A Study of Progression in Science Process Skills During A Midwestern Public Research University's Stem Summer Camps

Anila Fiaz Gill
anilafgill@hotmail.com

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ABSTRACT

A STUDY OF PROGRESSION IN SCIENCE PROCESS SKILLS DURING A MIDWESTERN PUBLIC RESEARCH UNIVERSITY’S STEM SUMMER CAMPS

Anila Fiaz Gill, Ph.D.
Department of Educational Technology, Research and Assessment
Northern Illinois University, 2019
Dr. Ying Xie, Director

This study explored the impact of STEM summer camps (held at a Midwestern university) on campers’ science process skills (SPS). Upon analysis statistically significant positive growth in SPS was observed, evidenced by the increase from presurvey to postsurvey SPS scores, over the period of these short duration camps. There were no statistically significant differences in growth (presurvey to postsurvey) by gender, grade level, or ethnicity. While there were no significant main effects for gender (male vs. female) and grade level (middle vs. high school) on science process skill scores, there was a significant main effect of ethnicity (white vs. nonwhite) in SPS. As part of their daily reflections, campers generated questions daily throughout the camp. It was observed that a large number of campers did not reflect by generating questions. Using the PREG model for coding the level/rating of questions generated by camper, it was concluded that there was no statistically significant change in the ratings of the questions over time. Regression analysis also showed no statistically significant relationship between campers’ change in SPS and change in the level of their generated questions. There was also no significant effect of the change in SPS survey scores on the change in ratings of campers’ generate questions over time.
A STUDY OF PROGRESSION IN SCIENCE PROCESS SKILLS DURING
A MIDWESTERN PUBLIC RESEARCH UNIVERSITY’S
STEM SUMMER CAMPS

BY

ANILA FIAZ GILL
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A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE
DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATIONAL TECHNOLOGY, RESEARCH AND ASSESSMENT

Doctoral Director:
Dr. Ying Xie
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CHAPTER 1
INTRODUCTION

Background

The overarching goal of this research study is to evaluate the impact of STEM camps on the campers. The camps were organized by a Midwestern state university’s outreach department. Summer camps and their attendance have grown exponentially over the years everywhere, leading to many research studies on the impact of camps. The common tools used to collect data for camp evaluation and for research purposes include pre/post surveys, interviews, and focus groups. For this study, quantitative data came from campers’ presurvey and post survey. The qualitative data was campers’ generated questions, as part of daily reflections; posted on Edmodo, an educational social networking site (ESNS).

Nonformal Education

Learning that takes place in camps falls under the nonformal mode of education (e.g., Fields, 2009; Bell, Lewenstein, Shouse & Feder, 2009). Camps provide the environment which is relatively less structured and confining compared to a classroom, expecting and enabling participants to take responsibility of their own learning experiences. Relatively recent papers
(e.g., Eshach, 2007; Etling, 1993; Nelson, Cushion & Potrac, 2006) have definitions for nonformal education very similar to those found in earlier papers, such as those by Kleis, Lang, Mietus and Tiapula (1973); and Coombs, Prosser and Ahmed (1973). According to Kleis et al. non-formal education can be defined as:

Any intentional and systematic educational enterprise (usually outside if traditional schooling) in which the content is adapted to the unique needs of the students (or unique situations) in order to maximize learning and minimizing other elements which often occupy formal school teachers (i.e., taking rolls, enforcing disciplines, writing reports, supervising study hall, etc.). (p. 6)

According to Eshach (2007), non-formal education is not only out of school but also usually supportive, structured, usually prearranged, usually voluntary, may be guide or teacher lead where learning is not evaluated, and typically not sequential. This is in contrast to formal learning which is delivered in classrooms, and is structured by a fixed curriculum. There is also the informal education, which deals with everyday life experiences, which are characterized as unplanned and unorganized hence also called incidental learning (Etling, 1993).

**Science Camps**

“Do people learn about science in nonschool settings? This is a critical question for policy makers, practitioners, and researchers alike—and the answer is yes.” (Bell, Lewenstein, Shouse, & Feder 2009, p.1). There is a lot research on camps, including summer science camps. These camps allow campers to spend a relatively short but rigorous, hands-on experience during summer (Fields, 2009). Camps provide such opportunities where science learners can work in small groups and interact with scientific processes in natural and synthetic environments.
Overtime camps have become more structured, more hands-on, and more meaningful. This is response to the needs of our current global world. For example, as the need for technicians arises along with the competition among the economically well countries, various organizations/universities establish summer camps to recruit youth for a career as scientists or technicians (Lindner & Kubat, 2014). This happens because camps spark interest and motivation for STEM. Research studies not only gauge the success of camps within the period of duration of camp, but also, wherever possible, through career and educational trajectories of campers (e.g., Fadigan & Hammrich, 2004).

**STEM Education**

Although there are many definitions and explanations of STEM education, there are no clear consensus on its actual meaning (Reeve, 2015). For example, STEM education could refer to a stand-alone STEM course (e.g., physics or calculus) or a program of study that includes variety of courses from the STEM areas. Although there is no clear consensus on the meaning of STEM education, the term is often used in a context that emphasizes an immediate need to improve education in STEM. Tsupros, Kohler, and Hallinen (2009) provided an often quoted definition of STEM education:

> An interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise, enabling the development of STEM literacy and with it the ability to compete in the new economy. (p.1)
Social Networking Sites (SNSs)

SNSs are defined as websites which provide opportunities for users to increase levels of communication and sharing personal content, the essentials of online communities (Boyd & Ellison, 2007; Buss & Strauss, 2009), showcase their creativity, and get rapid feedback from their friends (Wheeler, Yeomans, & Wheeler, 2008). SNSs are a comfortable way to connect in a disconnected world (Junco & Mastrodicasa, 2007).

