EFFECTS OF STEM SUMMER CAMP ON MOTIVATION AND INTEREST IN MATHEMATICS AND SCIENCE

A Thesis

by

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Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

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May 2016

Major Subject: Curriculum and Instruction

ABSTRACT

The objective of this thesis was to investigate students' affect towards mathematics and science and their perceptions of hands-on activities as it relates to their motivation to learn during STEM summer camp. In addition to identifying the effects STEM camp has on student affect and motivation, results of the current research will give researchers a better understanding in the value of engaging students in STEM activities in informal educational settings. The current research considers both quantitative and qualitative perspectives of students' participation in a STEM summer camp's activities.

The focus of the first study was on how STEM summer camp influences students' affect contributing to their commitment in mathematics and science. Instructors administered the *STEM Attitude Survey* electronically to the students before and after the STEM camp to address the respondents' attitudes and interests towards science, technology, engineering, and mathematics. The results indicated student affect towards mathematics and science improved with participation in STEM activities during a summer camp environment. The rise in student affect scores on the last day of camp, suggests that students' commitment to mathematics and science does improve with an informal STEM education.

In the second study, thirty-six participants were interviewed to provide insight into students' experiences involving hands-on activities during a summer camp and highlights students' perceptions of the activities in relation to their motivation to learn.

The motivating features of the activities outlined in this study were interest, relevance, and enjoyment. The findings indicated favorable outcomes when implementing hands-on activities in a veterinary science course during a week-long summer camp. Students were interested, found the activities relevant, and enjoyed the hands-on activities. Recommendations include educators designing and creating hands-on activities students find interesting, relevant, and enjoyable to increase students' motivation in learning science.

Both of these studies support providing students with informal learning experiences involving hands-on activities to increase student affect and motivation. Educators should utilize these results to create opportunities for exposing students to STEM experiences in mathematics and science and for using hands-on activities in science.

ACKNOWLEDGEMENTS

First and foremost, I thank my mother and father who have been constant sources of support throughout my educational career. Thank you to my boyfriend for his patience, for never letting me give up, and for the countless hours spent sitting at coffee shops with me while I worked. Thank you for listening to me when I cried, hugging me for reassurance, and for constantly telling me that I was capable. This would not have been possible without any of you.

I would like to thank my committee chair, Dr. Capraro, and my committee members, Dr. Goldsby and Dr. Zarestky for their guidance and unending support throughout the course of this research.

I thank my roommate for being my ongoing source of laughter and comic relief for the past six years. Thank you for reminding me to take breaks often, go on adventures when the opportunity arises, and just enjoy life.

Finally, a special thanks to my freshman high school English teacher, Dr. Nancy Weber, for being the mentor and educator I aspire to be. Words will never capture the gratitude, respect, and honor I have in calling you my teacher and friend. Thank you for the many times you stopped what you were doing to help me. I am forever grateful for your support over the years.

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CHAPTER I

INTRODUCTION: THE IMPORTANCE OF RESEARCH

Through professional experience and academic coursework, I have developed an interest in finding ways to improve students' interest and motivation in the disciplines of mathematics and science. My initial review of the literature identified potential positive gains, both academic and attitude gains, through STEM education and hands-on activities in informal learning environments. In addition to identifying the effects STEM camp has on students, research results will aid educators in developing a better understanding for the value of engaging students in STEM activities in informal educational settings. This research considers both the quantitative and qualitative perspectives of participation in STEM summer camp activities regarding its effectiveness on student interest and motivation.

Statement of the Problem

Recently, the United States received negative publicity for failing to prepare a sufficient number of individuals in science, technology, engineering, and mathematics (STEM) fields (Kuenzi, 2008). The increasing concern regarding the nation's ability to maintain a competitive position in the global economy led to an increased interest in STEM education for all ages. Policy makers have implemented initiatives and efforts to increase students' interests in these STEM subjects. Policy recommendations include increasing the investments in STEM programs, preparing STEM educators, and increasing the number of students awarded degrees and pursuing careers in STEM fields among many other suggestions (Toulmin & Groome, 2007). In addition, an emphasis on the advancement of STEM education for K-12 is one way to meet the need for an increasing number of individuals who are interested in science, technology, engineering, and mathematics (NAS, 2005). STEM education is just one avenue interested individuals are using in attempting to strengthen the STEM pipeline.

Students' attitudes towards the fields of mathematics and science are factors which maintain the potential to influence and contribute to students' willingness to pursue STEM coursework. In order to counteract the current decline in interest and motivation of students pursuing careers in science and mathematics, it is important to examine situational factors, which may garner or increase students' interest in science and mathematics, such as hands-on activities that accompany STEM education (Holstermann, Grube, & Bogeholz, 2010). Supporters of STEM education believe by increasing exposure to STEM disciplines, students academically perform at a higher level and as a result, are more prepared for advanced education or careers in the STEM fields (Brown, Brown, Reardon, & Merrill, 2011).

Purpose of Study

The primary purpose of conducting the research connected with this thesis was to increase the knowledge base surrounding the impact that STEM activities implemented through a summer camp have on students' interest and motivation in the areas of mathematics and science. The current research sequence looks at students who participated in a university STEM summer camp to determine the impact the activities had on students' interest and motivation. The first manuscript contained in Chapter 2 of the thesis considered middle and high school students who attended either of the two sessions of a two-week long STEM summer camp. It involved a quantitative approach to determine the effectiveness of the STEM camp's activities on students' interest in pursuing mathematics and science. The second manuscript contained in Chapter 3 used a qualitative approach to investigate students' perceptions regarding hands-on activities in veterinary science activities during a one-week summer camp. Findings from these studies provide educators and policy makers information to further their understanding of the value of informal STEM activities and provide a basis to evaluate possible interventions, such as hands-on activities, implemented in traditional classrooms as efforts to strengthen the STEM pipeline.

Literature Review

The United States developed a need to provide education in the STEM disciplines to children in grades K-12 in an effort to increase the number of individuals entering STEM fields. STEM education is a set of comprehensive and interdisciplinary instructional and learning practices for grades K-12 (Capraro, Capraro, & Morgan, 2013). STEM education offers individuals the opportunity to develop different strategies allowing them to solve interdisciplinary problems while gaining the skills and knowledge needed to sustain scientific leadership and economic growth in the United States. Recent studies have provided evidence that STEM education maintains the potential to positively influence students' attitudes, interests, and academic achievement for a variety of students (Dickerson, Echoff, Stewart, Chappell, & Hathcook, 2014; Doppelt, 2003; Han, Capraro, & Capraro, 2014; Lou, Shih, Diez, & Tseng, 2011; Tawfik, Trueman, & Lorz, 2014; Tseng, Chang, Lou, & Chen, 2011). STEM teaching practices and learning centers around authentic problems requiring the use of hands-on tools to examine innovative ways to solve current issues in the world (Merrill, 2009).

STEM education is often delivered through Project Based Learning (PBL) activities, which start with a well-defined outcome accompanied by summative assessments to assist students in meeting well-defined objectives (Capraro et al., 2013). STEM PBL is an instructional strategy that challenges and motivates students while providing opportunities for individuals to develop higher order thinking skills through solving meaningful real-world problems (Capraro et al., 2013). The positive effects students experience in content knowledge and in their attitude towards learning is contributed to the hands-on activities situated field-based contexts (Kaldi, Filippatou, & Govaris, 2011).

Hands-on learning is a broad term encompassing a large diversity of activities across disciplines and grade levels. In general, hands-on activities are utilized during instructional approaches whereby students physically touch and manipulate objects or materials they are studying (Flick, 1993; Haury & Rillero, 1994; Rutherford, 1993). Hands-on activities are commonly used in science education, which through these hands-on science activities, the learner forms connections between concrete actions and the abstract concepts, which may lead to increased student motivation and engagement (Flick, 1993; Haury & Rillero, 1994). For this reason, using hands-on activities as an integral part of STEM education may increase students' interest in pursuing STEM careers.

STEM and Constructivism

STEM education utilizes an instructional and learning approach grounded in the theoretical framework of constructivism. Constructivists view learning as a process in which students' knowledge is constructed and actively built up by the individual rather than as a product where students passively receive information from the teacher (Bruner, 1964; Dewey, 1938; von Glasersfeld, 1989). STEM PBL takes a constructivist-based approach to learning with hands-on activities and real-world problems allowing the learner to explore and discover on their own as they receive information. Allowing the learner to interact with materials, manipulate variables, and apply principles, create opportunities to discover patterns and strengthen learning in ways that are more effective (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011). Therefore, the active involvement required from hands-on activities allows the learner to construct new knowledge.

STEM PBL is an instructional strategy. It was developed from the project method that defines students as active investigators rather than passive recipients in the learning process (Dewey, 1938; Kilpatrick, 1918). Similar to constructivist's beliefs, both PBL and the project method encourages students to be active learning constructors. Recently, there has been an increase in STEM PBL implementation into K-12 classrooms to facilitate deep understanding in students, which occurs when instructors provide appropriate scaffolding and formative assessments within social structures (Barron et al., 1998).

Through the integration and presentation of STEM fields into normal educational experiences, students can benefit from experiencing real-world problems allowing the student to make connections to different STEM fields within the workforce. Creating links between the STEM fields and real world experiences early on in students' academic careers may attract their interest and potentially result in an increased number of students to enroll into the STEM fields (Brophy, Klein, Portsmore, & Rogers, 2008). Allowing students to make connections between real-world problems and the STEM fields will prepare students for a future in a STEM career.

