and career decision-making self-efficacy. It is through the results of the aforementioned studies that I aim to study the extent which integrating an innovative learning tool during classroom instruction with elementary school students fosters an interest in pursuing a STEM-related career as it has been found that career development begins at an early age.

Kirdok and Harman (2018) came to the conclusion through a career decision-making difficulties questionnaire and Rotter's internal-external locus of control scale completed by over 500 ninth to twelfth grade students that a "lack of readiness, lack of information and inconsistent information" emerged as difficulties experienced by students during the career decision-making process (p.242). This implication demonstrates the direct need for students to gain knowledge of career choices at an early age in order for students to increase their understanding, career decision-making self-efficacy, and maintain a strong internal locus of control. As Kirdok and

Harman (2018) explain, an adolescent that has a high external locus of control, their decision-making process is more likely to be riddled with indecision because they're focused on factors other than themselves. Control over one's behavior or internal locus of control, leads to increased motivation and a greater sense of self (Schultheiss, Palma, & Manzi, 2005) thereby concluding that school initiatives and interventions should focus on the development of an internal locus of control. Offering a career education class to students proves to be beneficial of knowledge acquisition, but there is a need for continual support to not only increase knowledge, but to support career decision-making self-efficacy for long-term gains (McWhirter, Rasheed, & Crothers, 2000).

Defining and Measuring Self-Efficacy as it Relates to Science

Measuring attitude towards science has been a topic of interest as early as Dewey's 1934 *The Supreme Intellectual Obligation* where he discusses observing and testing beliefs in scientific attitude and through Victor Noll's experimental approach to measure how people think, especially as it relates to their scientific attitude just one year later (Noll, 1935). In 1983, Munby published a report challenging the validity of 56 different instruments claiming to measure attitude in science education in research studies conducted between 1967 and 1977 (Munby, 1983). Self-efficacy theory, presented by Bandura in the late 1970s, served as the foundation for Taylor and Betz's (1983) study about self-efficacy expectations and career indecision. The college-aged participants in their quantitative study that reported low self-efficacy in decision-making tasks reported higher amounts of career indecision as compared to their counterparts. Taylor and Betz's (1983) implications for practice are therefore connected to interventions needed within high schools to prevent indecision and a growing need to introduce career development in lower grade levels to build a knowledge base and initiate interests in a variety of career pathways. The claim then becomes that self-efficacy is a predictive factor in levels of career decision and indecision. Instructional practices which lend itself to increased self-efficacy are maintaining specific learning goals and strategic instruction (Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006). Interactive science notebooks, the independent variable in my study, is the learning tool used as strategic instruction and the specific learning goals will be the Next Generation Science Standards for fourth and fifth grades in a rural independent school in Kentucky. As a results of a comprehensive literature review, self-efficacy has been defined, a validated instrument has been chosen to measure the proposed variables, and both quantitative and qualitative methodologies have been selected to analyze data.

Defining Self-Efficacy

Research involving the term self-efficacy will eventually lead back to the social cognitive theorist and psychologist Albert Bandura of Stanford University. Social cognitive theory comprises of the development of knowledge competencies, which serve as a cognitive guideline or structure, for behavioral outcomes (Bandura, 1999). Bandura defines self-efficacy as an individual's perceived ability to complete a task and their confidence in doing so (Bandura, 1986). Self-efficacy is a foundational belief system affecting action therein connecting to the social cognitive theory (Bandura, 1999). Such beliefs in personal capabilities influence how people feel, act, and think as they approach a task (Yancy, 2013). Self-efficacy, as it relates to my research study, is an elementary school student's belief that he or she can or cannot express science content knowledge through the use of an interactive science notebook. Essentially, does a student feel as if he or she can reach the desired outcome of representing their understanding of science content in a way the student feels successful. Students with a strong sense of self-efficacy are more likely to put forth more effort in task completion as compared to their counterparts that have low aspirations in task completion as a result of previous patterns in failed outcomes (Bandura, 1977). Self-efficacy beliefs, “affect whether individuals think in self-enhancing or self-debilitating ways, how well they motivate themselves and persevere in the face of difficulties, the quality of their emotional well-being and their vulnerability to stress and depression, and the choices they made at important decisional points” (Bandura & Locke, 2003, p.87).

Measuring Self-Efficacy

According to Bandura, measuring self-efficacy is based upon the four efficacy expectations: performance accomplishments, vicarious experience, verbal persuasion, and emotional arousal (1977). Performance accomplishments are based upon mastery. The more successes that one experiences positively increases self-efficacy in the task at hand. When occasional failures occur then he or she is likely to overcome the obstacle quicker than someone that has repeated failures because of their mastery expectations (Bandura, 1977). Performance self-efficacy is therefore influenced by the patterns of experience. Efficacy expectation through vicarious experience depends on others modeling a behavior or action first which reduces vulnerability and “have a reasonable basis for increasing their own sense of self-efficacy” (Bandura, 1977, p.197). Verbal persuasion is an attempt to influence human behavior by suggesting a positive or different outcome compared to a previous experience in which a struggle was experienced (Bandura, 1977). This is similar to the placebo effect where one begins to believe that changes are occurring based upon the power of suggestion. Verbal persuasion as an expectation of personal efficacy is common practice within elementary school classrooms, especially in STEM. As students struggle with mastering content or problem solving, I continually persuade students to persevere through tasks and encourage peer support. Emotional arousal influences personal competency. As anxiety, fear, and potential threats increase, performance declines. Quantifying a behavioral change thus becomes specific to the analyzed variable. Finding a generalized and valid instrument to measure self-efficacy was a challenge.

Johnson's (2013) student confidence survey created for her action research on the impact of interactive science notebooks on student success in science is an instrument that I considered in the initial stages of my research design because of its parallels to my research questions, but ultimately decided that a valid and reliable instrument was needed. Johnson's survey included over thirty questions or statements in which students used a Likert scale continuum to respond. Her survey was given to high school students whereas I would've had to modify the survey to meet the needs of my elementary school participants by reducing the amount of questions and using age-appropriate vocabulary. In addition, not all of the questions and statements that she included in her quantitative study would be necessary or applicable for the purpose of my two research questions. Modifying her instrument for use in my research study would not yield reliable results because I wouldn't use it in its entirety and would have to make significant changes further decreasing the validity and reliability of the instrument. Johnson's survey served as a catalyst for understanding how to draft open-ended questions used in my qualitative analysis with closed questions in a quantitative survey.

Another example of an instrument used to measure self-efficacy was in a longitudinal study of over 200 secondary school students. Phan (2016) used eight of the original 44 items from the motivated strategies for learning questionnaire as an instrument to measure personal self-efficacy. The questionnaire was originally developed to measure learning strategies and academic motivation of college students. Using only a part of the original questionnaire provided an opportunity for direct analysis of data relevant to his study, but in statistical analysis that can invalidate data because the instrument used for measurement is now unreliable since altering the original questionnaire impacts its statistical significance.

The Riggs (1988) science teaching efficacy belief instrument (STEBI) was created to measure science teaching and learning self-efficacy of preservice elementary school teachers (Enochs & Riggs, 1990). The initial STEBI included 25 statements in which the preservice teachers rated their responses on a Likert continuum of strongly agree, agree, uncertain, disagree, and strongly disagree. The final instrument was modified and included thirteen statements on the personal science teaching efficacy belief scale and ten statements on the science teaching outcome expectancy scale. The attitudes toward science inventory (ATSI), used in Gogolin and Swartz's (1992) mixed methods study of non-science college students' attitudes towards science, is a 48 item Likert instrument with six categories each containing eight statements. The six categories are: perception of the science teacher, anxiety toward science, value of science in society, self-concept in science, enjoyment of science, and motivation in science. Their findings supported their initial idea which validates the use of the ATSI. The categories within the ATSI all pertain to science and could provide useful information to influence science instruction, but would need to be modified to suite the purpose of measuring self-efficacy of expressing science content. Further evidence that creating an instrument is necessary is noted in the development of the attitudes toward science and technology (A-ST) scale created by Gokhale, Brauchle, and Machina (2009) after their literature review yielded no results in a valid and reliable instrument that was relevant for their study about college freshman attitudes toward science and technology. Again, their instrument was specific to their population and would require significant alterations thus requiring me to conduct multiple studies in order to validate the modified version.

For my research study I have selected the student attitudes toward STEM (S-STEM) survey created by the Friday Institute for Educational Innovation (2012) supported by the National Science Foundation under Grant No. 1038154 and by the Golden LEAF foundation. “Attitude is defined as a positive or negative sentiment, or mental state, that is learned and organized through experience and that exercises a discrete influence on the affective and conative responses of an individual toward some other individual, object, or event” (Reid 2006). Attitude, for purposes of this instrument, is a composition of both self-efficacy and expectancy-value beliefs towards a specific subject (Unfried, Faber, Stanhope, & Wiebe, 2015). There was a common thread with expectancy-value theory when identifying the relationship between self-efficacy and academic subjects. Expectancy-value theory is an individual’s constant self-assessment of whether or not they are likely to achieve their desired goal and the ability to rate the gained outcomes or losses of completion (Eccles & Wigfield, 2002) therefore complementing self-efficacy theory when associated with career aspirations and career decision-making. Instrument validity for the S-STEM survey was conducted through exploratory and confirmatory factor analysis using SAS/STAT® software and analytic tests of measurement invariance using Mplus® In addition, Cronbach’s alpha was used to measure internal-consistency reliability for each of the four constructs: attitudes toward science, math, engineering/technology, and 21st century skills (Unfried, Faber, Stanhope, & Wiebe, 2015). The S-STEM Likert survey was created as an instrument to measure changes in elementary students’ self-efficacy in STEM-related subjects, 21st century learning skills, and attitudes towards STEM careers. The first part of the survey asks students to rate their attitudes and self-efficacy in math, followed by science, and then technology and engineering. My focus was on science and attitudes towards STEM careers in the S-STEM and was applicable to the quantitative analysis of my research questions about student self-efficacy in expressing science content knowledge and their interest in pursuing a STEM-related career. The final part of the S-STEM survey is a Likert rating scale about students' attitudes towards twelve STEM career fields. This quantitative instrument was used in tandem with qualitative methods of interviewing participants and anecdotal notes recorded by the two participating teachers therefore utilizing an explanatory sequential multiple-method research design.

A Quantitative Approach

There are two main research questions in my study: To what extent do interactive science notebooks influence self-efficacy in expressing science content knowledge? To what extent do interactive science notebooks foster an interest in pursuing a STEM-related career in fourth and fifth grade students? In both cases, the interactive science notebook serves as the independent variable because it is considered the treatment or tool used during science instruction that affects the dependent variables. In the first research question, self-efficacy in expressing science content knowledge is the dependent variable. In the second research question, interest in pursuing a STEM-related career is the dependent variable. Both of the dependent variables relate directly to my research questions because I aimed to explore the extent at which interactive notebooks, as a learning tool during science instruction, influenced elementary school students' self-perception of how they are able to express their science content knowledge and whether the use of the identified learning tool influenced career decision-making.

Administering the S-STEM Likert survey at the beginning of the study served as a quantitative pretest or baseline measurement. The same survey was administered at the conclusion of the study's proposed timeframe as a means of comparison. A Likert scale is, "often used to measure people's opinions, attitudes, or preferences" and "measure attributes along a continuum of choices" (Bowen, 2016, p.8). For elementary school students, completing a survey is not common practice and having a visual scale provides a quantitative representation of their responses rather than being open-ended. A descriptive analysis of the S-STEM Likert survey was conducted as recommended by the Friday Institute for Educational Innovation (2012). The Likert ratings were converted into a numerical scale. A student rating of “strongly disagree” was assigned the numerical representation of 1, “disagree” was 2, “neither agree nor disagree” was assigned the number 3, “agree” was 4, and “strongly agree” was represented by the number 5. In the science construct, there is one statement that was reverse coded because it is negatively worded and, as explained by the Friday Institute for Educational Innovation (2012), “must be assigned values in the reverse order of all the other questions (“5” for strongly disagree, “4 for disagree,” etc.), since agreement to those questions represents an attitude opposite of the attitude for agreement with the other questions.” By doing so, the mean, a measure of central tendency, was analyzed for each survey statement and the standard deviation for the population was calculated to best represent the distribution of responses in the entire group of scores in the population representing a descriptive statistics analysis to highlight the learning tool’s influence on both attitudes toward science and interest in STEM-related careers. The advantage of reporting standard deviation is that it is, “the most commonly used measure of variability in statistics” (Bowen, 2016, p. 76). Finally, the selected visual tool to categorize data retrieved from the S-STEM results was pie charts. A pie chart is a visual representation of categorized data and its corresponding frequency (Bowen, 2016). I created a pie chart with multiple sections to report the number of students interested in each of the twelve STEM career fields included in the S-STEM survey at the two selected intervals, pre and post study.

This research study took place during the 2018-19 school year. The research population size involved two classes, one fourth and one fifth grade class totaling 25 students. A larger population increases instrument reliability because the consistency within the collected data will indicate reproducibility, repeatability, and stability of the collected data (Bowen, 2016). The population was determined at the start of the study in January 2019 and concluded in March, lasting approximately 55 days of instruction. A unit of study in science, approximately fifty-five instructional days, was a reasonable time frame to obtain proper data collection to determine the extent which interactive science notebooks influenced student self-efficacy in expressing science content knowledge and interest in pursuing a STEM-related career.

The validity of the research study was projected to be limited due to a historically unstable population of transient students. Student enrollment at the study's site was known to continually fluctuate during a school year. Prior to the start of the study, it was believed that there would be possible changes to the population size, but there were no changes to the population over the course of the study. In a transient community, the population size may remain the same as one moves to a different location another joins the classroom, but the students' needs and educational background could have potentially impeded on the progress and results of this study and the implementation of a new learning tool. I aimed to overcome the potential obstacle by focusing on the population at the start of the study. The enrolled fourth and fifth grade students that obtained consent to participate was the targeted population, thus determining my participants and size of 25 students.

Summary

Zubair and Nasir (2011) found as they developed a scale to measure attitude, the importance of studying positive attitudes towards an academic subject and its positive outcomes with enrollment and interest. They administered their attitude towards science learning scale to

464 eighth and ninth grade students and came to the conclusion that a positive attitude towards science will have a positive relationship with enrollment, achievement, and interest in scientific careers (Zubair & Nasir, 2011). By drawing such conclusions it suggests that interactive science notebooks may positively influence an interest in students' career decision-making due to the development of a positive attitude towards science. Instruction which provides opportunities for students to feel successful in an academic subject should therefore increase self-efficacy in the identified subject matter (Hushman & Marley, 2015). Through a guided instruction approach, students learned how to appropriately use the two-column format of an interactive science notebook to organize their learned information and to express their learned content knowledge in a meaningful way that suited his or her needs. It was through guided instruction that Hushman and Marley (2015) found the greatest change in science self-efficacy as compared to direct or minimal instructional teaching practices in elementary school classrooms. This study utilized both quantitative and qualitative data collection. Multiple-methods research added complexity or multidimensionality to my study's overall research design and findings (Creamer, 2018).

A Qualitative Approach to Examining Innovative Learning Tools in Science

An educator's understanding of *The Origins of Intelligence in Children* (Piaget, 1952) lends itself to better understanding the elementary school students that walk through the door each morning during the school year. Understanding theories of intelligence and how individuals make sense of their surroundings begins with Swiss scientist Jean Piaget. Cognitive development evolves as a result of biological maturation, active exploration of the environment, social experiences, and self-regulation (Piaget, 1970). "Classrooms are places where individuals are actively engaged with others in attempting to understand and interpret phenomena for themselves, and where social interaction in groups is seen to provide the stimulus of differing perspectives on which individuals can reflect" (Driver, Asoko, Leach, Mortimer, & Scott, 1994, p.7). Classroom environments impact all four factors shaping children's thinking. Qualitative methods are all about the process, making meaning, and generating understanding. Qualitative methods can help us understand the nature of classrooms as socially and culturally organized environments for learning (Erickson & Gutiérrez, 2002).

This study utilized an explanatory sequential multiple-method research design for data collection and analysis, integrating both quantitative and qualitative methods. It was built upon a conceptual framework because my research study was something that is constructed, not found. It incorporated pieces that were borrowed from elsewhere, but the structure, or overall coherence of the research design, was something that was created, not something that existed already (Maxwell, 2013, p.41). The aim of the study was to encourage theory development that is useful to instructional practice (Dickson, Adu-Agyem, & Emad, 2018; Maxwell, 2013), influence student self-efficacy in expressing their science content knowledge, and foster interest as it relates to career decision-making in science, technology, engineering, and mathematics careers.

Qualitative Methods

There were two main research questions in my study: To what extent do interactive science notebooks influence self-efficacy in expressing science content knowledge? To what extent do interactive science notebooks foster an interest in pursuing a STEM-related career in fourth and fifth grade students? In both questions, the interactive science notebook served as the independent variable because it was considered the treatment or tool used during science instruction that affected the dependent variables. In the first research question, self-efficacy in expressing science content knowledge was the dependent variable. In the second research question, interest in pursuing a STEM-related career was the dependent variable. Both of the dependent variables related directly to my research questions because I aimed to explore the extent at which interactive notebooks, as a learning tool during science instruction, influenced elementary school students' self-perception of how they were able to express their science content knowledge and whether the use of the identified learning tool influenced career decision-making.

Both quantitative and qualitative methods of data collection and analysis were used throughout this research study. A multiple-methods approach added multidimensionality to the study's overall research design and findings (Creamer, 2018). The student attitudes toward STEM (S-STEM) survey created by the Friday Institute for Educational Innovation (2012) was selected as the valid quantitative instrument to measure changes in elementary students' attitudes toward science and 12 STEM career pathways. I collected quantitative data at two points in the study, at the beginning and end of a 55 instructional day period beginning January 2019 (Bowen, 2016). Administering the S-STEM Likert survey at the beginning of the study served as a baseline measurement. The same survey was administered at the conclusion of the study's proposed timeframe as a means of comparison and was analyzed using descriptive statistics. The standard deviation for pre and post S-STEM data for the entire population was calculated. Finally, the selected visual tool to categorize data retrieved from the S-STEM results were two pie charts representing pre and post S-STEM data. A pie chart is a visual representation of categorized data and its corresponding frequency (Bowen, 2016). The pie charts contain multiple sections to report the number of students interested in each of the 12 STEM career fields included in the S-STEM survey at the two selected intervals. The quantitative instrument was the prioritized form of data collection and the analysis of the S-STEM informed the qualitative methods of interviewing participants and teacher anecdotal notes therefore utilizing an explanatory sequential multiple-methods research design.

After students completed their initial S-STEM, students orally responded to a series of constructed, open-ended questions. Open-ended questions allowed participants to include more information than the Likert survey provided, such as their attitudes towards the use of interactive science notebooks, their self-efficacy in expressing science content knowledge, and their feelings towards science. Closed-ended questions or statements, as used in the S-STEM, may not necessarily reflect students' overall feelings because surveys are not a common practice in elementary school classrooms. There was a possibility that students may have a hard time narrowing down their responses into the continuum scale which rendered the need for including qualitative methods of analysis. The open-ended questions were worded in a way that provided clarity and explanation for student responses to the S-STEM survey to include reasoning and background information reflecting their interests in STEM careers. Participants expressed their science content knowledge throughout 55 days of instruction in a variety of student-selected outputs or formats such as: diagrams, graphic organizers, poems, songs, drawings, pop-ups, and comic strips (Jaladenki & Bhattacharya, 2014). The interactive science notebooks were arranged into a two-column format: input and output. The input organized core content received during instruction and the output allowed students to synthesize the learned content in an engaging and creative way of their choosing (Young, 2003). Due to a population of 25 fourth and fifth grade students, all students participated in a pre and post S-STEM as well as three subsequent interviews. The purpose of the semi-structured interviews were to ask for clarity, explanation, and reasoning for their S-STEM ratings. During the final interview, students were asked to select one output entry that served as the artifact they were most proud of and detailed their reasons and feelings regarding their success and achievements made throughout the integration of utilizing this learning tool during science instruction with an emphasis on their self-efficacy in expressing science content. Oral responses were transcribed and analyzed through traditional qualitative analysis. In lieu of analog coding, written responses were imported into the computer-aided qualitative data analysis software (CAQDAS), NVivo 12 Plus, to categorize and classify data by identifying emergent codes and to conduct a thematic analysis for each open-response question (Saldana, 2013). By identifying emergent codes, the software then found reoccurring codes which created a theme. Once the overarching themes of participant responses were created, I was able to analyze the findings through a thematic analysis which allowed me to determine the extent at which interactive science notebooks influenced student self-efficacy in expressing science content knowledge and the degree by which the learning tool fostered an interest in pursuing a STEM-related career (Creswell & Poth, 2018).

Qualitative Analysis of Innovative Learning Tools in Science

Innovative learning tools in STEM curriculums are becoming more and more prevalent in classrooms all around the world which demonstrates a high demand and need for continued growth in classrooms nationwide in order to prepare our students to be successful in a global and competitive workforce. While reading about innovative STEM learning tools, there was an obvious disparity between the amounts of qualitative versus quantitative research studies.

In recent years, much emphasis has been placed on Dewey's empirical philosophy of project-based learning resulting in shifts in pedagogical thought and practices as a direct response to the needs of 21st century learners (Shin, 2018). In a study of 79 college students enrolled in an English language course at Hannam University, participants completed a group project wherein they created a storyboard leading to the culminating resume and cover letter video as opposed to a traditional format to apply for a job at a fictitious company (Shin, 2018). The study took place over the course of three months and data was analyzed through a motivational questionnaire with questions pertaining to English language learning motivation, self-efficacy, and their experience with project-based learning (Shin, 2018). As a result of this student-centered learning approach, student data reported their motivation to learn English was enhanced through the use of project-based learning and the use of technology as the innovative learning tool. A correlational relationship was found between students' self-efficacy and perceptions towards project-based learning (Sin, 2018). Project-based learning is often linked with STEM curriculums because of its collaborative nature and connection to solving real world problems. The study was limited in its explanation of the video production, which served as the innovative learning tool. More emphasis was placed on providing an opportunity for students to complete a project-based learning challenge without details of the actual learning process, interactions with their peers, or experience with video production.