SNSs have been referred to as ESNS, educational social networking sites (Cankaya, Durak & Yünkül, 2013). ESNS, such as Edmodo, Ning, Elgg, are educational environments with features those of social networking capabilities. Thus, just like formal and informal education, social network sites can also be categorized into formal and informal category. Formal SNSs, are mostly used in educational activities, and Inform SNSs be used for both educational and social activities (Sohaei & Iahad, 2014). Edmodo mimics the look of common social networking sites (Trust, 2012). It enables teachers and students to collaborate through discussion, question and answer sessions, online quizzes, and other academic activities (Wendt & Rockinson-Szapkiw, 2015). Edmodo’s use in middle/secondary schools (e.g., Wendt & Rockinson-Szapkiw, 2014 & 2015) and undergraduate level (e.g., Al-Said, 2015; Al-Kathiri, 2014; Çankaya et al., 2013) has been studied. Apparently, there are many more studies on SNSs in formal education (than regarding informal education), at both middle/secondary school (e.g., Wendt & Rockinson-Szapkiw, 2014 and 2015) and undergraduate level (e.g., Al-Said; Çankaya et al.). The appearance of educational social networks allow students and educators to minimize the privacy and safety concerns (Kevin, Lori, & Bethany, 2010).
Science camps fall under nonformal learning (e.g., Fields, 2009; Lockyer, Lori and Patterson, 2008) and there is a well-developed body of literature that supports nonformal learning (Marsick & Watkins, 2001). Although students spend a very limited time at camps, the goal is to provide a concentrated time on very specific activities, to inspire them for their future academic and career decisions (Fadigan & Hammrich, 2004; Lindner & Kubat, 2014). Interaction, such as sharing of ideas, providing peer feedback, and engagement in critical thinking have been studied (Selwyn, 2006; Balasubramanian, Jaykumar, & Fukey, 2014).

Problem Statement

**Importance of STEM Thinking**

According to Reeve (2015) Science, Technology, Engineering, and Mathematics (STEM) educators need to be interested in STEM areas and begin showing students how these are connected. Teachers need to be role models as “STEM thinkers” who can show their students how STEM is involved in their daily lives. “STEM thinking” can be defined as “purposely thinking about how STEM concepts, principles, and practices are connected to most of the products and systems we use in our daily lives” (p. 8). It is believed that STEM education can contribute essential skills, such as problem-solving skills, critical thinking, and analytical thinking in students (Brophy, Klein, Portsmor, & Rogers, 2008; National Science Board, 2007). New K-12 Standards, including the Next Generation Science Standards (NGSS, http://www.nextgenscience.org), stress the importance of developing students’ inquiry skills to better prepare them for college and career. The economic events of the 21st century have made it
evident that the teaching STEM is required for the global economic competition. STEM education is now considered as a meta-discipline, desegregating disciplines. STEM education uses current technological tools, to focus on designing solutions to complex problems. Science process skills (SPS) are important to discuss when talking about STEM thinking and STEM education.

**Science Process Skills (SPS) required for STEM thinking**

SPS are the tools used to attain information about the world (Osborne & Freyberg, 1985; Ostlund, 1992) and extremely important for science literacy (Ferreira, 2004; Harlen, 1999). Given the importance of SPS in the scientific inquiry, researchers and educators are constantly working towards figuring our measures to equip students with SPS (Yildirim, Çalık, & Özmen, 2016). SPS are considered the backbone for scientific inquiry. Thus, scientists use them for scaffolding knowledge and possible solving. The American Association for Advancement of Science (AAAS) provides the comprehensive list of science process skills, categorizing them based on operational difficulties and intellectual demands. These categories with their component skills are: the basic science process skills: include; observing, measuring, inferring, classifying, predicting, and communication; and the Integrated science process skills, include: formulating hypotheses, identifying variables, defining variables operationally, designing investigations, experimenting, analyzing data, indicating causes and effect relationship and formulating variables/models (AAAS).
**Question generation skill required for STEM thinking**

Many of the fastest growing areas within the workforce require critical thinking skills and problem-solving skills that are fostered by question-asking (Minigan, 2017). Several researchers have suggested that by exploring students’ self-generated questions, one can better understand what they want to know about a given topic and how they think actively about it (Demirdogen & Cakmakci, 2014). Interestingly, spontaneously generated questions and ideas a better gauge of students’ interests than their responses to questionnaires by adults (Baram-Tsabari & Yarden, 2005, 2008, 2009; Falchetti et al., 2007; Yardelen-Damar & Eryilmaz, 2010; Cakmakci et al., 2012). Asking questions is important for student learning (Balzer, Evans, & Blosser, 1973). Student-generated questions can be used as a starting point for the development of scientific ideas in the classroom (Yarden et al., 2008). Research and scientific inquiry relies on scientific curiosity leading to questions asking. Questions asking leads to identifying or defining a problem and hypothesizing. Thinking in questions helps investigators assess data, dive deeper into their research, and make conclusions based on gathered evidence (Minigan, 2017).

**Challenges faced in accessing STEM education**

Today’s education is missing the focus of teaching children to solve real world problems. It is also not interdisciplinary, nor collaborative enough (DeAngelis, 2014). According to the U.D. Department of Education statistics (U.S ED), only 81 percent of Asian-American high school students and 71 percent of white high school students attend high schools offering full
range of math and science courses, such as, Algebra I, Geometry, Algebra II, Calculus, Biology, Chemistry, and Physics. American Indian, Native-Alaskan, Black, and Hispanic high school students have even limited access. U.S. department of education reported that only 29 percent of Americans rated this country’s K-12 education in STEM subjects as above average or the best in the world (U.S ED). The need is eminent for college-ready students who can thrive in a modern STEM economy.