Informal Educational Environments

The nature of formal learning environments which often take place in traditional school classrooms, present numerous limitations and lack exposure to the STEM fields. Therefore, opportunities for informal learning about science, technology, mathematics, engineering have the opportunity to present STEM fields in a new light to students. Research has suggested informal learning opportunities may offer educational experiences which are more effective in regards to science and mathematics when compared to formal school learning environments (Bicer, Boedeker, Capraro, & Capraro, 2015; Mohr-Schroeder et al., 2014; Morgan, Capraro, & Capraro, 2012; Sullenger, 2006). An informal learning environment is any environment outside of the traditional classroom setting where learning takes place (Sullenger, 2006). The types of informal learning environments vary across many different learning opportunities such as clubs, organizations, museums and science centers including the individual learning which takes place through everyday experiences (Mohr-Schroeder et al., 2014; Sullenger, 2006). Therefore, an informal learning environment provides K-12 students with opportunities to develop deeper STEM concepts they may not have gotten the chance to experience in traditional school settings.

In response to strengthen the STEM pipeline, advocates are creating informal learning environments around various STEM issues to address the increased need for individuals to enter STEM related fields (Mohr-Schroeder et al., 2014). Each informal experience is designed to expand students' interest and engagement in STEM fields while using hands-on applications to enrich students' experiences in the STEM fields and real-life applications (Mohr-Schroeder et al., 2014). Research findings suggested STEM summer camps have the potential to successfully motivate and increase students' interest in STEM disciplines and careers (Bachman, Bischoff, Gallagher, Labroo, & Schaumloffel, 2008; Hayden, Ouyang, Scinski, Olszewski, & Bielefedlt, 2011; Mohr-Schroeder et al., 2014; Nugent, Barker, Grandgenett, & Adamchuk, 2010; Yilmaz, Ren, Custer, & Coleman, 2010).

Ultimately, STEM camps expose individuals to more authentic STEM experiences providing individuals with the opportunity to "become more deeply involved in STEM activities and concepts that might not be possible in a more formal educational setting or short-term workshops, where the typical time constraints make extended involvement with a particular STEM application more difficult" (Nugent et al., 2010, p. 404). The current research sequence focuses on the belief that exposure to authentic learning experiences in STEM disciplines through informal learning environments will positively affect students' interest and motivation towards learning and pursuing STEM careers.

Research Questions

The purpose of this study is to examine the effects of STEM activities implemented through a summer camp on students' interest and motivation in mathematics and science, and provide suggestions for increasing students' interest in STEM fields. The specific questions addressed by the research include:

1. What is the effect of participating in summer STEM camp on students' affect towards science and mathematics?
2. How do students perceive their motivation to learn after participating in informal hands-on veterinary science activities?

Method

Two different research methodological approaches were used during this research sequence. A quantitative method was used in the first manuscript (Chapter II) through analysis of pre and post survey responses from each student assessing their attitudes towards continuing their interest in mathematics and science. Statistical outcomes include an effect size to quantify the effect the STEM summer camp activities had on student affect. In the second manuscript (Chapter III), the researcher used a qualitative perspective to examine how students perceived the hands-on activities as they related to the students' motivation to learn. Focus groups (Kitzinger, 1995) were used to consider the different perspectives of the students who participated in the STEM camp. Analysis of the interviews provided different ideas about how hands-on activities contributed toward motivating students to learn.

CHAPTER II

CHANGES IN STUDENT AFFECT TOWARDS MATHEMATICS AND SCIENCE DURING STEM SUMMER CAMP

Currently, the United States is receiving attention for failing to supply enough students, teachers, and professionals who are adequately prepared in science, technology, engineering, and mathematics (STEM fields) (Kuenzi, 2008). The increasing concern about the nation's ability to compete in the global economy, referred to as efforts in strengthening the STEM pipeline (NAS, 2005), has sparked interest in STEM education for all ages. Fostering STEM education is one way to meet the need for individuals who are interested in science, technology, engineering, and mathematics (NAS, 2005). Many initiatives and efforts have been implemented to increase students' interests in these STEM subjects. Increasing investments in STEM programs, adequately preparing STEM educators, and increasing the number of individuals who are obtaining degrees and pursuing careers in STEM fields are just some of the current policy recommendations (Toulmin & Groome, 2007). STEM education is just the beginning in trying to strengthen the STEM pipeline.

Students' attitudes towards the fields of mathematics and science should be examined as a potential factor influencing and contributing to students' willingness to pursue STEM coursework. In order to stop the current decline in interest and motivation of students to pursue careers in science and mathematics fields, it is important to consider situational factors, such as hands-on activities that accompany STEM education, that have the potential to garner or increase students' interest in science and mathematics (Holstermann, Grube, & Bogeholz, 2010). Advocates of STEM education believe that with an increase in exposure to the STEM disciplines, students will academically perform better and be more prepared for advanced education or careers in the STEM fields (Brown, Brown, Reardon, & Merrill, 2011). Increasing the number of students who have an interest in and are prepared to enter the STEM fields will strengthen the STEM pipeline.

Literature Review

STEM Education

In recent years, an interest in providing education in the areas of science, technology, engineering, and mathematics (STEM) to children in grades K-12 across the country has increased. However, the meaning of STEM education has expanded to imply more than just the four disciplines in the field of education. STEM education is defined as a set of comprehensive and interdisciplinary instructional and learning practices for grades K-12 (Capraro, Capraro, & Morgan, 2013). Through STEM education, individuals can develop different techniques to solve interdisciplinary problems while gaining the skills and knowledge needed for the United States to maintain scientific leadership and economic growth in the world. STEM teaching practices and learning focuses on authentic problems that require the use of hands-on tools and equipment to examine innovative ways to solve the wants and needs of the world around them Merrill (2009). In addition, researchers have found that STEM education has the potential to positively influence students' academic achievement for students (Dickerson, Echoff, Stewart, Chappell, & Hathcook, 2014; Doppelt, 2003; Han, Capraro, & Capraro, 2014;

Lou, Shih, Diez, & Tseng, 2011; Tawfik, Trueman, & Lorz, 2014; Tseng, Chang, Lou, & Chen, 2011). STEM teaching practices and learning focus on authentic problems that require the use of hands-on tools and equipment to examine innovative ways to address the wants and needs of the world around them (Merrill, 2009).

STEM education is often delivered through a Project Based Learning (PBL) activity beginning with a well-defined outcome accompanied by summative assessments along the way to aid students in meeting the objective (Capraro et al., 2013). STEM project based learning is a current instructional strategy that is both challenging and motivating while providing opportunities for individuals to develop higher order thinking skills through the process of solving meaningful real-world problems (Capraro et al., 2013; Han et al., 2014). Peer communication and collaboration are necessary components of PBLs requiring students to attain a potential solution to the given problem (Han et al., 2014). The hands-on activities and field-based contexts are the primary reasons for the positive effects students experience in content knowledge and in their attitude towards learning (Kaldi, Filippatou, & Govaris, 2011). STEM PBL components come together as an instructional tool placing the learner in meaningful learning situations to focus on the solution to a problem involving real-world applications (Lou et al., 2011).

STEM PBL and Constructivism

STEM PBLs are an instructional and learning approach grounded in the theoretical framework of constructivism. Constructivists view learning not as a product but as a process in which students' knowledge is constructed and actively built up by the individual rather than passively received from the teacher (Bruner, 1964; Dewey, 1938; von Glasersfeld, 1989). STEM PBL takes a constructivist-based approach to learning by using hands-on activities and real-world problems allowing learners to explore and discover on their own as they receive information. By allowing the learners to interact with materials, manipulate variables, and apply principles, students will be able to discover patterns and learn in ways that are seemingly stronger and more effective (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011). Through the active involvement in hands-on activities, students are able to construct new knowledge.

STEM PBL is an instructional strategy developed from the project method that defined students as active investigators rather than passive recipients in the learning process (Dewey, 1938; Kilpatrick, 1918). The primary component of both PBL and the project method is that it encourages students to actively construct knowledge as they learn similar to constructivist's beliefs. Recently, STEM PBL has been implemented into K-12 classrooms more pervasively and frequently than in the past in order to encourage students' deep understanding that occurs when effective scaffolding and formative assessments within social structures were provided (Barron et al., 1998).

Through the integration and presentation of STEM fields into regular educational experiences, students benefit from experiencing real-world problems allowing them to make connections to the different STEM fields and workforce. Creating those links between the STEM fields and real world experiences early on in the students' academic careers can spark their interest and potentially increase the number of individuals who enter into STEM fields and careers (Brophy, Klein, Portsmore, & Rogers, 2008).

Experience in making connections between real-world problems and their relationships to the STEM fields will better prepare students for a future in a STEM career.

Informal Educational Environments

Due to the limitations of formal learning settings that often take place in traditional school classrooms and the lack of exposure to a dynamic culture of the STEM fields, opportunities for informal learning about science, technology, mathematics, engineering become an important part in presenting these fields from a new perspective to students. Research has suggested that informal learning opportunities can offer learning experiences that are more effective in conveying science and mathematics concepts when compared to formal school learning environments (Mohr-Schroeder et al., 2014; Sullenger, 2006). An informal learning setting is defined as any environment outside of a normal classroom where learning takes place (Sullenger, 2006). The types of informal learning environments vary across many different learning opportunities such as clubs, organizations, museums and science centers including the individual learning that takes place through everyday experiences (Mohr-Schroeder et al., 2014; Sullenger, 2006). Therefore, an informal learning environment provides K-12 students with opportunities to develop deeper insights into STEM concepts that they may not be able to experience in formal traditional school settings.

