Building Stem Career Interest Through Curriculum Treatments

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Abstract

Watson and McMahon's (2005) work identified a need for research to examine the what and how of children's career development learning; this research is a start to answering that call, specifically focusing on STEM career interest as a precursor to development due to the current needs nationally for an increase in the STEM pipeline. This study examined the impacts of design-based learning and scientific inquiry curriculum treatments with embedded career content on the career interest of fifth-grade students as compared to traditional classroom methods. Findings show an upward trend in interest with the use of these curriculum treatments, though the change is not significant in most career areas, likely due to the short time period of the unit and/or small *n*.

Introduction

Despite the fact that one in three American schoolchildren attend a rural school (Rural School Community Trust, 2003), in comparison to urban education, research on rural areas is scarce (Tieken, 2014). While research on STEM career interest and ability is on the rise, few efforts to expand and diversify the STEM workforce account for regional differences (an example would be Ali & Saunders, 2009). Research regarding career development in rural Appalachia, more than 1,000 miles and 420 counties in 13 states on the Eastern and mid-Atlantic region of the United States which is known for its poverty and unemployment rates, is even rarer (Ali & Saunders, 2009).

The Appalachian Access and Success Study ([AAS], Spohn, Crowther, & Lykins; 1992) found that cost and a students' academic ability, career goals, and their expectations for the future influenced students' decisions to pursue higher education (Spohn, Crowther, & Lykins; 1992). It also reported that social and academic under-preparedness and a student-perceived lack of intelligence to complete a college degree also contributed to the students' decisions not to pursue higher education. This lack of confidence in self and their schools may first be articulated in literature at the high school level, but that does not mean the problem begins there. It is systemic; real change must begin at the foundation of a student's education- elementary school. By changing the educational practices early on, students can build higher self-efficacy levels that can sustain them through their high school careers, which is beneficial since self-efficacy beliefs independently predict Appalachian youth's expectations to attend college (Ali & Saunders, 2006). These self-efficacy levels, in turn, affect their STEM attitudes, which is a major component in STEM career development.

Career Development in Children

Career development in children is dynamic and interactional (Watson & McMahon, 2005). In the empirical research found, children begin framing ideas and making judgments about their future occupations, and that vocational knowledge was a significant predictor of career aspirations and expectations, as early as four years old (Schmitt-Wilson & Welsh, 2012; Trice & Rush, 1995). While it starts early, career development and choice is a complex process that involves numerous factors that may play a role in a child's decision-making process, and becomes more complex over time; the children themselves cannot always identify the factors that have contributed to their career aspirations, that ability appears to emerge over time (Trice, Hughes, Odom, Woods & McClellan, 1995). Developmental patterns of progression like this are present throughout the literature on student career choice. Research on factors that influence children's career aspirations has uncovered a multitude of contextual and environmental, interpersonal, and intrapersonal factors that impact and shape children's career aspirations. These systemic factors are a mix of overt and covert influencers of career choice across student age groups (e.g., the need for money, McMahon & Patton, 1997, Howard, Flanagan, Castine, & Walsh, 2015; Phipps, 1995), as well as some that appear at specific developmental stages (e.g., role models are identified as being influential as early as third grade, Phipps, 1995; or in high school, students consider the developmental nature of a career, Borgen & Young, 1982). Parker & Jarolimek (1997) found that when young people map out their futures, they tend to choose professions that are familiar, and knowledge of career options in general is necessary for students (Skolnik, 1995). The factors researched are numerous and varied, which is understandable given the complexity of the process, as a field we look to literature reviews for a compilation of findings.

Recent reviews of childhood career development research compile the empirical research and provide a macro-view of childhood career development; they will be discussed next. Collectively, they provide a clear focus on career aspirations and expectations; the amount of knowledge children have about careers, the world of work, and themselves; and important factors relevant to how and when student career choice develops. This study is structured around two well-cited reviews (Hartung Porfeli, & Vondracek, 2005; Watson and McMahon, 2005).

Hartung, Porfeli, and Vondracek's (2005) review uses a life span developmental framework to consolidate previous empirical research on childhood career development, with a focus on early to late childhood (3-14 years); this aligns with Super's career development life span theory (1957, 1990). Super's Growth stage consists of three substages: Fantasy (4-10 years) where role-playing is important, but needs dominate; Interest (11-12 years) where preferences are the major source of activities and aspirations; and Capacity (13-14 years) where the child considers abilities, training, and job requirements (Schultheiss, 2008). Understanding this breakdown ensures selected career connections are developmentally appropriate.

Through a content analysis of existing literature, Hartung, et al.'s (2005) review is organized in five dimensions: career exploration, career awareness, vocational expectations and aspirations, vocational interests, and career maturity/adaptability. The authors find that steady progress across these five dimensions aligns with the shift from vocational to career exploration, "a process that begins as an orientation to the world-of-work and becomes an examination of the self within the world-of-work coupled with overt behavior in support of this process" (Hartung, et al., 2005, p.390). This vocational development, a part of career choice, begins much earlier in the life span than assumed (as early as 4 years old), and affects the choices they make as adolescents and young adults with regard to their future careers. Hartung, et al. (2005) conclude the perception of children's career development as a passive process needs to change to that of an interactive process in which children engage with the world-of-work. They also find that, "Preliminary evidence suggests that steady progress in vocational exploration, awareness, aspirations and expectations, interests, and adaptability during childhood facilitates the development of personal identity and connectedness to the social and interpersonal world" which is important not just for career choice, but also holistically for the child as it may reduce delinquent and deviant behaviors (p. 411). This is important to note because there is a gap in research and practice; currently, research shows that starting early is beneficial to career development, but prior to the secondary level, most schools do not incorporate career development into their programming.