Fab Lab Tulsa is one of over 2,000 MIT-chartered Fabrication or Fab Labs in more than 78 countries with a mission to "better our community by providing education, community and business programming that teaches innovation, design-thinking, problem-solving and change-making, together with open access to 21st Century digital fabrication tools, equipment and technology" (fablabtulsa.org, 2018). Through a nine month longitudinal study of 158 children ranging in ages from 8-15, Fab Lab Tulsa examined the impact of their offered programs with school-aged children's attitudes toward STEM, self-efficacy, and skill attainment (Dubriwny, Pritchett, Hardesty, & Hellman, 2016). An attitude toward STEM and STEM self-efficacy pretest was given to students at their initial orientation of the Fab Lab and after four to twelve sessions they completed a posttest. Researchers identified that their major limitation was the length of time participants spent at the Fab Lab working on their projects. They didn't account for the large discrepancy between the number of sessions that participants needed to complete their projects possibly impacting their self-efficacy and attitude ratings. The study found that through the use of the Fab Lab, participants' STEM self-efficacy increased and there was a slight increase in attitude toward STEM although not statistically significant (Dubriwny, Pritchett, Hardesty, & Hellman, 2016). Even though the data was analyzed using quantitative methods, a possible consideration for a future study would be to interview students to talk about their project or key artifact created while at the Fab Lab.

One hundred twenty-eight biology students from four different high schools in Denmark participated in a virtual laboratory simulation on a desktop computer pertaining to evolution lasting 1.5 hours. The data collected from their virtual laboratory simulation experience was compared to students that received a similar lesson on evolution, but presented in a traditional format. Learning outcome was determined through a 20 question multiple choice test and self-efficacy was measured using the motivated strategies for learning questionnaire and through an intrinsic motivation inventory. Students also rated their interest in biology from one to five and then a 15 item scale was developed by the researchers to measure students' outcome expectations aligned with Bandura's social cognitive career theory (Thisgaard & Makransky, 2017). The overall conclusion determined that virtual learning simulations, "are at least as efficient in enhancing learning and self-efficacy as traditional lessons" (Thisgaard & Makransky, 2017, p.11). A limitation to this study is the length of time students participated in the virtual laboratory simulation. Researchers should address this limitation by completing a series of lessons or unit of study comparing the virtual lab with traditional lessons. One of the considerations listed for a future study was to integrate student experiences and reflections through qualitative analysis.

As a call to address the gender gap in STEM, Fashion FUNdamentals, an enrichment program for middle school girls, was developed by the Department of Design and Merchandising at Colorado State University in an effort to increase interest in STEM. Fashion FUNdamentals is a free, two week summer program for females aged 11-14 (Ogle, Hyllegard, Rambo-Hernandez, & Park, 2017). Researchers recruited a total of 72 middle school girls to participate in a mixed methods study. Quantitative data collection was in the form of a pre and posttest assessing self-efficacy in science and math using a Likert scale and a content knowledge assessment solving word problems in science and math linked with state standards. For qualitative data collection, two focus groups were conducted. "Questions focused on girls; perceptions about the usefulness of math and science in everyday life, what they learned about their participation in Fashion FUNdamentals (FF), and how their participation in FF shaped their feelings about themselves and others" (Ogle, Hyllegard, Rambo-Hernandez, & Park, 2017, p.37). As a result of participation, the girls' self-efficacy in math and science and their math knowledge increased. The quantitative results for science content did not yield a positive influence, but focus group data revealed an increased appreciation and interest in new applications of science (Ogle, Hyllegard, Rambo-Hernandez, & Park, 2017). Researchers noted that 20 out of the 72 participants did not complete the pre and/or post assessment thus presenting a rather significant limitation in their overall findings. Participation in research has been found to be a regular concern for researchers as it is often addressed in the limitations of studies.

There were more limitations in my research design with my chosen qualitative methods as compared to the quantitative S-STEM survey. The epistemological framework through which

I viewed my research study and analyzed its results was not necessarily a limitation, but should be noted because my world-view and experiences may have inherently impacted the lens in which I viewed the research study. Through dialectical pluralism epistemology (Onwuegbuzie & Frels, 2013), I identify with both pragmatism-in-the-middle and a social constructivist perspective (Creswell & Poth, 2018; Merriam & Tisdell, 2016). I am concerned with how students construct knowledge and make meaning of the content and believe that the classroom provides an environment which fosters social constructivism because students have the opportunity to interact with their peers and make meaning or connections through shared problems and experiences (Creswell & Poth, 2018; Driver, Asoko, Leach, Mortimer, & Scott, 1994). Instructional lessons were facilitated by two teachers and my own professional views of student interactions and pedagogical practices may have elicited an additional theoretical perspective by which I approached the multiple-method research design.

The term empirical derives from the Greek *empeirikos* meaning “experienced” thus “relying on experience or observation alone often without due regard for system and theory” (merriam-webster.com, n.d.). My research design arises from experience and most data collected is qualitative, because it is the “best choice for helping to make visible the everyday activities of life in classrooms that often go unexamined but may offer explanations for how some students interact with content, construct meaning, and develop their efficacious beliefs” (Kozleski, 2017, p.24). Since observations and experiences elicit a possible element of subjectivity or loss of recorded information due to human error, staunch quantitative researchers are critics of this method of data collection. To account for discrepancies the use of a CAQDAS was used during qualitative analysis.

Another limitation to the multiple-methods research design is that I cannot say with a

100% certainty that the gains in data were due to the integration of interactive science notebooks because there were external factors within the classroom environment and internal factors linked with a participant's intrinsic motivation that had to be accounted for. Population size, a limitation from a quantitative methodological stance, was also relevant in qualitative data collection and analyses. The validity of the research study was projected to be limited by the unstable population size due to a notoriously transient population at the study's site in a rural community in Kentucky. Student enrollment was known to fluctuate prior to the start of the 55 instructional day research study. It was determined that the enrolled fourth and fifth grade students that obtained consent to participate at the start of the study in January 2019 was the targeted population. Data was collected from two classrooms. To account for different teaching styles and not having a fully established relationship with each participant, both classes came together two times in a shared space, during recruitment and the official start of the study after parent consent and student assent forms were collected. I conducted the initial lessons about the purpose and set-up of an interactive science notebook and guided students through several examples utilizing the input and output format until both teachers and students felt comfortable with utilizing the learning tool. In addition to the quantitative pre and post S-STEM survey, three interviews occurring after the initial S-STEM, halfway through the study, and after the final S-STEM, the participating teachers recorded anecdotal notes while students worked in their interactive science notebooks. Anecdotal notes focused on comments, reactions, and questions that students had as they related to their self-efficacy in expressing science content and interest in STEM careers while using their interactive science notebook. Anecdotal teacher notes were used to support student ratings and were analyzed in the same manner as interviews, through the use of NVivo 12 Plus software.

Qualitative Analysis of Notebooks within Science Instruction

Jaladenki and Bhattacharya's five month case study (2014) details the usage of interactive journals in high school physics classes as taught by one teacher, Bill Jacobs, in South Texas. Interactive journals, as a learning tool, were used to increase interest and generate success for their population of high school students. Interactive journals, as explained by the authors, increase student production through Venn diagrams, concept maps, graphic organizers, diagrams, poems, songs, etc. This qualitative study collected data through student interviews, document analysis, and observations conducted by the researchers. They analyzed students' experiences using an interactive science notebook during physics instruction and analyzed how students described the role of the learning tool in informing their understanding of physics concepts. Jaladenkia and Bhattacharya (2014) found that there is further need to follow-up and find supplemental research opportunities at the primary level because they noted that even though their case study was focused on a specific subject, they believe their results wouldn't only be confined to a physics classroom, but would extend to all content areas. Both Jacobs and the students reported an overall positive outcome of interactive science notebooks with the evidence supporting that the learning tool was an effective strategy of instruction and met students' needs in understanding relevant content. The strength of this study is including the teacher's experience of integrating a new learning tool into his classroom.

Another study examined the impact of written teacher feedback in interactive student notebooks and middle school students' science process skills as they performed a specific, local assessment (Mallozzi & Heilbronner, 2013). The researchers noted that their research design was built upon Green's (2010) study which aimed to determine if the use of interactive student notebooks during science and math instruction affected standardized test scores. Teachers had been provided two 18-week unit plans, one for math and one for science so that the information disseminated during instruction was uniform. This is unique and is trying to account for a loss of control in variables. Even though Green (2010) couldn't significantly determine that an interactive notebook increased student achievement in math, they still made a claim for the need of studying how interactive student notebooks impact a specific set of activities which was the catalyst for Mallozzi and Heilbronner (2013) to study teacher feedback with interactive student notebooks and students' achievement scores. Their qualitative findings indicated that seventh grade students liked using the learning tool and it benefited their science processing skills, but written teacher feedback was not a predictive factor in achievement on a local assessment. Students reported that teacher feedback encouraged the effort they put forth and teachers reported that they preferred verbal feedback as written feedback was time consuming. Both of these studies provided initial insight in using interactive notebooks in content areas other than science.

Johnson's (2013) unpublished thesis study through Montana State University is a quantitative study that proved to be the closest to my research design. Her study also utilized interactive science notebooks, but she was analyzing the impact between high school students' summative test scores and their scored interactive science notebook. Interactive science notebooks were scored using a rubric created by Johnson and compared with student test scores for a unit on cellular structure and function and a unit on energy transfer in ecosystems. While researching quantitative tools that measured student self-efficacy in science, Johnson (2013) created her own student confidence survey for her action research as an instrument to measure the impact of interactive science notebooks on students' perceived success in science. It was an instrument that was considered during the initial stages of developing my research design because of its parallels to my research questions, but it was ultimately decided that a valid and reliable instrument was needed. Johnson's survey included over 30 questions or statements in which students used a Likert scale continuum to respond. Her survey was given to high school students whereas I would've had to modify the survey to meet the needs of elementary school students by reducing the amount of questions and using age-appropriate vocabulary. In addition, not all of the questions and statements that she included in her quantitative study were necessary or applicable for the purpose of my two research questions. Modifying her instrument to use in my research study would have yielded unreliable results. Johnson's survey served as a catalyst for understanding how to draft open-ended questions used in my qualitative data collection with closed questions in a quantitative survey.

The discussion about best practices for implementing learning tools is necessary for an educator's growth mindset. Best practice is for teachers to immerse themselves into the learning process and become the student. Morrison (2008), the researcher and science methods course instructor at Washington State University, introduced science notebooks to elementary preservice teachers enrolled in her course. The preservice teachers were required to use their science notebook throughout the course for investigations both inside and outside of the classroom, data collection and analysis, and individual inquiry. The intended goal of the study was to explore preservice teachers' attitudes and perception towards a science notebook's use in their future classroom. Results indicated that preservice teachers became more comfortable and confident in the utilization of such a learning tool and expressed a variety of intended uses in their own future classrooms including assessment, communication of science understanding, and increased writing expectations during science instruction (Morrison, 2008). If teachers are able to experience a treatment or intervention prior to students, they have the opportunity to actively engage in behaviors that will be similar to their students' experiences thus impacting pedagogical practices. Best practice "is to lead students toward conventional science ideas, then the teacher's intervention is essential, both to provide appropriate experiential evidence and to make the cultural tools and conventions of the science community available to students. The challenge is one of how to achieve such a process of enculturation successfully in the round of normal classroom life" (Driver, Asoko, Leach, Mortimer, & Scott, 1994, p.7). In this case, science ideas are learned through the use of curricular materials, interactions with peers, and other forms of media. The intervention is an interactive science notebook and the enculturation process is creating a systemic approach to utilizing the learning tool and having a shared vocabulary among the entire grade level. "The teacher's role is to provide the physical experiences and to encourage reflection. Children's meanings are listened to and respectfully questioned" (Driver, Asoko, Leach, Mortimer, & Scott, 1994, p.7). Best practice as highlighted through qualitative research is reflective in nature by which the teacher actively analyzes his or her role in the classroom, reflects upon the designs of lessons, and recognizes all students' access to the learning environment (Kozleski, 2017). Another identified best practice, especially in the growing area of STEM education, is the development of a common and shared language to support growth in academia, professional development, and communication between all stakeholders concerned with STEM success (Capraro et al, 2018). This has a direct correlation to my study because having a shared language and understanding about how interactive notebooks are utilized and organized within classrooms will increase transferability among grade levels and content areas.

Summary

The aim of this explanatory sequential multiple-methods research design utilizing both quantitative and qualitative methods is to validate the legitimacy of an innovate learning tool and analyzing its influence on student self-efficacy in expressing science content knowledge and STEM-related career interest into two elementary school classrooms in a rural community in Kentucky (Frels & Onwuegbuzie, 2013). "Student science notebooks are a student's personal record, an extension of their mental activities, and a store of personally valued information" (Klentschy, 2008, p.3). As a learning tool in the elementary school classroom, it provides an opportunity for students to make meaning of their ideas and findings in an expressive and personal record of "data that students collect, facts they learn, and procedures they conduct. The science notebook also becomes a record of students' reflections, questions, speculations, decisions and conclusions all focused on the science phenomena. As such, a science notebook becomes a central place where language, data, and experience operate jointly to form meaning for the student" (Klentschy, 2008, p.3). It is important to regularly study best practices in teaching in order to experience professional growth and to meet student needs so they are successful in our ever-changing dynamic world. The idiom "wear many hats" is often used by teachers of all ages. One such hat is the role of being a life-long learner. The teacher that remains current in scholarly works and engages in continual professional development represents true best practice. Other forms of best practice in education is to continually reflect upon one's role in the classroom, integrate student interests into content, and have a shared language among colleagues to allow for an inclusive and unified opportunity for professional discourse (Capraro et al, 2018; Kayalar & Ari, 2017; Morrison, 2008). As I fully integrated interactive science notebooks into my own classroom alongside the two participating teachers in my research study, it was imperative that I was aware of my teacher identity and those of my colleagues as an important factor of control influencing science notebook entries as experienced by students (Madden & Wiebe, 2013). Through my study's research design, the quantitative data was enhanced and extended through qualitative explanations (Mason, 2006). An explanatory sequential multiple-methods research design was used to maintain validity and reliability for quantitative data and transferability among qualitative data. The quantitative S-STEM was the initial data collection which was the driving force behind the student interviews. The initial S-STEM data was analyzed through descriptive analysis and following in sequence was an initial student interview. The S-STEM ratings were better supported and the student ratings were explained through an initial interview. The final interview was also based upon student ratings on the final S-STEM taken after 55 instructional days.

Addressing Challenges of a Specific Student Population

Before applying to the integrative STEM education doctoral program at Virginia Polytechnic Institute and State University I started thinking about why I wanted to pursue such a degree and reflected upon teaching environments and populations which have impacted my pedagogical practices and interest in the pursuit of continued professional growth and development. Most of my professional experience has been working with a heavily transient population of military dependents. Students mobility can negatively impact both social development and academic achievement (Sparks, 2016). Sufficient staffing and small school size, typical of a classroom within at the study’s site, has a positive impact on student performance (Smrekar & Owens, 2003). Small class size can help address many of the common challenges that most teachers face, but is especially important in an environment riddled with change and anxiety due to a fluctuation in population as a result of migrant farm workers or a parent seeking employment resulting in a change of residence. Developing a sense of awareness as students experience a shift in socioemotional behaviors and/or academic change is especially important in supporting the needs of transient students (Stites, 2016).

Identifying and Addressing Challenges of a Transient Population in an Education

At the start of my PhD journey at Virginia Tech I wanted my research to focus on the military population that I taught. Having been raised by two Marines and having my own experiences with schools on military installations and in civilian communities, I had a preconceived notion that military dependents' achievement scores on high-stakes standardized tests would be lower compared to their counterparts as a result of their transient lifestyle. Hemenway's (2016) quantitative study used standardized test data to determine whether or not there was a correlation between mobility and performance outcomes in the STAAR reading and mathematics subjects. Data was separated into groups based upon the date of student enrollment, the dependent variable, and then means of test scores, the independent variables, were calculated and then compared using a Pearson correlation. The results of the study concluded that there was no significant correlation between standardized test scores and mobility for the military dependents at two elementary schools on a military installation in Texas. The results of this study were a surprise because the literature review and common assumptions would be that the more a student moves, the greater the impact on overall performance would be negatively impacted. These results had a significant impact on my research design due to the transient student population used. Hemenway's research study provided great background for my study because it revealed information about the population I serve and the parallels with the transient population involved in my study. Working with military dependents has added challenges because a classroom roster at the beginning of the school year is different compared to the last day of school. This is also true for the location of the research study, but represents a different type of mobility. In Hemenway's literature review she found that military dependents move on average of nine times in their K-12 career. This is significantly higher than non-military students. With a higher mobility rate, Hemenway's research questions about the correlation between performance and mobility is quite relevant. Her literature review also found that students attending Department of Defense Educational Activity schools did not experience a negative impact on their overall academic performance because the schools are used to a transient population. Military dependents, classified as a transient population, are often times attending schools on a military installation in which the community has training and a better understanding of how to serve the unique population. Migrant farm workers or changes in residence as a result of employment are also classified as a transient population and may not be afforded the same support system or funding.

It is important to recognize teacher identities and possible bias or barriers in perceptions. A teacher's background experiences, epistemological view, and perceptions about a student population can present barriers and challenges within the classroom environment. In my case, my perceived view on military students' achievement scores created an additional lens through which I viewed transient students thus impacting my teaching, their learning, and possible outcomes for my study also working with a different population with a high mobility rate.

Murphy (1986) explored whether or not a father's absence impacted anxiety levels in elementary school students grade 3-6 through a causal comparative quantitative analysis. Murphy (1986) found that when comparing military dependents to non-military students, the teachers and students rated behavior and anxiety similarly, but when the study analyzed findings related to the absence of fathers then the data revealed different information. Results indicated that students with absent fathers were observed to have difficulties with paying attention in class, had difficulties controlling anger, experienced difficulties with social interactions, and lacked self-confidence. Student rating scales of those with absent fathers reported higher anxiety levels.

Teachers used the Burks' behavior rating scale and students completed a study-specific instrument measuring anxiety and social desirability. This was initially thought to impact my own research study because the population consisted of students possibly experiencing the absence of a parent due to availability of employment resulting in removing a parent from the household. Based upon Murphy's (1986) findings, this had the potential to have a negative effect on my study. As a classroom teacher, the absence of a parent has a direct impact on shifts in student behavior as seen through my own observations and direct experience. When a student has to move during the school year, the weeks leading up to their change in residence often results in a decline in performance and results in a negative shift in behavior since the student knows that he or she is leaving and moving into an unknown situation thereby increasing anxiety (Stites, 2016). The results of Murphy's study (1986) found increased negative behaviors and anxiety when a father was absent, and there are implications in research findings that an absent mother, or possibly both parents at a given time could also negatively impact socioemotional behaviors. In that case, then grandparents or another family member have temporary custody of the child while both parents are deployed or temporarily reassigned or seeking employment which poses a whole new set of factors impacting student behavior, anxiety, and performance. In the case of the school site in a rural Kentucky community, teachers face a similar situation with a negative shift in behavior and/or academic performance because the student is experiencing the trauma of an absentee parent figure.

A way to address one of the many challenges that teachers face while working with a transient population is to always keep the end in mind. By doing so, Sprenger (2005) details how educators should focus on the letter 'E.' In her book, 'E' stands for expectations, enduring understandings, essential questions, evidence, evaluation, entry points, and experiences. Through the seven steps of the learning cycle, Sprenger (2005) emphasizes *reach* as a means to connect with students in an effort to retain content. Interactive journals connect with her theories because they grab student attention, increase motivation, support learning styles, and enhance meaning.

One strategy to engage an ever-changing population is through discursive talk. Through this interchange of ideas (merriam-webster.com, n.d.) within a science classroom, Tytler and Aranda (2014) found an increase in student interest and conceptual knowledge. Knowledge gained as a result of the study was to be shared with similar educators to promote interactive talks within science classrooms. Interactive talk, in an effort to increase content retention, links with interactive journals due to student connectivity with content and their ability to represent their understanding in a variety of ways. Researchers further emphasize that traditional classrooms are centered on teacher talk, but discourse patterns which emphasize student interaction positively impact conceptual understanding in science classrooms.

Strategic intervention for improving students' memory by building memory pathways, stimulating experiences and connections, and enriching the learning environment will not only help build peer-to-peer relationships, but will also help an incoming student make meaning of the grade-level content that was already taught (Willis, 2007). Through Willis' strategies (2007), she discusses brain-mapping techniques, finding relationships among content areas, and describes the scope of experiential learning. This text serves as a foundation for pedagogical practices which are supported by the use of interactive journals in the classroom to enhance student understanding and progress and will support a transient or mobile population by connecting with their background experiences to make content more meaningful.

Contemplative education addresses the needs of the whole child and is a critical component of a supportive, safe, and respected learning environment. It reduces anxiety and increases focus through brain breaks and exercises, and focuses on the whole child rather than strictly content (Roeser & Peck, 2009). In addition to describing attributes of contemplative education, Roeser and Peck (2009) introduced the basic levels of self (BLoS) model which monitors motivation and self-regulation of a learner. Through the use of this model, they found that students should be able to shift away from distracting thoughts back to those that are on topic and to be able to redirect themselves to focus on goal-oriented thinking for a sustainable amount of time which will allow the learner to achieve success. This relates with part of my research because I studied self-confidence in learning and its impact on student success. Even though self-confidence is not a skill tied directly to standards, it is geared towards the whole person. Having worked with a transient population for most of my professional career, building student self-confidence is imperative in a child's overall success within a learning environment because a student is more willing to take risks and participate if he or she perceives an efficacious outcome. In addition, integrating strategies into the classroom environment which help reduce anxiety will support the needs of a population that experiences heightened levels of anxiety through frequent relocation and parent absenteeism.

Existing Literature on Interactive Science Notebooks

One of the first journal articles that I found which led to the integration of interactive science notebooks in my classroom was in the National Science Teachers Association (NSTA) publication Science Scope. *Science interactive notebooks in the classroom* (2003) as described by Jocelyn Young, a middle school teacher in California, describes how to set-up interactive notebooks with organizational procedures and offers a rubric for assessing student performance. Through her article, I was able to understand that notebooks are arranged into a two-column format which helps students categorize and process information in an engaging and creative way that turns into a reference tool of information learned. Young's article guides teachers in implementation of interactive journals and provides a context for why and how they are used in a K-12 setting. The article was a narrative centered around setting-up a notebook and literature supporting the reasoning of utilizing such a learning tool during science instruction, instead of focusing on a specific study she conducted or data analyses.