Informal learning may occur in any contexts. It is generally outside of the curriculum that has already been established in the educative institutions (Livingstone, 2006). In response to the call to strengthen the STEM pipeline, informal learning environments are being created around various STEM issues so that the increased need of individuals who are interested in the STEM fields is met (Mohr-Schroeder et al., 2014). Each informal learning experience seeks to help students become interested and engaged in STEM fields while using hands-on applications to enhance students' experiences in the STEM fields (Mohr-Schroeder et al., 2014). STEM summer camps have the potential to positively benefit students by motivating and increasing students' interest in STEM disciplines and careers (Bachman, Bischoff, Gallagher, Labroo, & Schaumloffel, 2008; Hayden, Ouyang, Scinski, Olszewski, & Bielefedlt, 2011; Mohr-Schroeder et al., 2014; Nugent, Barker, Grandgenett, & Adamchuk, 2010; Yilmaz, Ren, Custer, & Coleman, 2010). STEM camps are created to expose students to more authentic STEM experiences and allow the students to "become more deeply involved in STEM activities and concepts that might not be possible in more formal educational settings or short-term workshops, where the typical time constraints make extended involvement with a particular STEM application more difficult" (Nugent et al., 2010, p. 404). Many students identified as struggling in the traditional classroom setting were successful in an out-of-school setting, and continued their success in STEM professions (Lauer et al., 2006).

STEM and Social Cognitive Career Theory (SCCT)

The focus of this study is on student affect, which refers to the attitudes, interests, and values about a particular content area such as mathematics and science that an individual has (Popham, 2009). Mohr-Schroeder et al. (2014) emphasized that the key components in inspiring students to pursue a career or path in STEM education is their personal interest and motivation. In order to further examine the process individuals go through to develop interests, make choices, and achieve academic and occupational success, social cognitive career theory (SCCT) was used (Lent, Brown, & Hackett, 1994). This theory was used to explain why and how individuals go about developing career and academic interests, select and pursue choices according to those interests, and persist in their occupational and educational goals (Soldner, Rowan-Kenyon, Inkelas, Garvey, & Robbins, 2012). According to the Social Cognitive Career Theory, career development is influenced by objective environmental factors that include the quality of the educational experiences an individual has been exposed to (Lent et al., 2000). The focus of this theory explained how three social cognitive variables, self-efficacy, outcome expectations, and goals, interact with the other aspects of the individuals environment (Lent et al., 2000).

Social cognitive career theory is a useful framework for understanding the process individuals go through when making career decisions, developing interests, and dealing with the obstacles in their educational and career pathways (Lent et al., 1994; 2000; Soldner et al., 2012). SCCT centers on the psychological processes influencing an individual to act and on how these factors affected their tendency to move toward or away from STEM fields (Herrera & Hurtado, 2011). According to SCCT, students will develop interests in STEM career s if they hold positive beliefs concerning their ability to perform and the possible results of their involvement in their chosen STEM career field (Herrera & Hurtado, 2011).

The purpose of this study is to examine how STEM summer camp influenced students' affect contributing to their commitment in mathematics and science. Through analysis of pre and post survey responses from each student, I examined how the experiences of participation in STEM classes during a summer camp environment influenced students' attitudes towards mathematics and science.

Methodology

Participants

A STEM Summer Camp program took place in Texas during the summer of 2015. Students were able to register for the camp online several months before the start of the camp. The camp consisted of students who were entering grades 7 through 12 from many states and several countries around the world, Honduras, Guatemala, Canada, and Italy. There were 130 students attending the camp however, only 97 students (62 male, 34 female) provided pre and post-survey responses. The ethnic backgrounds of the students were Hispanic (*n*=23), Caucasian (*n*=26), White (*n*=25), Asian (*n*=6), Black (*n*=4), and Indian (*n*=3). The remainder of students (*n*=10) did not specify their ethnicity. All of the students and parents provided informed consent before the start of the camp.

Intervention

The camp was two-weeks long and students spent each day engaged in a variety of STEM classes. On the first day of the camp, students filled out preference sheets and instructors matched students to their preferred STEM PBL activities for the entire two-weeks. Students participated in at least two STEM PBLs over the course of the camp. All of the students participated in either the Bridge Building (engineering) or the Trebuchet projects for the entire two-weeks that they were attending the camp. In both the Bridge Building and Trebuchet classes, students participated in PBL activities that required each group to design and build either a bridge or trebuchet. Each project had specific requirements that needed to be met before the final products could be tested for successfulness on the last day of the camp. Students could also choose among other additional activities to participate in such as solar renewable energy, 3D printing, multimedia marketing, cosmetic chemistry, statistics, Russian or Greek languages, cryptography, and SAT preparation.

Students from both the first and second sessions provided pre/post survey pairs. Both camp sessions offered the same PBL activities; however, there were a few PBL activities in the second session that were taught by different instructors due to various reasons but all instructors received the same training before the start of the camp.

Instrumentation

During this study, students spent between 30 to 60 minutes responding to questions adopted from the *Student Attitude Towards STEM Survey* developed by Mahoney (2010). The reported Cronbach's alpha score for each STEM discipline on the survey was ≥ .95 for 23 items. The survey administered during the camp included 96 Likert-type question items addressing the respondents' attitudes and interests towards science, technology, engineering, and math (1 = "least like them," 2 = "somewhat like them," 3 = "more like them", and 4 = "most like them"). The categories on the survey included awareness, perceived ability, value, and commitment. The focus of this study was on the last part of the survey, which included 10 items related to the general attitudes of students toward continuing their interest in pursuing further study in mathematics or science.

Procedure

During this study, the researcher selected a quasi-experimental pretest-posttest design. Researchers surveyed all 130 students before and after the STEM summer camp regarding their attitudes and interest towards science, technology, engineering, and math (the STEM fields). Students provided pre-survey data as soon as they arrived on the first day of the summer camp before the intervention took place. Students then provided post-survey data on the last day after spending 90 hours participating in the summer camp. Surveys were administered electronically to each student on the first day of camp and on the last day of camp. Several students left the summer camp early for various reasons therefore; the post-survey results were not available from these individuals.

Professors and graduate students instructed the various PBL activities offered. All instructors had previously received training on implementing PBL activities during the camp. The PBL lesson plans were analyzed before the start of the camp to ensure the objectives aligned with the content that was tested at the end of the camp.

In order to answer the research question, the researcher used a paired sample *t*-test. The statistical software package SPSS23 was used to perform the paired sample *t*-test. The student responses on the surveys, before and after the camp, were used to assess the attitudes of the students towards pursuing their interest in mathematics and science due to exposure to STEM PBL activities during the camp.

Results

The survey was designed to measure four factors: (a) affect towards science (b) affect towards mathematics (c) affect towards engineering and (d) affect towards technology. However, only the first two factors were the focus of this study: (a) affect towards science and (b) affect towards mathematics. The reliability coefficients for affect towards science and mathematics were satisfactory at 0.88 and 0.89, respectively. For this study, calculating the mean of each factor created two composite variables. Changes in students' attitudes towards mathematics and science were determined by using descriptive statistics and hypothesis testing.

Descriptive statistics were calculated to understand the center and the spread for each variable. The mean for post survey responses in mathematics (*M*=3.2309, *SD*=.81155) was higher than the mean for pre survey responses in mathematics (*M*=3.033, *SD*=.87877). The mean for post survey responses in science was also higher (*M*=3.4082, *SD*=.78151) than the pre survey responses in science (*M*=3.245, *SD*=.84385). From these results, students' attitudes towards pursuing interest in science and mathematics increased from pre to post survey responses. Standard deviations were relatively the unchanged from pre to post survey responses in mathematics and in science (See Table 1).

Table 1

Means, Standard Deviations, and Mean Differences of Attitude Survey Scores

Groups	N	*M*	*SD*	Mean difference	Sig. (2-tailed)
Science Pre Survey	97	3.245	.844	Pre-Post:	p = .071
Science Post Survey	97	3.408	.782	.163	
Mathematics Pre Survey	97	3.033	.879	Pre-Post:	p = .033*
Mathematics Post Survey	97	3.231	.812	.198	

Note: * Significant at $p < 0.05$

Changes in students' attitudes towards pursuing interest in mathematics and science were determined by using a paired samples *t*-test. The students' pre and post survey scores revealed a statistically significant increase in student affect for mathematics ($t(96)=2.168$, p =.033) but no statistically significant increase in student affect for science ($t(96)=1.825$, p = .071). These results suggested that STEM summer camp had a positive effect on student's attitudes towards certain STEM fields, specifically mathematics. The calculated effect size, Cohen's *d*, were .234 and .200 for mathematics and science respectively. The effect size for both mathematics and science indicated the effectiveness of a two-week long summer camp on student's attitudes towards continuing to pursue their interest in mathematics and science. While students' attitudes towards science were not statistically significant, the effect size revealed the practical significance over a short period.

Discussion

Students start to develop attitudes towards learning and develop interest in certain subjects at a very young age. A student's attitude towards a particular content area, such as mathematics and science, is not fixed which means it can change as students are exposed to different experiences. One factor that may influence and contribute to students' willingness to pursue STEM coursework is their attitudes towards the fields of mathematics and science (Mohr-Schroeder et al., 2014). STEM project based learning allows individuals to develop higher order thinking skills through the process of solving meaningful real-world problems (Capraro et al., 2013). There is potential to spark students' interest and increase enrollment into the STEM fields if students are able to create links between the STEM fields and real world experiences early on in their academic careers (Brophy et al., 2008).

Null hypothesis statistical significance testing (NHSST) has been the common method of statistics used in research for many years. However, the p value does not report the importance or the replicability of the results (Thompson, 2006). Therefore, reporting effect sizes is important because it measures the magnitude of the effect (Kirk, 1996). The interpretation of an effect size involves deciding what benchmarks constitute the effect as small, medium, and large within the context of the study (Capraro, 2004; Thompson, 2006). A very small effect size for a very important outcome, such as reducing an individual's chance of having a stroke, can be noteworthy. It is up to the researcher's judgement to determine the importance when interpreting the effect size. In addition to determining the importance of the findings, reporting effect sizes along with

NHSST allows researchers to compare and interpret their own findings within the context of the current literature (Capraro, 2004). It is important to remember that reporting an effect size is useful in determining the practical significance of the results, especially when no statistical significance is found.