Watson and McMahon (2005) used learning as a unifying theme to structure their review of research on career development in children, examining 76 articles relevant to the career development of children up to 13 years old that span from 1971 to 2003, including seven previous reviews. They see career development as having a "dynamic and interactional nature;" stating we can "understand more holistically the influences on and the process of career development learning" (p. 119). They argue there is a need for dual focus research to examine the what and how of children's career development learning. Watson and McMahon (2005) suggest that in relation to career development, children's learning is a recursive process between the child and their social and environmental constructs, such as family, home environment, school, media, ethnic background, and society. They also note a relative absence of childhood research on intrapersonal constructs such as self-concept, self-efficacy, career maturity, and values, which are common factors explored in adult career choice. This recursive nature is important to note; students' attitudes and beliefs are constantly evolving, and as such, effective career development efforts need to be structured to account for this with recurring learning opportunities.

Career development, while on the way to career choice, proceeds along a continuum and through an increasingly complex process where numerous factors play a role in a child's decision-making process, including a multitude of interpersonal, intrapersonal, environmental, and contextual factors. An essential part of this process is gaining the knowledge of career choices available (career awareness) and interest to the child; this is happening concurrently in all parts of the child's life, to include home, school, and their community at large. School is a large part of a student's daily life, inclusion of career development here has the potential to make a difference in their later outcomes.

Career awareness follows a developmental course beginning in early childhood (Dorr & Lesser, 1980; Hartung, et al., 2005). At fifth grade, students are at a stage where their vocational thinking include interests and abilities but are also starting to consider the activities or behaviors characteristic of an occupation (Howard & Walsh, 2011), so this information should be integrated into curriculum. Active engagement is one form of interaction with the world-at-large that students learn about potential career choices from. By 10 years old, children rely on their own experiences when considering future careers. Opportunities such as hobbies, after-school jobs or activities, and the school itself all offer opportunities to explore careers of interest (Seligman, Weinstock, & Heflin,1991). At school, there are a variety of effective elementary career interventions noted in research, such as: action-oriented classroom guidance activities (e.g., Beale, 2000; Beale, 2003; Brathwaite, 2002); role playing (Super, 1957; Beale, 2003), or coursework that has career awareness activities or skills integrated into the curriculum (e.g., Ernst, et al., 2011; Capobianco, Diefes-dux, Mena, & Weller, 2011). By actively trying on different aspects and tasks associated with specific careers through active engagement, children gain essential knowledge about themselves and the potential careers in an authentic manner, providing them more input with which to make a sound decision.

In summary, influence and experience are found in the home, school, and community-at-large; they are continually providing input to the student, and as the student progresses developmentally, they are mentally prepared to reflect and assign meaning to the input, which in turn helps them in their career choice. Watson and McMahon suggest that in relation to career development, children's learning is a recursive process between the child and their social and environmental constructs, such as family, home environment, school, media, ethnic background, and society (e.g., socioeconomic status and gender role socialization) (Watson & McMahon, 2005; Schultheiss, 2008). This is supported by the empirical studies discussed above. They also point out the need for research to examine the what and how of children's career development learning; this research is a start to answering that call, specifically focusing on STEM career interest as a precursor to development due to the current needs nationally for an increase in the STEM pipeline.

In combining the issues of rural education and career interest experiences, a study was initiated to investigate the impact of hands-on science units with embedded career connections on elementary rural students STEM career interest. Two curriculum treatments were identified for this study, scientific inquiry and design-based learning, and paired with a control group that used a traditional science unit. In a traditional pedagogy-based classroom, after passively receiving information, students are assigned tasks that have little resemblance to professional practices. However, learning is less concerned with what learners do, and more what they know and how they come to acquire it (Jonassen, 1991; Uden & Beaumont, 2006). Therefore, it is less about the activity, and more about the potential the activities hold for student knowledge and knowledge acquisition. DBL has the potential to enhance students' success in science class by increasing students' desire to learn and students' interest in science topics (Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008) as well as their efficacy and attitudes relating to STEM concepts (Ernst, Bottomley, & Parry, 2012). Under the right circumstances, scientific experiments can be effective in promoting intellectual development, inquiry, and problem-solving skills (Tamir, 1991; Tobin, 1990).

While both experimental treatment methods benefit students, they do so by focusing on different academic, scientific, and non-cognitive skills. In the *Taking Science to School* report (2007), Duschl suggested that science education research is based upon curricular resources that do not align with National Science Education Standard goals to promote science literacy for all students and old-fashioned views of learning. Both scientific inquiry and design-based learning counteract that in unique ways. In the classroom, design-based learning "enables students to experience the construction of cognitive concepts as a result of designing and making individual, inventive, and creative projects, to initiate the learning process in accordance to their own preference, learning styles, and various skills" (Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008). With scientific inquiry, students learn to embody a set of values; these "values include respect for the importance of logical thinking, precision, open-mindedness, objectivity, skepticism, and a requirement for transparent research procedures and honest reporting of findings" (NRC, 2012, p.248). So, while there are specific differences between the two methods, both support knowledge construction and important scientific skills.

Research Question

This research study was designed to investigate and identify the impacts, if any, that design-based learning and scientific inquiry curriculum treatments with embedded career content have on the career interest of fifth grade students. To guide this investigation, one overarching research question was posed:

1. What differences in career interest are demonstrated when Scientific Inquiry, Design-Based Learning, or a traditional science unit are used?

This research examined curriculum treatment implementation through a quasi-experimental design, which consisted of experimental/treatment and control features to measure career interest using random assignment. The primary intent is to gauge the effectiveness of active learning curriculum treatments with embedded career connections as an opportunity to affect vocational thinking in efforts to further inform teacher practices.