**Consequences of lack of STEM skills and science process skills (SPS)**

Rillero’s editorial (1998) emphasizes that individuals who cannot use science process skills will face challenges in succeeding in daily life, for the simple reason that development at science process skills enables learners to gain the skills necessary to solve everyday problems (Kazeni, 2005). Lack of science process skills is an obstacle before science literacy since science literacy in turn requires efficient use of science process skills (Ewers, 2001). Padilla, Cronin, and Twiest (1985) reported surveying the basic process skills of 700 middle school students with no special process skill training. They found that at the eighth-grade level only 10% of the students scored above 90% correct. The challenges related to SPS are observed not only in students but also teachers. Studies reported that attitudes of teachers towards learning science process skills were not sufficient (Radford et al., 1992; Miles, 2010). In teacher training programs there should be need to emphasize more on skills acquisition (Akani, 2015). The reason for this kind of attitude towards SPS, could that teachers are not adequately informed about what is suggested in teaching programs about the teaching of SPS along with concepts (Aydogdu, 2015).
Consequences of lack of question generation skill

Question generation is not prevalent. In typical classroom settings, students rarely ask questions and they are often expected to answer questions (Colbert, Olson, & Clough, 2007).

Students at any grade level should be able to ask questions of each other about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations. For engineering they should ask questions to define the problem to be solved and to elicit ideas that lead to the constraints and specifications for its solution. (NRC Framework, 2012, p. 56)

Additionally, only a small proportion of students’ questions reflect genuine intellectual curiosity (De Jesus, Teixeira-Dias & Watts, 2003). To assume that learners will be vigorous question generators is idealistic (Graesser & Olde, 2003). The great number of learners struggle with identifying their own knowledge deficits (Baker, 1985; Hacker, Dunlosky, & Graesser, 1998) and asks very few questions (Dillon, 1988; Good, Slavings, Harel, & Emerson, 1987; Graesser & Person, 1994).

Importance of Reflection

Reflection that occurs in a variety of forms, could be a process of communication for deep learning (Henderson, Napan, & Monteiro, 2004). Through reflecting learners review their learning and practice, and are enabled to think critically for knowledge production and problem solving (Park & Son, 2011). Reflection brings about “growth of the individual – morally, personally, psychologically, and emotionally, as well as cognitively” (Branch & Paranjape, 2002, p. 1187). On the other hand, reflection is also reported to be an “annoying interruption” and time
consuming (CALT Learning Support, 2007). Learners’ lack of experience with reflection can negatively affect their reflections; for example inexperienced learners can overthink about reflections (Ajeneye, 2005). This is the reason why “reflective practice requires continual evaluation of beliefs, assumptions and hypotheses against existing data” (Ajeneye, p. 573). Thus it is essential that the use of reflection is completely justified in its use, with reflections focusing learners’ engagement and participation in the reflective practice.

Role of Reflection in STEM education

Reflection was used by Socrates more than 2,000 years ago (Kori et al., 2014). Dewey’s (1933) approach is still being used for applying reflection in learning settings. Kori et al.’s (2014) reported significant associations between the development of the students’ inquiry skills and reflection quality based on research that involved designing prompts for guided reflection and validated the same empirically. These guided reflections were then applied in an online learning environment, used with lower secondary school biology students. Kori et al. (2014) supported their methodology by citing research that supported that one way to link inquiry learning and reflection is to use technology-enhanced learning environments. Technology is widely used in science education for learning through inquiry (for example, Shapiro, Roskos, & Philip, 1995, Wang & Hannafin, 2005). Kori et al. concluded because students’ reflection quality and inquiry skills are correlated.

Engaging students in self-reflection also helps in math learning (Choi et al., 2017). According to Choi et al. (2017) both self-reflection and higher self-confidence level lead to to
higher final course performance. Their study aimed at analyzing assessment data from virtual schools to explore the association between self-reflection and math performance. Comparisons were reported for patterns found in student self-reflection impact on math performance in an online learning environment, across elementary, middle, and high school levels. To collect data they employed self-reflection assessments at multiple times within several math courses in eight virtual schools during a school year. Their students reflect on their understanding of the knowledge and skills they learned in the preceding math lessons. Reflections surveys, along with pre- and posttests were used to see the impact on a large number of introductory and advanced Geology students’ spatial thinking skills through regular, short interventions throughout an academic semester (Gold et al., 2018). It was reported that students who participated also in hands-on training interventions had additional gains.

**Online Reflections using Social Networking Sites (SNS)**

One of the important requirements of STEM camps in this research study, was for campers to reflect at least once a day, on the online portal, an educational social networking site (SNS or ESNS) Edmodo. The reflections were based on prompted questions. The reflections did not have to be comprehensive; to prevent campers from being deterred from reflecting due to the length of reflections. Campers’ reflections might not have followed all the rules of an effective reflective practice.

According to Park & Son (2011) if reflective writing is used for collaboration on an SNS, it is essential that both reflective learning process and the writing process be integrated into the
SNS (Park & Son, 2011). However, Park and Son (2011) and Park and Kastanis (2009) concluded that use of SNSs are not appropriate for reflective learning; deeming SNSs as mere personal log books lacking reflective learning elements such as individual reflection and collaboration. Park and Kastanis identified three major obstacles in adopting SNSs for reflective learning: (1) insufficient time for reflective learning; (2) technical difficulties in using various media formats; and (3) insufficient integration of the reflective learning process and characteristics of SNSs. The SNS, Edmodo was employed in this research study, as it was used as the one portal for online communication between campers, counselors. All artifacts and presentations for the purpose of improvement of camps were collected on Edmodo by the camp directors. After discussion with the camp director it was decided that, an additional online portal just for reflections or another method of collecting reflections was not feasible.