Hypothesis testing revealed statistically significant results for mathematics but not for science, however, the effect size d=.234 for mathematics and d=.200 for science appears to be reasonably relative to the amount of time students spent engaged in instructional activities during an informal learning environment despite the cognitive load. There were many complexities such as working with and learning new software in the 3D printing, app design, and renewable energy courses. Students arrived at the camp with little to no prior experience with a majority of the technology they used during the camp. In 3D printing, many students struggled to learn the required program and thus did not have the opportunity to develop or print their final product. In the bridge building and trebuchet activities, students spent much of their time researching information about the materials they would be using, about the possible structure designs, and learning important calculations before designing their own structures. Even though students spent a majority of their time preparing and learning new software thus leaving little time to complete their final product, this did not seem to decrease their affect towards mathematics and science.

Students' attitudes towards mathematics increased slightly more from pre to post in contrast to students' attitudes towards science. This could be because science is generally a more favorable topic of interest than mathematics from the start as indicated by comparing the pre survey responses for each discipline. This allowed more room for growth in mathematics. In addition, students were required to apply their knowledge in mathematics rather than solving problems on a worksheet. Students were able to experience mathematics from a different perspective, which shed light on the relevance of mathematics in their lives. Overall, students experienced a variety of activities that required the use of both mathematical and scientific skills. Individuals might not have been fully engaged in all the activities but at least one of the activities helped change their attitudes towards mathematics and science. Another reason for the increase in students' attitudes could be the informal learning environment, which created a more relaxed atmosphere with the freedom to choose the activities they wanted and left room for creativity. Students were able to work with their friends and instructors did not use grades as a form of evaluation. A combination of these factors or just one of them might have contributed to the changes in affect towards mathematics and science.

The results of this study indicate that student affect towards pursing mathematics and science improves with participation in informal STEM activities during a summer camp. The rise in students' attitude scores on the last day of camp, suggests that students' commitment to mathematics and science does improve with exposure to activities in a STEM focused informal setting. Data analysis revealed that the STEM summer camp had a positive impact on students' attitudes towards mathematics and science, which is consistent with other researchers (Bachman et al., 2008; Hayden et al., 2011; Mohr-Schroeder et al., 2014; Nugent et al., 2010; Yilmaz et al., 2010). A likely contributing factor is the exposure to hands-on activities and their connection to real-world applications (Holstermann et al., 2010; Kaldi et al., 2011). Students were actively engaged by designing and building their final products using materials that they chose to use in various creative ways. For example, students who participated in the cosmetic chemistry course were able to create their own flavor of lip-gloss by mixing certain elements. Students in the 3D printing course were able to work with the 3D printers along with the software to design and print their final product. Along with the hands-on component, each activity was situated in a real-world context. These activities were all designed around a problem with constraints individuals would encounter on a daily basis in that particular field. The bridge building course required students to take on the role of engineer to design and build a bridge that was wide enough for a toy car to drive through with ramps on either side. Instructors specifically designed each activity to engage and allow students to work within a real-world context. Students became active learners while making connections to life experiences in STEM careers.

In reflection on whether or not evidence from this study provides insight into informal STEM camp influencing student affect toward mathematics and science, it appears to be a qualified yes. STEM PBL integrates direct teaching with contextual learning and allows students to make connections between content-specific skills and real-world context. An important aspect of STEM PBL is that students are able to work within a real-world context, thus exposing them to the different possibilities these fields have to offer. Through the hands-on activities associated with each activity, students become active participants in applying their content specific skills and experienced how disciplines like mathematics is not limited to worksheets that require repetitive computational problems. While science was not statistically significant it was practically significant and student gains were not negligible. Therefore, a larger sample size, increasing the power, would be a suitable solution for detecting the true effect. Overall, an informal STEM camp provides insights for students into a world of possibilities related to the STEM disciplines that course work in traditional classrooms do not generally convey.

The present results indicate favorable outcomes when implementing STEM PBL. More can be done to determine the value of implementing STEM PBL at the middle and high school levels. Studies evaluating the effectiveness of STEM PBL implementation in more formal educational settings over longer periods would be informative because this particular study took place during a two-week long summer camp. Further studies can be conducted to provide greater insights into the benefits of STEM PBL as a means of increasing students' interest in STEM careers.

Conclusion

Overall, results from the study indicate there was an increase in students' attitudes towards their interest in pursuing STEM careers specifically in the fields of mathematics and science. Research has shown that early experiences to a variety of STEM opportunities are related to subsequent STEM careers later on in life (Wai et al., 2010). The findings have implications for the field of STEM education as they highlight the impact of STEM activities on student affect towards continuing their interest in mathematics and science. By increasing student affect towards mathematics and science, students may be more committed to pursuing majors in those fields leading to obtaining higher education degrees and careers fulfilling the need for more individuals in the STEM fields. More individuals in the STEM fields will allow the U.S. to be more competitive in the global economy.

CHAPTER III

THE EFFECTS OF HANDS-ON LEARNING ON STUDENT MOTIVATION

Educators often wonder how to enhance the academic performance of students. Unsatisfactory academic performance among students is a result of either their cognitive aptitude or their lack of effort (Hidi & Harackiewicz, 2000). Educators likely observe the loss of academic motivation and loss of interest in students who appear to neglect putting effort into their studies. Research indicates students' academic motivation weakens over time; and as children grow older, their interest and attitudes regarding school and academic disciplines such as mathematics and science tend to decline (Anderman & Maehr, 1994; Eccles, Wigfield, & Schiefele, 1998; Haladyna & Thomas, 1979; Harter, 1981). There is a pressing need to improve scientific knowledge and interest for all students, especially students in grades K-12, as society continues to experience rapid advances in science disciplines (Department of Education, 2015). Thus, it is important educators and educational researchers commit to finding ways to reverse these trends.

In order to counteract the current decline in interest in science disciplines and to motivate students to pursue careers in science fields, educational authorities recommend conducting hands-on activities in science classes either in field or laboratory settings (NABT, 2005). In general, hands-on refers to learning which takes place through experiences and more specifically in science, hands-on refers to the manipulation and use of instruments or objects students are studying (Rutherford, 1993). There exist diverse amounts of hands-on activities, which vary in terms of time, structure, purpose, or materials used. An experience through hands-on activities is a situational factor with the potential to excite students' interest and motivate them to learn (Bergin, 1999). This research was guided by a desire to find ways to increase the academic motivation of students and focuses on three specific areas of motivation research: interest, relevance, and enjoyment. The current investigation aims to contribute to this important issue by examining how students perceive hands-on activities as it relates to their motivation to learn science.

Literature Review

Motivation

Student motivation is an important component in science education. Unfortunately, teachers regularly complain about unmotivated students in their classrooms. Ryan and Deci (2000) defined motivation as being "moved to do something" and a person who is motivated as "someone who is energized or activated towards an end" (p.54). Motivation explains why individuals think and behave as they do (Weiner, 1992). Motivation is a complex phenomenon in that individuals vary in the level of motivation and what type of motivation (Ryan & Deci, 2000). This means individuals may demonstrate different levels of motivation and experience differing types of motivation depending on the attitudes and goals driving the individual to act (Eccles et al., 1998; Weiner, 1992). For instance, a student might be highly motivated to study for a test out of personal interest and curiosity or because he or she strives to gain the approval of a parent or mentor. Even though students appear to be equally motivated in certain situations, the reason for and direction of their motivation varies. For the purpose of this study, motivation will refer to the reasons influencing students to stay focused and engaged throughout the lesson.

There are several possible determinants, interacting simultaneously, which may explain why a person pursues a particular action. Some of these determinants are located within the person (states, moods, emotions) while others are located in the environment (Weiner, 1992). Self-Determination Theory distinguishes between extrinsic and intrinsic motivation, determined according to the various reasons or goals leading an individual to act (Ryan & Deci, 2000). Intrinsically motivated individuals will engage in an activity because they find it naturally interesting or enjoyable (Eccles & Wigfield, 2002; Ryan & Deci, 2000). Individuals who are motivated extrinsically will engage in an activity because of a separable outcome such as receiving a reward or avoiding punishment (Eccles & Wigfield, 2002; Ryan & Deci, 2000). Students often require a catalyst to perform tasks that are inherently neither interesting nor enjoyable, thus, understanding ways to promote intrinsic motivation is a necessity for teaching and learning (Ryan & Deci, 2000). In this study, important variables examined as motivators include whether the participants believed the course experiences, specifically the hands-on activities, were interesting, relevant, and enjoyable.

Interest as a motivator. Interest is a motivational construct promoting focused attention and engagement towards various aspects of the environment (e.g., objects, activities, ideas) of importance (Hidi, Renninger, & Krapp, 2004). Individuals are susceptible to two main areas of interest: situational interest and individual or personal interest. Situational interest refers to a state of interest developed when individuals interact with contextual factors found in the environment (Ainley, Hidi, & Berndorff, 2002; Hidi, 1990; Schiefele, 1991). The directed attention and interest elicited by situational stimuli may or may not last as it represents more of an immediate affective reaction (Hidi, 1990; Schiefele, 1991). On the other hand, individual interest focuses on the origins and effects of objects, tasks, or subject areas individuals find personally interesting (Ainley et al., 2002; Hidi, 1990; Schiefele, 1991). Whereas situational interest uses environmental factors to promote interest in a particular context, individual interest concentrates more on enduring preferences developed over time (Bergin, 1999; Mitchell, 1993).

Although situational and individual interests are distinctly different from one another, there exists a relationship between the two. The two types of interests correlate with one another by interacting and influencing the other's development in an individual (Hidi, 1990; Hidi & Harackiewicz, 2000). For instance, situational interest may play an important role in learning, especially for students who maintain minimal interest in any of the academic disciplines by motivating students whom are academically unmotivated (Bergin, 1999; Hidi, 1990; Hidi & Harackiewic, 2000; Mitchell, 1993). Individuals who experience both positive feeling-related experiences (involvement in doing the activity creates enjoyment) and positive value-related experiences (goals and values in performing the activity) together develop individual interest in the content (Schiefele, 1991). Teachers maintain minimal influence over the personal interest of their students; however, educators attempt to aid in the development of such interests by creating environmental settings to promote situational interest (Bergin, 1999; Mitchell, 1993).