Methodology

Participants

School participants came from a city that falls squarely in a region known as south-central Appalachia (Appalachian Regional Commission, 2010), where, at 27.5%, the poverty rate is near twice the national average and it has less than the national average of college graduates,

Demographic Characteristic	Percentage of Respondents Traditional (n=32)	Design-Based Learning (n=21)	Scientific Inquiry (n=29)	TOTAL (n=82)
Gender				
Male	43.8%	61.9%	51.7%	51.2%
Female	56.3%	38.1%	48.3%	48.8%
Ethnicity				
White/Caucasian	81.3%	85.7%	69.0%	78.0%
Ethnic Minority	18.8%	14.3%	31.0%	22.0%
Free/Reduced Lunch				
Receives	62.5%	61.9%	55.2%	56.1%
Does not receive	37.5%	38.1%	44.8%	43.9%

Table 1. Student Demographic Characteristics

27% compared to 46% nationally (U.S. Census Bureau, 2011). This area is part of an "invisible minority because they do not appear outwardly different from mainstream Americans" (Tang & Russ, 2007, p. 34). Students in this region are under-represented in STEM fields, even at the universities that lie within its borders, and then later in STEM fields regardless of whether they require a degree.

Participants in this study were fifth graders enrolled at the county's upper elementary school, during September 2017. The school is a state-identified Title I focus school as 26% of students receive Title I services. All six fifth-grade classes participated in the study, with two classrooms assigned to each group. To control for differences in teacher STEM efficacy, and ensure internal validity, teachers were grouped by score (high and low) on their T-STEM before their classes were randomly assigned to a treatment; each treatment received a high-efficacy and low-efficacy teacher. Each class included between 18 and 23 students. Students whose parents consented to their participation and who also agreed, were given the S-STEM survey. Twenty-five students from the 126 fifth graders declined to participate, and 21 students had incomplete data, so there were 82 participants. Within the study, there were 40 female and 42 male students, 78% identified as white, and 56.1 % of the students received free/ reduced-price lunch (Table 1).

Curriculum Treatments

For the purposes of this study, there were three treatment groups: traditional, design-based learning, and scientific inquiry. In this project, the traditional unit consisted of PowerPoint presentations and worksheets as prescribed by the county's curriculum guide. Experimental groups experienced the same material differently. With both experimental groups, there was a focus on active learning methods to increase student engagement in the material (Prince, 2004; Gleason, Peeters, Resman-Targoff, Karr, McBane, Kelley, & Denetclaw, 2011) and tying the material to specific career areas via quick connections. Examples of a quick connection found embedded in the slides are "Work with your assigned research partner and compare notes... Timeliness is important in science, and you don't want to miss out on the next assignment." or "Work with your design team and share your notes... Deadlines are important in engineering, and you don't want to miss out on the next assignment." These quick connections draw attention to how the student's current work in the classroom relates to the expectations within the career area.

When the active learning strategies and career connections come together, the student has the opportunity to experience different career areas while engaging in the content. For example, on day 6, all three groups covered food webs, but each group's experience was different. Table 2 shows the differences between the group's day in more detail, but in general, the control group spent an hour working through a PowerPoint and several worksheets, while the scientific inquiry group listened to science parodies with lyrics screening on YouTube and then began identifying and analyzing a marine food web, while the DBL group did a review of their truncated lesson the day before, and was then introduced to the engineering design process while building and testing a spider web prototype. The day prior, all three groups had spent in lecture, again with slight modifications for the treatment groups. After a work check and hands-on warm-up, the DBL group had the bulk of the required food web material in a condensed version of the traditional slides to make time for their design challenge. Whereas, having completed a mini-activity on lab reports on day 4, the scientific inquiry group's adapted slide deck was paced more similarly to the traditional group, still using their journal instead of standalone worksheets.

While both scientific inquiry investigations/experiments and design challenges are forms of hands-on learning, there are very clear differences and benefits to each. Pragmatically, in the design challenge activity, students were provided a problem and asked to collaborate in small groups (3-4) to engage the engineering design process and create a solution. Students were provided an engineering notebook to sketch ideas, materials to use in building their artifact, and a list of criteria and constraints to adhere to. To prepare for their activity, students practiced and explored critical thinking and the engineering design process. Whereas in the scientific inquiry experiment, student pairs conducted investigations to test questions about the natural world by engaging the scientific method. Students were provided a lab notebook, materials to use in their scientific experiments, and a basic experiment framework to test their hypothesis. To prepare for their activity, students practiced and explored measurement, analysis, and critical thinking. The artifact was not a solution (no problem is presented), but rather an evidence-based lab report that supports their conclusions and a rationale that connected the evidence to the claim. Table 3 gives a comparison of the three represented curricula types. To summarize, in the design challenge, students used the engineering design process (PBSkids, n.d.) to physically construct an artifact/solution to the problem presented; while in the scientific inquiry experiment, students conducted investigations through scientific inquiry, then used their results to articulate an explanation in terms of scientific concepts and principles, and the traditional group completed a lecture-based unit.

	Warm-Up	Activity	Wrap-up
Traditional	8-10 minutes complete Food Web worksheet while listening to Mr. Parr songs	40 minutes Review slides and videos on food chains and food web. 5 minutes Then place provided cards into a food chain for teacher to check.	5 minutes complete Food Chain Worksheet
Scientific Inquiry	8-10 minutes Listen to Mr. Parr songs * Food Chain * Energy Flow	35 minutes quick intro then into marine food web activity- document energy flow and reinforce vocabulary and numerical representations with a tally chart and bar graph for formative assessment	5 minutes review life cycles via slides
Design-Based Learning	8-10 minutes Listen to Mr. Parr songs * Food Chain * Energy Flow	5 minutes review food web from previous day 30 minutes* spider web design challenge- introduce the engineering design process to build and test a spider web that catches multiple-sized bugs.	5 minutes review life cycles via slides

*Note: One class opted to continue iterating their designs during a break, however requirements were met prior to that.