Gilbert and Kotelman (2005) detail the effectiveness of notebooks as integrated into science classrooms throughout a K-8 district using a numerical format which emphasize *Five Good Reasons to Use Science Notebooks*. Through their research findings, Gilbert and Kotelman were able to create, discuss, and support five key reasons for the integration of science notebooks: notebooks are thinking tools, guide instruction, enhance literacy skills, support differentiated learning, and foster teacher collaboration. Each section includes brief explanations of how the research led to the outcome of that particular reason for using a science notebook, has student examples, and a "bottom line" representing implications for practice in the classroom. In this easy-to-read format, teachers can quickly view notebooks as a learning tool which allows students to represent their own conceptual understanding as a differentiated method of documenting students' thinking. A similar way to present research findings instead of through a numerical list is to present information in themes (Rheingold, LeClair, & Seaman, 2013).

Waldman and Crippen's (2009) publication provides comprehensive coverage of interactive notebooks as a personal, organized, and comprehensive strategy of learning and expression of conceptual understanding. Also noted through their findings is that students view their journals as a personal reflection of the content and is a tool that referred to long after their academic school year. Interactive notebooks are assessed using a rubric and is a method in which students feel they are in control, thus empowering them as learners. Through their simple subheadings of design empowerment, implementation, and conclusion, teachers that yet to integrate this learning tool into their classrooms will have a basic understanding of the purpose of an interactive notebook, how to implement them into the classroom environment, and tables which provide a visual for how to organize the notebooks (Waldman & Crippen, 2009). The structural overview of an interactive notebook is one of this journal article's greatest strengths because the limited research that is currently out there specific to interactive science notebooks give reasoning to support their use, but do not necessarily teach the reader how to implement the tool in their own classrooms.

Through the use of interactive notebooks for inquiry-based science, Chesbro (2006) details how they serve as an opportunity to promote constructivist pedagogical practices which represent a differentiated record of learning throughout an entire school year. Students can use their interactive science notebooks as a learning tool throughout the year. Science notebooks, as described by Chesbro (2006), are an engaging method of tracking content which promotes higher-order thinking skills and allows for students to personally connect with their grade level content. The crux of his journal article is positioned around the format and usage by Young (2003) and includes subheadings related to using and assessing interactive science notebooks in the classrooms.

Mason and Bohl's (2017) *More than data: Using interactive science notebooks to engage students in science and engineering* article published in NSTA's Science and Children journal, begins with a comparison of traditional science notebooks to a more modern format. Learning about how to set up an interactive science notebook, using it as an assessment tool, engaging students, and increasing communication in science is all expressed through Mrs. B's experience as an elementary school teacher. The article is written in a relatable way and focuses on a teacher's experience as expressed through a narrative. The reader, most likely an educator, will be able to imagine themselves as Mrs. B, thus increasing the likelihood of transferability.

Most NSTA publications are four to five pages in length and written for a specific audience, the classroom teacher. Since teachers do not often have a lot of free time, the authors get right to the point and in Robinson's (2018) case, a bulleted format is used to highlight separate, but significantly important best practice strategies for integrating and utilizing interactive science notebooks in the science classroom. The latter part of the article is dedicated to digital notebooks and includes a screenshot visual. Researching studies that have used notebooks within science instruction is important in understanding similarities and critical in paying attention to the implications the results have on the classroom. It is just as important to analyze how the information is presented. The aforementioned articles thus served as a foundation for which my manuscripts were created.

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CHAPTER 3 MANUSCRIPT #1

Self-Efficacy in Expressing Content Knowledge Using Interactive Science Notebooks

Abstract

The purpose of this study was to investigate the influence of interactive science notebooks on student self-efficacy in expressing science content in 25 fourth and fifth grade students in a rural community in Kentucky. A positive influence on student self-efficacy in their performance of science content was found. Quantitative data determined that 76% of the population had a positive increase in their overall average ratings toward science. Qualitative data revealed that 22 of the 25 participants referenced an increase in science interest as a result of using an interactive science notebook at the end of 55 instructional days. Qualitative analysis further revealed increased interest in science influenced participants' self-efficacy in expressing their science content knowledge. Data supported that interactive journals are a positive learning tool which could be implemented on a consistent basis across grade levels and specific professional development could be tailored to the integration process in order to support student needs during science instruction.

Introduction

In a rural community along the Ohio River approximately .6 square miles with 1,200 residents is an independent school with an enrollment of just over 100 students. According to the 2010 Census of Population and Housing by the United States Census Bureau, the community's population was 797 residents and the median income for a household was $29,792 with 20% of its population below poverty line. Situated along the Ohio River, the town is prone to annual flooding which impacts its one school serving pre-kindergarten to eighth grade students. As the only school within the independent school district in Hardin County, Kentucky its student demographic is represented by 91% Caucasian, 4% two or more races, 2% Asian, and 3% other. According to the 2017-18 school report card by the Kentucky Department of Education, of that school population, 64% of the students received free breakfast and lunch, 17% received reduced cost meals and 20% receive no meal assistance. In addition, much of the employment sought by adults in this community are linked with the transient lifestyle of military service members, migrant farm workers, construction workers, and seasonal employees tied to Louisville's horse industry, cattle farms, or coal mining. Migrant students are present in four hundred sixty-two schools across Kentucky and the communities that surround these schools recognize the unique atmosphere that must be provided in order to support the children that walk through the doors each and every morning. Teachers and staff are trained by school counselors, district personnel, and non-profit organizations about the effects of migrant families and the impact of a mobile lifestyle and its effects on academics and behavior. Mobile students may have added challenges compared to their peers, but over the past several years teachers, parents, and community partners have voiced their concerns and needs in order to support this unique population and the state is responding through funds, professional development, and providing supplemental academic support for students that qualify during summer months and after school programs (ESCORT State University of New York at Oneonta, 2016). Migrant farm workers and transience due to one or more parents seeking employment, also classified as a transient population, should also be afforded the same support system or funding as their peers to accommodate for their unique needs. It is all the more reason why building self-efficacious behaviors is important in a student's overall academic success.

Self-efficacy is as an individual's perceived ability to complete a task and their confidence in doing so (Bandura, 1986). Self-efficacy is a foundational belief system affecting action (Bandura, 1999). Such beliefs in personal capabilities influence how people feel, act, and think as they approach a task (Yancy, 2013). Self-efficacy, as it relates to the research study, is an elementary school student's belief that he or she can or cannot express science content knowledge through the use of an interactive science notebook. Essentially, does a student feel as if he or she can reach the desired outcome of representing their understanding of science content in a way the student feels successful. Verbal persuasion, one of Bandura's identified influences on self-efficacy (1977), is vital for a transient student because it connects with influential or trustworthy people and experiences as a means to positively contribute to the individual's belief system. Students with a strong sense of self-efficacy are more likely to put forth more effort in task completion as compared to their counterparts that have low aspirations in task completion as a result of previous patterns in failed outcomes (Bandura, 1977). A student's self-efficacy, combined with their transient background, is especially important because they may have greater educational gaps in their learning or have not received proper interventions if they have not been in one educational setting long enough for assessments, meetings, and recommendations. More importantly, the transient student may not have had an opportunity to build relationships with influential people which would strengthen their self-perceptions about performance and success.

Expectancy-value theory is an individual's constant self-assessment of whether or not they are likely to achieve their desired goal and the ability to rate the gained outcomes or losses of completion (Eccles & Wigfield, 2002) therefore complementing self-efficacy theory when associated with behaviors, actions, and outcomes in a specific content area such as science. "Attitude is defined as a positive or negative sentiment, or mental state, that is learned and organized through experience and that exercises a discrete influence on the affective and conative responses of an individual toward some other individual, object, or event" (Reid, 2006).

Attitude, for purposes of the selected quantitative instrument student attitudes toward science (S-STEM), and as identified by the creators of the survey, is a composition of both self-efficacy and expectancy-value beliefs towards a specific subject (Unfried, Faber, Stanhope, & Wiebe, 2015). A student with a high mobility rate may not have had an opportunity to develop desired outcomes in a classroom setting if they are prone to change educational institutions throughout a school year; therefore, increasing the likelihood of repeating patterns in failed outcomes and negatively influencing their self-efficacy in academic achievement (Bandura, 1977).

Through an explanatory sequential multiple-methods research design, “quantitative data are collected and analyzed before qualitative data are collected in order to contextualize the data” (Mafuba & Gates, 2012, p.292). One form of data collection informed the other and worked in tandem to reveal a deeper, more meaningful representation of student self-efficacy in expressing science content knowledge through the use of an interactive science notebook (Saldana, 2013). The approaches to data collection and analysis were compatible (Creswell, 2009). The S-STEM, given to participants as a pre and posttest, along with three oral interviews occurring at three intervals throughout the study, and teacher anecdotal notes were collected and analyzed independently, but compared or related in order to interpret the results.

The purpose of this study was to investigate the influence of interactive science notebooks on student self-efficacy in expressing science content. The study aimed to promote discourse among administration, educators, and students regarding pedagogical practices linked with increasing student self-efficacy in science. Analyzing the extent at which interactive journals influence self-efficacy in expressing science content has implications for shifts in pedagogical practices in elementary school classrooms nationwide. A positive influence on student self-confidence in their expression of science content has implications for the consistent implementation of interactive science notebooks in elementary schools and increases the need for specific professional development tailored to the integration process.

Research Question

The problem explored in this study was to provide empirical evidence to support the use of interactive science notebooks as a learning tool to influence student self-efficacy in expressing science content in fourth and fifth grade students. The research question explored was, to what extent do interactive science notebooks influence self-efficacy in expressing science content knowledge?

Methods

The research study took place at a Title 1 school located in a rural community along the Ohio River from January 2019 to March 2019 during science instruction, totaling 55 days of instruction, using purposive sampling of two classes, fourth and fifth grade consisting of 25 students. The study's sample comprised of 12 fourth grade students and 13 fifth grade students. The population at the start of the study in January 2019 was 25 fourth and fifth grade students and 25 students at the conclusion. The participants included 14 males and 11 females with two students on an Individualized Education Plan and three receiving educational accommodations through a 504 plan, representing 20% of the study's population receiving support services. All 25 students obtained permission from a parent or guardian to participate in the study and all students assented to participate. Within the timeframe of the study, there were no changes to the population.

Research Matrix

The research matrix (Fig.1) outlined below identifies the data sources and collection techniques for research questions in Manuscript #1 and Manuscript #2.

Figure 1 *Research Matrix: Research questions, data sources, and collection techniques for manuscripts #1 and #2*

Research Questions	Data Sources	Collection Techniques
Research Question 1: To what extent do interactive science notebooks influence self-efficacy in expressing science content knowledge?	Participants were given the S-STEM survey at the beginning (January 2019) and end of the research period (March 2019), all participants were interviewed at three different intervals related to the research question, and students selected an artifact narrative based upon a chosen output and integrated their explanation and reasoning for selecting their output into the final interview.	• S-STEM Survey (pre and post) • Three Student Interviews (beginning, middle, and end) • Artifact narrative (end, within student interview)
Research Question 2: To what extent do interactive science notebooks foster an interest in pursuing a STEM related career in fourth and fifth grade elementary school students?	Participants were given the S-STEM survey at the beginning (January 2019) and end of the research period (March 2019) and participated in three interviews related to their knowledge and interest regarding STEM related career fields.	• S-STEM Survey (pre and post) • Three Student Interviews (beginning, middle, and end)

Quantitative and Qualitative Instruments

The selected validated instrument used to quantitatively measure student self-efficacy in expressing science content knowledge was the student attitudes toward STEM (S-STEM) survey created by the Friday Institute for Educational Innovation (2012) supported by the National Science Foundation under Grant No. 1038154 and by the Golden LEAF foundation. During the study, participants completed the S-STEM survey at two intervals, the initial start of the study in January 2019 and at the close of the study in March 2019.

Three interviews were conducted with each participant to support S-STEM ratings, after the initial S-STEM, half-way through the study, and at the conclusion of the 55 instructional day time period. Interview questions were directly linked with student ratings on the S-STEM. As an explanatory sequential multiple-methods research design, the quantitative S-STEM survey was followed by an interview, a qualitative data collection, based upon participant S-STEM ratings. Approximately halfway through the 55 instructional day period, all participants were once again interviewed with a series of open-ended questions reflective of the research question.

At the conclusion of the study, the S-STEM was re-administered and analyzed quantitatively. Students were asked a series of constructed open-ended questions in a final interview as a direct connection to their final S-STEM ratings. Initial S-STEM and post S-STEM surveys were present during the final interview so students were able to comment on their changes in ratings or lack thereof. Having the two surveys available allowed for direct questioning to individual responses to the science construct. As a part of the final interview, students selected an output, a visual representation of the science content learned, that they were most proud of and best represented their ability to express science content. Students explained their output and why it was selected thereby connecting with the main research question regarding their self-efficacy in expressing science content.

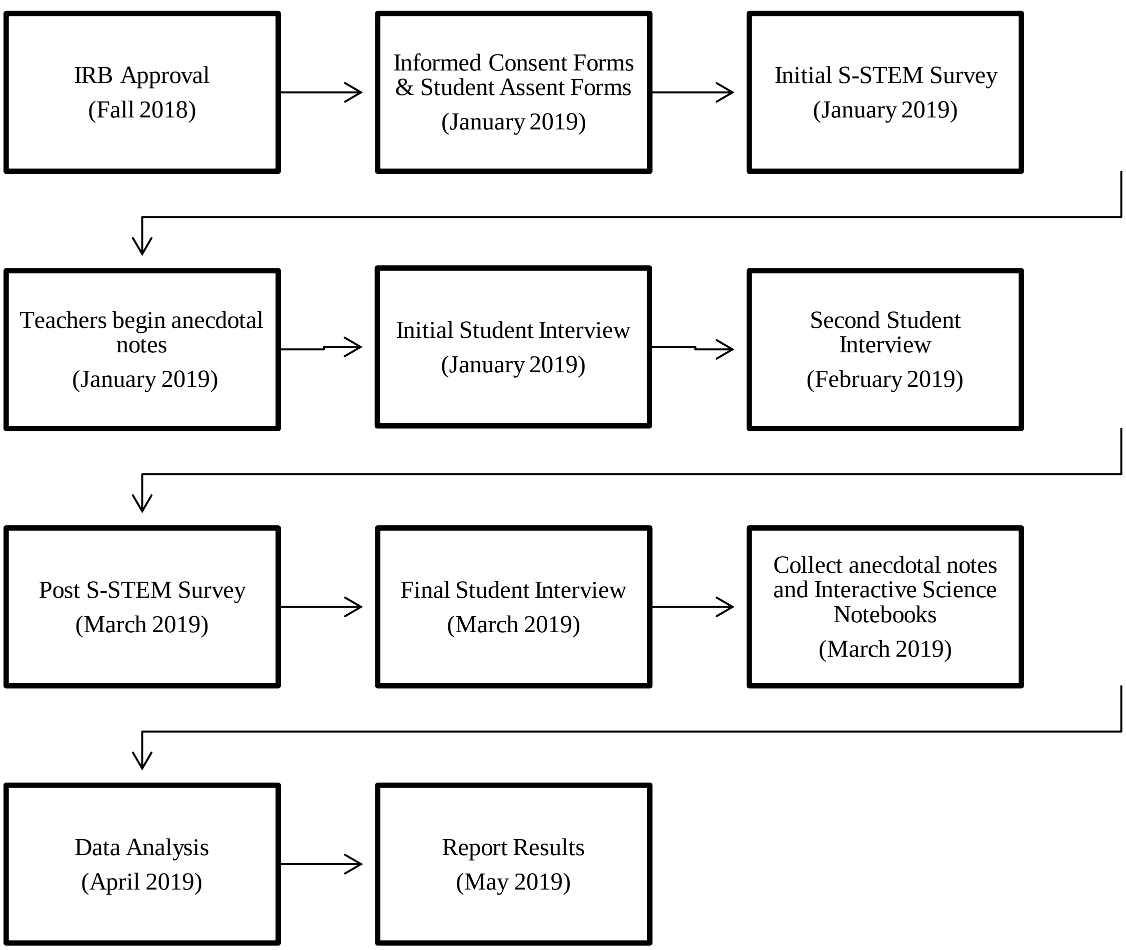
Throughout the study, the participating fourth and fifth grade teachers recorded anecdotal notes in their given observational notebook related to student comments, questions, interactions, and experiences pertaining to student self-efficacy in expressing science content.

Procedures

Prior to the start of the study in January 2019, the researcher obtained an exemption determination from the Western Institutional Review Board (WIRB) and a letter from the superintendent of the study's site to satisfy both the doctoral requirements for Virginia Polytechnic Institute and State University and district requirements of conducting a study on school premises with elementary students.

Recruitment took place once the study was accepted by the WIRB and the superintendent of the study's site. Once approved, all fourth and fifth grade guardians received an informed consent form for their child to participate in research since participants were minors. The informed consent form clearly explained the purpose of the study, the type of research intervention, participation selection, voluntary participation, expectations of students throughout the 55 days of instruction, risks, benefits, confidentiality, sharing the results, and the option to withdraw at any time. Informed consent forms were collected throughout the recruitment period until the first day of the study. As a requirement to conduct research with participants under the age of 18, WIRB required an assent form. After approval of the research design, but before the initial start of the 55 instructional day data collection period, both fourth and fifth grade classes came together for a meeting to explain the purpose of conducting research, the rationale for the study, and what the study entailed. At the conclusion of the meeting, all students were given an assent form. Assent forms were collected up until the first day of the study. For those students that were absent, the researcher met with them upon their return in order to obtain their assent to participate.

Figure 2 *Research Design Flow Chart*



The research design flow chart and research matrix (Fig. 1 and Fig. 2) visually depicts data collection throughout the study. At the start of the 55 instructional day study, the student attitudes toward STEM (S-STEM) survey was administered to all participants. The S-STEM was administered with both classes, fourth and fifth grade, at the same time. The researcher read aloud the survey statements for the attitude towards science and STEM career constructs. All initial S-STEM surveys were collected by the researcher for initial descriptive analysis. Both participating teachers began recording anecdotal notes in a designated observation notebook after each science lesson throughout the duration of the study. After initial descriptive analysis on the S-STEM, the researcher interviewed all 25 participants in which students responded to a series of open-ended questions directly linked with their ratings on specific statements within the S-STEM regarding how they feel about science, if they were going to choose a career in science, and their overall success in science. Another oral student interview took place approximately halfway through the 55 instructional day period. Student interviews at this stage of the study focused on student self-efficacy in expressing science content. Students were asked questions about how they felt about science as it directly correlated with their experience of using an interactive science notebook, their preferred ways and reasoning for how they liked to express their content knowledge, and their overall interest in science since using an interactive science notebook. After 55 days of instruction, the S-STEM was administered as a post survey. The S-STEM was administered using the same protocol as the initial survey. Final student interviews were conducted after the final S-STEM data was quantitatively analyzed. All students participated in a final interview at the conclusion of the study related to their S-STEM ratings for the science construct, their experience using the learning tool, and overall interest in science. Students also selected an output within their interactive science notebook they were most proud of which provided more details connected with the research question about student self-efficacy in expressing science content. Anecdotal notes from classroom teachers were collected and qualitatively analyzed. After the quantitative was analyzed through descriptive analysis and qualitative data yielded themes, results were interpreted and reported back to Virginia Polytechnic Institute and State University and the school site, per doctoral requirements and district request.

Multiple-Methods Research Design

This study aimed to support the quantitative S-STEM survey ratings through qualitative forms of data collection, oral interviews and anecdotal notes, which provided participants with a richer opportunity for their voice to be heard and understood as well as for their experience to be captured via teacher observations and interactions. Pre and post S-STEM responses were supported by asking interview questions relevant to individual S-STEM ratings, participants selected and explained an output and provided a narrative to support student self-efficacy in expressing science content during the final interview, and teacher anecdotal notes were used to address student behaviors and experiences as related to interactive science notebooks.

Quantitative Data Collection

S-STEM Survey

The selected quantitative tool used for the study was the upper elementary student attitudes toward STEM (S-STEM) survey created by the Friday Institute for Educational Innovation (2012) supported by the National Science Foundation under Grant No. 1038154 and by the Golden LEAF foundation. There are two versions of the S-STEM, upper elementary and middle/high school S-STEM. The upper elementary version was created for fourth and fifth grade students and the middle/high school S-STEM was adapted for sixth through twelfth grade students.

The research question for this study used the term self-efficacy and the S-STEM measures attitude. The instrument was selected because the definition of attitude encompasses the idea that self-efficacy is a belief system and is connected with attitude because both influence responses or actions towards something or someone. In this case a specific academic subject. Furthermore, the attitudes toward science construct consists of items measuring self-efficacy related to science and expectations for future value gained from success in science thus connecting the two terms, attitude and self-efficacy (Unfried, Faber, Stanhope, & Wiebe, 2015). The S-STEM uses the terms self-efficacy and attitudes as synonyms to extract the same meaning.

Instrument validity for the S-STEM survey was conducted through exploratory and confirmatory factor analysis using SAS/STAT® software and analytic tests of measurement invariance using Mplus® In addition, Cronbach's alpha was used to measure internal-consistency reliability for each of the four constructs: attitudes toward science, math, engineering/technology, and 21st century skills (Unfried, Faber, Stanhope, & Wiebe, 2015). The S-STEM Likert survey was created as an instrument to measure changes in elementary students' self-efficacy in STEM-related subjects, 21st century learning skills, and attitudes towards STEM careers. The first part of the survey asks students to rate their attitudes and self-efficacy in math, followed by science, and then technology and engineering. The next rating scale is about 21st century skills. The statements within the science construct link with the research question examining how students feel about their ability to express their science content knowledge through the use of an interactive science notebook. The final part of the S-STEM survey is a Likert rating scale about students' attitudes towards twelve STEM career fields. This quantitative instrument was used in tandem with qualitative methods of interviewing participants in an effort to provide verbal explanations and reasoning for ratings and experiences, and anecdotal notes from classroom teachers; therefore, utilizing a multiple-methods research design. More specifically, an explanatory sequential multiple-methods research design prioritizes data collection and analysis to drive the final interpretation. The qualitative data collection occurred after the quantitative survey at two different points in the study. The results of the initial S-STEM were further supported in student responses to structured open-ended questions which allowed students to provide additional evidence or support for their ratings for the science attitude section of the S-STEM. With permission from the Friday Institute for Educational Innovation, the S-STEM instrument can be used in totality or modified by construct to align with the purpose of a study since each section of the S-STEM can be considered an individual construct. The math attitudes construct yielded a 0.89 reliability in Cronbach's Alpha, science attitude had a reliability coefficient of 0.83, the engineering and technology attitudes construct's reliability coefficient was 0.84, and 21st Century learning attitudes was 0.87 (Friday Institute for Educational Innovation, 2012). An acceptable reliability coefficient for most social science research studies is 0.70 (Goforth, 2015). Each construct's coefficient in the eighties demonstrates relatively high internal consistency. An exploratory and confirmatory factor analysis was also completed using SAS/STAT® software to check for dimensionality within each of the constructs. For this reason, it was determined that only the science attitude construct was used as a quantitative measurement for student self-efficacy in expressing science content knowledge through the use of an interactive science notebook.