**STEM camps assist in becoming STEM thinkers**

Camps teach important skills to campers. Camps can help to connect curriculum-based science concepts and real world scenarios. Camps can introduce and help develop 21st century learning skills (Little, Wimer, & Weiss, 2008; Eguchi, 2016). Naizer, Bell, West, and Chambers (2003) reported an improved understanding, confidence and attitudes in teachers toward teaching inquiry-based science, based on their pre- and post-assessment scores. These teachers attended a 3-week professional development program for preservice and inservice elementary teachers to engage in hands-on, inquiry-based science learning and then apply their learning by working with students in the concurrent science summer camp.
Recent calls for reform are pointing to changes in the foci and progression of K-12 science, in a cross-disciplinary manner (Stevens, Shin, Delgado, Cahill, Yunker, & Krajcik, 2007). American Association for the Advancement of Science’s (AAAS) *Benchmarks for Science Literacy*, highlights the importance of helping students understand the interconnectedness of knowledge and the impact of recent developments in science on society (AAAS, 1993). Apprenticeship camps allow interactions between participants and “real” scientists (for example, Barab & Hay, 2001; Leblebicioglu, Metin, Yardimci, & Cetin, 2011). Science camps play a pivotal role, in introducing science to young learners, in a way that not only sparks their interest in learning more about things around them, but can also guide their college and career paths.

**Science camps assist in question generation skill**

Studies have considered how questions asked by students influenced and modified the content and structure of ongoing classroom discourse (Aguiar et al. 2010) and how teachers can encourage students to raise questions (Chin, 2004; Colbert et al., 2007; Rosenshine, Meister, & Chapman, 1996). The results of these studies suggest that classroom interactions initiated by students’ questions of intrigue can stimulate active intellectual engagement in classrooms, which can help develop classroom discourse and foster a ‘culture of inquisitiveness’ in science classrooms (Chin, 2004).

Although more research about question generation is in a classroom or formal settings, there are studies about the same in informal and nonformal settings including camps. For
example, Barab and Hay (2001) reported a study where campers posed questions to scientists. Cakmakci et al. (2011) investigated Turkish primary school students’ interest in science by analyzing their self-generated questions.

**Conclusion**

Reflections and question generation by students have been studied in classroom settings. Few studies have reported the use of an ESNS for question generation as part of reflections in nonformal settings, and even fewer in STEM summer camps settings. This research attempted to study the impact of several one-week long camps of various STEM themes, held at a university campus, for middle and high school students. The study analyzed the growth in Science Process Skills (SPS) through the presurvey and postsurvey scores, as well as the progression in the level of question generation as part of reflections using an ESNS, Edmodo; the presence of a possible correlation between the two was also looked at.

**Purpose of Study**

This study addressed two main areas of concern, coming out of research literature. Firstly, the “STEM thinking” (defined and discussed before) and development of Science Process Skills (SPS), which also includes the skill of generating question. The goal of this research study was to evaluate the impact of STEM summer camps on campers, organized by the
Outreach department of a Midwestern public research university, focusing on their progression in SPS and question generation skill, and attempting to seek a correlation between the two. Data was collected using a presurvey and a postsurvey, and from campers’ generated questions as part of their daily reflections. The question generation data was collected by implementing the use of an educational social networking site, Edmodo (Wendt & Rockinson-Szapkiw, 2015; Cankaya et al., 2013). In this dissertation study, these STEM camps implemented Edmodo for the first time, for collecting campers’ reflective entries and social postings. This research allowed to study the potential of the use of ESNS in a nonformal educational setting of camps; more specifically, the ability of campers to generate questions about their camp projects.

The purpose of this research study was two-fold: firstly, to evaluate the change in Science Process Skills (SPS) of campers in accordance with the Science Process Skills Inventory (SPSI) (Arnold & Bourdeau, 2013) because of attending STEM summer camps; secondly, to study the progression of campers’ question generation about their camp projects; as part of daily reflection on the ESNS, Edmodo. The change in SPS was measured in this context from the difference in scores on presurvey and the post survey.

**Research Questions**

The following are the research questions that determined the specific methodologies, data collection and analyses in this research. For each quantitative question, a null and alternative hypothesis is presented.
Research Question 1. Was there a change in science process skills of campers from the beginning to the end of the camp, in accordance with the Science Process Skills Inventory (SPSI)? Was there an effect of gender, grade, ethnicity, and their interactions on the change of science process skills of campers?

Research Question 1. Null Hypothesis. There is no change in science process skills of campers from the beginning to the end of the camp, in accordance with the Science Process Skills Inventory (SPSI)? There was no an effect of gender, grade, ethnicity, and their interactions on the change of science process skills of campers?

Research Question 1. Alternative Hypothesis. There was a change in science process skills of campers from the beginning to the end of the camp, in accordance with the Science Process Skills Inventory (SPSI)? There is an effect of gender, grade, ethnicity, and their interactions on the change of science process skills of campers?

Research Question 2. Is there a progression in campers’ question generation about their camp projects; as part of daily reflection on the ESNS, Edmodo?

Research Question 2. Null Hypothesis. There is no progression in campers’ question generation about their camp projects; as part of daily reflection on the ESNS, Edmodo?

Research Question 2. Alternative Hypothesis. There is progression in campers’ question generation about their camp projects; as part of daily reflection on the ESNS, Edmodo?

Research Question 3. Is the change in campers’ survey scores related to the progression in their level of their generated question?
Research Question 3. Null Hypothesis. The change in campers’ survey scores is not related to the progression in their level of their generated question?

Research Question 3. Alternative Hypothesis. The change in campers’ survey scores is related to the progression in their level of their generated question?