Table 2. Day 6 Material Comparison

	Traditional	Scientific Inquiry	Design Challenge
Groups	Single-student	Pairs (2)	3-4 students
Materials	Worksheets, printed PowerPoint slides	Lab notebook, materials to use in their scientific experiments, and a basic experiment framework	engineering notebook to sketch ideas, materials to use in building their artifact, and a list of criteria and constraints
Student Preparation	Memorization of facts	Critical thinking, measurement, analysis	Critical thinking, engineering design process
Basis	Traditional collection of identified material	Scientific method	Engineering design process
Process	Teacher-centered lecture	conduct investigations to test questions about the natural world	engage the engineering design process and create a solution to the problem at hand
Artifact	unit test	Lab report + unit test	Constructed solution + unit test
Benefits	Efficiency; ability to tailor to standards provided by the state.	build values, including "respect for the importance of logical thinking, precision, open-mindedness, objectivity, skepticism, and a requirement for transparent research procedures and honest reporting of findings" (NRC, 2012, p.248)	"enables students to experience the construction of cognitive concepts as a result of designing and making … to initiate the learning process in accordance to their own preference, learning styles, and various skills" (Doppelt, et al., 2008).

Table 3. Comparison of Curriculum Treatments

Sequence of Events

The district science pacing guide allotted nine school days to the living systems unit; given that a long-term goal of project staff is to provide the school system with a sustainable Integrative STEM curriculum, units provided were designed for a comparable time frame. The control group completed the unit as prescribed in the current pacing guide, with only the addition of a pre-test on day one being added to the curriculum plan. Both the scientific inquiry group and the design-based learning group went through a condensed version of the traditional curriculum, and completed two small applied learning exercises designed to prepare the students for their activity period being completed on days 2-6. On day 7, both experimental groups used a double period to complete either their design challenge or science experiment; to keep class times similar between the three groups, this time was allocated by not holding class on day 1 of the study for those two groups. All three groups completed their unit test and the project's post-survey on day 9. An enrichment day where all students partook in the hands-on components they had not yet received was held on day 10 after data completion ended.

Day	Traditional Method	Scientific Inquiry	Design-Based Learning
Day 1	populations, communities and ecosystems habitats and niches	none	none
Day 2	populations, communities and ecosystems habitats and niches	populations, communities and ecosystems habitats and niches	populations, communities and ecosystems habitats and niches
Day 3	adaptations	adaptations	adaptations
Day 4	adaptations	adaptations*	adaptations*
Day 5	food webs	food webs	food webs*
Day 6	food webs	food webs* niche and life cycle	food webs* niche and life cycle
Day 7	niche and life cycle	experiment	design challenge
Day 8	human influence	review connect activity to human influence	review connect activity to human influence
Day 9	unit test and post-survey	unit test and post-survey	unit test and post-survey
Day 10 (Enrichment)	experiment design challenge	design challenge	experiment

Table 4. Comparison of Unit Pacing by Treatment

Table 4 shows the layout of how each of the major events occurred for each group, including the pre-test, lesson plans by topic, the design challenge, scientific inquiry investigation, and unit test. As mentioned above, day 10 is not part of the official unit; the study and timeline were designed so that each student will get to participate in the design build and scientific inquiry experiment without compromising the experiment.

As discussed above and seen in Table 4, while each unit plan is nine periods long, there is an intentional difference is in the unit pacing guidefor each of the project's three groups (control, scientific inquiry, and design-based learning). While all groups progress through the sequence of lessons in the same order and ultimately spend the same amount of class time on the unit, the amount of time spent on each topic differs between the control and experimental groups. All teachers had access to the same content, just presented in a different way to account for the introduction of careers and active components of the experimental groups. All three curricula were aligned to the original unit goals; testing was designed as a Virginia SOL review, the majority of questions were previously released questions from the state.

Procedures

Teachers were administered the T-STEM in August and then rank ordered based on their overall score on the T-STEM. They were then divided into a low and high group, three teachers in each, however there was a close separation between the third and fourth ranks. The overall scores between the two middle-scoring teachers had a difference of only three points (<1% of the possible total points), so the Elementary STEM Instruction subtest was used to confirm groupings, where there was a seven percent difference in scores that confirmed the existing rank order of the teachers. One teacher from both the high and low groups were then randomly assigned to either the control, scientific inquiry treatment group, or design-based learning treatment group.

Students brought home letters explaining the study along with a copy of the informed consent document in their initial paperwork packet that goes home at the start of the school year. Written student consent, signed by both parent and student, was collected from students before completing their pre-test at the start of the ecosystems unit, which took nine school days to complete. Unit pre- and post-tests were completed with a traditional paper format; all students' utilized the same tests. The S-STEM responses were collected via a Google Form; the school leverages Google products in the classroom so students were familiar with this format. Following the post-test, an additional day was allocated for enrichment activities in which the control group completed an abbreviated scientific inquiry lab and the design challenge, and the experimental group completed either the lab or challenge they had not yet completed.

During the unit, the researcher spent an equal number of days in each classroom to prevent resentful demoralization of the control group (Onghena, 2005). As described in previous sections, each group had a variation of the same curriculum; the control group used the teachers' traditional curriculum and pacing guide, to and to make space for the lab or design challenge, the experimental groups used an abbreviated version of the same curriculum with an altered pacing (see Table 4).

Ensuring Validity

Inherent in all classroom-based studies is a certain amount of variability in teaching practices between treatment groups. Differences in subject characteristics is an internal validity concern to all studies, and nearly half of studies do not address it properly (Horton, McConney, Woods, Barry, Kraut, & Doyle, 1993). In this study, there was concern about how to account for the natural variability in teaching practices between the treatment groups. To control the potential bias, several safeguards were put in place. First, the project staff used the T-STEM to create groups as described above to measure teachers' STEM efficacy and use the scores as part of the grouping assignments; teachers will be assigned to the high or low efficacy group (three teachers in each), and then one high efficacy and one low efficacy teacher were randomly assigned to each treatment. Additionally, all teachers used the assigned curriculum, which included daily presentations, activities, worksheets, and homework when applicable, and a pacing guide to stay on target. The researcher was present in teacher classrooms at the start of the school year, and for four of the nine days the unit was taught either observing or co-teaching. These were done so factors relating to variability in teaching practices that might have affected outcomes should be equivalent across intervention conditions, and, as such, do not pose major threats to the internal validity of the present study.