Mitchell (1997) concluded, by creating situational interest in a statistics class, students who previously maintained no prior interest in the subject matter developed individual interests in statistics. This suggests that by designing the learning environment and activities appropriately, teachers can stimulate situational interest in a way that motivates learners and improves their academic performance in areas where learners initially lack interest.

Educational researchers should consider focusing on task and environmental factors to promote situational interest among individuals. Interest-based motivation results from either individual or situational interest so when attempting to measure interest, it may be hard to quantify how much comes from individual interest and how much comes from situational interest (Hidi et al., 2004). Therefore, throughout this study, interest encompasses both situational and individual interest emphasizing the role hands-on activities play in developing students overall interest in learning.

Relevance as a motivator. A second motivational construct, relevance, is necessary because “sustained motivation requires the learner to perceive that important personal needs are being met by the learning situation” (Keller, 1983, p. 406). Relevance refers to the extent to which the student feels the classroom instruction and course material connects to their important personal needs, values, or goals (Keller, 1983). Usually, individuals will develop an interest in something if they perceive their engagement in a particular task as meaningful and likely to satisfy a basic need or if they receive positive emotional feedback while participating in the task (Keller, 1983; Krapp, 1999). The modifications of teaching materials and strategies in addition to how educators present the tasks may aid in the development of situational interest within the learning environment (Guthrie & Wigfield, 2000; Lepper & Cordova, 1992; Lepper & Henderlong, 2000). For example, researchers attempted to stimulate interest in students by presenting educational instruction in more contexts that are meaningful by making it personally relevant to the individuals to illustrate the significance of learning (Cordova & Lepper, 1996; Mitchell, 1993; Parker & Lepper, 1992; Ross, 1983). More specifically, students' situational interests were enhanced by participating in personally relevant engaging activities during a statistics class (Mitchell, 1997). Overall, efforts to promote situational interest include focusing on designing the features of the tasks and the learning environments relevant to the lives of the students.

Fun and enjoyment as a motivator. The elements of fun and enjoyment are potential influences when determining the factors that influence students' interests and motivation to learn. Fun is defined as "(1) someone or something that is enjoyable: an enjoyable experience or person (2) an enjoyable or amusing time (3) the feeling of being amused or entertained (4) Playful" (Webster's Dictionary, 2015). Experiences creating a sense of fun and enjoyment fulfill one of the five basic human needs, the need to find pleasure, to play, and to laugh (Glasser, 1998). Science can be thought of as serious logical thinking while play represents silliness and childishness. However, the relationship between these two distinct concepts is established as, "the act of play is in itself an intense scientific study, unassigned and internally motivated" (Pearce, 1999, p. 3). Playful learning encourages students to become active participants instead of passive recipients (Resnick, 2004).

Fun and playfulness contribute to the positive emotional feedback needed for the development of interest in a topic or task (Krapp, 1999). There is a strong correlation between enjoyment and developing an interest suggesting certain activities involving students in a playful manner are determined to be the most interesting from the students' perspective (Bulunuz, 2012; 2015). Exposing students to activities that are fun, exciting, and new to them over time may enhance their perception of learning science (Palmer, 2004). In addition, after observing children at an interactive science center, preservice teachers identified the importance of using hands-on activities as an effective teaching strategy to make learning science fun (Palmer, 2002). Fun increases learners' motivation (Middleton, Littlefield, & Lehrer, 1992; Resnick, 2004) and motivation is a catalyst for individuals to put forth effort without resentment.

Hands-on Learning

Hands-on learning may take many different forms across each discipline and grade level. Implementing hands-on activities allows students to learn by experience and requires students to physically touch and manipulate the items they are studying (Haury & Rillero, 1994; Rutherford, 1993). More specifically, hands-on science refers to a teaching strategy, which engages students in a multi-sensory fashion through hands-on activities in a science classroom (Flick, 1993). Hands-on activities must meet three conditions to claim students are engaged: students are (a) manipulating objects or materials in the environment, (b) applying information to understand their natural environment, and (c) held accountable for their observations, inferences, and conclusions (Flick, 1993). For the purpose of this study, hands-on activities refers to activities that allow students to interact with their environment, learn by experience and observation, and physically manipulate objects in their environment through active participation.

Hands-on activities in science are part of a general approach to an instructional design based on the constructivist philosophy. Constructivism is the idea that knowledge is constructed and is actively built up by the individual rather than passively received from the teacher (von Glasersfeld, 1989). Constructivists advocate using hands-on learning activities to allow the learner to construct knowledge and form meaning as they explore different concepts (Clements & Battista, 1990). By allowing the student to interact with materials, manipulate variables, and apply principles, he or she will be able to discover patterns and learn in ways, which are seemingly stronger and more effective (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011). Through the engagement of in-depth investigations using these objects, students become active participants in their own learning process. It is through the active involvement these hands-on activities provide that students are able to construct new knowledge.

In hands-on science, students are able to relate to abstract concepts through their concrete, kinesthetic actions while potentially increasing students' motivation and engagement (Flick, 1993; Haury & Rillero, 1994). Previous research has indicated there are benefits to using hands-on activities in the classroom in both formal and informal learning environments. Researchers (Holstermann, Grube, & Bögeholz, 2010) conducted a study to investigate the quality of different types of hands-on activities in a high school biology classroom. They found, despite the differences between the activities, many of the hands-on activities positively influenced students' interest in learning science.

Another study found similar results using Hands-on Biology, a program designed in collaboration with a nearby museum as a science curriculum for elementary school students. Students who participated in the program experienced improved attitudes about science from pretest to posttest (Paris, Yambor, & Packard, 1998). Additionally, Blue STEM Camp, a week-long camp during the summer for middle school students, provided a variety of STEM experiences for students. Results revealed an increase from pretest to posttest in interests towards STEM careers and students who participated in the camp expressed the authentic, hands-on activities were fun and interesting (Mohr-Schroeder et al., 2014). Therefore, students may benefit in multiple ways by participating in engaging hands-on activities.

Informal Learning Environments

The definition of curriculum has expanded to encompass all formal and informal learning and life experiences contributing to students' growth and values (Slattery, 2012). Within a formal classroom environment, educators are limited in the types of instructional strategies available for use. As a result, students lack exposure to a vibrant culture of science and opportunities, which extend beyond the basic scientific knowledge and skills. Opportunities for informal learning regarding science and its cultural impact are particularly crucial. Any environment outside of the classroom or university where learning takes place classifies a learning environment as informal (Sullenger, 2006). Informal learning environments include many different learning opportunities such as clubs, organizations, museums and science centers along with the individual learning occurring through everyday experiences (Mohr-Schroeder et al., 2014; Sullenger, 2006).

Informal learning usually occurs in contexts outside of the established curriculum in educative institutions (Livingstone, 2006). Whichever format of the informal learning experiences, each seeks to help students become more interested and engaged in the field they are studying by incorporating hands-on applications to enhance students' experiences (Mohr-Schroeder et al., 2014).

Informal learning environments are created around various STEM issues in response to the recent increases in number of individuals entering the scientific workforce (Mohr-Schroeder et al., 2014). For science education, informal learning environments may play a significant role in helping students develop scientific inquiry practices and skills while allowing students direct access to scientific experiences involving the natural world (Bartels, 2001). Various informal learning settings are another venue educators use to improve student achievement, support students' academic interest and promote motivation to learn a particular discipline (Bartels, 2001). Research has indicated informal learning opportunities have the potential to offer increased learning experiences in science-technology, which are more effective than traditional school learning environments (Mohr-Schroeder et al., 2014; Sullenger, 2006). Therefore, an informal learning environment gives K-12 students the opportunity to dive deeper into concepts they may not regularly experience in more formal school settings. In addition, specifically STEM summer camps have the potential to motivate and promote students' interest in STEM disciplines and careers (Bachman, Bischoff, Gallagher, Labroo, & Schaumloffel, 2008; Hayden, Ouyang, Scinski, Olszewski, & Bielefedlt, 2011; Mohr-Schroeder et al., 2014; Nugent, Barker, Grandgenett, &

Adamchuk, 2010; Yilmaz, Ren, Custer, & Coleman, 2010) . Therefore, exposing students to multiple learning experiences, both inside and outside of the classroom, is an essential component of education (Eshach 2007; Hofstein & Rosenfeld 1996).

Overall, informal learning environments expose individuals to authentic hands-on experiences. These experiences allow students to "become more deeply involved in STEM activities and concepts that might not be possible in a more formal educational setting or short-term workshops, where the typical time constraints make extended involvement with a particular STEM application more difficult" (Nugent et al., 2010, p. 404). Students who struggle in traditional classroom settings have the opportunity to experience success in out-of-school settings leading to continued success in various STEM professions (Lauer et al., 2006). For the purposes of exposing middle to high school students to hands-on learning experiences occurring in science, this paper focuses on the belief that informal learning environments will positively affect their interest and motivation towards learning.

Methodology

The purpose of this qualitative study was to investigate students' perceptions on the use of hands-on activities during a summer camp course as it related to their motivation to learn science. Students were separated into focus groups (Kitzinger, 1995) to gather perspectives from as many students as possible in a short amount of time. By gathering students' perceptions, the researcher was able to identify specific motivating factors produced by their involvement in hands-on activities.