Significance of Study

The research goal was to assess the impact of a Midwestern public research university’s STEM summer camps focusing on the progression in SPS and camper generated questions. This study incorporated an ESNS, an educational social/collaborative platform to collect qualitative data: social postings, reflections, and camper generated questions. However, only the camper generated questions were analyzed for this study. Most Edmodo-based research studies have been in formal/classroom settings, for example, Wendt and Rockinson-Szapkiw (2014, 2015). This study provides a rather unique setting for utilizing Edmodo features.

Theoretical Framework

The overarching theoretical framework of Experiential Learning Model (Kolb, Boyatzis, & Mainemelis, 2001; Kolb & Kolb, 2005) is the grounding assumption for these STEM summer camps for middle and high school students, which were conducted by the Outreach department of a Midwestern public research university. Experiential learning occurs through direct engagement with the subject matter, interaction with others, and detailed observation (Dillivan &
The STEM camps under study, allow campers learn STEM concepts and principles via project-based learning based on guided inquiry, providing hands-on experiences for project-based activities (Nugent, Barker, Grandgenett, & Adamchuk, 2010). According to National Research Council (2007), three factors, including, STEM learning, their self-efficacy, and the value for STEM tasks and activities. Affect youths’ level of engagement in STEM education and careers. Studies on camps report that participation in STEM camps can generate a high degree of student interest and engagement in math and science careers (e.g., Dillivan & Dillivan, 2014; Bialeschki, Fine, & Bennett, 2015; Sawyer, Kant, Benning, Fick, & Burckhard, 2014). All STEM camp activities under analysis in this dissertation study were project-based using guided inquiry. That means the campers were given a project, for example, making a trebuchet with the longest distance and highest accuracy. The campers had to research and learn about the trebuchets, and make a trebuchet using the materials available. The complexity of the trebuchet was decided by the camper. Thus, engagement in these inquiry-based, hands-on camp activities required campers to identify relevant information, individually and collectively troubleshoot, anticipate results, and apply findings. Experiential learning is also known as involved or evidential learning (Hawtrey, 2007), and is a vital component of STEM camps. Experiential learning leads to changing today’s student expectations in the classroom (Hawtrey), because “one size-fits-all” classroom experience does not justify the recent learning theories. Experiential learning is about the learning process that incorporates active, participatory learning opportunities. It is sometimes called situational learning. Ideally, in experiential learning, the learner progresses from being a passive listener to an active respondent. In it most simple form in a classroom, it can involve asking for a show of hands. In more advanced situations, experiential learning allows students to
engage in “data learning,” by being proactive in team work, expressing opinions, and using inductive reasoning (Hawtrey). The STEM camps in general, and specifically the STEM camps in this dissertation study, provide ample opportunities for learners to be responsible for their learning through working in small teams, troubleshooting problems, testing their methods and inferring from the data collected. Team effort is an essential requirement of camp activities. Campers need to collaborate and communicate with team members to work through projects. Experiential learning enhances social and academic development by enabling social interaction and cooperative learning (Junge, Manglallan, & Raskauskas, 2003). According to Hawtrey (2007), experiential learning requires students to make connections between the academic knowledge and their everyday experiences. STEM camps in general, and specifically the STEM camps in this dissertation study, provide ample opportunities for campers to work on activities that put academic knowledge to work. Camps also allow campers to interact with real scientists and professional to see how the content covered in schools is in practical use in real life scenarios (for example, Barab & Hay, 2001; Leblebicioglu, et al., 2011).

**Research Assumptions**

Assumptions in this research study may have come from various sources. For example, from previous arguments or findings those are being adopted into the current conjecture or argument. The assumptions could also come from the selected theory, by assuming theory is true in order to conduct research. The author might have assumed that a variable exists in order to test for the theory.
Definitions

1. **Educational Social Networking Sites (ESNS)**

   SNSs are defined as web sites which provide opportunities for users to increase levels of communication and sharing personal content, the essentials of online communities (Boyd & Ellison, 2007; Buss & Strauss, 2009), showcase their creativity, and get rapid feedback from their friends (Wheeler, Yeomans, & Wheeler, 2008). SNSs are a comfortable way to connect in a disconnected world (Junco & Mastrodicasa, 2007).

2. **Science process skills (SPS)**

   Science process skills (SPS) are defined as tools that acquire information about the world (Osborne & Freyberg, 1985; Ostlund, 1992). Basic science process skills: observing, measuring, inferring, classifying, predicting, and communication; Integrated science process skills: formulating hypotheses, identifying variables, defining variables operationally, designing investigations, experimenting, analyzing data, indicating causes and effect relationship and formulating variables/models.

3. **STEM thinking**

   “Purposely thinking about how STEM concepts, principles, and practices are connected to most of the products and systems we use in our daily lives” (Reeve, 2015, p. 8).
4. Reflection

Reflection is a process of communication for deep learning and occurs in a variety of forms, including self-reflection and collaboration (Henderson, Napan, & Monteiro, 2004). Reflection is a metacognitive activity and that can serve to inform the learner of his/her developments in concept understanding and lead to deeper understanding (Hodson, 1998; Paris & Ayres, 1994). Reflection enable learners to review their learning and practice, leading them to critical thinking (Park & Son, 2011).

Reflective Practice helps learners to develop metacognitive strategies which facilitate the understanding of the learning process and the development of responsible lifelong learners. According to Schön (1987) it involves ‘reflection-in-action’ and ‘reflection-on-action’. It also emphasizes the importance of dialogue, generating collaborative and critical reflection, where both learners and teachers are reflective practitioners, seeing the learning institution as an environment for reflective practice (see Schön, 1983 & 1987; Pereira, 1999).