The Hawthorne effect is a concern for all field experiments, present in 48% (Horton, et al., 1993); it can be defined "the problem in field experiments that subjects' knowledge that they are in an experiment modifies their behavior from what it would have been without the knowledge" (Adair, 1984, p. 334). When applied to teaching situations like those in this study, the Hawthorne effect can have positive implications. Simply stated, "when a person becomes convinced that what he is doing is important, he will try to do it better"; therefore, project staff will use intentional language to show the teachers that their efforts in the study are important "in a direct way" to the school's well-being, "that their performance in front of their students on any day, in fact every day, is important" (Armenti & Wheeler, 1978, p. 123). Of course, the Hawthorne effect could affect student results; however, this is being controlled for by having the project staff present regularly throughout the school year before the study begins, so the novelty will be less a concern, as the project staff will be viewed as a regular fixture in every classroom, including the control groups' (Adair, 1984). So even if the Hawthorne effect was to be of concern for student scores, it would be even across all groups, and therefore there would be no special attention concerns, and awareness of experiment participation would be evenly distributed between all the students (Adair, 1984).

Instruments

S-STEM. The study measured student career interest using the Upper Elementary School (4-5th) S-STEM Survey (Friday Institute for Educational Innovation, 2012). The S-STEM instructs students that "As you read about each type of work, you will know if you think that work is interesting" and then has students score their attitudes toward 12 STEM-based career areas using a Likert scale ranging from 1(not at all interested) to 4(very interested). The career areas include: physics, environmental work, biology, veterinary work, mathematics, medicine, earth science, computer science, medical science, chemistry, energy/electricity, and engineering; each career area includes a short, age appropriate, description. The instrument's reading level was analyzed by 10 upper elementary teachers, who indicated that the surveys were at an appropriate length and difficulty for students (Unfried, Faber, Stanhope, & Wiebe, 2015). In addition to measuring STEM career interest, the S-STEM is designed to measure changes in students' confidence and efficacy in STEM subjects (their STEM attitudes) and 21st century learning skills, however these responses are not within the scope of this study.

School records. Student demographic information was collected from school records to provide a picture of the population, to include student age, sex, race/ethnicity, IEP and 504 statuses, gifted program status, and free/reduced-rate lunch status.

T-STEM. This study utilized the elementary teacher version of the Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey to measure teachers' STEM career awareness and their science and math teaching efficacy and beliefs and expected outcomes. Cronbach alphas of the utilized subscales ranged from .814 to .945.

Results

In order to answer the research question (What differences in STEM career interest are demonstrated when scientific inquiry, design-based learning, or a traditional science unit are used?), students were asked to score their attitudes toward 12 STEM-based career areas using a Likert scale ranging from (1) "not at all interested" to (4) "very interested" on the last day of the unit (day 9). These responses, along with the demographic data, were cleaned and compiled into SPSS, and then examined for data entry accuracy, missing values, and outliers; 82 of the 101 participants had complete data for the areas being examined and were retained for the analyses. To assess the curriculum treatments' impact on STEM career interest, an analysis of variance (ANOVA) on career interest by curriculum treatment was conducted. There were no outliers in the data, as assessed as being greater than 3 box-lengths from the edge of the box in a boxplot. Data for the career subtest was normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$). Other areas had a p-value of greater than .05. However, calling on previous research, Norman (2010) finds, "both theory and data converge on the conclusion that parametric methods examining differences between means, for sample sizes greater than five, do not require the assumption of normality, and will yield nearly correct answers even for manifestly non-normal and asymmetric distributions like exponentials." So, while the individual question Likert scale responses are not normally distributed, this is to be expected given the topic and the ANOVA was deemed best because it is robust to deviations from normality. There was homogeneity of variances for all career areas except mathematics ($p=.027$), as assessed by Levene's test for equality of variances, $p > .05$.

Analysis of Variance (ANOVA)

As mentioned above, a one-way ANOVA was conducted for each of the twelve measured career areas to determine if career interest score was different for different treatment groups. Participants were classified into three groups: traditional ($n = 32$), scientific inquiry ($n = 29$), and design-based learning ($n = 21$). There were no outliers at 3 box-lengths from the edge of the box, as assessed by boxplot (See Figure 1); and there was homogeneity of variances, as assessed by Levene's test of homogeneity of variances (engineering $p = .999$). Data is presented as mean ± standard deviation.

Within the ANOVAs conducted, there was not a significant main effect for the career areas of physics $F(2, 79) = .355$, $p = .703$; environmental work $F(2, 79) = 1.157$, $p = .320$; biology $F(2, 79) = .1.081$, $p = .344$; veterinary work $F(2, 79) = .098$, $p = .907$; mathematics $F(2, 79) = .195$, $p = .824$; medicine $F(2, 79) = 1.607$, $p = .207$; earth science $F(2, 79) = .239$, $p = .788$; computer science $F(2, 79) = .266$, $p = .767$; medical science $F(2, 79) = .318$, $p = .728$; chemistry $F(2, 79) = .505$, $p = .605$; or energy/electricity $F(2, 79) = .824$, $p = .443$. The career interest score for engineering was statistically significantly different between different treatment groups, $F(2, 79) = 3.281$, $p < .05$, with a small effect size ($\eta 2 = .077$). Interest in an engineering career area increased from the scientific inquiry ($n = 29$, $M = 42.55$, $SD = 0.948$), to traditional ($n = 32$, $M = 2.75$, $SD = .95$), to design-based learning ($n = 21$, $M = 3.24$, $SD = .944$) groups, in that order.

As there was an overall statistically significant difference in group means ($p=.043$) for the engineering career area, a Tukey's Post Hoc analysis was conducted to confirm where the differences occurred between groups. Effect size was calculated using eta squared, which is equal to partial eta squared in a one-way ANOVA (Levine & Hullett, 2002).

Tukey post hoc analysis revealed that the mean increase from the scientific inquiry to design-based learning group (.686, *SE*=.272) was statistically significant (*p*=.036); no other group differences were statistically significant at .05 α.