Participants

Students across the state of Texas participated in a STEM summer camp program located in the state. The camp staff held enrollment for students entering grades 10 to 12, ages 14 to 18. These invited students must have placed in first through fifth place at the state science fair to register. This particular camp was for science fair winners meaning the campers did not have to pay for their attendance because it was included in their prize for having a winning project. Every student who registered for the camp was distributed a waiver and informed of the study. All students and parents agreed to participate. While 40 students had originally registered for and attended the camp, only 36 students (22 male, 14 female) participated in the focus group interviews. Several students left early during the summer camp intervention and interview responses were not available from these individuals. The ethnic backgrounds of the students were Hispanic/Latino, and Mexican American (n=7), Caucasian/White (n=8), African American (n=2), Asian/Asian American (n=19), Indian (n=3), and multiracial (n=1). Students were numbered 1 through 36 according to the order they participated in the focus groups. These numbers were used to identify students throughout the study.

Intervention

The STEM camp the students attended consisted of four classes: Biochemistry, Veterinary Science, Engineering, and Food Science. The camp consisted of science fair winners, which meant that not every student was originally interested in the sciences. However, the camp as a whole was designed to expose students to hands-on experiences in the STEM fields. The hands-on activities during the veterinary science class part of the camp were the focus of this study. College professors and graduate students instructed the veterinary science lectures and activities. Each day of the week, instructors introduced students to a new topic. Students spent roughly forty-five minutes listening to a lecture on the information and then spent about twenty minutes on an activity relating to the information in the lecture. Topics for instruction included nutrition, orthopedics, animal behaviors, stereology, and wildlife. The various hands-on activities included games, labs, computers, and field trips to the wildlife centers on campus. The design of the activities was left to the discretion of the instructors. All activities required that students participated and worked together in groups rather than individually. Students were required to apply their knowledge presented during the lectures to complete the activity component of the lesson successfully. Table 1 displays a description of the various activities implemented throughout the week during the veterinary science class.

Table 2

Hands-on Activities During Veterinary Science Summer Camp Class

Activity	**Description**
Bone Density Lab	Students calculated the density of various pieces of animal bones to determine which part of the bone was more or less dense. This led to further identification of which part of the bone was more susceptible to fractures.
Intestine Demonstration	Students stimulated the small intestine's ability to absorb nutrients by having students form two lines across from each other (walls of the small intestine) and having one student (the nutrient) try to make their way through the tunnel without being caught. Students forming the walls of the small intestine experienced various limitations, such as using only their elbows, to demonstrate what happens when the intestine does not work right; it will not capture the nutrients your body needs.
Cellular Microscopy	Students examined an image containing blood cells on the computer and used an overlay with squares to count how many blood cells were present. Students recorded their numbers in a spreadsheet already set up to calculate and compare the number of red and white, healthy and unhealthy, blood cells in the image.
Wildlife/Bird Aviary	Students visited the wildlife center and bird aviary on the university campus. Students were able to get up close to the animals, without touching them, in their habitat when touring the facilities. Students were able to observe animals in their habitats and witness how humans have come in to care for and allow the animals to live long, healthy lives.
Animal Behavior Activity	This activity was a behavior training simulation where one student was the dog. The rest of the class used clickers to try to get the "dog" to go to the predetermined destination in the room.

Research Question

The following research question for this study directed the researcher throughout the process in gathering insights into students' perceptions about motivation. The research question addressed throughout this study was: How do students perceive their motivation to learn after participating in informal hands-on veterinary science activities?

Data Collection

To answer the research question, data were collected from both participant focus groups and observations. The researcher chose focus groups (Kitzinger, 1995) with a semi-structured interview protocol (Creswell, 2012) to maximize the amount of information gathered in such a short amount of time and to allow students to discuss their thoughts with each other. There was not enough time to interview each student from the camp individually.

Focus groups. All students in the camp participated in the focus group meetings except for those students who left early as mentioned previously. The 36 students were broken into focus groups containing four to eight participants in each group. Students were pulled into each group as they finished their final activity or as they volunteered to be interviewed at the particular time, whichever came first for the student. Focus group meetings lasted between 10 and 25 minutes depending on the participants' willingness to share responses. The researcher asked each focus group the same previously prepared six open-ended questions and encouraged students to elaborate as much or as little as they wanted. The questions were designed ahead of time to align with existing literature to gather students' thoughts on how the hands-on activities affected their interest, relevance, and enjoyment as factors that influenced their motivation. A small recording device audio recorded the interviews that the researcher later transcribed into a word document. One focus group interview took place on the second to last day of camp to gather responses from students who were leaving the camp that day, while the other five focus group interviews took place during the final camp activity on the last day of the camp. The ideas emphasized between the different focus groups varied because one vocal participant directed the ideas in the conversation, which is a common occurrence during focus groups (Kitzinger, 1995), but there was still an equal representation of ideas across groups.

Observations. The camp was divided into two groups (group A and group B) of about 20 participants in each group. Group A consisted of students ranging from 14 to 16 years of age and group B consisted of students ranging from 16 to 18 years of age. Both groups participated in the same classes and activities throughout the week. For this reason, the researcher chose to observe only group B as time did not allow for the observation of both groups. Observations from group B were recorded in a journal during the week of the camp as students participated in the lectures and activities of the class.

Analysis

Upon completion of the focus groups, the interviews were transcribed into electronic format. Thematic analysis was used to code and identify occurring themes throughout the focus group data (Boyatzis, 1998; Creswell, 2012). Review of preexisting literature identified interest, relevance, and enjoyment, as factors having the potential to influence student motivation. Therefore, during the initial analysis, the focus group transcriptions were coded for key phrases and words pertaining to students' interest, relevance, and enjoyment (Boyatzis, 1998; Creswell, 2012). In addition to coding for interest, relevance, and enjoyment, the researcher coded for additional factors affecting student motivation (Boyatzis, 1998; Creswell, 2012). Keywords and phrases included ideas such as motivated when, interested, more interesting, engaging because, relate to, fun, and entertaining. Once the transcriptions were coded, the researcher individually sorted segments of the interview data into several different categories according to the key words and phrases highlighted during the initial coding phase. From thematic analysis of the focus group data, four main themes emerged: (a) students' interest, (b) relevance of activities to the students, (c) students' enjoyment, and (d) passionate and enthusiastic instructors.

Further analysis of interview segments in each theme identified several subthemes within each of the core themes. For example, with the theme interest, the researcher identified the following subthemes: interest because of new information, interest because of the activities, and interest because of the wildlife and aviary centers. Another team member double-checked the final categories and subthemes, and a consensus resolved any discrepancies. During the first and second analysis phase, the researcher labeled each response with the students' assigned number, the number to the question their response was from, and what section of their response was used in order to keep track of where and whom the responses came from.

Findings

The interview questions were designed to align with the existing literature. Analysis of the transcriptions revealed three themes, interest, relevance, and enjoyment, which also aligned with the existing literature. In addition, the analysis revealed another important factor, passionate instructors, which affected students' motivation. While most of the students expressed favor towards the hands-on activities, not all of the activities had the same effect on each individual. The findings from the analysis will be discussed below according to the main themes identified.

Students Developed Interest

Students described how various aspects of the class, including the hands-on activities, tended to increase their interest in learning the material during the veterinary science class. Throughout the week, students learned new information, were introduced to new experiences outside of the university classroom, and performed several activities, which they commented as being interesting to them. Overall, when students expressed interest throughout the class, their motivation to learn increased which was apparent through observations indicating their on task engagement.

Twenty five percent (9) of students said the presentation of new information, through both lectures and hands-on activities, interested them and kept them focused throughout the lesson. Student 19 mentioned that participating in the bone density lab gave the student "new information on bones such as the fact that they are constantly reshaping and they also reshape really really quickly." Student 4 was motivated to learn after seeing new images of the human eye and monkey tongue, which the student found to be interesting. After viewing the images, the student's response was "Whoa, how did you do this? So that made me question and ask how can we do this and that was kind of motivating." In response to a question asking to compare students' normal high school classrooms to the veterinary science class, student 9 stated: "I'm weird because I think I actually like learning and so over here I would say I was pretty motivated to see what I could learn from these university professors." The concept of looking for new information was a motivating factor for students in the class.

Thirty three percent (12) of students talked about how the different activities held their interest throughout the class, which was different from activities they had previously experienced at school. Students commented that the veterinary science class activities sparked and maintained their interest in the lesson. The instructors "had engaging activities on the same days where we would usually just have notes in our class so it was a lot more interesting than school classes" student 24 reported. Students felt that their interest was because the activities required students to put in effort and participate. Student 27 stated: "if we were walking around, if we were like up and moving, then I was more interested in it rather than just like sitting there and listening to a lecture." Several students mentioned that the more effort the student put in, the more engaged and interested the student was in learning the material. In addition, many of the activities were "new and quite interesting," as student 32 explained, because it was something different from their normal learning experiences.

Lastly, thirty percent of students found the trips to the wildlife center and bird aviary to be the most interesting part of the class. Students enjoyed these experiences because as students 13 and 21 explained, "it allowed us to have interaction with the animals" and "seeing the animals hands on." Student 24 found it "interesting to see how people were able to take care of wildlife animals". Student 18 stated he was "really motivated and engaged to learn" when visiting the wildlife center and bird aviary while his classmate, student 7, mentioned that they were motivated because they were interested in seeing the animals "first hand…because you could actually see it and then you would remember it like how annoying they are and what they need". Not only were the experiences interesting to students but also they were able to apply what they had previously learned in the class to the animals they saw during these experiences.

Relevance Extended Beyond Students' Lives

Students were able to find the information and the activities in the veterinary science class relevant to their future goals, their prior knowledge, the world around them, and their current lifestyles. Students expressed how the relevance of the activities and information increased their interest in learning the material, which together led to an increase in motivation.