4. Question Generation

When one encounters something also experienced in the past, one’s memory is awakened since this knowledge is stored away; in other words, curiosity is awakened by the question generated, otherwise, the path ends caused by lack of interest (Shaw, 2006). Questions are asked when individuals are confronted with obstacles to goals, anomalous events, contradictions, discrepancies, salient contrasts, obvious gaps in knowledge, expectation violations, and decisions that require discrimination among equally attractive alternatives. The answers to such questions
are expected to restore equilibrium and homeostasis (Graesser & Olde, 2003). When one encounters the unknown, the thinking process may generate new questions bridging to prior knowledge, thereby arousing curiosity (Loewenstein, 1994).
CHAPTER 2
REVIEW OF THE LITERATURE

Introduction

Neuroscience research indicates to the significance of motivation, interest, and emotion in the learning process itself, concluding that when people are interested and curious about something, there is a high possibility that they take action toward gaining meaningful learning (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003). “Do people learn science in nonschool settings? This is a critical question for policy makers, practitioners, and researchers alike—and the answer is yes.” (Bell et. al, 2009, p.1). One popular form of nonformal science education, is ‘science camps’, programs where students spend a relatively short but intensive period of usually summer time while school is not in session (Fields, 2009). Camps provide the environment which is less structured and confining compared to a classroom enabling participants to take responsibility of their own learning experiences. This is in comparison to formal learning which is delivered in school classrooms, is structured by a fixed curriculum, and is determined to be useful for all students.

In this research, the goal is to study a possible a change in campers’ science process skills after going through a week of STEM summer camp. The presurvey and postsurvey provided the quantitative data for such analysis. The campers used an online medium, Edmodo, for posts and daily reflection. In their daily reflections, campers generated questions about their daily camp activities. Thus, the qualitative data is collected using an ESNS, Edmodo.
Current research in nonformal STEM education, more specifically in summer camps, shows that participation in nonformal STEM learning has an overall positive impact on student interest in the STEM fields (Ahrenkiel & Worm-Leonhard, 2014; Fadigan & Hammrich, 2004; Fields, 2009; Birinci Konur, Seyihoglu, Sezen, & Tekbiyik, 2011). Findings have indicated that after attending the camp there was a significant increase in the participants’ attitude towards the Science and Technology course and in their scientific attitude (Birinci Konur et al., 2011). It was also reported that most students liked camp activities, and the camp had a positive effect on increasing the students’ self-confidence towards learning science. In a similar study, Fields (2009) explored American high school students’ views of the benefits of a summer astronomy camp. His research concludes that camps can successfully be used to encourage interdisciplinary approach to learning and practicing science, as well as practicing general skills of working as a team. Additional studies have also shown that participation in informal STEM experiences not only increase students’ understanding of STEM, most specifically science, but also have a positive impact on motivation and decisions about career pathways (e.g., Fadigan & Hammrich). Understanding how to not only improve students’ skills and knowledge but also spark a continued interest in STEM is important for sustained engagement in the STEM fields. When people are interested and curious about something, there is a high possibility that they will follow up on that feeling with action, resulting in meaningful learning (Dierking et al., 2003).

The literature review focuses on two areas: the construct Science Process Skills (SPS), and the specific skill of question generation as part of daily reflections. Each of these areas are discussed with reference to: 1. Theoretical framework; 2. Importance of STEM thinking; 3. STEM is challenging for students; 4. Importance of Reflection; 5. STEM camps as a new way to
support STEM thinking; 6. Learning Outcomes of STEM camp; and 7. Use of Social Networking Sites in Education.

1. Theoretical Framework

The Experiential Learning Model (Kolb, Boyatzis, & Mainemelis, 2001; Kolb & Kolb, 2005), is the theoretical framework for this study (explained in detailed in chapter 1). One of the research questions is to investigate the growth in campers’ SPS. Knowledge, including STEM knowledge is a “construction by individuals and is relative to the current context (community)” (Cunningham & Duffy, 1996, p. 172). As aforementioned, Experiential learning occurs through direct engagement with the subject matter, interaction with others, and detailed observation (Dillivan & Dillivan, 2014). STEM camps allow campers to have hands-on experience with inquiry based projects, using their prior knowledge, and the newly acquired knowledge. As a learner experiences something new, it is internalized through previously established experience or knowledge (Robinson, Molenda, & Rezabek, 2008). For effective learning to occur, learning needs to take place within a meaningful and authentic situation in which experience and knowledge are shared and adapted collectively (von Glaserfeld, 1984). STEM camps allow campers to work in a nonformal educational environment, with other learners with similar interests, working on hands-on inquiry based projects, in a collaborative manner.

Another research questions investigates the progression in campers’ question generation as part of daily reflection. According to Dennehy, Sims, and Collins (1998) the process of experiential learning is complex as it requires that learners understand how the new knowledge is
related to their existing knowledge. Learning involves the making of meaning rather than a transmission of knowledge. Learners interact with others and with artifacts of their worlds.

Learners in trying to make sense of those interactions, make meaning out of the dissonance between what is known and what is desired to be known. This dissonance guarantees at least some ownership of the knowledge by the learner (Land & Jonassen, 2012). This dissonance is also the basis of PREG question-asking mechanism, used to do questions in this study. According to Otero and Graesser’s (2001), “The essence of PREG's question-asking mechanism is the existence of discrepancies between the representation of text and the reader's domain knowledge about the topics in the text” (p. 143). There are several models in cognitive science that predict that questions are triggered by anomalous information (Graesser, Person, & Huber, 1992; Klahr & Dunbar, 1988; Ram, 1990). According to Gunstone and Champagne (1990), optimal learning results from hands-on activities that require students to generate questions, along with reflecting, that leads to developing new hypotheses, and designing experiments. Reflective observation includes activities such as discussion and reflective questions that require students to reflect on their hands-on experiences. The daily, project-related reflections and question generation by the campers, allowed them to ponder on the progression of their project.