Qualitative Data Collection

Student Interviews

After students completed their initial and final S-STEM survey, they responded to a series of semi-structured, open-ended questions specifically connected with their ratings on the S-STEM. Participants were asked to explain their ratings for three of the statements included in the science construct: I feel good about myself when I do science; I might choose a career in science; and I can understand most subjects easily, but science is hard for me to understand. Open-ended questions allowed participants to include more information than the Likert survey allowed by having an opportunity to provide details to support their responses. This qualitative form of data collection supplemented their quantitative responses. Closed-ended questions or statements, as used in the S-STEM survey, may not necessarily reflect students' real feelings because surveys are not a common practice in elementary school classrooms and students may have a hard time narrowing down their responses on the provided scale thus rendering the need for including qualitative methods of analysis. Likert scales operate on a numerical scale and it is hard to quantify the difference between two numbers (Bowen, 2016). For example, the statement, "I feel good about myself when I do science" can receive a rating of a 4 for "agree," but an elementary school student may not be able to determine what would constitute a rating of "strongly agree." Using a numerical representation of their feelings, without the ability to explain or support their rating, may not be an accurate representation of their response. The open-ended questions were worded in a way that provided students the opportunity to clarify and explain their individual ratings on the S-STEM. This included reasoning and possible background experiences impacting their selection. The aim of this interpretive qualitative method was to gain insight and better understand the participants' ratings on the quantitative study (Denzin & Lincoln, 2013). By integrating qualitative methods in tandem with a quantitative instrument, student responses better reflect their intended outcome in the explanatory sequential multiple-methods research design.

Interviews allowed the researcher to elicit information from the participant that was otherwise lacking from the quantitative instrument. Approximately half-way through the study, as a means to provide additional evidence of participant interest in science and their experience using an interactive science notebook, all participants participated in a second interview containing a series of semi-structured, open-ended questions connected with the research question. The aim of the questions at this stage in the research design was to note any influence that interactive science notebooks had on student self-efficacy in representing science content and to identify any common themes in how students chose to synthesize their learned information.

A final interview was conducted after the post S-STEM was administered. The purpose of the semi-structured interview was to ask for clarity, explanation, and reasoning for responses on the post S-STEM as it related to their attitude toward science. The interviews conducted throughout the study elicited responses through semi-structured, open-ended questions because participant data on S-STEM surveys couldn't be determined until after data collection and analysis. The interview questions created prior to the start of the survey served as a guide since the nature of an elementary school classroom was ever-changing and often times included unexpected occurrences derailing the intended plan. Working with human subjects, especially children, was unpredictable. It was important to plan, yet remain flexible. Committing to a structured set of questions may have interrupted the natural order of progression in a student's thought or conversation thus negatively impacting the outcome. As recommended by Creswell and Poth (2018), the researcher should use an interview protocol or guide to stimulate the social interaction between the participant and interviewer and the interviewer takes on a responsive role throughout the interview process with the ability to alter questions in a manner that remains true to the study.

Artifact Narrative

After the post S-STEM was administered, students selected one output, or visual representation of science content, that served as the artifact they were most proud of. Students described the selected artifact, to include its format and the content it expressed, and detailed their reasoning and feelings regarding their selection. Narratives also described their successes, achievements, and possible frustrations experienced throughout the integration of utilizing this learning tool during science instruction with an emphasis on their self-efficacy in expressing science content. Participating teachers identified their students as reluctant writers, therefore it was decided that the artifact narrative was integrated into the final interview. The purpose of selecting an artifact allowed students to personally connect with something that was meaningful to them. Including an artifact narrative in the research design diversified data collection and gave the researcher an insider's perspective as it related to integrating an interactive science notebook into an elementary school setting. In addition, analyzing multiple data sources was desirable in supporting outcomes in data collection (Creswell & Poth, 2018).

Anecdotal Notes

In addition to the quantitative S-STEM survey and three interviews, the two participating teachers recorded anecdotal notes over the course of the 55 instructional day period while students were working in their interactive science notebooks. The two participating teachers have varying professional backgrounds representing a wealth of experience in education and have taught in a variety of learning environments with lower socio-economic populations. The fourth grade teacher has been in the classroom for four years, but has worked with children in some capacity for over 20 years. She has experience using a science notebook and has integrated them into her own classroom, but this was the first time she used the interactive science notebook format with an input and output. The fifth grade teacher has had a variety of teaching positions in elementary and intermediate settings over the past eight years to include arts and humanities, math, and social studies. This was her first year teaching solely fifth grade and her first time integrating interactive science notebooks into her classroom instruction.

Teachers recorded comments, interactions, behaviors, observations, and activities that students had as they related to their self-efficacy in expressing science content. The intention of including anecdotal notes as a form of data collection was to support student S-STEM ratings and used as evidence to gain further understanding and meaning of interview statements made by participants throughout the study. Capturing the participating teachers' experiences while integrating a new learning tool was a first-hand account to support future implementation in other classroom settings and allowed the researcher to have further evidence of student outcomes as it related to the integration of interactive science notebooks, especially when the researcher was not present during instruction (Jaladenki & Bhattacharya, 2014). The anecdotal notes were a continuous form of data collection to support changes in initial S-STEM ratings as well as statements made during the first and second participant interview. The third interview occurred after the post S-STEM and anecdotal notes were already collected. Anecdotal notes were recorded in a three-column format, as recommended by Saldana (2013). The first column was for the descriptive notes, the second column was for the researcher to jot down preliminary codes and brief notes, and the final category was for the final codes (Saldana, 2013). By doing so, it allowed for initial themes to be revealed via analog coding before importing the notes into NVivo 12 Plus, a computer-aided qualitative data analysis software.

Data Analysis

S-STEM Survey

As recommended by the Friday Institute for Educational Innovation (2012), the Likert rating categories were coded with a numerical value. A student rating of "strongly disagree" was assigned the numerical representation of 1, "disagree" is 2, "neither agree nor disagree" was assigned the number 3, "agree" was 4, and "strongly agree" was represented by the number 5. There are nine statements within the science construct. Of the nine statements, eight are worded positively. "I feel good about myself when I do science" has a positive connotation; therefore the statement, "I can understand most subjects easily, but science is hard for me to understand" was reverse coded due to its negative wording. A rating "strongly disagree" was then given the numerical representation of 5 and the remaining rating categories decreased by one with a "strongly agree" selection yielding 1 as its numerical value. Individual construct scores were calculated by finding the average of all items within its given construct as the survey was not created to compare individual questions from one participant to the next (Table 1).

Table 1

Pre and Post S-STEM Science Construct Data, Standard Deviation

	n	M	VAR	SD	Normal Range[a]
Pre S-STEM	25	28.24	58.42	7.64	20-36
Post S-STEM	25	30.72	35.66	5.97	25-37

Note. n = number of participants; M = mean; VAR = variance; SD = standard deviation.
[a]Normal range indicates the individual raw scores which are within one standard deviation. Raw scores outside of normal range are considered outliers.

With permission from the Friday Institute for Educational Innovation (2012), only one of the four original constructs was scored and analyzed, science attitudes. By doing so, the mean, a measure of central tendency, was calculated for the construct. The raw scores from all survey statements were added for each participant, then the individual raw scores were added together and divided by the number of participants to determine a mean score of 28.24 which was rounded to 28 (Table 1). Next, the variance of the data was calculated by taking the raw score difference from the mean squared, then averaged. Finally, the square root of the variance calculated the standard deviation of the data. The purpose of measuring central tendency was to have one number represent the center of the distribution (Bowen, 2016). Central tendency doesn't reveal specific information about individual data. The standard deviation for the population was calculated to best represent the differences in distribution of responses in the entire group of scores in the population and used for descriptive analysis (Table 1). Standard deviation is a measure of variability of data calculated to find the average distance that each value is away from the mean revealing spread between individual data (Patel, 2009; Bowen, 2016). A visual depiction representing the mean data for pre and post S-STEM survey data was created in an effort to inform qualitative data collection and provide a visual analysis of survey ratings.

Student Interviews

Semi-structured interviews were conducted at three different intervals throughout the study: after the initial S-STEM survey, approximately halfway through the 55 instructional day timeline, and after the post S-STEM survey. Interviews were audio recorded, transcribed by the professional service provider REV, and imported into NVivo 12 Plus software. Using the auto code wizard, the software identified nodes or codes. This served as a first cycle of coding data for identifying common codes that emerged across all student interviews. During the first cycle of coding, themes were broad and simple. A thematic analysis allowed for categories to emerge from the data as opposed to having a predetermined set of themes prior to the start of the interviews which may not necessarily be applicable once interviews are transcribed (Saldana, 2009). Through a thematic analysis common key phrases can be identified and coded. Utilizing a second cycle pattern coding method, emergent themes were categorized allowing commonalities and relationships to surface (Saldana, 2009).

After students completed their post S-STEM survey, their quantitative data was compared with their verbal responses to a series of constructed, open-ended questions. The questions were intended to supplement their responses to the science construct and their self-efficacy in expressing science content knowledge. By doing so, students provided clarity and explanation in a qualitative manner to compare their S-STEM survey ratings. Responses were transcribed using REV, a professional transcription service, and imported into NVivo 12 Plus software. Nodes or codes were created and written responses were sorted for each question through its auto coding feature. After that, an initial query using the word frequency feature was conducted in an effort to uncover a “broad brush-stroke representation” of written responses for each question by recognizing key words and phrases (Saldana, 2009; Saldana, 2013). High-frequency words that emerged led to holistic coding to capture the overall sense of the content and emerging categories. Through pattern coding, as a second cycle coding method, emerging themes were organized along with an attributed meaning (Saldana, 2013). The same steps of analysis were completed for the initial student interview, the interview conducted halfway through the study, and the final interview after completing the post S-STEM survey. This ensured consistency in qualitative data analysis.

Artifact Narrative

At the conclusion of the study, students were asked to select one output entry that served as the artifact they were most proud of. Participants provided details of their reasoning and feelings regarding their selected output, and described their success and achievements made throughout the integration of utilizing this learning tool during science instruction with an emphasis on their self-efficacy in expressing science content. Responses were imported into the NVivo 12 Plus software and manually coded using the values coding method which is utilized when investigating human experience (Saldana, 2013). Values coding reflected the participant's values, attitudes, and beliefs towards a particular experience. For purposes of this study, the values coding focused on participants' attitudes towards interactive science notebooks and their beliefs about their ability to express science content knowledge. The researcher manually coded text connected with student attitudes and beliefs. Afterwards, the identified text for each category was analyzed through a word frequency query to help reveal emerging themes. A meta-code or category labeled during second cycle pattern coding revealed similar themes within all of the data and assisted in attributing meaning associated with the research question (Saldana, 2013). The qualitative data analysis for the artifact narrative supported the quantitative S-STEM science construct results by connecting efficacious descriptions to its quantitative counterpart on the Likert scale.

Anecdotal Notes

Throughout the course of the study, teachers recorded anecdotal notes in an observational notebook in a three-column format as previously described. The rationale was to establish consistency among the two, fourth and fifth grade teachers participating in the study. Teachers recorded comments, interactions, behaviors, observations, and activities that students had as they related to their self-efficacy in expressing science content. All written responses were imported into the computer-aided qualitative data analysis software NVivo 12 Plus to organize the data.

NVivo 12 Plus software identified codes and emergent themes. Once the overarching themes of anecdotal notes were identified, a thematic analysis was conducted to determine if the anecdotal notes revealed a theme previously identified in other data collection methods. Through axial coding, the analysis revealed dominant categories that appeared throughout all data collection methods and allowed the researcher to see the whole picture thus providing a qualitative representation of the extent at which interactive science notebooks influenced student self-efficacy in expressing science content knowledge. Anecdotal notes were then manually coded to its applicable theme across data collection. Organizing anecdotal notes in this way simplified data analysis, supplemented student data, and solidified the explanatory sequential multiple-methods research design by supporting both quantitative and qualitative data collection.

Results

Initial S-STEM

The quantitative analysis of the initial S-STEM data revealed that 68% of the population had an average attitude toward science at or below a 70% with raw scores averaging 3.5 or below (Table 2). In most academic institutions, a 70% is a 'C' average and does not necessarily represent a positive data reference. According to the Department of Education (2008), criterion-referenced grading systems used throughout the United States associates a 70% with fair to poor performance with an 80-89% representing good and 90% or higher as excellent. In most elementary schools, the traditional fixed numeric scale is the basis for assigning letter grades to student performance. In comparison, if 68% of the population held an attitude at or below a 70% it can be inferred that the majority of the participants had a fair or average feeling towards science. Initial attitudes toward science were determined by the average of all nine statements in the science construct.

Table 2

S-STEM Attitude toward Science Construct, Pre and Post Averages

Participant	Pre Raw Scores	Post Raw Scores	Pre AVG	Post AVG	+/- AVG
1	26	25	2.9	2.9	-0.1
2	27	36	3	4	+1.0
3	**45**	**43**	5	4.8	-0.2
4	28	33	3.1	3.7	+0.6
5	**12**	27	1.3	3	+1.7
6	29	27	3.2	3	-0.2
7	22	**24**	2.4	2.7	+0.3
8	27	31	3	3.4	+0.4
9	23	32	2.6	3.6	+1.0
10	**16**	**17**	1.8	1.9	+0.1
11	**41**	**40**	4.6	4.4	-0.2
12	35	30	3.9	3.3	-0.6
13	**39**	**40**	4.3	5	+0.7
14	27	34	3	3.8	+0.8
15	23	31	2.6	3.4	+0.8
16	26	27	2.9	3	+0.1
17	28	33	3.1	3.7	+0.6
18	32	31	3.6	3.4	-0.2
19	35	36	3.9	4	+0.1
20	22	33	2.4	3.7	+1.3
21	24	32	2.7	3.6	+0.9
22	23	32	2.6	3.6	+1.0
23	**40**	**41**	4.4	4.6	+0.2
24	23	37	2.6	4.1	+1.5
25	33	36	3.7	4	+.3

Note. Attitudes toward science consists of items measuring self-efficacy related to science and expectations for future value gained from success in science. (Friday Institute for Educational Innovation (2012). Student attitudes toward STEM survey Upper elementary school students. Raleigh, NC: Author.) Pre S-STEM standard deviation range was a raw score of 20-36 and post S-STEM standard deviation range was a raw score of 25-37 as outlined in Table 1. Numbers in bold indicate an outlier.

The quantitative data from the S-STEM data was a basis for the qualitative form of data collection, the participant interview, which aligned with the explanatory sequential multiple-methods research design because the interview questions were refined once the analysis from the S-STEM from the preceding stage was complete (Mafuba & Gates, 2012).

The S-STEM statement, “I feel good about myself when I do science” lent itself to a variety of follow-up questions based upon initial ratings. If a student had a rating of “strongly agree” then he or she was asked to explain why they felt good about themselves during science, whether or not there was a specific topic within the content area that increased those positive feelings, or if there was a specific learning modality that influenced their rating. The semi-structured interview questions were fine tuned for each participant, yet aimed to yield themes within responses to determine the reasoning or influence behind student S-STEM ratings.

After the standard deviation for the pre S-STEM data was calculated (Table 1), a descriptive analysis of the data revealed that there were six participants that had raw scores in the science construct outside of the normal range of 20-36 (Table 2). For the participants with raw scores below 20, their initial interview questions were refined to focus on their low science attitude. For example, participant number 10 (Table 2) revealed during her initial interview that she attended a reading remediation program during science instruction so her less than average attitude towards science was attributed to her inability to participate during science instruction which never allowed her to build her own self-efficacy if she was not present during lessons. Participants that were outliers on the high end of raw scores had follow-up questions to determine why they felt successful in science and their reasoning for having such a positive attitude toward science. Therefore, the descriptive analysis of the pre S-STEM data was explained in sequence with the qualitative data collection following the quantitative instrument as an explanatory sequential multiple-methods research design.

Initial Student Interview

The initial interview involved a series of questions, but three were specific to the S-

STEM so that the researcher could gleam a better representation of initial survey ratings. Students were asked to explain their ratings for the statements: “I feel good about myself when I do science” (S-STEM, 9), “I might choose a career in science” (S-STEM, 10), and “I can understand most subjects easily, but science is hard for me to understand” (S-STEM, 16). For students that agreed with statement nine on the S-STEM, there were two themes which emerged from coding: hands-on increases understanding and references to topics that students liked. The two identified themes support that if students feel better about themselves when they conduct experiments or hands-on learning then educators need to recognize this feedback. The other theme associated with what students like to learn about can be increased if their learning modality is honored. There is a likelihood that students will feel better about themselves in more topics within science instruction if there were more hands-on experiences for them to feel confident. Their confidence in understanding is then reflected within their interactive science notebook. “It doesn't matter the topic, I just like experiments” and “I won't say always [feel good about myself when I do science], but like whenever I got into like experiments and all that I would definitely say so” represent the voices of all participants and identify an area of pedagogical practices that can be positively influenced in order to support student needs. Both participating teachers said that their teaching style changed over the course of the study to “include more interesting experiences for students.” For example, the fourth grade teacher integrated a design challenge which led to students constructing terrariums that they could take home. From studying about the earth, animals, aquatic organisms, chemistry, and weather, those student references connected how learning about their interests made them feel better about themselves because they were more confident in participating during classroom instruction and paid more attention because it was a topic they enjoyed learning about. The participants that rated themselves negatively about how they felt when they do science identified that science was too hard, there was too much writing, or their rating was based solely on one topic within the entire science content area. Those couple of students revealed they didn't like learning about rocks because it was hard and not interesting to them, therefore, they did not like science. Through an analytical lens, this was an extreme or an outlier. "It's really hard," "It's too much work," and, "whenever you're like writing a lot it's not that fun" represented the sentiments for those that had a negative rating. As a follow-up to their negative ratings, four of the students stated that using an interactive science notebook could help them understand content. As revealed in the qualitative data, if a student felt like he or she could understand the content, they exuded more self-efficacious behavior as it related to their performance and production.

There were eight codes during the initial coding process for the statement, "I might choose a career in science" to organize data: didn't understand the career included science, engineer, earth science, life science, physical science, family or friend influence, neither agree nor disagree, and disagree. There were 17 references to questions about whether or not careers included science or statements connecting with a lack of understanding about certain career attributes or skills needed. For example, a student said she wanted to be a physical therapist, but her rating was "disagree." Her initial rating indicated that she was not going to pursue a career in science, yet physical therapy, her desired career is heavily linked with science. When asked if there was any science in physical therapy she said, "I don't know." Many of the other participants expressed a similar sentiment. They didn't know. During the initial interview with another student he asked, "But is an astronaut a scientist?" When one student was asked whether or not being a veterinarian involved science, she replied, "Um, no." When further explaining that being a veterinarian will require her to understand how an animal's body works and knowing how to treat the animal, she interjected, “That's science?” The theme was blatantly clear. Students did not understand the different sciences and the real-world connection between what they were learning and their future (Table 3). Integrating conversations, research opportunities, and learning activities connecting science content with potential career paths may influence student interest thereby influencing their self-efficacy in being able to express themselves. If a student thinks that what they are completing will positively impact their future, then effort increases as does a positive self-image.

Table 3

Interview 1, Qualitative Data, Science Attitudes

Themes	Participant Quotes
Hands-on increases understanding	“It doesn't matter the topic, I just like experiments.” “I won't say always [feel good about myself when I do science], but like whenever I got into like experiments and all that I would definitely say so.”
Negative association to science	“It’s really hard.” “It’s too much work.” “Whenever you're like writing a lot it's not that fun.”
Depends on the topic	“There are only a couple of things that are confusing, but the rest is easy to understand.” “In science, typically, when I learn it, is pretty easy for me. Yeah. Except for the rocks.”
Interest increases understanding	“Sometimes it's easy whenever I think about it long enough, but like if I like thinking about something too strongly or if I don't understand it, it's kind of hard, so I just normally don't try to do it as much as I usually would if I knew something about it.”

The statement on the S-STEM, “I can understand most subjects easily, but science is hard for me to understand” was the only statement within the science construct that was negatively worded and considerably impacted student comprehension behind the intent of the question. During the interview, several students changed their rating once they understood that the statement was actually asking them to rate whether or not science was hard for them to understand. Many students rated themselves as “disagree” because they interpreted the statement to mean that they could easily understand science. They should’ve marked “agree” to acknowledge that science was hard for them to understand. The majority of participants chose "neither agree nor disagree" and their responses yielded the themes: depends on the topic, interest increases understanding, and assistance needed from teacher to understand (Table 3). "There are only a couple of things that are confusing, but the rest is easy to understand" or "in science, typically, when I learn it, is pretty easy for me. Yeah. Except for the rocks" support that comprehension is topic-based. Another student said, "Sometimes it's easy whenever I think about it long enough, but like if I like thinking about something too strongly or if I don't understand it, it's kind of hard, so I just normally don't try to do it as much as I usually would if I knew something about it" which implies that his interest level would cause him to try harder. "Sometimes there's big words that, really, I don't know about. And sometimes the words that I sometimes I do know about, or we talk about it and then I start to know about it." Her statement, explaining her rating of "neither agree nor disagree" connected to the difficulty of science was impacted by her ability to obtain assistance from her teacher. She said in the beginning, she may think that the science lesson was hard, but then once she received support from her teacher or learned more about the topic then it became easier.

Second Student Interview

Halfway through the 55 instructional day study, all fourth and fifth grade students participated in a second interview. Students were asked if their interest in science increased, decreased, or remained the same since the integration of interactive science notebooks during their classroom instruction (Table 4). In addition, students were asked about the ways they liked to express their content knowledge as their outputs and explained the reasoning for their preferences. For students stating that their science interest has remained the same since their initial S-STEM they said, "I love science still" and "It's probably my favorite" indicating a history of preferred interest of the subject matter. One student explained that the reason for his decreased interest in science was "I only get F's on it." When inquiring why he believed so he said, "Because I don't try. I don't try." He then stated that he hated science. His post S-STEM survey later revealed that his overall science attitude went from a 2.6 overall average to 4.1 which was a positive increase of 1.5. He later attributed the considerable increase to the interactive science notebook for the reason why he changed so drastically because as a future artist he now had more opportunities to draw during science and he better understood how careers were connected to his learning, more importantly how chemistry was connected to art.