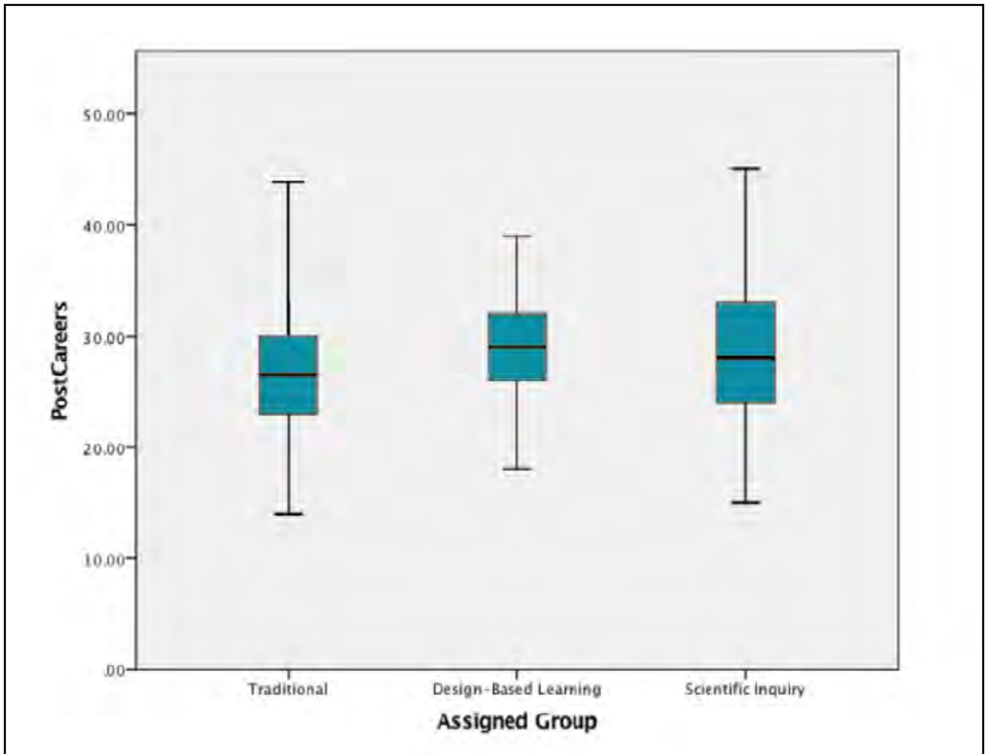

Figure 1. Boxplot of Career Areas Subtest Scores

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, *n*=32	21.9%	43.8%	25%	9.4%	100%
Design-Based Learning, *n*=21	28.6%	33.3%	28.6%	9.5%	100%
Scientific Inquiry, *n*=29	27.6%	44.8%	24.1%	3.4%	100%
Total	25.6%	41.5%	25.6%	7.3%	100%

Table 5. Physics Values

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, *n*=32	25%	34.4%	31.3%	9.4%	100%
Design-Based Learning, *n*=21	9.5%	57.1%	28.6%	4.8%	100%
Scientific Inquiry, *n*=29	10.3%	27.6%	58.6%	3.4%	100%
Total	15.9%	37.8%	40.2%	6.1%	100%

Table 6. Environmental Work Values

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, *n*=32	21.9%	37.5%	28.1%	12.5%	100%
Design-Based Learning, *n*=21	14.3%	28.6%	42.9%	14.3%	100%
Scientific Inquiry, *n*=29	13.8%	24.1%	44.8%	17.2%	100%
Total	17.1%	30.5%	37.8%	14.6%	100%

Table 7. Biology Values

Crosstabulations

After the ANOVAs were completed, a more detailed examination of the score spread was completed on each career area via a cross tabulation of proportion of scores. Physics was introduced to students on the S-STEM with the following passage: "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. These are topics in the field of Physics." Across all groups, students were more likely to have little to no interest in physics as a career area, selecting (1) "not at all interested" or (2) "not so interested" rather than (3) "interested" or (4) "very interested." Less than 10 percent of students in any group said they were "very interested" in a career in physics (see table 5). Within the traditional group, 34.4% of students identified as (3) "interested" or (4) "very interested" in physics as a career, as compared to 38.1% of students assigned to the DBL group and 27.5% of students assigned to the scientific inquiry group (see table 5).

Environmental work was introduced to students on the S-STEM with the following passage: "People study how nature works. They study how waste and pollution affect the environment. They also invent solutions to these problems. These are the foundation of environmental work." Students in the traditional group were more than twice as likely to be (1) "not at all interested" in environmental work when compared to both design-based learning and scientific inquiry groups (see Table 6). Within the traditional group, 40.7% of students identified as (3) "interested" or (4) "very interested" in environmental work as a career, as compared to 33.4% of students assigned to the DBL group and 62% of students assigned to the scientific inquiry group (see Table 6).

Biology was introduced to students on the S-STEM with the following passage: "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. These are topics in biology." Likert scores across the three groups were similar for the area of biology (see Table 7). Within the traditional group, 40.6% of students identified as (3) "interested" or (4) "very interested" in biology as a career, as compared to 57.2% of students assigned to the DBL group and 62% of students assigned to the scientific inquiry group (see Table 7).

Veterinary work was introduced to students on the S-STEM with the following passage: "People who prevent disease in animals. They give medicines to help animals get better and for animal and human safety. This is veterinary work. "Those in the traditional group were twice as likely to be (1) "not at all interested" in veterinary work, as compared to the DBL group. Those in the DBL group also had the highest chance of being (4) "very interested" in this career area. Of those that showed an interest in veterinary work within the DBL group, there was a higher chance of the student being "very interested" than "interested" when compared to the other two groups (see Table 8). Within the traditional group, 53.2% of students identified as (3) "interested" or (4) "very interested" in veterinary work as a career, as compared to 38.1% of students assigned to the DBL group and 58.6% of students assigned to the scientific inquiry group (see Table 8).