Eleven percent (4) of students expressed their excitement in the class when they realized that they had already learned the material in their high school classes during the previous school year. Student 31 expressed excitement for already knowing the information: "all of the stuff we talked about I remember in my biology teacher teaching me so as soon as we got out of that class I spammed him with a bunch of text messages about how he taught me and I actually listened". Even though students already knew the information, they were still interested and expressed their desire to learn more. Student 6 stated: "I really liked the nutrition one because I just learned about all the body systems this year in my health science class it was a nice review to go through the digestive system and kind of go a little bit more in depth". The connection between their prior knowledge and the new information provides students the confidence to continue building on their preexisting body of knowledge.

Sixty six percent (24) of students explained how they could relate the material to their lives. Of the twenty-four, seven participants stated, specifically the hands-on activities related to either their lives or their academic interest. Several students were able to relate the activities to their science fair projects. Student 17 found the cell lab relevant because “mainly for my science fair research cells and cellular processes and counting them is a major process that I have to do and gave me some more tips I can use to be more efficient”. Student 8 mentioned that the nutrition and dog activities helped motivate the student to learn because the student understood the relevance of the activities. The student stated “I was like oh, that it actually something that I could use in my life”. Student 5 explained how the nutrition activity was relevant to improving her lifestyle because the she lives a sedentary lifestyle. The student commented that learning about fat cells never dying was “interesting to learn and sort of scary.” Another participant, student 4, expressed how the blood cell counting activity was “really interesting because it made me think more about what was inside me. And it inspired me to start working on…creating a program that would count it for us.” In this instance, the student found the activity interesting and relevant to their life resulting in motivation to work on a new project.

Twenty five percent (9) of students discussed how the information was relevant to their future goals. Student 3 stated that the quantitaitve microscopy activity “motivated me because whenever the professor…was showing us … where he got those actual images, I noticed that a lot of it said medical school and vet school and I want to go into a premed program and do medical school so to me it was good motivation good experience to kind of get to know what you are going to be dealing with in the future once you get to that level". Student 28 explained how they planned to get a dog in the future and one of the activities gave perspective of what to expect when training the dog. In response to the lesson on behavior, the student stated "this is really relevant to owning a pet… I plan to get a corgi hopefully and owning a dog requires good skills and training and the activity today especially helped me to realize what the process is like". Lastly, several students were able to find the activities relevant to the working world outside of the classroom. Students stated that the hands-on activities gave perspective of what it is actually like to work in the field. Student 16 stated, "I enjoyed the most the hands-on activities like the labs and the various activities we would do to get a feel what it is like in the real world". As a whole, students were able to find the activities and material relevant and interesting influencing their motivation.

Participation Leads to Engagement and Enjoyment

Several students mentioned how their engagement and participation in the hands-on activities effected their motivation, were fun and enjoyable, and improved their understanding of the content during the veterinary science class. Students consistently mentioned how they enjoyed the general nature of the hands-on activities because they were engaging, interactive, and visual. Student 9 liked "that there were many interactive activities so we were engaged and actually doing something" compared to normal classroom experiences.

Thirty eight percent (14) participants commented on the activities during the vet science class to be fun and entertaining, more specifically the behavioral activity involving clickers. Students described the activities as fun because the activities were engaging and required them to participate. Student 7 liked " when we got up and we actually did like demos" such as the digestion activity "some of us stood on the side and pretended to be stomach villi and then we actually did it so that was like a fun getting up and actually doing it and learning it". Even though the activities were fun, students claimed it was a result of being engaged in the learning process, which kept them from, as student 25 described, "getting sleepy".

Nineteen percent (7) of the participants commented that they felt the hands-on part of the lessons kept them interested, engaged, and motivated to learn throughout the class. All seven students agreed that their participation in the activities kept their focus and prevented them from being bored. Student 25 explained how he was "really motivated to learn a lot when we had activities that involved us actually participating as individuals". The behavioral activity not only kept the student from getting sleepy, but it also increased their interest in the material. Student 28 mentioned that "I liked how directly following that there was a lab that all of us had to participate in so that also helped motivate me because I wanted to do well in the lab and that's why I learned the information pretty well". This individual recognized that in order to be successful in the activity, he must stay focused throughout the lesson. Student 23 expressed that "the labs do a good job of keeping us focused and concentrated on what it going on". For example, in reference to the small intestine activity, the student claimed, "it really jolted me awake to see exactly how those digestive process work" when describing how it kept him engaged in what was going on.

Lastly, about forty two percent (15) of the participants stated that the hands-on activities aided in their learning of the material. After participating in the activities, students expressed they now had a better understanding or different perspective of the material. After participating in an activity, student 26 was motivated to learn more about the subject because the dog activity "helps you understand more about how a dog would feel similarly to you cause they would also feel confused on what they should be doing and what they shouldn't be doing." Other students mentioned that because they were up and moving around they were able to remember more of what they learned compared to when they were just sitting there listening to a presentation. Student 7 stated, "the actual activities that we did where we had to get up and move and stuff actually made us learn more because we remembered what we did because we were actually moving instead of thinking how boring it was." Some students felt that using a good balance of lectures and activities were necessary because each contributed different information to the class. Student 28's favorite part of the class was how it was structured, "usually there would be a PowerPoint with notes and information and after all that was covered there would be a an engaging activity like a demo where we would all take part and it would help illustrate some of the concepts we just learned." The hands-on activities were able to enhance the learning process for the students throughout the week as reinforcement for the material presented.

In addition to the three themes mentioned above, which aligned with the existing literature, twenty eight percent (10) of students felt that the passion and enthusiasm from the instructors also affected their motivation in the class. Student 1 explained how even though she did not care for the topics being discussed “the professor’s enthusiasm and their passion for it made it all more interesting.” Student 12 agreed in that “the teachers were more enthusiastic and that way I was able to pay more attention and I learned a lot more that way”. Students were able to feel the excitement and enthusiasm from the instructors, which made the topic or task more interesting. Another theme identified was some activities were favored more than others were by students. For example, the bone density and blood counting activities received mixed results from students. Student 31 did not care for either of the activities because she thought it was “really really boring and super confusing”. Student 10 agreed with her, he “thought it was pointless because we had to do so many repetitions of it…it became monotonous work” during the blood counting activity. In contrast to the overwhelming favor for the dog activity, student 32 felt the instructors went overboard with the activity by using too many examples. In reference to the activity, he stated “I was getting kind of bored of it and I was like ehhhh click click click click…”

Discussion

Every day, as students enter their classrooms, many struggle to find the motivation to learn. Motivation is a complex concept in which individuals can vary in the amount of motivation they have towards a subject and vary in the areas their motivation is directed (Eccles et al., 1998; Ryan & Deci, 2000). Because motivation is driven by different factors for each individual, educators need to strive to design instructional strategies around those factors. As research reported earlier suggested, implementing hands-on activities in an informal learning setting can support interest and develop motivation to learn science (Bergin, 1999; Holstermann et al., 2010; NABT, 2005).

In this study, after participating in a vet science class, students were interviewed on their perceptions of involvement and motivation to learn. Three distinct themes emerged from analysis of the interview transcriptions, however; during the analysis there was some overlap between the three themes, which indicates the use of hands-on activities has the potential to influence students’ motivation to learn positively in more than just one area. For example, students were able to see how different elements in the activities were relevant to their lives or future career goals, which they found interesting and as a result motivated them to stay focused throughout the lesson. The findings from the current study demonstrate activities allowing students to form connections between science concepts and their lives promotes both interest and motivation for students consistent with existing literature (Cordova & Lepper, 1996; Mitchell, 1993; Ross, 1983). Students also claimed some of the activities to be fun and interesting, which motivated them throughout the lesson. The overlap between the themes provides evidence there exists a relationship between interest, relevance, and enjoyment influencing individuals’ motivation to learn (Keller, 1983; Krapp, 1999; Mitchell, 1997; Resnick, 2004).

Even though the three themes overlapped, findings indicated students do not necessarily need to experience all three factors at the same time to be motivated. Although, in some instances, it might be hard to experience one without the other, these factors can work to impact motivation together because motivation depends on the attitudes and goals driving the individual to act (Eccles et al.,1998; Ryan & Deci, 2000). This may partly explain why the three identified factors appeared to affect each student differently. Several students expressed their favor towards certain activities while others thought the same activities were overdone or boring. These findings indicate not every activity affects each student the same way and supports the idea that each individual is motivated by different factors (Eccles et al., 1998; Ryan & Deci, 2000). When designing activities to increase interest and motivation, it is important to consider there is no guarantee each activity will work for all students in a classroom (Holstermann et al., 2010). Thus, educators need to consider activities that influence students in more than one area so at least one of the elements may increase motivation in students.

The dog activity was one of the more popular activities mentioned among the students and is a great example of how one activity can reach students' interest level, relevance and enjoyment while increasing students' motivation to learn. Because the dog activity appeared in all three themes, this suggests when designing activities, not only is it possible, but necessary in order to reach all students in a classroom setting. These three factors seemed to work together in increasing motivation in students who participated in the activities. Activities designed to influence students in one area might not be as effective as activities meeting students in several areas. Overall, the dog activity appeared to be successful because students expressed they found the dog activity to be entertaining, memorable, aid in their learning, and interesting to them for learning the material.

Another component students commented on was the interaction and requirement of their participation influenced whether they found the activity to be interesting, relevant, or enjoyable. This indicates the necessity for students to get up and move around rather than sitting in their seats all day (Alfieri et al., 2011; Clements & Battista, 1990; von Glasersfeld, 1989). Not only does the activity itself engage the learner, but also knowing there will be an activity at the end of a lesson motivates students to pay attention to the information so they will be prepared to complete the activity successfully. Students enjoyed getting up and moving around allowing them to stay awake and pay attention. As a result, students became active in their learning process, keeping them focused throughout the lesson. Having different activities throughout the week that accompanied each lecture proved to be an effective lesson structure for the students during the camp. Instructors presented students with information on animal's health and behaviors then required students to apply that knowledge for a deeper understanding during the activity.