Table 4

Interview 2, Qualitative Data, Science Attitudes

Codes	Participant Quotes
Increased Interest	"I like it better than I did because I thought it was all just hard and stuff, but now I think it's getting easier with this interactive science notebook." "I'm doing pretty good on it. I'm getting better." "Whenever we take notes, I know more, and whenever I don't know it, I can go back and look into it."
Decreased Interest	"I only get F's on it. Because I don't try. I don't try."
Interest Remained the Same	"I love science still." "It's probably my favorite."

His ability to choose drawing as a form of expression to demonstrate his understanding of learned science content increased his self-efficacy and overall science attitude. He was initially flagged during data collection because he was an outlier in the initial S-STEM survey and shared rather negative sentiments during the second interview. Those students citing an increased interest in science said that it was because science was easier with an interactive science notebook. "I like it better than I did because I thought it was all just hard and stuff, but now I think it's getting easier with this interactive science notebook" was the voice reflected for this question in the second interview.

The three themes which emerged from how students felt about science were: interactive science notebooks helped students understand content, science was more interesting, and they now had a reference tool in science which had positively influenced how they felt about science. In reference to having an interactive science notebook, “I was pretty good at science, but then I would just know it in my head. Now if I don’t know the answers I would feel like I get like answers right a little bit.” A sense of pride could be felt with, “I'm doing pretty good on it. I'm getting better.” Confidence was expressed in the statement, “whenever we take notes, I know more, and whenever I don't know it, I can go back and look into it.” These sentiments directly supported the quantitative results reported on the post S-STEM and final interview. Students also gave feedback about their experience using the learning tool at the halfway point and cited choice as their favorite attribute of an interactive science notebook with nearly every participant saying they preferred to draw and use sticky notes in their notebooks to help them understand content. Choice was the most powerful indicator of interest and was supported in teacher anecdotal notes that students had increasing levels of excitement throughout the study related to creating their outputs and they noticed by the halfway point that students were adding more details and effort into how they chose to express their understanding of the lesson’s content. Students also said they liked how the formatting was organized and that they could see themselves refer back to their work to help them study for tests or answer questions during class. This further cements the notion that interactive science notebooks positively influenced self-efficacious behavior.

Post S-STEM

The post S-STEM data for the science construct found that 19 of the 25 participants, or 76% of the population, had a positive increase in their science attitudes at the end of the 55 instructional day study (Table 2). S-STEM results were converted to a 1 to 5 rating scale, the closer the average to 5 was considered to be a more positive attitude toward science. Five of the six participants with a decreased average in their overall science attitude went down by one or two tenths. One student's average fell from a 3.9 to 3.3. For the statement, "When I am older, knowing science will help me earn money" she originally rated "strongly agree" and for her post-survey response she indicated "strongly disagree." The other significant change in response was from "strongly agree" to "neither agree nor disagree" for "In the future, I could do harder science work." The Friday Institute for Educational Innovation (2012) explains that constructs were created for data to analyze the whole construct instead of individual statements, but in cases where student averages decreased, it was important to analyze the individual's responses in an effort to initiate future conversations or activities to help rectify that decline in overall attitude. Although her overall science attitude increased by one tenth, there was one student that was more than one standard deviation away from the mean at both intervals, pre and post study. She rated herself with an overall science attitude at 1.8 and then 1.9 (Table 2). This data was quite alarming because it was clear that this student's self-confidence was quite low in this subject matter and special attention needs to be directed towards this student as a result. This student frequently attended a remedial reading program, Read 180, during science lessons and her teacher voiced that she didn't have much of an opportunity to get involved in science lessons since she was "pulled for a resource class." Her classroom presence and lesson participation may have had an impact on her rating, but other interventions needed to be in place for this student if she had such a low attitude towards science and no opportunities for remediation. She was not given the same opportunity as her peers to be present during science instruction.

The standard deviation was calculated for all post S-STEM survey data and through descriptive analysis showed that a raw score ranging from 25-37 was a normal distribution of data. There were six students or 24% of the population that were outside of the normal distribution. Four students had a raw score of 41, 40, 40, and 43 which were above the normal distribution and two students had a raw score of 24 and 17. Of those two, one was well below the standard deviation of the mean data and the other was very close to the normal distribution range. Descriptive data analysis of student surveys found the outliers within a population and was an integral component for the classroom teachers in their instructional approach. Overall, 16 participants had an average of 3.5 or higher in the science construct, representing a 70% or higher overall science attitude which was still relatively low. A more desirable percentage was 80% as it reflected a good percentage compared to a fair percentage, as referenced by the Department of Education’s criterion-referenced grading scale. The initial averages for the science construct had 68% of the population rating a less than average attitude towards science, but the post S-STEM revealed that 40% of the population had a less than average rating towards science. This implied that 28% of the population went from a less than average attitude towards science to at least an average attitude or higher. Data analysis from multiple forms of data collection supported a positive increase in students’ feelings towards science.

Final Student Interview

Quantitative data determined that 76% of the population had a positive increase in their overall average ratings toward science (Table 2). The qualitative data revealed that 22 out of the 25 participants referenced an increase in science attitude, two participants stayed the same, and one noted a decrease in interest. “In a way it's kind of lowered actually.” The student citing a decrease in interest specifically identified the input of content by saying, “Just 'cause these input things have confused me so much, and all the writing that we still have to do after that." When asked if he was talking about the notes he took and the information he received from his teacher during classroom instruction, he responded with, "I guess." While explaining the output he was most proud of, this student voiced his desire to draw and struggled with following directions on a task by explaining, "Well just because of how the art is. Miss Ross actually, I didn't know this, we were supposed to write it, and I didn't know that, I had already started it, so it was this big thing, while everybody else had just writing. She didn't exactly realize that until she looked through it. Well actually I told her about it that day, and she was like, 'Well you're supposed to do this, but I guess because you already have it done, you better just know what they are.' And I said, 'Okay. I do.'" His reluctance to write was clearly intimated through statements such as, "I don't like to write much" and "I'd rather draw, writing is not my thing."

Table 5

Interview 3, Qualitative Data, Science Attitudes

Themes	Participant Quotes
Better grades	"I think I've been doing better with my grades and stuff, so I think I like it a little bit better."
More interesting content	"I used to think that science was hard except for when we did experiments, I thought that was fun. I used to think it was harder. Then as we went, I thought it was more fun and interesting as we went." "It's interesting to learn about the human body, and the nature of what's all around us and stuff. Learning about the ground and stuff, it's really interesting."
Note-taking	"Well when we first started I wasn't real sure how to take notes and then my teacher showed us that how to make them shorter and how we're supposed to write our notes down, to only have like the specific thing in there."
Teaching changed	"Because we get to do projects that are cool" and "Back then, we used to barely ever use these [composition notebooks]. Now we use them all the time. I love it."

The first cycle coding of the interviews citing an increased interest in science had four themes: better grades, more interesting content, note taking, and teaching changed (Table 5). Of those four, more interesting content and teaching changed held the most references. During her final interview one student said, “I used to think that science was hard except for when we did experiments, I thought that was fun. I used to think it was harder. Then as we went, I thought it was more fun and interesting as we went” in reference to using her interactive science notebook during science instruction. This same student had a science attitude increase from 3 to 3.8 by the end of the study. Another student said, “It's interesting to learn about the human body, and the nature of what's all around us and stuff. Learning about the ground and stuff, it's really interesting.” Other references to learning about more interesting content during science instruction included, “It [science interest] changed way more. Because now I know a lot more about the deep sea life. And now we're learning about the stomach. But before, we were learning about deep sea life. And I'm being a marine biologist. So that helped me a lot” and “I learn new stuff and I get to draw.” The references to a change in teaching practices noted that participants were doing science regularly and had been able to watch more videos and conducted more experiments since January 2019, “It's kind of cooler now because I never even watched videos before in class. It's cool. Whenever we do experiments and stuff, like the last one we did, how they did an experiment on it is different in a good way.” More stated, “Because we get to do projects that are cool” and “Back then, we used to barely ever use these [composition notebooks]. Now we use them all the time. I love it.” There were also students that referenced that the reason for their increased interest in science was because they learned how to take notes or their grades had improved which caused them to like science more. “Well when we first started I wasn't real sure how to take notes and then my teacher showed us how to make them shorter and how we're supposed to write our notes down, to only have like the specific thing in there.” In reference to grades, “I think I've been doing better with my grades and stuff, so I think I like it a little bit better.” All examples extracted from a qualitative data analysis demonstrated how the interactive science notebook positively influenced science interest and supported the quantitative data with a rise in student self-efficacy in science.

Artifact Narrative

The final interview also contained a series of questions about student experience using an interactive science notebook and detailed an output which they were most proud of as an artifact narrative which demonstrated their self-efficacy in expressing science content knowledge. The purpose of students selecting an output was two-fold; to hear their sentiments regarding their own source of pride and to determine the methods which students preferred to express their understanding of content knowledge for further potential research as a classroom educator trying to recognize what motivated students to learn.

Three themes were identified as to why students selected the output they were most proud of: effort, increased understanding, and topic of interest. Within the reference for effort, students explained that they had more details and were neater with their work. “It has everything on it, 'cause my other ones don't really have everything, but this one has everything on with these” and another student said that her selected output “gives a lot of examples and detail.” Another participant said, “This is also one of the very few that's colored some. And I think I did my best on this one and it is also one of my favorite things that we learned about.” Most students were not able to provide details why they were proud of their work, but effort with nine references became the largest theme after pattern coding. In reference to a food web, “It tells me what they eat, and if I'm on a test, I can tell what that animal eats and what eats that animal” thus providing qualitative evidence that a reason for increased interest in science was attributed to understanding how the format of an interactive science notebook increased understanding of content knowledge thereby increasing student self-efficacy in expressing themselves. Another student that stated their selected output increased their understanding said, “I drew a really good picture and it helps me explain what I learned.” By learning a topic of interest, nine students referenced that they did a better job with their output, learned more because they were interested, and had an overall increased interest in science when they liked the topic. “It's [output] picking up trash instead of like putting like trash in the environment. And stuff. And I don't like the environment being dirty and stuff like that. And like being all trashed 'cause animals are eating the trash.” This student further detailed the classroom lessons about ways that humans negatively affect the environment really impacted her and that she continued to think about it, even outside of school. She said she started thinking about how she could change her actions so that she wasn’t a part of the problem. Her sentiment during her interview was of concern for the environment and her desire to help. She was proud of her drawing because it made her “feel like she had to do something.” This same student had a post S-STEM science attitude of 4 out of 5 which was a higher average than most of the population with only 32% averaging 4 or above.

Final Reflection

All participants were asked to talk about their experience using an interactive science notebook and its use as a learning tool. The intended purpose of asking students these questions was to determine if the learning tool was a possible factor impeding their interest in science or their own self-confidence in expressing themselves. Initial coding for their experience using an interactive science notebook found that students felt they learned more, liked that their learning was all in one place, and that they were much more detailed in their synthesis of content learned during instruction compared to performance prior to the start January 2019. Their responses indicated a positive experience. With an overwhelmingly positive experience of using this new learning tool, the conclusion that interactive science notebooks positively influenced interest in science and self-efficacy in expressing science content could be drawn. Teacher anecdotal notes also supported a positive student experience with increased student interactions, shared experiences, more participation, and an excitement for science lessons. Teachers also observed that as the study progressed, students were more prone to share their notebooks with their peers which inferred increased pride or self-efficacy in expressing their learning.

Discussion

Self-efficacy is an important concept for educators to understand as it relates to their students. This multiple-methods study focused on elementary school students and their self-efficacy in expressing science content. The study could have easily been conducted with middle school or high school students because their self-efficacy is just as important to understand, especially as they begin exploring future career options and enter the work force. Self-efficacy and one’s confidence was shown, in this study, to have an influence on self-expression of content knowledge. Students felt as if they could reach the desired outcome of representing their understanding of science content in a way that he or she felt successful. According to Bandura, students with a strong sense of self-efficacy are more likely to put forth more effort in task completion as compared to their counterparts that have low aspirations in task completion as a result of previous patterns in failed outcomes (1977). This multiple-methods study was specific to expressing science content through the use of an interactive science notebook, but as revealed in student interviews and teacher anecdotal notes, interactive notebooks were thought to be beneficial in other content areas such as: mathematics, language arts, and history. Students believed that their self-efficacy in expressing content would be similar with other disciplines because they would still have the ability to choose the representation of content in their output which would meet their needs and interest.

A student with a transient background often times struggles to make connections with their peers and teachers because the length of time he or she stays in one place is unknown. Building relationships can be difficult, especially if you know it won't last. This study found a positive influence between a learning tool and self-efficacious behavior which has quite powerful implications for a child that has experienced a lot of transition. This is especially important for educators to understand because instruction which provides opportunities for students to feel successful in an academic subject should therefore increase self-efficacy in the identified subject matter (Hushman & Marley, 2015). Participants embraced the power of choice and ownership for the output they chose to represent their understanding of content. They believed in themselves and felt confident in what they created. By doing so, that feeling can transfer over to their new learning environment because they have found a tool which helps them synthesize information, positively influences how they feel about themselves and their skills, promotes interactions among their peers, and provides entry-points for them to integrate their own background experiences. Self-efficacy beliefs, "affect whether individuals think in self-enhancing or self-debilitating ways, how well they motivate themselves and persevere in the face of difficulties, the quality of their emotional well-being and their vulnerability to stress and depression, and the choices they made at important decisional points" (Bandura & Locke, 2003, p.87).

A possibility for future research is to analyze the forms of output that students preferred to use throughout the study. By doing so, this will allow teachers to focus on some initial forms of representation to teach students how to use when integrating notebooks into their classroom for the first time. The participating teachers stated that at the beginning of the study their students were not used to choice and making their own decisions to best represent their understanding of content, therefore, specific professional development can be catered to teaching educators about output representations which can increase interest in content matter as well as be used as an alternative to assessments. This has implications for future research as well as influence on pedagogical practices. Anecdotal notes were of special importance because both participating teachers noted increased student interactions and peer support while working on their output of science content. The verbal persuasion and feedback that students were giving one another increased their self-efficacy in synthesizing learned information (Bandura, 1977) and the anecdotal notes offered invaluable insight which can be integrated into future professional development regarding the implementation of this learning tool. An interactive science notebook not only had data to support a positive influence on student self-efficacy in expressing content knowledge, but it was also a preferred learning tool used during classroom instruction.

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CHAPTER 4 MANUSCRIPT #2

Using Interactive Science Notebooks to Foster STEM-related Career Choice

Abstract

Twenty-five elementary school students, fourth and fifth grade, in a rural community in Kentucky participated in a multiple-methods study to determine the extent which interactive science notebooks foster an interest in pursuing a STEM related career. The study aimed to promote discourse among administration, educators, and students regarding pedagogical practices linked with innovative learning tools which influence student interest in pursuing a STEM related career. After conducting a descriptive analysis of the impact of interactive notebooks on career choice, 10 out of 12 STEM careers yielded a positive increase in interest and 16 participants referenced a better understanding of STEM careers as a result of using an interactive science notebook during their final interview. The results have implications for shifts in pedagogical practices in elementary school classrooms nationwide.

Introduction

In a rural community along the Ohio River with 1,200 residents sits an independent school serving approximately 100 pre-kindergarten to eighth grade students. According to the 2010 Census of Population and Housing by the United States Census Bureau, the community's population was 797 residents and the median income for a household was $29,792 with 20% of its population below poverty line. Prone to annual flooding and a high poverty rate increases the likelihood of fluctuations in population throughout the year. As the only school situated in the center of this small town, teachers and administrators have an added challenge of meeting the needs for a highly mobile or transient population. According to the 2017-18 school report card by the Kentucky Department of Education, 64% of the students received free breakfast and lunch, 17% received reduced cost meals and 20% receive no meal assistance. Representing that student population, was a reported demographic of 91% Caucasian, 4% two or more races, 2% Asian, and 3% other.

Much of the employment sought by adults in this community are linked with the transient lifestyle of military service members, migrant farm workers, construction workers, and seasonal employees tied to Louisville's horse industry, cattle farms, or coal mining. Migrant students are present in 462 schools across Kentucky and the communities that surround these schools recognize the unique atmosphere that must be provided in order to support the children they serve. Teachers and staff are trained by school counselors, district personnel, and non-profit organizations about the effects of migrant families and the impact of moving seasonally or every few years seeking employment and its effects on academics and behavior. Migrant students have added challenges compared to their stationary peers and over the past several years teachers, parents, and community partners have voiced their concerns and needs in order to support this unique population. The state has responded through funds, professional development, and providing supplemental academic support for students that qualify during summer months and after school programs (ESCORT State University of New York at Oneonta, 2016). A notoriously mobile population, as recognized by the surrounding communities and state, should be afforded the same support system or funding as their stable counterparts to accommodate for their unique needs. It is all the more reason why exposing students to a variety of achievable, stable, and desirable careers at a young age is important in their overall academic success and future.

The purpose of this study was to explore the influence of interactive science notebooks on student interest in pursuing a STEM related career. The study aimed to promote discourse among administration, educators, and students regarding pedagogical practices linked with an innovative learning tool which influenced student interest in pursuing a STEM related career. Analyzing the impact of interactive journals on career choice has implications for shifts in pedagogical practices in elementary school classrooms nationwide. With a positive influence on student interest in pursuing a STEM-related career, interactive journals could be implemented on a consistent basis and specific professional development could be tailored to the integration process. With the growing need for STEM professionals, an increased interest in STEM related career fields as a result of integrating interactive science notebooks in elementary classrooms could have a positive impact on their future success in a competitive, global market.

The selected quantitative instrument, student attitudes toward STEM (S-STEM) measures attitude towards 12 different STEM career pathways. “Attitude is defined as a positive or negative sentiment, or mental state, that is learned and organized through experience and that exercises a discrete influence on the affective and conative responses of an individual toward some other individual, object, or event” (Reid, 2006). Attitude, for purposes of this instrument and as identified by the creators of the survey, is a composition of both self-efficacy and expectancy-value beliefs towards a specific subject (Unfried, Faber, Stanhope, & Wiebe, 2015). Expectancy-value theory is an individual’s constant self-assessment of whether or not they are likely to achieve their desired goal and the ability to rate the gained outcomes or losses of completion (Eccles & Wigfield, 2002) therefore complementing self-efficacy theory when associated with behaviors, actions, and outcomes in a specific area of interest such as career decision-making. The instrument was selected because the definition of attitude encompasses the idea that self-efficacy is a belief system and is connected with attitude because both influence responses or actions towards something or someone. In other words, the pursuit of future endeavors and career pathways can be linked with a student's attitude towards a career field and its related content area.

Through an explanatory sequential multiple-methods research design, the quantitative data was first collected and analyzed followed by qualitative data collection. By doing so, the descriptive analysis of the quantitative S-STEM instrument captured the context connected with student interest in STEM careers and the qualitative student interviews and teacher anecdotal notes enhanced validity through confirmation and provided a layer of understanding the social complexities of a mobile population (Mafuba & Gates, 2012). One form of data collection supported the other and worked in tandem to reveal a deeper, more meaningful representation of student interest in pursuing a STEM related career through the use of an interactive science notebook (Saldana, 2013). The approaches to data collection and analysis were compatible which allowed for a better interpretation of data (Creswell, 2009). The S-STEM, given to participants as a pre and posttest, along with three oral interviews occurring at three intervals throughout the study, and teacher anecdotal notes were collected independently, but used in sequence to interpret data collected throughout the 55 instructional day multiple-methods study.

Research Question

The problem explored in this study was to provide empirical evidence to support the use of interactive science notebooks as a method to foster an interest in pursuing a STEM-related career in fourth and fifth grade elementary school students. The multiple-methods design was created to answer, to what extent do interactive science notebooks foster an interest in pursuing a STEM related career in fourth and fifth grade elementary school students?

Methods

The research study took place at a Title 1 school located in a rural community along the

Ohio River from January to March 2019 during science instruction, totaling fifty-five days of instruction, using purposive sampling of two classes, fourth and fifth grade, totaling 25 students. The study's population consisted of 12 fourth grade students and 13 fifth grade students. The population at the start of the study in January 2019 was 25 fourth and fifth grade students and 25 students at the conclusion. The participants were comprised of 14 males and 11 females with two students on an Individualized Education Plan and three receiving educational accommodations through a 504 plan, representing 20% of the study's population receiving support services. All 25 students obtained permission from a parent or guardian to participate in the study and all students assented to participate. Within the timeframe of the study, there were no changes to the population which is of special significance due to a historically transient student body.

Quantitative and Qualitative Instruments

The selected validated instrument used to quantitatively measure student interest in STEM career fields was the student attitudes toward STEM (S-STEM) survey created by the Friday Institute for Educational Innovation (2012) supported by the National Science Foundation under Grant No. 1038154 and by the Golden LEAF foundation. The S-STEM was given at the beginning of the study in January 2019 and end of the study in March 2019. Three interviews were conducted, after the initial and final S-STEM as well as halfway through the 55 instructional days. The initial and final student interviews were a secondary form of data collection following in sequence behind the quantitative instrument. As an explanatory sequential multiple-methods research design, the S-STEM survey was followed by qualitative data collection through initial interview responses to semi-structured, open-ended questions directly linked with student ratings in the construct representing 12 different career pathways linked with science, technology, engineering, and mathematics. Halfway through the study, all participants were interviewed. The aim of the second interview was to determine if there were any changes in pursuing a STEM career as a direct result of having some experience with an interactive science notebook. At the conclusion of the study, the S-STEM was re-administered and analyzed through descriptive analysis. Students were interviewed a final time and asked a series of semi-structured, open-ended questions as a direct connection to their final S-STEM ratings. As an explanatory sequential multiple-methods research design, the interview questions were refined to reflect the descriptive analysis of the final S-STEM. In addition, the two participating teachers recorded anecdotal notes in their given observational notebook related to student comments, questions, interactions, observations, and experiences pertaining to student interest in STEM careers throughout the 55 instructional day multiple-methods study.

Procedures

Prior to the start of the study in January 2019, the researcher obtained an exemption determination from the Western Institutional Review Board (WIRB) and a letter from the superintendent of the study's site to satisfy both the doctoral requirements for Virginia Polytechnic Institute and State University and district requirements of conducting a study on school premises with elementary students.