With the growing incorporation of SNSs or ESNSs in formal education, it is important to observe the role educational social networking sites (ESNS) can play in furthering the goals of non-formal education (Brady, Holcomb & Smith, 2010; Cankaya et al., 2013). However, this dissertation study did not include the above mentioned analysis, even though an ESNS (Edmodo) was used throughout the camp by campers to post and communicate with each other, as well as
to generate questions, as part of their daily reflections. As access to and use of the SNSs and ESNSs becomes more widely and representatively distributed worldwide, new opportunities exist for data collection online. There is a research gap because the actualization of the potential of SNSs, especially in a camp setting research has been rather modest thus far. Educators started using SNSs in educational environments (e.g., Kabilan, Ahmad, & Abidin, 2010; Selwyn, 2009; Tonta, 2009). There seems to be much more research about the use of SNSs in formal education, than in non-formal education, at both middle/secondary school (e.g., Howard, Curwen, Howard, & Colon-Muniz, 2015; Wendt & Rockinson-Szapkiw, 2014 and 2015) and undergraduate level (e.g., Celik, Yurt, & Sahin, 2015; Al-Said, 2015; Çankaya et al., 2013). The social networks, focused on teaching and learning, allow students and educators to minimize the privacy and safety concerns (Kevin, Lori and Bethany, 2010). The high positive student perceptions of Edmodo (and mobile learning in general), were due to the convenience of anytime learning, as well as increase in interaction and communication between students and the teacher (Al-Said, 2015); The probable reasons provided for the high positive student perceptions about ESNSs and Mobile learning in general were: the proficiency students had in dealing with mobile phones in their day to day life, having no apprehensions about its use in learning (Al-Said, 2015); students’ comfort level with the devises, provided it is available and implemented on and off the campus (Khwaileh & AlJarrah, 2010); learning made fun by attracting students’ attention, making teachers work easier, and making the lesson effective and organized (Cankaya et al., 2013); the fact that the wireless networks increased access to resources in learning (Jacob & Issac, 2007); the encouragement of both, student engagement and responsible learning (Sanders, 2012). Although, for the purposes of this dissertation study, the ESNS, Edmodo, was used in a non-
classroom setting, a camp, the ability to use Edmodo to not only post campers’ comments and share ideas, but also reflect and generate questions about the projects at hand, allowed for easily collecting the valuable qualitative data to be collected for studying the progression in the generated questions.

2. Importance of being STEM thinkers

Introduction

STEM education refers to teaching and learning in the fields of Science, Technology, Engineering, and Mathematics; including educational activities across all grade levels, in both formal and informal classroom settings (Gonzalez & Kuenzi, 2012). Scientific Inquiry deals with the designing a question to be answered through investigation, while Engineering Design, deals with the formulation of a problem to be solved through constructing and evaluating during the post design stage. STEM education brings designing question and designing problems together through all four disciplines of Science, Technology, Engineering and Mathematics (Kennedy & Odell, 2014).

It is believed that STEM education can contribute essential skills, such as problem-solving skills, critical thinking, and analytical thinking in students (Brophy, Klein, Portsmor, & Rogers, 2008; National Science Board, 2007). According to Merrill (2009) the focus of STEM teaching and learning involves authentic content and problems, using hands-on, technological tools, and procedures to help solve problems. New K-12 Standards, including the Next Generation Science Standards (NGSS, http://www.nextgenscience.org), reflect the importance of
developing students’ inquiry skills to better prepare students to succeed in their careers and in college. Institutes of higher education work to prepare STEM students to enter the fastest growing areas of the workforce. The Programme for International Student Assessment (PISA) associated students’ interest in science to responses that (i) demonstrate curiosity about science (ii) demonstrate willingness to acquire scientific knowledge, as well as skills through a variety of resources, and (iii) demonstrate ongoing interest in science (OECD, 2008).

In the 21st century STEM teaching has gained new importance due to global economic competition. STEM education is now a meta-discipline, removing the traditional barriers between these subjects. Using current tools and technologies, it focuses on innovation and the applied process of designing to solving problems.

**Science process skills required for STEM thinking**

Science process skills (SPS) are defined as tools that acquire information about the world (Osborne & Freyberg, 1985; Ostlund, 1992). SPS are highly important for science literacy (Ferreira, 2004; Harlen, 1999). The American Association for Advancement of Science (AAAS) classifies science process skills into two categories based on operational difficulties and intellectual demands. The basic science process skills: include; observing, measuring, inferring, classifying, predicting, and communication; and the Integrated science process skills, include; formulating hypotheses, identifying variables, defining variables operationally, designing investigations, experimenting, analyzing data, indicating causes and effect relationship and formulating variables/models. For today’s education, one of the important objectives is to enable
learners to adopt the scientific thinking skills and the science process skills. Recently, many countries have put emphasis on the scientific thinking and the science process skills in their curricula (Yumusak, 2016).

Gultepe (2016) reported that science process skills are the tools that students use to investigate the world around them and to construct science concepts, so it is essential that teachers have a good understanding of these skills. The study was descriptive using the survey model to gauge teachers’ thoughts about the importance of science process skills in teaching science. This was done to identify the frequency of these skills and the problems encountered by teachers. The research involved around 30 Turkish teachers, in chemistry, physics, and biology. They used seven questions and concluded that teachers are more successful in identifying skills of observing, predicting, experimenting, and inferring, than other skills. All of the physics teachers and most of the other teachers argued that SPS supported concept learning; however, several teachers thought that these skills hindered concept learning. The activities they performed in classes were intended to enhance concept learning, not particularly the attainment of SPS by students. Other ten teachers claimed that SPS had no effect on or hindered concept learning, as they found SPS a great waste of time in the current education system, arguing that teaching concept knowledge theoretically could be possible and sufficient. Akani (2015) investigated the levels of possession of science process skills by a sample of 200 final-year students of a Nigerian certificate in Education. The instruments for data collection were the Science Process Skills Tests (SPST) and a 28-item Assessment format for science process skills (AFSPS). The participants displayed high level of observation, experimentation and
measurement skills, but low level of communication and inference skills; as well as significant difference in level of possession of the skills based on gender.