Mathematics was introduced to students on the S-STEM with the following passage: "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. This is mathematics work." Within the traditional group, 37.5% of students identified as (3) "interested" or (4) "very interested" in mathematics as a career, as compared to 52.3% of students assigned to the DBL group and 48.2% of students assigned to the scientific inquiry group (see Table 9).

Medicine was introduced to students on the S-STEM with the following passage: "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. This is the practice of medicine." Within the traditional group, 28.2% of students identified as (3) "interested" or (4) "very interested" in medicine as a career, as compared to 19.1% of students assigned to the DBL group and 48.3% of students assigned to the scientific inquiry group (see Table 10).

Earth science was introduced to students on the S-STEM with the following passage: "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. This is called earth science." Within the traditional group, 28.2% of students identified as (3) "interested" or (4) "very interested" in earth science as a career, as compared to 42.8% of students assigned to the DBL group and 37.9% of students assigned to the scientific inquiry group (see Table 11).

Computer science was introduced to students on the S-STEM with the following passage: "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. This is computer science." Within the traditional group, 50% of students identified as (3) "interested" or (4) "very interested" in computer science as a career, as compared to 47.6% of students assigned to the DBL group and 44.8% of students assigned to the scientific inquiry group (see Table 12).

Medical science was introduced to students on the S-STEM with the following passage: "People study human diseases and work to find answers to human health problems. This is medical science." Within the traditional group, 21.9% of students identified as (3) "interested" or (4) "very interested" in medical science as a career, as compared to 23.8% of students assigned to the DBL group and 41.4% of students assigned to the scientific inquiry group (see Table 13).

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, n=32	28.1%	18.8%	34.4%	18.8%	100%
Design-Based Learning, n=21	14.3%	47.6%	9.5%	28.6%	100%
Scientific Inquiry, n=29	17.2%	24.1%	44.8%	13.8%	100%
Total	20.7%	28%	31.7%	19.5%	100%

Table 8. Veterinary Work Values

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, n=32	25%	37.5%	15.6%	21.9%	100%
Design-Based Learning, n=21	19%	28.6%	33.3%	19%	100%
Scientific Inquiry, n=29	20.7%	31%	31%	17.2%	100%
Total	22%	32.9%	25.6%	19.5%	100%

Table 9. Mathematics Values

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, n=32	37.5%	34.4%	9.4%	18.8%	100%
Design-Based Learning, n=21	47.6%	33.3%	4.8%	14.3%	100%
Scientific Inquiry, n=29	27.6%	24.1%	27.6%	20.7%	100%
Total	36.6%	30.5%	14.6%	18.3%	100%

Table 10. Medicine Values

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, n=32	18.8%	53.1%	18.8%	9.4%	100%
Design-Based Learning, n=21	19%	38.1%	33.3%	9.5%	100%
Scientific Inquiry, n=29	13.8%	48.3%	31%	6.9%	100%
Total	17.1%	47.6%	26.8%	8.5%	100%

Table 11. Earth Science Values

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, n=32	18.8%	31.3%	28.1%	21.9%	100%
Design-Based Learning, n=21	19%	33.3%	23.8%	23.8%	100%
Scientific Inquiry, n=29	31%	24.1%	24.1%	20.7%	100%
Total	23.2%	29.3%	25.6%	22%	100%

Table 12. Computer Science Values

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, n=32	31.3%	46.9%	9.4%	12.5%	100%
Design-Based Learning, n=21	38.1%	38.1%	9.5%	14.3%	100%
Scientific Inquiry, n=29	34.5%	24.1%	27.6%	13.8%	100%
Total	34.1%	36.6%	15.9%	13.4%	100%

Table 13. Medical Science Values

Chemistry was introduced to students on the S-STEM with the following passage: "People work with chemicals. They invent new chemicals and use them to make new

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, *n*=32	25%	25%	34.4%	15.6%	100%
Design-Based Learning, *n*=21	14.3%	38.1%	28.6%	19%	100%
Scientific Inquiry, *n*=29	31%	27.6%	34.5%	6.9%	100%
Total	24.4%	29.3%	32.9%	13.4%	100%

Table 14. Chemistry Values

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, *n*=32	25%	25%	34.4%	15.6%	100%
Design-Based Learning, *n*=21	14.3%	38.1%	28.6%	19%	100%
Scientific Inquiry, *n*=29	31%	27.6%	34.5%	6.9%	100%
Total	24.4%	29.3%	32.9%	13.4%	100%

Table 15. Energy/Electricity Values

	Not at all interested	Not so interested	Interested	Very Interested	Total
Traditional, *n*=32	9.4%	31.3%	34.4%	25%	100%
Design-Based Learning, *n*=21	4.8%	19%	23.8%	52.4%	100%
Scientific Inquiry, *n*=29	17.2%	24.1%	44.8%	13.8%	100%
Total	11%	25.6%	35.4%	28%	100%

Table 16. Engineering Values

products, like paints, medicine, and plastic. This is chemistry." While the percentages vary somewhat, the response pattern for each group is similar, with the bulk of students responding (1) "not at all interested" or (2) "not so interested". Within the traditional group, 37.5% of students identified as (3) "interested" or (4) "very interested" in chemistry as a career, as compared to 28.5% of students assigned to the DBL group and 41.4% of students assigned to the scientific inquiry group (see Table 14).

Energy/electricity was introduced to students on the S-STEM with the following passage: "People invent, improve and maintain ways to make electricity or heat. They also design the electrical and other power systems in buildings and machines. This is energy/electricity work." Within the traditional group, 50% of students identified as (3) "interested" or (4) "very interested" in energy/electricity as a career, as compared to 47.6% of students assigned to the DBL group and 41.4% of students assigned to the scientific inquiry group (see Table 15).