Recruitment took place once the study was accepted by the WIRB and the school site. Once approved, all fourth and fifth grade guardians received an informed consent form for their child to participate in research since participants were minors. The informed consent form clearly explained the purpose of the study, the type of research intervention, participation selection, voluntary participation, expectations of students throughout the 55 days of instruction, risks, benefits, confidentiality, sharing the results, and the option to withdraw at any time. Informed consent forms were collected throughout the recruitment period until the first day of the study. As a requirement to conduct research with participants under the age of eighteen, WIRB required an assent form. After approval of the research design, but before the initial start of the 55 data collection period, both fourth and fifth grade classes came together for a meeting to explain the purpose of conducting research, the rationale for this study, and what the study entailed. At the conclusion of the meeting, all students were given an assent form. Assent forms were collected up until the first day of the study. For those students that were absent, the researcher met with them upon their return in order to obtain their assent to participate.

As outlined in the research design flow chart and research matrix (Fig.1 and Fig.2), at the start of the 55 instructional day study, the student attitudes toward STEM (S-STEM) survey was administered to all 25 participants. The S-STEM survey was administered to both classes, fourth and fifth grade, at the same time. The researcher read aloud the survey statements for the STEM career constructs to prevent any boundaries between participant and reading abilities. All initial S-STEM surveys were collected by the researcher for initial descriptive analysis. After each science lesson, both participating teachers recorded anecdotal notes in a designated observation notebook for the duration of the study. After initial data analysis on the S-STEM, the researcher interviewed all 25 participants. Students responded to a series of semi-structured, open-ended questions directly linked with their ratings to the "Your Future" construct within the S-STEM. Another oral student interview took place approximately halfway through the 55 instructional day period. Student interviews at this stage of the study focused on interests or lack thereof in STEM careers. After 55 days of instruction, the S-STEM was re-administered as a post survey. The S-STEM was re-administered using the same protocol as the initial survey. Final student interviews were conducted after the post S-STEM data was quantitatively analyzed through descriptive analysis. All students participated in a final interview at the conclusion of the study related to their S-STEM ratings for the "Your Future" construct and their experience using an interactive science notebook as a learning tool during science instruction. Anecdotal notes from classroom teachers were collected and qualitatively analyzed. After all forms of data were analyzed an interpreted, the multiple-methods research results were reported back to Virginia Polytechnic Institute and State University and the study's site, per doctoral requirements and district request.

Multiple-Methods Research Design

Through an explanatory sequential multiple-methods research design, one form of data collection informs the other and works in tandem to reveal a deeper, more meaningful representation of student interest in pursuing a STEM related career as a result of using an interactive science notebook (Saldana, 2013). The approaches to data collection and analysis were well-suited to provide a richer opportunity for interpretation (Creswell, 2009). This study aimed to support the quantitative S-STEM survey ratings through qualitative forms of data collection, student interviews and teacher anecdotal notes, which provided participants with a more well-rounded representation and better opportunity for their voice to be heard and understood.

Quantitative Data Collection

S-STEM Survey

The selected quantitative tool used for the study was the upper elementary student attitudes toward STEM (S-STEM) survey created by the Friday Institute for Educational Innovation (2012) supported by the National Science Foundation under Grant No. 1038154 and by the Golden LEAF foundation. There are two versions of the S-STEM, upper elementary and middle/high school S-STEM. The upper elementary version was created for fourth and fifth grade students and the middle/high school S-STEM was adapted for sixth through twelfth grade students. Instrument validity for the S-STEM survey was conducted through exploratory and confirmatory factor analysis using SAS/STAT® software and analytic tests of measurement invariance using Mplus® In addition, Cronbach's alpha was used to measure internal-consistency reliability for each of the four constructs: attitudes toward science, math, engineering/technology, and 21st century skills (Unfried, Faber, Stanhope, & Wiebe, 2015). The S-STEM Likert survey was created as an instrument to measure changes in elementary students' attitudes in STEM-related subjects, 21st century learning skills, and interests toward STEM careers. The first part of the survey asked students to rate their attitudes or self-efficacy, terms used interchangeably, in math, followed by science, and then technology and engineering in the same section. The next rating scale was about 21st century skills. The final part of the S-STEM survey was a Likert rating scale about students' attitudes or interests as related to 12 STEM career pathways. This quantitative instrument was followed by a student interview. The qualitative method of interviewing participants provided explanations and reasoning for individual S-STEM ratings. In addition, anecdotal notes from classroom teachers were used to support S-STEM ratings and statements made during student interviews, therefore, utilizing a multiple-methods research design.

The results of the initial S-STEM were further supported in student responses to semi-structured, open-ended questions which allowed students to provide additional evidence or support for their ratings representing the "very interested" and "not at all interested" rating categories for types of work associated with STEM careers. With permission from the Friday Institute for Educational Innovation, the S-STEM instrument could be used in totality or could be modified to suit the purpose of a study since each section of the S-STEM could be considered an individual construct. The math attitudes construct yielded a 0.89 reliability in Cronbach's Alpha, science attitude had a reliability coefficient of 0.83, the engineering and technology attitudes construct's reliability coefficient was 0.84, and 21st Century learning attitudes was 0.87 (Friday Institute for Educational Innovation, 2012). An acceptable reliability coefficient for most social science research studies is 0.70 (Goforth, 2015). Each construct's coefficient in the eighties demonstrates relatively high internal consistency. An exploratory and confirmatory factor analysis was also completed using SAS/STAT® software to check for dimensionality within each of the constructs. Due to the nature of the research question, only the "Your Future" construct was descriptively analyzed as it directly related to interest in STEM related career fields.

Qualitative Data Collection

Student Interviews

Interviews allowed the researcher to elicit information from the participant that was otherwise lacking in the selected quantitative instrument. Due to a population of 25, all participants were interviewed after the initial administration of the S-STEM, halfway through the 55 instructional study, and a final interview was conducted after the post S-STEM was descriptively analyzed. The purpose of the semi-structured interviews were to ask for clarity, explanation, and reasoning for responses on the S-STEM as well as a method to monitor overall STEM career interests. The interviews conducted at the beginning, middle, and end of the study were semi-structured because the quantitative data had yet to be collected and creating a concrete set of interview questions did not suit the needs of the study. The interview questions created prior to the start of the survey served as a guide since the nature of the elementary school classroom was ever-changing and often times included unexpected occurrences derailing the intended plan. Working with human subjects, especially children, was unpredictable. It was important to plan, yet remain flexible. Committing to a structured set of questions may have interrupted the natural order of progression in a student's thought or conversation thus negatively impacting the outcome. As recommended by Creswell and Poth (2018), the researcher should use an interview protocol or guide to stimulate the social interaction between the participant and interviewer and the interviewer takes on a responsive role throughout the interview process with the ability to alter questions in a manner that remains true to the study (p.164). This also supports an explanatory sequential multiple-methods research design because the student interview questions, which followed the initial and post S-STEM, were modified once descriptive analysis of the quantitative data occurred.

Open-ended questions allowed participants to include more information than the Likert survey allowed by having an opportunity to provide details to support their responses. This qualitative form of data collection supplemented their quantitative responses. Closed-ended questions or statements, as used in the S-STEM survey, may not necessarily reflect students' real feelings or experiences because surveys are not a common practice in elementary school classrooms and students may have a hard time narrowing down their responses on the provided scale thus rendering the need for including qualitative methods of analysis. Likert scales operate on a numerical scale and it is hard to quantify the difference between two numbers or associated categories (Bowen, 2016, p.8). For example, the 12 different types of work included in the S-STEM survey included a brief description with ratings ranging from "not at all interested" to "very interested." Determining what would constitute a rating of "interested" to "very interested" may have proved to be a challenge for fourth and fifth grade students. Using a numerical value to represent their feelings, without the ability to explain or support their rating, may not have been an accurate representation of their response. The open-ended questions were worded in a way that provided students the opportunity to clarify and explain their individual ratings on the S-STEM survey. This included reasoning and possible background experiences impacting their selection. The aim of this interpretive qualitative method was to gain insight and to better understand the participants' ratings on the quantitative study (Denzin & Lincoln, 2013, p.7). By integrating qualitative methods in tandem with a quantitative instrument, student responses better reflected their intended outcome.

Anecdotal Notes

In addition to the quantitative S-STEM survey and three interviews, the two participating teachers recorded anecdotal notes as related to STEM career interests over the course of the 55 instructional day period while students were working in their interactive science notebooks. The two participating teachers have varying professional backgrounds representing a wealth of experience in education and have taught in a variety of learning environments with lower socio-economic populations. The fourth grade teacher has been in the classroom for four years, but has worked with children in some capacity for over 20 years. She has experience using a science notebook and has integrated them into her own classroom, but this was the first time she used the interactive science notebook format with an input and output. The fifth grade teacher has had a variety of teaching positions in elementary and intermediate settings over the past eight years to include arts and humanities, math, and social studies. This was her first year teaching solely fifth grade and her first time integrating interactive science notebooks into her classroom instruction.

Teachers recorded comments, interactions, behaviors, observations, and activities that students had as they related to their interest in STEM-related careers. The intention of including anecdotal notes as a form of data collection was to support student S-STEM career interest ratings and used as evidence to gain further understanding and meaning of interview statements made by participants throughout the study. Capturing the participating teachers' experiences while integrating a new learning tool was a first-hand account to support future implementation in other classroom settings and allowed the researcher to have further evidence of student outcomes as it related to the integration of interactive science notebooks, especially when the researcher was not present during instruction (Jaladenkia & Bhattacharya, 2014). The anecdotal notes were a continuous form of data collection to support changes in initial S-STEM ratings as well as statements made during the first and second participant interview. The third interview occurred after the post S-STEM and anecdotal notes were already collected. Anecdotal notes were recorded in a three-column format, as recommended by Saldana (2013). The first column was for the descriptive notes, the second column was for the researcher to jot down preliminary codes and brief notes, and the final category was for the final codes (Saldana, 2013). By doing so, it allowed for initial themes to be revealed via analog coding before importing the notes into NVivo 12 Plus, a computer-aided qualitative data analysis software.

Data Analysis

S-STEM Survey

As recommended by the Friday Institute for Educational Innovation (2012), the Likert ratings for STEM careers was converted into a numerical scale. A student rating of "not at all interested" was assigned the numerical representation of 1, "not so interested" was 2, "interested" was assigned the number 3, and "very interested" was 4. By doing so, the mode and mean, measures of central tendency, was analyzed for each STEM career survey statement and was representative of a descriptive study. Afterwards, individual student data was combined and a percentage of the population was calculated for each response for each career. For further data collection, the “interested” and “very interested” raw scores were combined and a new percentage was calculated representing a positive interest in the overall population at two points, beginning and end of the study. Two pie charts were created to serve as a visual representation of a pre and post item analysis of student interests in all 12 types of work included in the S-STEM survey in an effort to inform qualitative data collection and provide a visual analysis of survey ratings.

Student Interviews

After students completed the S-STEM survey, their quantitative data was supported with an initial interview consisting of a series of semi-structured, open-ended questions. The questions were intended to supplement their responses to the survey construct about their future career interests. By doing so, students provided clarity and explanation in a qualitative manner to support their S-STEM survey ratings. Interviews were recorded and transcribed using REV, a professional transcription service. Transcribed interviews were then imported into NVivo 12 Plus software. Broad nodes or codes were created for each question through its auto coding feature. By doing so, this served as a first cycle of coding data for identifying common themes that emerged across all student interviews. After that, an initial query using the word frequency feature was conducted in an effort to uncover a “broad brush-stroke representation” of written responses for each question by recognizing key words and phrases (Saldana, 2009; Saldana, 2013). High-frequency words that emerged lead to holistic coding to capture the overall sense of the content and emerging categories. Through pattern coding, as a second cycle coding method, emerging themes were organized along with an attributed meaning (Saldana, 2013). The purpose of using pattern coding was to determine whether or not there were experiences or specific attitudes that lead to increased interest in STEM careers. Utilizing a second cycle pattern coding method, emergent themes were categorized which allowed commonalities and relationships within constructs to surface (Saldana, 2009). Ensuring consistency in qualitative data analysis, the same steps of analysis were completed after the second interview and for their final interview which occurred after students completed the post S-STEM survey.

Anecdotal Notes

Throughout the course of the study, teachers recorded anecdotal notes in an observational notebook in a three-column format as previously described. The rationale for doing so was to establish consistency among the two teachers participating in the study. Teachers recorded comments, interactions, behaviors, and activities that students had as they related to their interest in STEM careers. All written observations were imported into the computer-aided qualitative data analysis software NVivo 12 Plus to organize the data. NVivo 12 Plus software identified emergent themes. Once the overarching themes of the anecdotal notes were identified, a thematic analysis was conducted to determine if the anecdotal notes revealed a theme previously identified in other data collection methods. Through axial coding, the analysis revealed dominant categories that appeared throughout all data collection methods and allowed the researcher to see the whole picture thus providing a qualitative representation of the extent at which interactive science notebooks foster an interest in pursuing a STEM related career in their future. Anecdotal notes were then manually coded to its applicable node or theme across data collection. Organizing anecdotal notes in this way simplified data analysis, supplemented student data, and solidified the mixed methods research design by supporting both quantitative and qualitative data collection.

Results

There were twelve STEM careers represented in the S-STEM survey: physics, environmental work, biology, veterinary work, mathematics, medicine, earth science, computer science, medical science, chemistry, energy/electricity, and engineering.

Initial S-STEM

In January 2019, at the start of the study, the careers that students rated as "interested" or "very interested" with the highest percentages were veterinary work and biology with 72% and 64%, respectively. The next closest careers presenting themselves as interesting to the 25 participants were earth science, computer science, and chemistry at 48%. Environmental work followed with 44%, physics 40%, mathematics 36%, energy/electricity 32%, and both medicine and medical science at 28% (Table 6). Upon first glance, the data revealed two distinct career paths that proved to be an overall interest for the fourth and fifth grade participants. Veterinary work was rated at interesting or very interesting to 18 out of the 25 participants and biology was 16 participants. The data also revealed the STEM careers, medicine and medical science, which were of interest to only 7 participants meaning that 72% of the rest of the population were "not at all interested" or "not so interested." The S-STEM was read aloud to students along with the

Table 6

"Your Future" S-STEM, Pre and Post Data, Interested and Very Interested Participant Ratings

n =25	Pre Raw Score	Post Raw Score	Pre S-STEM %	Post S-STEM %
Physics	10	11	40	44
Environmental Work	11	13	44	52
Biology	16	18	64	72
Veterinary Work	18	17	72	68
Mathematics	9	11	36	44
Medicine	7	10	28	40
Earth Science	12	16	48	64
Computer Science	12	13	48	52
Medical Science	7	5	28	20
Chemistry	12	16	48	64
Energy/Electricity	8	11	32	44
Engineering	10	15	40	60

brief descriptions for each career which were included on the survey potentially eliminating boundaries between reading Lexile and the participant. Career exposure and an understanding of career responsibilities and attributes weren't accounted for using the survey alone, but were revealed during the initial interview.

Initial Student Interview

After the initial S-STEM data was interpreted through a descriptive analysis, all 25 students participated in an individual interview. After first cycle coding, the most significant theme that was revealed with 17 references was that participants didn't understand that there was science, technology, engineering, or mathematics involved in their preferred career choice (Table 7). One student said he wanted to be a baseball or basketball player when he grows up and that his future career wouldn't involve STEM. When asked if he thought there was any science involved in sports he replied, "No, I don't know." We continued the conversation about keeping track of statistics is mathematics, why we don't play baseball with a cement bat, and itchy materials for uniforms. He was surprised how science, technology, engineering, and mathematics was all around us and had a lot to do with sports. Towards the end of the interview he said, "I had no idea." His statement was reflected in many of his peers and was a startling realization that as content standards are being taught within the classroom environment, it is crucial that students also understand the connection to the real world with examples that are meaningful to their interests. For the future athlete to understand that mathematics is going to be a pivotal component to his future or understanding how physics will be useful at a young age could influence the trajectory of his future career path. Another student indicated on her survey that she was not very interested in multiple STEM careers, but when asked about her future she said she wanted to be a teacher. Being an educator was not specifically listed as one of the twelve identified careers in the survey, but within each of those broad categories there are teachers and she simply didn't understand that her desired profession involved much of the subject matter included within the survey. The future chef, astronaut, artist, physical therapist, singer, mechanic, NFL player, and soldier all failed to recognize connections to any of the 12 STEM careers within the S-STEM. The qualitative data revealed information that the quantitative survey results could not.

Table 7

Interview 1, Qualitative Data, STEM Careers

Themes	Participant Quotes
Didn't understand a connection to STEM in preferred career choice	"No, I don't know." "I had no idea."
Caring for others	"I want to take care of animals." "Veterinary is very interesting because I really love animals and I don't like seeing them be sad."
Family or Respected Adult Influence	"I have a cousin in the Army." "Because someone's in my family that works with medicine. And I want to be just like them." "I've seen my dance teacher is one, and I've heard her talk about it and it really sounded like it was fun."

Two themes revealed during second cycle coding of the initial interview relating to STEM career interest were caring for others and family influence (Table 7). There were 18 students which expressed an interest in veterinary work. Their initial interview supported their ratings and was coded as caring for others based upon statements such as, "I want to take care of animals," "veterinary is very interesting because I really love animals and I don't like seeing them be sad," and "that you just help animals and see if you can cure the incurable things about them." The other theme which emerged when asked about the careers selected on the S-STEM as interesting or very interesting was family influence (Table 7). When speaking with a student about his future in the military, he said, "I have a cousin in the Army" and further explained that knowing someone in the military helped him know what he wanted to be when he was older.

When asked about her ratings, one of the few students interested in the medicine and medical science careers said, “Because someone's in my family that works with medicine. And I want to be just like them.” In another example, a future mechanic spoke about his aunt that could fix any car. He gave details about the time they spend together beyond working on cars, but it was clear that his aunt played a significant role in his life thus influencing his career choice. Another student, interested in being a physical therapist, cited her interest for no other reason than knowing her dance teacher, a familiar and respected mentor in her life, had a background in physical therapy. She stated, “I've seen my dance teacher is one, and I've heard her talk about it and it really sounded like it was fun.”

Second Student Interview

The second interview was conducted halfway through the 55 instructional day time frame of the study. Students were asked how their interest in STEM careers changed since the integration of interactive science notebooks during their lessons and talked about their experience using the learning tool since January. The purpose of tracking their experience using an interactive science notebook throughout the study was to determine if their experience was positive or negative. A negative experience may have potentially impacted their effort and overall interest in learning as well as their final S-STEM ratings.

Transcribed interviews were initially coded as interest in STEM careers increased, interest in STEM careers decreased, and interest in STEM careers same based on the nature of the interview question (Table 8). No students reported a decreased interest in STEM careers since working with interactive science notebooks, six students referenced an increase in STEM careers, and 19 participants noted that at this stage in the study their interest had remained the same.

Table 8

Interview 2, Qualitative Data, STEM Careers

Themes	Participant Quotes
Interest in STEM careers increased	"We was talking about Biologists and stuff, about things in the water and that's what my job's gonna be." "Interest in science and being a scientist increased more because now I kinda understand more." "It all just clicks now."
Choice is important	"I like that we can draw, and like doodle what we're learning about." "As we are learning, no matter what age we still should have a choice in the way that we do things not the way that we have to do things because I think after a certain age you should be allowed to choose. "If you like to do it, then you would do more of it."
Reference tool	"The book really kind of helps me remember stuff and keep it ... So when I'm thinking of other stuff, I don't got to try to remember that. It's just in the book, so I can just look back."

A secondary cycle of coding was conducted to further disaggregate data. Two themes emerged from the responses noting an increase in STEM interest, exposed to new jobs and an interactive science notebook would help with their future career. "We was talking about Biologists and stuff, about things in the water and that's what my job's gonna be." This student, a future marine biologist, mentioned he didn't know about marine biology and that he was fascinated with sharks. He made the connection between his classroom lessons about aquatic life cycles and said while working on his output he was really excited about the topic. During a different classroom lesson about green technologies and human impact on ecosystems, a student realized he was interested in solar energy and cited an increase in STEM careers because solar energy, "can be connected with earth science, energy, electricity, engineering, and mathematics." Another student said that his, "interest in science and being a scientist increased more because now I kinda understand more." When asked what he meant about "understanding more" he said that since he started using the learning tool, "it all just clicks now" and now that he understands science a little more he was interested in more of the careers that involved science. In reference to an interactive science notebook helping in the future, a student interested in being a veterinarian said, “I think that, after I learn something, I could write it all down so that I could remember it. So, when I'm studying for maybe like a test or something, or when I'm doing my job, I could look back in my notebook, and I could remember.” Her increased interest was associated with the notebook being a reference tool for her as she pursued her future career. Another student, in reference to an increased interest in becoming a scientist stated, “Like I said earlier, to keep all my memories in it, and if I am doing something hard and I don't know what the answer is, or I have to answer what it is, I can flip back in it and get all my facts right.” Both examples provided evidence that interactive science notebooks positively influence the pursuit of a STEM related career. Nineteen of the participants stated in their interview that their interest in STEM careers had remained the same since notebook implementation. All of those students referenced the same career mentioned in the initial interview and did not specifically mention if an interactive science notebook influenced any further interests in STEM careers at that time, but instead detailed their positive experience and increased interest in using an interactive science notebook during instruction.