Another theme identified through analysis of the interviews was the passion and enthusiasm the instructors displayed. This suggests instructors have the ability to influence the way the activities are delivered affecting the way students feel about the activities. The enthusiasm is contagious and passed on to the students allowing them to get excited to be involved in their learning (Patrick, Hisley, & Kempler, 2000). The enthusiastic instructors encourage students to become more engaged enhancing students' learning experiences. Therefore, successful implementation of hands-on activities may require some level of enthusiasm from the instructors.

As a whole, the current findings indicate presenting students with a variety of activities during an informal setting keeps students engaged in the material because it is interesting, enjoyable, and relevant to different aspects of their lives. Students were able to apply the information they learned to different situations outside of the classroom, such as training a dog. Students were also able to find new information they could use to improve their science fair projects. Throughout the camp, individuals were exposed to a variety of science experiences and tools they could use that they generally would not have access to in a regular classroom setting. These new experiences were fascinating for the students. The results indicate participation in hands-on activities during a STEM summer camp positively influences student motivation.

Overall, students stated they enjoyed the variety of activities throughout the week during the veterinary science class. Students felt these activities helped them to learn more, kept them engaged and interested, and students enjoyed the interaction requiring them to communicate with their peers and move around the room. Students also felt the activities gave them the opportunity to experience what working in certain fields is like. Some of the activities may have worked better for certain individuals, but overall the majority of the students expressed their involvement in all the activities as either interesting or motivating throughout the week.

While this study utilized qualitative interviews whereas other studies used surveys, the findings corroborate with previous findings (Holstermann et al., 2010; Hulleman, & Harackiewicz, 2009; Johnson, Wardlow, & Franklin, 1997; Paris et al., 1998). Hands-on activities are more than just a fun activity. It is an instructional tool enhancing students' learning. The variety of hands-on activities available can reach diverse learning styles in a classroom setting, provide deeper and clearer understandings of the information, and increase enjoyment. These findings indicate the significance in designing a variety of hands-on activities for science that generate interest, create enjoyment, and are relevant to students. The next step for this study would be to understand how the quality of each activity impacts students' motivation and then how to improve the quality of the hands-on activities implemented to engage and motivate all students to learn. Allowing the researcher to gain better insights into how the different qualities of the hands-on activities affects students' motivation, the researcher would then be able to offer suggestions and implementation strategies that will increase students' motivation to learn in both formal and informal learning settings.

Conclusion and Recommandations

Teaching methods in science education often favor rote learning and memorization. As a result, students view science as dull, distant, and challenging. Curriculum that incorporates the use of hands-on activities can be a motivational tool for science education. These activities can be fun and exciting, making science more approachable for students. The hands-on activities require a conceptual understanding of science, therefore, making a natural connection between the activities and conceptual understandings in science. This study provides insight into students' experiences involving hands-on activities during a summer camp and highlights how students perceive the activities to influence their motivation to learn. The present findings indicate favorable outcomes when implementing hands-on activities in a veterinary science course during a week-long summer camp. Overall students were interested and enjoyed the hands-on activities. Students expressed they felt more engaged in their learning and made multiple comments that the activities were "fun" and "exciting". The motivating features of the activities highlighted in this study were interest, relevance, and enjoyment. Hands-on activities are just one approach for creating motivating learning opportunities in science education.

It is recommended that educators design and create activities students find interesting, relevant, and enjoy participating in whenever possible to increase students' motivation in learning all topics especially science. Because each activity affects students differently, educators should consider presenting students with options to allow them to choose which activity would work best for them. When implementing hands-on activities, educators should exhibit enthusiasm and encourage students to do the same. Another recommendation for educators is to search for opportunities to provide students with experiences outside of the formal learning setting. There is a whole world beyond the walls of a formal classroom where students can experience allowing them to apply the knowledge and skills they are learning (Slattery, 2012). Lastly, it is recommended that educational researchers take a closer look at the qualities of each activity to determine which instructional strategies make up affective hands-on activities in terms of motivating students. Further research should also include how the activities affect students in different settings, both informal and formal.

CHAPTER IV

SUMMARY AND CONCLUSIONS

STEM education for K-12 is one avenue to increase the number of individuals pursuing higher education and careers in science, technology, engineering, and math (NAS, 2005). One factor that may influence and contribute to students' willingness to pursue STEM coursework is their attitudes towards the fields of mathematics and science (Mohr-Schroeder et al., 2014). Students develop attitudes and interest towards learning specific disciplines at a young age. An individual's attitude towards a particular content area, such as mathematics and science, can change as the individual participates in different experiences. Creating experiences where students can engage in solving meaningful real-world problems is a key component of STEM project based learning (Capraro et al., 2013). Providing students with opportunities to create links between the STEM fields and real world experiences early on in their academic careers has the potential of sparking students' interest and increasing enrollment into the STEM fields (Brophy et al., 2008).

The first article (Chapter 2) focused on how STEM summer camp experiences influenced students' affect contributing to their commitment in mathematics and science. The results of this study indicated that student affect towards pursing mathematics and science improves with participation in informal STEM activities during a summer camp. The study supports the notion that STEM summer camp experiences have a positive impact on students' attitudes towards mathematics and science (Bachman et al., 2008; Hayden et al., 2011; Mohr-Schroeder et al., 2014; Nugent et al., 2010; Yilmaz et al., 2010). The findings from this study highlight the positive impact of STEM activities on student affect towards mathematics and science during an informal learning environment. Practical significance for both subject areas revealed despite the cognitive load of the activities during the camp, students were more interested in and committed to learning more in the disciplines of mathematics and science. Thus, by increasing student affect towards mathematics and science, students may be more committed to pursuing and obtaining higher education degrees and careers in the STEM fields meeting the need for more individuals in the STEM fields. Research has shown early exposure to a variety of STEM opportunities relate to subsequent STEM careers later on in life (Wai et al., 2010). Having more individuals entering the STEM fields will allow the U.S. to compete in the global economy.

In addition, student motivation is an important factor in the learning process for students, especially in science. Motivation is a complex construct because individuals can vary in level of motivation towards a subject and vary in the direction of their motivation (Eccles, Wigfield, & Schiefele, 1998; Ryan & Deci, 2000). Because different factors drive motivation for each individual, educators need to strive toward designing instructional strategies around those factors. Previous research has suggested the implementation of hands-on activities in an informal learning setting can support students' interest and development of motivation to learn science (Bergin, 1999; Holstermann, Grube, & Bögeholz, 2010; NABT, 2005).

A qualitative approach was used for the second study (Chapter 3) to examine students' perceptions on the hands-on activities in relation to their motivation to learn during the STEM summer camp veterinary science class. The findings from this study indicated the importance of designing hands-on activities pertaining to more than one motivational factor, more specifically interest, relevance, and enjoyment. It was apparent from the students' responses these three factors affected each student's level of motivation differently. Therefore, these motivational factors can work together or independently to impact motivation because the attitudes and goals driving the individual to act determine their motivation (Eccles, Wigfield, & Schiefele, 1998; Ryan & Deci, 2000). The enthusiasm and the passion for science the instructors displayed also had an effect on students' motivation. This supports the notion that the way hands-on activities are delivered can affect the students' feelings towards the activities (Patrick, Hisley, & Kempler, 2000). In addition, the different hands-on activities used during the veterinary science class provided students with deeper and clearer understandings of the information, and students were more likely to find the activities enjoyable compared to taking notes from a presentation. Hands-on activities are just one teaching method to make science more accessible to students.

The second study demonstrates how hands-on activities used during an informal learning setting can improve motivation. The first study reveals students' affect towards mathematics and science increases after participating in STEM summer camp. Together these studies suggest the importance of students' attitudes, interest, and motivation towards mathematics and science. Rather than ignoring these factors, educators should consider them in addition to designing instructional strategies that improve academic performance. Students' affect and motivation are necessary components for individuals to be successful in mathematics and science. Both studies used different formats of hands-on activities allowing students to apply their knowledge and make connections between the classroom and the world they live in. The results and findings from both studies show creating activities that are personally relevant and meaningful engage students in the learning process. This enables students to identify with future science careers, and develop interest in science-related academic paths. The ideas presented from the findings in the second study can be used when designing and implementing PBLs to increase students' affect and motivation towards science.

Overall, both of these studies support increasing students' affect and motivation towards mathematics and science. Educators for grades 6-12 should utilize the results from these studies to design activities and informal learning experiences that motivate and interest students in mathematics and science. Educational researchers should consider looking further into the benefits of incorporating PBL and hands-on activities in more formal educational settings as informal experiences are not always available for every student. The combined studies imply the importance of allowing students to be active learners rather than passively taking notes or listening to lectures (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011; von Glasersfeld, 1989). Together these studies provide educators for grades 6-12 with research supporting the use of PBLs and hands-on activities in informal learning environments to increase students' affect and motivation towards mathematics and science.

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APPENDIX A

Questions from the *Student Attitude Towards STEM Survey*

1. I will continue to enjoy science/math

   1 2 3 4

2. I am not interested in a career involving science/math

   1 2 3 4

3. I am interested in alternative programs in science/math

   1 2 3 4

4. I would like to learn more about science/math

   1 2 3 4

5. I am committed to learning science/math

   1 2 3 4

APPENDIX B

Focus Group Interview Questions

1. How do you learn best?
2. What did you like the least or the most about the lessons in Dr. Johnson's veterinary science class?
3. In what ways were you able to relate any of the knowledge in Dr. Johnson's veterinary science class to your own life experiences?
4. Can you describe a situation in which you were interested or motivated to learn this past week? How did your involvement in the activities or lack of involvement in the activities motivate or hinder you to learn?
5. Can you compare the experiences in Dr. Johnson's class to your normal high school classroom learning environments?
6. What is the most memorable less from this past week in Dr. Johnson's veterinary science class and why?