Engineering was introduced to students on the S-STEM with the following passage: "People use science, math and computers to build different products (everything from airplanes to toothbrushes). Engineers make new products and keep them working." As seen in table 16, the traditional group participants were nearly twice as likely to select (1) "not at all interested" in engineering over the design-based learning group. The DBL group is also more than twice as likely to be (4)"very interested" in engineering as compared to the traditional group, and four times as likely when compared to scientific inquiry participants. Within the traditional group, 59.4% of students identified as (3) "interested" or (4) "very interested" in engineering as a career, as compared to 76.2% of students assigned to the DBL group and 58.6% of students assigned to the scientific inquiry group (see Table 16).

Discussion

Although there were identifiable differences noted in the crosstabulations of multiple career areas when using the scientific inquiry or design-based learning treatments, these differences were not significant at the .05 a level for any ANOVAs outside of the engineering career area. This is not unexpected; given the short time frame of the unit (nine days) and a lack of intentional focus on the majority of those career areas. This aligns with existing literature which shows exposure over time is a key variable for increasing student STEM efficacy and positive progression in STEM attitudes (e.g., Ernst, et. al, 2012); it's logical that exposure over time will render different results for career interest as well.

Of the 12 career areas identified on the S-STEM, three were intentionally discussed in a classroom: environmental work, chemistry, and engineering. The amount of time spent discussing career connections was minimal in each group, less than 10 minutes total in each classroom. The career area of environmental work was discussed on two occasions in the scientific inquiry classrooms and once within the design-based learning classrooms; these conversations appear to have made a difference, as students in both groups were less than half as likely to be "not at all interested" in environmental work as compared to the traditional group. Chemistry as a career path was discussed in the scientific inquiry classroom as part of their science experiment, which involved evaluating water filters effects on water pH; students in the scientific inquiry were most likely to show an interest in chemistry (41.4% of the group) (see Table 14). While most of these differences are not statistically significant, they ahold practical importance because of the implication that students career interest may be affected by career discussions aligned with the work they are doing.

As mentioned in the results section, the ANOVA for the engineering career area was statistically significant, $F(2, 79) = 3.281$, $p < .05$. While the Tukey post hoc analysis revealed that the mean increase from the traditional to design-based learning group was not statistically significant, given the similarities between the traditional and scientific inquiry scores, it is likely due to the lower n of the DBL group and it has the potential to yield different results with increased exposure. The engineering career area was mentioned within classrooms assigned to the design-based learning group on seven of the nine days; students in this group were half as likely to be "not at all interested" in engineering when compared to the traditional group (engineering=4.8% and traditional=9.4%, respectively) and twice as likely to be "very interested" (engineering=25% and traditional=52.4%, respectively) (see Table 16). Given that the engineering career area is the only one that had a statistically significant ANOVA, it could be postulated that it was the recurring connection between the students' work and the career area made a difference.

The most visible differences appear when you compare the two experimental groups reported interests. Those in the scientific inquiry group participated in an active learning unit that made connections to chemistry, where students were twice as likely to rate their career interest as (4) "very interested" as compared to the design-based learning group. Similarly, the DBL group was almost four times as likely to rate their career interest as (4) "very interested" as compared to the scientific inquiry group within the engineering career area. This could be because at this age students are narrowing their interests based on the experiences they have and that as they select one interest, they begin to disregard options they know less about. This aligns with both theory (Super, 1957, 1990) and research (Watson & McMahon, 2005).

Also of interest is that the quantity of connections seems to correlate to the significance of the differences between groups; this infers that the more explicit career connections you make to hands-on work, the more likely it is to make a difference. Watson and McMahon (2005) discuss the recursive nature of children's career progression, so it makes sense that repetition is important. This aligns and builds on existing research; Parker & Jarolimek (1997) found that when young people map out their futures, they tend to choose professions that are familiar.

Repetition of the career connection can build familiarity; research shows career awareness is the first step (Skolnik, 1995).

In terms of model adoption for the school system, a merged pedagogical set with an emphasis on active learning opportunities and embedded career connections is being recommended based on these results. Based on these results, this model will provide students with the best opportunity to increase STEM career interest while building self-efficacy levels that can sustain them through their high school careers.

Limitations and Suggestions for Future Research

This study is based on several assumptions: first, that all students honestly answered the survey questions; second that quality of career connections is not as important as quantity, and finally that the S-STEM career area definitions would not create bias toward or against the career areas. If any of these assumptions turns out to be incorrect, the results could be impacted. There are other notable limitations with this study. For instance, this study has a relatively small sample size specific to one area of rural Appalachia; as such, the results are not necessarily generalizable to all Appalachian regions (or other rural areas). Although there were no statistical differences in the collected student demographic characteristics, it is unknown whether differences in variables that have shown to be statistically significant in other research but not measured in this study (e.g., parents' education level, parents' working in a STEM field, previous or concurrent participation in programs that could increase STEM career interest, etc.) could be effecting outcomes. It is recommended that similar studies be carried out in different regions to see if the results are generalizable. Follow-up studies concerning the quantity of connections made in each type of curriculum treatment are also recommended. Finally, a longitudinal study that examines the length of time or number of units required for overall STEM career interest increase a statistically significant amount would be another recommendation.

General Conclusions

Career development is a complex process, and the decisions young students' make rely on processing a wide range of information from many sources. Even looking at just a small portion of this process, career interest, relies on a large number of variables and interactions. The main aim of this research was to identify differences in career interest when active learning alternatives with embedded career connections are compared to traditional classroom methods. The answer found is, unsurprisingly, that it's complicated. Within this study, there is not a statistical difference in overall STEM career interest, or for most individual careers, when scientific inquiry or design-based learning is used in place of a single traditional science unit. However, there is a pattern of increased scores when a career area is addressed during an active learning unit that could become significant if given more time or a larger n.

A systematic integration of career-related concepts throughout signature pedagogy-based curricula and across content silos that is consistent with best practices is recommended for this age group. Treatments, like those described in this study (active learning opportunities with embedded career connections) should be integrated throughout a child's learning career, with explicit connections being drawn to the work they're doing to make a significant impact on their career interest. Ultimately, exposure to a variety of signature pedagogies that connect students to an assortment of career areas via embedded career connections will help students make informed decisions regarding their career path.

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