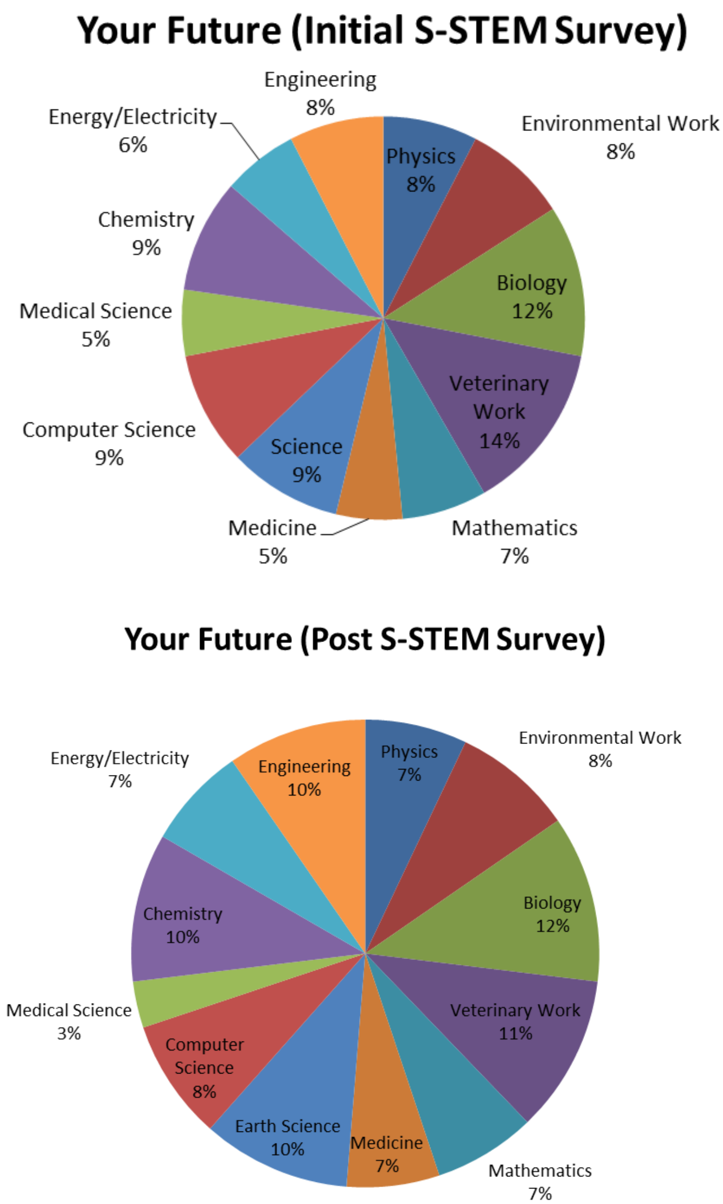
Although a majority of the participants did not note any change in their pursuit of a STEM career, students revealed an overall positive experience using interactive science notebooks. There were 15 positive references to having choice within expressing their science content knowledge. Some said, “If you like to do it, then you would do more of it,” “You get to draw and in your own words, not your teacher's words,” “I like that we can draw, and like doodle what we're learning about,” and “as we are learning, no matter what age we still should have a choice in the way that we do things not the way that we have to do things because I think after a certain age you should be allowed to choose.” Other students made personal connections to journals and there were six references to using a notebook with a similar format in other content areas. The other emergent theme was using an interactive notebook as a reference tool. Students liked that all of their information was organized and in one location so that they could go back and look at anything they had learned. “The book really kind of helps me remember stuff and keep it ... So when I'm thinking of other stuff, I don't got to try to remember that. It's just in the book, so I can just look back.” As students were gaining interest in utilizing their interactive science notebook, there were implications of a positive influence on interests in STEM careers as they were exposed to more curricular topics and had more documented experiences.

Post S-STEM

As seen in Table 6, the post S-STEM data once again identified that biology and veterinary work were the top two STEM careers selected as very interested or interested by participants. There were two more students noting an increase in interest from the initial S-STEM which brought the final percentage to 72% and veterinary work to 68%. Both chemistry and earth science had a 16% rise in interest from 48% to 64%. Engineering was rated as a 60% interest rising from 40%, and both computer science and environmental work was 52%. The percentage increase from pre to post S-STEM for environmental work was 8% and 4% for computer science. Descriptive analysis further revealed that an interest in physics, mathematics, and energy/electricity was 44%. The interest in physics rose 4%, mathematics 8%, and energy/electricity 12%. Medicine was 40% in the post survey having risen from 28%. The STEM career with the largest decrease in interest was medical science, from 28% to 20%. Veterinary work was the only other career with a decreased interest of 4%. When comparing pre and post data for each career, there was a 20% increase in interest in engineering; 16% increased interest in chemistry and earth science; 12% increase in energy/electricity and medicine; 8% increase in mathematics, biology, and environmental work; and a 4% increase in physics and computer science. Analyzing the “Your Future” construct of the pre and post S-STEM data for individual careers allowed for the greatest changes, positive and negative, to be seen. When determining if interactive science notebooks had an influence on fostering growth in the pursuit of a STEM career, the interpretation of the quantitative results indicated a positive change.

One of the ways that data was analyzed when careers were considered as a whole construct, as seen in Table 6, was organized by comparing the interested and very interested rating percentages to one another for pre and post S-STEM data. For example, as an individual construct, engineering had 10 students or a 40% interest rating on the initial S-STEM which when compared with the percentages that the other careers received, represented 8% of the population’s overall interest. From the initial S-STEM survey pie chart (Fig. 3) it can be seen that the ranking of overall interest was: veterinary work (14%), biology (12%), computer science (9%), science (9%), chemistry (9%), engineering (8%), environmental work (8%), physics (8%), mathematics (7%), energy/electricity (6%), medical science (5%), and medicine (5%). The final S-STEM data pie chart ranking of overall interest is: biology (12%), veterinary work (11%), earth science (10%), chemistry (10%), engineering (10%), computer science (8%), environmental work (8%), medicine (7%), physics (7%), energy/electricity (7%), mathematics (7%), and medical science (3%). When viewing data through this perspective it was easier to see the entire population’s overall interest. This can be useful when wanting to better understand which STEM careers are interesting to your students in an effort to integrate more meaningful activities connected with the real world. It may also be data to use to identify the career paths which are not of keen interest to students in an effort to expose them to information which might foster their interest in those given careers.

Figure 3 Your Future S-STEM Career Construct, Initial and Post S-STEM data



S-STEM career responses were also converted into numerical representations from 1-4. A rating of "not at all interested" held a numerical representation of 1; "not so interested" was given a 2; "interested" was a 3; and "very interested" was a 4. The raw scores for each career category were calculated based on this scale and then averaged for the 25 participant responses for both the pre and post S-STEM which occurred at the beginning and end of the 55 instructional day study (Table 9). By calculating the averages in this way, any changes in participant ratings could be factored into the descriptive analysis. Of the 12 career pathways, 10 held a positive change in student interest with only veterinary work and medical science citing a small decrease in overall averages, -.2 and -.1 respectively. The highest positive increase in career interest when comparing pre and post data averages was environmental work with an increase of +.5. Earth science, chemistry, and engineering all had a +0.4 increase in overall career interest. The qualitative data, student interviews, supported this change noting that science topics changed throughout the course of the study which reflected more interesting content for students. Anecdotal notes noted a change in teacher practices including more opportunities for student interactions and hands-on activities. Students also started learning about more career opportunities as a result of their instructional lessons.

Table 9

S-STEM Careers, Pre and Post Data Raw Scores and Averages

STEM Careers	Pre S-STEM Raw	Post S-STEM Raw	Pre S-STEM AVG	Post S-STEM AVG	+/- AVG
Physics	56	58	2.2	2.3	+0.1
Environmental Work	58	69	2.3	2.8	+0.5
Biology	70	74	2.8	3.0	+0.2
Veterinary Work	77	73	3.1	2.9	-0.2
Mathematics	53	59	2.1	2.4	+0.3
Medicine	54	63	2.2	2.5	+0.3
Earth Science	59	69	2.4	2.8	+0.4
Computer Science	61	64	2.4	2.6	+0.2
Medical Science	50	48	2.0	1.9	-0.1
Chemistry	63	72	2.5	2.9	+0.4
Energy/Electricity	50	58	2.0	2.3	+0.3
Engineering	55	64	2.2	2.6	+0.4

Final Student Interview

The final interview, conducted with all participants, included a series of semi-structured, open-ended questions, but one was specific to the research question for this manuscript. The main code yielded during initial analysis in NVivo 12 Plus was STEM career interest. During second cycle coding two themes emerged, interactive science notebook impact and understanding of careers. A student referenced that he had a “way better” understanding of careers since utilizing an interactive science notebook as a learning tool. In the beginning, this particular student had an overall negative view of science with statements such as “I hate science” and “I always get Fs on everything” and “I don’t like anything about it” to include 11 out of 12 careers rated as “not at all interested” with one, chemistry, as “not so interested.” On his final S-STEM he had one career pathway, medicine, as “not at all interested” and five careers as “not so interested.” That alone was a positive shift, but he also rated earth science and engineering as “interested” citing that in class they were learning about ecosystems and then had an opportunity to design and build their own terrarium which “boosted science on the radar” and he especially liked that he got to draw about all of that in his notebook. In addition, his final S-STEM survey revealed that he was very interested in environmental work, computer science, chemistry, and energy/electricity. During our three interviews he frequently expressed his love of drawing. During the first interview his sentiment towards science and STEM career interest was negative. All he wanted to do was draw and to be an artist. When I started having conversations with him about the chemistry involved in pigments, dyes, and art preservation, he started to gain an interest in learning more about science and what the different careers listed in the S-STEM entailed. During one of my visits he asked about environmental work. That same day his class was learning about the negative impacts humans had on the environment and he was actively drawing which also demonstrated a change in his focus and participation during classroom lessons. His interest in science positively changed and influence his self-efficacy in expressing his science content knowledge which further impacted the outcome within his interactive science notebook and career decision making. The learning tool held a positive connection between his comprehension and success. Another student, in reference to her increased interest in STEM careers since using an interactive science notebook, said, “I learned more about it. So when you learn more about it, then that helps with understanding and your interest.” One of her peers supported that with, “as you learn then you kind of get to know, understand more careers.” An interactive science notebook, “it'll help you out on if you really want to be that. And it'll help you learn even more about that subject.” Due to a large data set within those codes, a third cycle coding was conducted. By further breaking down the interviews, the tertiary codes were interests based on lessons and held one reference to family influence which hadn’t already been addressed in a previous interview. When speaking about how her interest in earth science changed, one student said, “Like on one of them that said something about pollution and helping the city and stuff like that. And last time I'm pretty sure that I said that I disagreed, and this time I said I agreed because if I couldn't be a veterinarian like I wanted to be, then I would think now I do something like with the pollution and making decisions for maybe that part of the town or something like that.” When following up with her statement, I asked her why she thought her interest changed and she replied, “We have learned about pollution stuff.” As she was talking she flipped through the pages of her notebook and highlighted a few titles of lessons, “this one's diversity and ecosystems coming up after clean air and water.” She then came to her own conclusion that she had been learning about living things in class and she didn’t like what people were doing to the environment which caused her to think more critically about her future.

Another student, when explaining why her interest in biology has “gone up,” said she was doing more in her interactive science notebook with plants and animals implying that her career interest increased as a result. When directly asked she replied with, “yeah.”

Both participating teachers integrated the interactive science notebook during each science lesson over the course of the 55 instructional day study. The statements made by students with the theme of STEM interests changed based on lessons demonstrated the positive influence that interactive science notebooks had on career paths. The one student that referenced family influence during his final interview held some significance to the overall results and connected with the learning tool’s influence on career choice and interest because he said his interest in engineering changed. His initial rating of “not at all interested” changed to “interested” because it “was within conversations that we've had at school and because of notebooks” that he started talking about it more at home. He said that he and his family started discussing engineering and he now understands the different types of engineers that he could be. He may not have directly credited the notebook for impacting his change of interest, but it can be interpreted that had he not been exposed to the learning tool his conversations at home may not have occurred. During the final interview, nine participants felt that their interest in pursuing a STEM career remained about the same or had no significant changes since their initial S-STEM (Table 10).
“I'm still going with computers and engineers, 'cause I can help the world with anything. With making computers better and make them all where they work more.” This student, along with others that were coded within this theme, had been thinking about their future career path prior to the start of the study and their interests in other careers didn’t waver during the three months because they appeared to be very passionate about their career choice from the initial interview.
“An artist. I've always wanted to be an artist.” When asked about his interest in marine biology,

one student replied, “It's been there for a couple of years” and another said, “Ever since I started watching 'Shark Week'.”

Table 10

Interview 3, Qualitative Data, STEM Careers

Themes	Participant Quotes
Increased interest in STEM Careers	“Boosted science on the radar.” “Way better” understanding of careers since utilizing an ISN as a learning tool.” “I learned more about it. So when you learn more about it, then that helps with understanding and your interest.” “As you learn then you kind of get to know, understand more careers.”
Interest remained the same	“I'm still going with computers and engineers, 'cause I can help the world with anything. With making computers better and make them all where they work more.” “An artist. I've always wanted to be an artist.”

Discussion

After a thorough analysis, it is evident that interactive science notebooks had a positive influence on fostering an interest in pursuing a STEM related career in fourth and fifth grade elementary school students. The quantitative data from the S-STEM at two different intervals, pre and post study, revealed overall gains in participants individual interests for 10 of the 12 STEM careers. The qualitative data retrieved from three interviews referenced how interactive science notebooks helped participants in the pursuit of their future career and success in science because they could be used as a reference tool and they had an increased understanding of content. Participants also recognized that using the learning tool exposed them to more STEM professions because they started making connections between the content and their future. The earlier students are exposed to STEM-related job opportunities, the earlier students can identify their interests and develop a plan (Falco, 2017). By middle school year, students navigate through significant changes and developments in their motivation and self-perceptions of achievement impacting their self-efficacy in academic and career trajectories (Falco, 2017).

Anecdotal notes from both teachers referenced an overall positive experience and noted that their own teaching styles changed because the formatting of the notebook made them more organized and explicit when delivering instruction. Having an account of their experience while integrating a new learning tool offered an insider's perspective on interactive science notebooks and fostered self-reflection in pedagogical practices (Jaladenki & Bhattacharya, 2014) which positively influenced the organization of both of their future classrooms. They were also more aware of facilitating conversations and interactions which connected their lessons with careers, especially as students gained an interest in the content. Making connections and building relationships was especially important for this notoriously transient population of students. In conversation, the fifth grade teacher said her students looked forward to when they had science and she heard students discussing what they wanted to be when they're older much more often since integrating interactive science notebooks in her classroom. As early as eight years old, students should begin to develop an awareness of STEM careers in order to foster their career development (Holmes, Gore, Smith, & Lloyd, 2017). Many of the students had at least one unemployed family member or one that was employed seasonally for the duration of the study. Students started making comments to their peers and teachers during the study about the importance of staying in school and held conversations about their future and staying on track to have a steady and successful career. This speaks to their transient lifestyle as a result of a parent regularly seeking employment. The two participating teachers both said, at the conclusion of the study, that they will both continue using the learning tool and will implement interactive science notebooks at the very beginning of the 2019-20 school year. Two classrooms, positively impacted by the integration of a new learning tool after a period of three months was a promising outcome that others within the school will follow in their lead especially with the support of the district's superintendent. As teachers continue integrating interactive science notebooks into their classrooms, the next phase of research is introducing a rubric for students to grade themselves or their peers. Future research can be conducted on using the notebooks as a form of assessment and peer feedback. To have further influence on STEM careers, teachers can create a section within their notebooks dedicated solely to careers they learn about with facts and information. In addition, guest speakers representing a variety of professions can come in to classrooms and students can take notes in their notebooks as they learn new information to stimulate research and interest.

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CHAPTER 5 CONCLUSIONS

Interactive science notebooks were found to have a positive influence on student self-efficacy in expressing science content knowledge and an influence on fostering an interest in pursuing a STEM related career in fourth and fifth grade students in a rural, independent elementary school situated along the Ohio River in Kentucky. Interactive science notebooks instigated an interest in environmental careers as a direct result of students becoming increasingly interested in content during instructional lessons. Student learning modalities were supported which positively increased effort within their interactive science notebook. Conversations about STEM careers, change in teacher pedagogy, and increased student participation during science instruction were all directly related to integrating interactive science notebooks into the fourth and fifth grade classes. Furthermore, career development coincided with student interests and their beliefs about themselves as learners (Falco, 2017).

Teachers often lack time to conduct a study within their own classroom when integrating a new learning tool because of the time that it takes to truly track and analyze data. What tends to happen is that we hear about a new learning tool or find an interesting idea while perusing the internet and immediately implement it without doing the necessary background research regarding its potential impact or take the time it takes to understand the appropriate way to integrate the learning tool. We see it, do it, and figure it out along the way. In that case, we are treating our classroom as science experiments without much regard to whether or not what we are doing is a valuable use of time and is meaningful for our students' growth and success. The implementation of interactive science notebooks came with a lot of background knowledge and consideration and was diligently tracked in two elementary school classrooms for over three months. At the conclusion of the study, all students expressed an interest in continuing the use of their notebooks and the two participating teachers said they would continue to integrate them for the duration of the 2018-19 school year and will start using the learning tool at the beginning of the next school year to maximize their science lessons. Several students said that they had goals to continue improving their note-taking skills (input) and add more details to how they synthesized the content (output). During my final conversations with students, their sentiment about interactive science notebooks was palpable. They were clearly proud of what they had created and had a sense of pride when looking back at how much their work improved throughout the study. This sense of pride transferred over into their academic performance and increased their participation during science lessons because they felt more successful. Much of the allotted classroom time for science instruction was devoted to student self-efficacy in expressing their science content knowledge as compared to careers in science, technology, engineering, and mathematics. Other than conversations during the three interviews and periodic connections that the two teachers and I would make as students were working on their output as we circulated the room, there was not much direction instruction linked with STEM-related careers. Even though student awareness about careers increased, if there was more explicit instruction about careers then I believe that notebooks would've have a greater influence on future career pathways. Both participating teachers also recognized that they did not spend much time talking with students about careers and acknowledged that they need to make more connections between the standards they are teaching and how they are applicable to students' lives and their future. Interactive science notebooks naturally promoted the integration of conversation and discussion about STEM careers once the content was taught. As fourth grade students learned about human impact on ecosystems and drew pictures in their output representing forms of pollution there were several students that made the connection between the roles of environmental engineers and solving real-world problems associated with energy and recycling. Through those interactions, students broadened their understanding and awareness of a variety of STEM-related careers and developed an increased interest especially as it related to their own success in being about to comprehend related content and appropriately represent their understanding. Self-efficacy expectations and career indecision, is a predictive factor in levels of career decision and indecision (Taylor & Betz, 1983). Low self-efficacious behaviors lead to higher amounts of career indecision as compared to their counterparts (Taylor & Betz, 1983). The implications for practice are therefore connected to interventions and specific instruction to prevent indecision and a growing need to introduce career development in lower grade levels to build a knowledge base and initiate interests in a variety of career pathways.

As an educator, I understand how the intention of what we want our students to learn and understand is there, but it easy for the lesson to pass without accomplishing everything that was set out to do. If that's the case, then intentionality is critical to the overall success of integrating interactive science notebooks into the scheduled instructional time frame. Whether it's with every science unit or a few minutes of each lesson that connect with jobs, college degrees, after-school clubs, or applicable websites, the time has to be set aside in order for a true influence on the pursuit of a STEM career to be determined.

There were several moments that really stood out to me during the study that let me know that interactive science notebooks had a positive influence on the classroom environment. At multiple points throughout the study, the fifth grade teacher expressed how much her teaching had changed and that she felt like she was being more intentional with pacing her lessons and activities. Her school did not have an adopted curriculum and since she was the only fifth grade teacher she did not have a grade level team for collaboration. She said that she did not make a pacing guide at the beginning of the year so until I started working with her in January, she taught lessons she thought students would be interested in, but they didn't connect with one another. I shared my pacing guide with her and had conversations about teaching in science units such as life science, earth science, and physical science so that the content standards would be taught and the lessons would connect with one another. As she integrated the notebooks into her classroom she said that they helped her with her own organization and felt like her own pedagogical practices were improving. Every interaction I had with her started off with positive comments related to the notebooks and she was always very excited to share how her students were interacting with one another more and they looked forward to science lessons. The fourth grade teacher had already started a science notebook at the beginning of the school year, but it was a traditional notebook for students to glue in notes or to copy from a textbook. She gave instant feedback that she never thought to add the output to her notebooks as a way to check for student understanding. She had implemented notebooks since she started teaching four years ago, but this new format really changed how she organized her lessons and thought about science grades and performance ratings. She started using the interactive science notebook as an assessment grade because students started to better represent their understanding of content compared to the multiple choice tests she had been using. Her use of utilizing the learning tool as a way to track student progress leads to the possibility of a future study about using a rubric to score interactive science notebooks and to use them as an alternative assessment. I went to the study site every week for three months which allowed me to build a good rapport with students. There was one student in particular that really struck a chord with me. At the beginning of the study he was incredibly negative about himself, his views towards science, and his own future. His teacher said that his responses, in any subject matter, was typically negative or he expressed impassivity towards learning. I regularly asked about his outputs and worked with him on his inputs during lessons so that he paid attention and comprehended the information. In the beginning I would hardly get any responses from him besides shaking his head or shrugging his shoulders. During our last interview, it was like I was working with a whole different student. His disposition was more pleasant, his mood was positive, and he even smiled! This interaction made this whole experience worthwhile. I feel as though interactive science notebooks positively influenced fourth and fifth grade students' self-efficacy in expressing their science content knowledge and fostered a growth in their interest of STEM careers and there is hope that the results will impact more grade levels in the upcoming school year with the support of both the fourth and fifth grade teacher.

The unique population represented in this study is historically known by the surrounding communities for its transient population, frequent flooding, unemployment rates, and struggling school district. The ten classroom teachers, specialists, and support staff understand that they are teaching a special population in a very unique setting. When I walked through their doors, they welcomed me with open arms and were not afraid to ask for support. The fourth and fifth grade teachers I worked closely with have a variety of experiences within the teaching profession and recognize that the population they are currently serving has some added challenges. While integrating interactive science notebooks we would discuss strategies that could support a student that has experienced multiple educational environments at such a young age and we always came back to building their self-confidence and beliefs in themselves. One strategy to engage an ever-changing population is through discursive talk. Through this interchange of ideas (merriam-webster.com, n.d.) within a science classroom, Tytler and Aranda (2014) found an increase in student interest and conceptual knowledge. Knowledge gained as a result of the study was to be shared with similar educators to promote interactive talks within science classrooms. Interactive talk, in an effort to increase content retention, links with interactive journals due to student connectivity with content and their ability to represent their understanding in a variety of ways. Traditional classrooms are centered on teacher talk, but discourse patterns which emphasize student interaction positively impact conceptual understanding in science classrooms. In essence, by integrating students' background experiences into the learning environment it increases their comfort in expressing themselves and interest in the content being presented because they have been given a voice in decision-making. An interactive science notebook can present the choice and decision-making that a transient child needs to positively influence their self-efficacy in expressing their content knowledge because it gives them a sense of control over their own learning and success.

APPENDIX A

September 19, 2018

Bradley Bowen, EdD
Virginia Tech
207 War Memorial Hall
Blacksburg VA 24061

Dear Dr. Bowen:

SUBJECT: IRB EXEMPTION—REGULATORY OPINION
Protocol Title: Interactive Science Notebooks: Exploring the Extent Which Integrating a New Learning Tool Supports Self-Efficacy in Expressing Science Content Knowledge and Interest in Pursuing a STEM Related Career
Investigator: Bradley Bowen, EdD

This letter is in response to your request to Western Institutional Review Board (WIRB) for an exemption determination for the above-referenced study. WIRB's IRB Affairs Department reviewed the exemption criteria under 32 CFR §219.101(b)(1):

> (b) Unless otherwise required by department or agency heads, research activities in which the only involvement of human subjects will be in one or more of the following categories are exempt from this policy:
>
> > (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

We believe that this project fits the above exemption criteria because the purpose of the project is to study the use of interactive science notebooks in fifth grade physical science classes. The research aims to answer whether the use of the notebooks can increase self-efficacy in expressing science knowledge and foster an interest in pursuing a STEM career. The notebooks will be used as a part of regular classroom instruction during the 2018-2019 school year.

This exemption determination can apply to multiple sites, but it does not apply to any institution that has an institutional policy of requiring an entity other than WIRB (such as an internal IRB) to make exemption determinations. WIRB cannot provide an exemption that overrides the jurisdiction of a local IRB or other institutional mechanism for determining exemptions. You are responsible for ensuring that each site to which this exemption applies can and will accept WIRB's exemption decision.

Please note that any future changes to the project may affect its exempt status, and you may want to contact WIRB about the effect these changes may have on the exemption status before implementing them. WIRB does not impose an expiration date on its IRB exemption determinations.

If you have any questions, or if we can be of further assistance, please contact Andrei Chertov, PhD, at 360-252-2458, or e-mail RegulatoryAffairs@wirb.com.

AOC:dao
B1-Exemption-Bowen (09-19-2018)
cc: Jennifer Farmer, VT
WIRB VT IRB
WIRB Accounting
WIRB Work Order #1-1114587-1

Western Institutional Review Board®
1019 39th Avenue SE Suite 120 | Puyallup, WA 98374-2115
Office: (360) 252-2500 | **Fax**: (360) 252-2498 | **www.wirb.com**

APPENDIX B

[redacted] School District

Established 1848

[redacted]

[redacted]

December 21, 2018

Re: Jessica Krachenfels PhD Dissertation Research

As the superintendent of [redacted] Independent Schools, I approve using [redacted] Elementary School as a research site in support of the research as outlined in Jessica Krachenfels' proposal for, "*Interactive Science Notebooks: Exploring the Extent Which Integrating a New Learning Tool Supports Self-Efficacy in Expressing Science Content Knowledge and Interest in Pursuing a STEM Related Career.*" Her methodologies and IRB protocol has been shared with me and I approve of the research process to take place in West Point Independents' fourth and fifth grade classes.

[redacted]

Superintendent

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APPENDIX C

Interactive Science Notebooks
Consent to Participate in Research

This informed consent form is for first and second grade students at [redacted] Elementary School in [redacted], Kentucky who are invited to participate in educational research titled, "Interactive Science Notebooks: Exploring the Extent Which Integrating a New Learning Tool Supports Self-Efficacy in Expressing Science Content Knowledge and Interest in Pursuing a STEM Related Career in Elementary School Students."

Researcher: Jessica Krachenfels
Sponsor: Virginia Polytechnic Institute and State University
Advisor: Dr. Bradley Bowen, Supervising Professor, Integrative STEM Education Program
Title of Study: Interactive Science Notebooks: Exploring the Extent Which Integrating a New Learning Tool Supports Self-Efficacy in Expressing Science Content Knowledge and Interest in Pursuing a STEM Related Career in Elementary School Students

This Informed Consent Form has two parts:

- Information about the study
- Certificate of Consent (you will be given a copy of the full Informed Consent Form if you allow your child to participate)

Part I: Information about the study

Introduction

I am Jessica Krachenfels, a fifth grade teacher in Fort Knox, KY and a PhD student at Virginia Tech. I am conducting research on the integration of an innovative learning tool in science, which will be used in the classroom to support learning standards. I am going to give you information and invite your child to be a part of this research. You do not have to decide today whether or not you would like your child to participate and can ask myself or your child's teacher any questions you may have regarding the research.

Purpose of the Research

Science is often viewed as a difficult or abstract subject for elementary school students. The purpose of this research is to explore how the integration of Interactive Science Notebooks supports student self-efficacy in expressing science content knowledge and their interest in pursuing a Science, Technology, Engineering, Mathematics (STEM) related career.

Type of Research Intervention

This research will involve student participation in using an Interactive Science Notebook during science lessons. In addition, students will be asked to complete the Student Attitudes Toward STEM (S-STEM) Survey created by the Friday Institute for Educational Innovation at North Carolina State University, write responses to open-ended questions, and participate in a brief interview. The S-STEM, written responses, and interview will occur during regular science instruction.

Participant Selection
Your child is being invited to participate in this research because understanding how Interactive Science Notebooks can contribute to the understanding and knowledge of student's confidence in expressing science content and their interest in STEM can have significant implications for pedagogical practices and gaps in future professional pursuits.

Voluntary Participation
Your consent for your child's participation is completely voluntary. Your child will still receive all the services provided and expected of his/her teacher should you choose not to allow your child to participate. The choice you make will have no bearing on your child's experiences in their fifth grade classroom and you may change your mind later and have your child stop participating even if you agreed earlier. Please note that we will be utilizing Interactive Science Notebooks as a part of regular classroom instruction to support standards and that the purpose of the consent form is to collect and analyze your child's data without using Personal Identifiable Information (PII).

Procedures
I am asking you to help teachers better understand effective learning tools during science instruction. I am inviting your child to take part in this research project through a Student Attitudes Toward STEM (S-STEM) Survey which will be given at the beginning and end of the study (Approx. January and April) and will take approximately thirty minutes to administer. Throughout the course of the fifty-five instructional day study, students will be selected to participate in an audio-recorded interview as a means to follow-up or clarify responses, and students will be asked to write about an entry that they are most proud of and accurately represents their understanding of science content. Data will only be collected during designated science instructional time and students will never have to share any knowledge or experiences that they are not comfortable sharing.

Duration
The research will take place over an approximately fifty-five instructional period. During that time, students will engage in two S-STEM surveys, at the beginning and end, written responses to open-ended questions in their Interactive Science Notebook, and participate in an interview which is comparable to a regular teacher-student conversation during classroom lessons.

Risks
There is a risk that your child may share some personal or confidential information by chance, however I do not wish for this to happen. Due to the nature of the research questions, I do not foresee that the survey, written responses, or interview questions will be too personal as students will never have their name, gender, ethnicity, or location revealed. In the case that a student includes the aforementioned information, it will be redacted from the research study.

Benefits
There will be no direct benefit to you, but your child's participation will likely help teachers find out more about integrating innovative learning tools into our regular classroom instruction in an effort to help your child feel successful and to increase interest in the pursuit of STEM related

careers, which is an identified societal need. Let it be known that no promise or guarantee of benefits have been made to encourage you to participate.

Reimbursements
You or your child will not be provided any incentive to take part in this research.

Confidentiality
The research being done within the fourth and fifth grade classes may draw attention and if you participate you may be asked questions by other people in the community. Your child's information will not be discussed outside of the grade level team and any published information will keep your child's identity private. It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

Sharing the Results
The knowledge that will be gained from this research will be shared with you, [redacted] Independent Schools, upon request, as well as Virginia Polytechnic Institute and State University. The results will be published so that other interested people may learn from the research.

Right to Refuse or Withdraw
You do not have to allow your child to participate in this research if you do not wish to do so, and choosing to participate will not affect your child's experience in their fifth grade classroom in any way. You may request, in writing, at any time throughout the forty-five day period for your child to no longer participate in the research.

Who to Contact
If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact Jessica Krachenfels at jtk83@vt.edu . This proposal has been reviewed and approved by Western IRB, which is a committee whose task it is to make sure that research participants are protected from hard. If you wish to find about more about the IRB, go to http://www.wirb.com/ .

Part II: Certificate of Consent

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have asked have been answered to my satisfaction. I hereby voluntarily consent for my child to be a participant in this study.

Print name of participant (child's name): ___________________________

Signature of Parent: ____

Date: ______________________

Statement by the researcher/person taking consent
I have accurately read out the research information to the potential participant, and to the best of my ability made sure that the parent understands what their child's participation entails. I confirm that the participant was given an opportunity to ask questions about the study, and all the questions have been answered correctly and to the best of my ability, I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this Informed Consent Form has been provided to the participant's parent.

Print name of researcher / person taking the consent _______________________________

Signature of researcher / person taking the consent _______________________________

Date: _________________________________

APPENDIX D

Student Assent Form

What is a research study?
Research studies help people learn by testing new ideas. Research studies ask a question and then try to find an answer.

What you should know…

- ✓ You can decide if you want to participate.
- ✓ You will be a valuable member to your classroom whether or not you choose to participate.

Why is this research study taking place?
The purpose of this research is to find out more about using Interactive Science Notebooks in an elementary school classroom.

What would happen if I join this research?
If you decided to be a participant, you would be asked to do the following:

- ✓ Take a brief survey called, "Student Attitudes Toward STEM (S-STEM) Survey" at the beginning and end of the forty-five day study.
- ✓ Write responses in your Interactive Science Notebooks to a series of questions related to your confidence in expressing your understanding of science content and interest in STEM careers.
- ✓ Participate in an interview which will be audio recorded.
- ✓ Select and write about an output in your Interactive Science Notebook that you are most proud of.

Could the research help me?
Being a participant in this study may help you find ways to express your understanding of science content that is meaningful to you and may possibly increase your interest and understanding about STEM career opportunities.

What else should I know about this research?
If you don't want to be in the study, you don't have to be. It is okay to say yes and change your mind later. If you wish to stop, please tell your teacher. You will not receive any benefits such as payment, extra credit, special treatment, etc. for participating in this study.

If you want to be a part of this research opportunity, please write your name below. The researcher will write their name too. This shows that the study was talked about, you had the opportunity to ask questions and received a response, and that you want to participate.

Name of participant: ____________________________________ Date: _________________

Printed name of researcher: ____

Signature of researcher: __________________________________ Date: _________________

APPENDIX E

Student Attitude Toward STEM (Science and Your Future Constructs)

Math

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. Math has been my worst subject.	○	○	○	○	○
2. When I'm older, I might choose a job that uses math.	○	○	○	○	○
3. Math is hard for me.	○	○	○	○	○
4. I am the type of student who does well in math.	○	○	○	○	○
5. I can understand most subjects easily, but math is difficult for me.	○	○	○	○	○
6. In the future, I could do harder math problems.	○	○	○	○	○
7. I can get good grades in math.	○	○	○	○	○
8. I am good at math.	○	○	○	○	○

Science

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
9. I feel good about myself when I do science.	○	○	○	○	○
10. I might choose a career in science.	○	○	○	○	○
11. After I finish high school, I will use science often.	○	○	○	○	○
12. When I am older, knowing science will help me earn money.	○	○	○	○	○
13. When I am older, I will need to understand science for my job.	○	○	○	○	○
14. I know I can do well in science.	○	○	○	○	○
15. Science will be important to me in my future career.	○	○	○	○	○
16. I can understand most subjects easily, but science is hard for me to understand.	○	○	○	○	○
17. In the future, I could do harder science work.	○	○	○	○	○

MISO
Maximizing the Impact of STEM Outreach

FRIDAY INSTITUTE FOR EDUCATIONAL INNOVATION
NC STATE UNIVERSITY COLLEGE of EDUCATION

Golden LEAF FOUNDATION
This project received support from The Golden LEAF Foundation.

Your Future

Below is a list of types of work that you could do when you are older. As you read about each type of work, you will know if you think that work is interesting. Fill in the circle under the words that describe how interested you are in doing that when you are older.
There are no "*right*" or "*wrong*" answers. The only correct responses are those that *are true for you.*

	Not at all Interested	Not So Interested	Interested	Very Interested
1. ***Physics: People*** study motion, gravity and what things are made of. They also study energy, like how a swinging bat can make a baseball switch directions. They study how different liquids, solids and gas can be turned into heat or electricity.	○	○	○	○
2. ***Environmental Work:*** *People study how nature works. They study how waste and pollution affect the environment. They also invent solutions to these problems.*	○	○	○	○
3. ***Biology: People*** work with animals and plants and how they live. They also study farm animals and the food that they make, like milk. They can use what they know to invent products for people to use.	○	○	○	○
4. ***Veterinary Work:*** *People who prevent disease in animals. They give medicines to help animals get better and for animal and human safety.*	○	○	○	○
5. ***Mathematics: People*** use math and computers to solve problems. They use it to make decisions in businesses and government. They use numbers to understand why different things happen, like why some people are healthier than others.	○	○	○	○
6. ***Medicine: People*** learn how the human body works. They decide why someone is sick or hurt and give medicines to help the person get better. They teach people about health, and sometimes they perform surgery.	○	○	○	○
7. **Earth Science:** People work with the air, water, rocks and soil. Some tell us if there is pollution and how to make the earth safer and cleaner. Other earth scientists forecast the weather.	○	○	○	○
8. ***Computer Science:*** People write instructions to run a program that a computer can follow. They design computer games and other programs. They also fix and improve computers for other people.	○	○	○	○

	Not at all Interested	Not So Interested	Interested	Very Interested
9. ***Medical Science:*** *People study human diseases and work to find answers to human health problems.*	○	○	○	○
10. **Chemistry:** People work with chemicals. They invent new chemicals and use them to make new products, like paints, medicine, and plastic.	○	○	○	○
11. ***Energy/Electricity:*** People invent, improve and maintain ways to make electricity or heat. They also design the electrical and other power systems in buildings and machines.	○	○	○	○
12. ***Engineering:*** *People* use science, math and computers to build different products (everything from airplanes to toothbrushes). Engineers make new products and keep them working.	○	○	○	○

APPENDIX F

Semi-Structured Interview Questions: Interactive Science Notebooks

Disclaimer: The questions listed below will be used as a guide and may have a slight variance during the course of the study.

After initial S-STEM Survey

- Why did you rate yourself the way you did about the statement, "I feel good about myself when I do science?"
- Can you explain your rating for the statement, "I might choose a career in science."
- Explain your rating for the following statement, "I can understand most subjects easily, but science is hard for me to understand."
- In the S-STEM Survey, you were asked about your interests in work. Which types of work were you "very interested" in? Why?
- Which types of work were you "not at all interested" in pursuing? Why?

Throughout the Study

- Now that you've had some practice with creating a variety of outputs in your Interactive Science Notebook, how do you feel about science?
- What are some of the ways (output) you like to express your content knowledge?
- Why do you think you prefer those forms of output?
- Has your interest in science increased, decreased, or remained the same since we've started using interactive science notebooks? Please explain.
- Has your interest in STEM careers increased, decreased, or remained the same since we've started using interactive science notebooks?

End of the Study

- Write about your experience using Interactive Science Notebooks as a learning tool.
- Select an output that you are most proud of. Explain why you are proud of this output. Do you think that your understanding improved because you were able to express yourself in your own way? Why/why not?
- Why did you choose that way to express your understanding?
- Has your interest in pursuing a career in a STEM related field increased or decreased as a result of using an Interactive Science Notebook? Why?

APPENDIX G

Interview #1

Nodes

Name	Description	Files	References
Agree	**I can understand most subjects easily, but science is hard for me to understand (S-STEM Survey)**	7	8
Hands-On Increases Understanding	Science is hard to understand, but hands-on activities increases understanding	10	10
Writing	Writing in science is difficult	1	1
Tests	Lessons are understood, but tests make science difficult	1	1
Misunderstood the statement	Participants didn't understand the wording of the question. They chose "disagree" because of the first part of the statement.	4	4
Neither agree nor disagree	I can understand most subjects easily, but science is hard for me to understand	7	7
Depends on topic	If it is a new topic or topic of disinterest then science is hard to understand	4	4
Interest increases understanding	Comprehension is influenced by interest	2	2
Needs assistance from teacher sometimes	Science is mostly understood independently, but sometimes needs help from an adult	2	2
Agree	**I feel good about myself when I do science (S-STEM Survey)**	12	13
Topics within science LIKE	Responses about science topics that participants like	7	8
Engineer		2	2
Physical Science		5	5
Life Science		7	7

Name	Description	Files	References
Disagree	I feel good about myself when I do science (S-STEM Survey)	5	6
Interactive Science Notebooks might help	Students do not feel good about themselves while doing science, but said ISNs might help them feel better	4	5
Reasons why students dislike science		8	8
Hard to understand	Science is hard for participant to understand (not topic specific)	4	4
Too much writing	Science involves too much writing; therefore it does not make the participant feel good about him/herself	2	2
Topic-Based (Dislike)	Certain topics within science are not liked which impacts how the participant feels about him/herself	2	2
Neither agree nor disagree		8	8
Agree	**I might choose a career in science (S-STEM Survey)**	6	6
Family or Friend influence on career		5	5
Neither agree nor disagree		1	1
Very interesting (careers)		25	46
Care for others	Careers selected as interesting based on the care for others (people and/or animals)	8	9
Family influence	Careers considered interesting based on family member	3	3
Pretend or play	Participant uses creative play at home related to interesting careers	1	1
Not interested at all (careers)		24	31
Boring	Careers not interested in were deemed as “boring”	2	2
Confusion about the	Participants didn’t understand the career	5	5

Name	Description	Files	References
career			
Changed interest rating during interview	Participant didn’t initially understand career and changed selection	1	1
Too hard	Careers that were not interesting to participants were because they were viewed as too difficult	6	6

APPENDIX H

Interview #2

Nodes

Name	Description	Files	References
Feel good about science	**Now that you've had some practice with creating a variety of outputs in your ISN, how do you feel about science?**	15	18
ISN helps understand content	Participant cited the ISN as a reason for feeling good about science	5	5
More interesting	Science is more interesting because of the ISN	5	5
Reference tool	Participant feels good about science because he/she can use their ISN to remember information	2	2
Decreased interest in science	**Has your interest in science increased, decreased, or remained the same since we've started using ISN?**	1	1
Effort	Participant cited lack of effort as the reason for not liking science	1	1
Increased interest in science		17	18
Comprehension and ISN	Science has become easier to understand with an ISN	5	6
Note taking	ISN helped note taking skills	2	2
Same interest in science		4	5
Decreased Interest in STEM careers	**Has your interest in STEM careers increased, decreased, or remained the same since we've started using Interactive Science Notebooks?**	0	0
Increased Interest in STEM Careers		6	6
Exposed to new science jobs	Learned about new science jobs during lessons	3	3
ISN Help in future	Participant made the connection between ISNs and their future (i.e. they could create their own ISN as	3	4

Name	Description	Files	References
	they are training for their future career to help)		
Same Interest in STEM careers		16	17
ISN Feedback	**Participants giving feedback about their experience using an ISN since the beginning of the study**	24	43
Choice	Participant noted choice as being a positive component of ISNs	14	15
Connection to other journals	Participant referenced personal journal writing	2	2
Interactive notebooks in other subjects	ISNs could be integrated in other content areas (mathematics, language arts, and social studies)	6	6
Organized	Information is organized in a clear format	1	1
Reference tool		5	8
Helps understand science	Because the participant can go back and look through their ISN, it helps comprehension of content	4	5
Note taking	Note taking has improved	4	5
Preferred Outputs	**What are some of the ways (Output) you like to express your content knowledge?**	24	35
Compare and Contrast	Participant divides paper in half and compares/contrasts content	2	2
Draw	Draw comics, representations of content, symbols, etc.	19	28
Graphic Organizer	Uses tables, venn diagrams, flow charts, etc.	6	7
Sticky Notes	Content vocabulary on the top of the sticky note with a drawing or definition underneath sticky note on ISN	15	22
Writing	Re-write learned content in own words; summary	6	10
Explaining preference for Outputs	Outputs are ways that students synthesize information within their ISN	11	13
Drawing	Drawings helps participant understand what he/she learned	7	7

Name	Description	Files	References
Organized	ISNs are organized (Input/Output format, table of contents)	2	2
Preparation for test	Preferred method helps participant study	3	3
Sticky notes are self-test	Sticky notes are an interactive way to pre-test or understand content	1	1

APPENDIX I

Interview #3

Nodes

Name	Description	Files	References
Experience using ISN	**Talk about your experience over the past few months using an ISN.**	25	32
Learned more	Science lessons more consistent	9	10
Better grades	Grades improved	4	4
Learning in one place	Learned information is in one place which helps participants locate information	5	5
More organized	Format of an ISN is easy to use	3	3
More details	A ISN has influenced how many details are included in the Input/ Output	14	15
Improved note taking	Note taking has improved; perceived as a positive experience	7	9
ISN as a learning tool	**What do you think about using ISNs as a way to learn?**	25	30
Choice	Participants like the ability to choose the way he/she synthesizes information	3	3
Draw	Drawing is the preferred method of choice for outputs	6	6
Helpful	ISNs are helpful	5	6
Organized	ISNs are helpful because they are organized	8	9
Reference	ISNs are helpful because participants can look back through their notes and Outputs	9	11
Note taking	ISNs help note taking	3	3
Output most proud of	**Select an Output you're most proud of. Describe it and tell me why you're proud of it.**	25	25

Name	Description	Files	References
Effort	Pride in Output linked with the amount of effort participant put in	9	9
Make others laugh	Output chosen because it made peers laugh	1	1
Increases understanding	Output helps participant understand content	7	7
Topic of interest	Output reflects a topic of interest	9	9
Science interest	**Talk about how you feel about science since using an ISN.**	24	24
Decreased	Participant feels like there is still too much writing involved in science	1	1
Increased		1	1
Better grades	Grades have improved since using an ISN	3	3
More interesting content	Science has become more interesting (topics)	9	9
Note taking	Note taking skills have improved	2	2
Teaching Changed	Style of teaching has changed to preferred methods by participants	5	5
Stayed the same		2	2
Interest depends on mood or topic	Interest depends on mood or topic	1	1
STEM career interest	**Has your interest in STEM careers changed since we've used ISNs?**	25	26
ISN impact		9	9
Interests changed based on lessons	Lessons made more connections between learned content and future careers	6	6
No significant change		9	9
Understanding of careers	Participants have a better understanding of careers	7	8
Family influence	Family member influenced career pathway since the	1	1

Name	Description	Files	References
	start of the study		

APPENDIX J

Anecdotal Notes

Nodes

Name	Description	Files	References
Initial hesitation with choice	Participant felt like choice was too open and difficult to narrow down (Output)	1	1
Positive Teacher Experience		4	6
Students excited about science	Observed student excitement while using an ISN	4	6
Style of Teaching		3	5
Hands-on	Increased hands-on opportunities for students	1	1
Open to new ways of monitoring progress	Outputs are an alternative form of checking student comprehension	2	2
Partner or Small group	Increased opportunities for student collaboration and discussion	3	3
Videos	Integrated more videos during classroom instruction	1	2
Students Interested in ISN		2	2
More interested in science	Students more interested in science and looking forward to lessons	3	5
Student Interactions	Students expressed interest in sharing their Outputs with one another	4	5