While experimentation and observation skills are the fundamental skills, the method of acquisition of scientific skills is a major component of the concept of science (Omiko, 2007). SPS studies showed that inquiry-based learning approach acted as a driving factor for developing SPS (e.g., Parim, 2009) because SPS and inquiry-based learning approach are intertwined in conducting science activities and/or scientific research with each other (Wilke & Straits, 2005). Myers, Washburn and Dyer (2004) reported that science process skills are the basis of science therefore science education. They conducted a study to investigate a base level of information of agricultural teachers’ knowledge and their scientific integrated process skills. They wanted to determine the influence of selected teacher variables on science integrated process skills. Participants were 40 middle school and high school teaching an agriscience course to freshmen students, who participated in one of three, two-day regional workshops. Test of Integrated Process Skills was used to measure the knowledge of basic science concepts. They reported that irrespective of learning style, years of teaching experience, area of teacher certification, or gender, agriculture teachers possessed a solid background knowledge in the integrated process skills considered to be essential to effective science instruction. This conclusion was based on the fact that these teachers responded correctly to 89% of the questions on the test. Thus studies, such as those by Arnold et al. (2013), focused more on this one skill in the SPS. They reported that the SPS of doing science inquiry to be a critical outcome for science learning conducted in positive youth development settings. They reported the development and testing of the SPS Inventory (SPSI), of survey items, and its usefulness for measuring science inquiry skill
development in youth development science programs. The SPSI was used to collect data from 252 youth in 6-8 grades, equal number of female and males from diverse ethnicities. The youth involved in their research participated in one of five science-focused residential camps held in the summers of 2007 through 2011. These youths completed the SPSI presurvey and postsurvey. The results of the psychometric testing of the SPSI were reported and the survey instrument measured a cohesive construct called science process skills; based on the cycle of science inquiry, and represented the important steps of the complete inquiry process. Inquiry involves building skills of learning through experience, and creating an atmosphere of learning that is consistent with the principles of positive youth development steps of the complete inquiry process. A closely interrelation between SPS and science applications plays a cornerstone role in teaching and learning scientific content knowledge (Harlen, 1999; Keil, Haney, & Zoffel, 2009). Yildirim et al. (2016) evaluated Turkish studies on SPS from 2000 to 2015. Their meta-synthesis was based on a matrix (needs, aims, methodologies, data collection tools, general knowledge claims, implications for teaching and learning), to summarize the findings and insights of SPS studies. They reported that inquiry-based learning approach acted as a driving factor in developing SPS. They suggested that curriculum developers should increase the number of science activities in science curriculum, since science curriculum plays an important role in improving students’ SPS. They also recommended more studies geared toward early childhood education, as it dominantly shapes students’ learning habits and attitudes towards science.

Science educators are always looking for effective ways to equip students with SPS (Yildirim et al., 2016). Several early researchers have found that teaching increases levels of skill performance (Thiel & George, 1976; Tomera, 1974). Science teaching should be planned in a
way to include teaching science process skills (Saat 2004; Yakar, 2014). Other studies evaluated the effect of NSF-funded science curricula on how well they taught basic process skills. Studies focusing on the Science Curriculum Improvement Study (SCIS) and Science - A Process Approach (SAPA), indicate that elementary school students, if taught process skills abilities, not only learn to use those processes, but also retain them for future use (Padilla, 1990). Researchers, after comparing SAPA students to those experiencing a more traditional science program, concluded that the success of SAPA lies in the area of improving process oriented skills (Wideen, 1975; Raun & McGlathery, 1970). Yildirim et al. (2016) reported that the expected curriculum outcomes via SPS are several including, facilitation of science learning, engaging students in active participation and analytical thinking, constructing knowledge through problem solving, and enabling students to retain newly gained knowledge/skills. To enable teachers to employ and develop curricula that emphasize process rather than content in problem solving (Shaw, 1983), teachers should also be educated about SPS. Teachers need to attain this knowledge so that they can educate actively participating students who ask questions, identify predictions and priorities, and can find and assess different views (Gultepe, 2016). According to Jeanpierre, Oberhauser, and Freeman (2005) it is important that teachers’ professional development integrates science content knowledge and science process skills. They investigated 20 secondary science teachers in a two, 2-week-long resident institutes, for the outcome of a professional development opportunity. The staff scientists provided instruction in inquiry, which included short inquiry-based research projects. It used a mixed-methodology analysis. To get information on teachers’ use of inquiry-based practices, teachers first completed an initial written survey of their current use of inquiry-based projects and field experiences, in their classroom. An
identical written survey was completed several months after their participation. The other source was field notes of project staff conversations with teachers, followed by evaluation of the completion and quality of the data and team-generated research projects. They concluded that the number of teachers providing opportunities for their students to conduct full inquiry increased significantly after their participation because they were given the opportunity to encounter deep science content and process knowledge with numerous opportunities for practice.

Yakar (2014) investigated the effectiveness of scientific process skills on pre-service science teachers in an elementary Science Teacher education program at a Turkish university, for four years. A descriptive survey (using Test of Integrated Process Skills) approach was used to investigate the effectiveness of science teacher education program on scientific process skills of 186 pre-service science teachers; in total from four different semesters of the program. The study concluded that that there were statistically significant differences found between pre-service teachers in freshmen and sophomore mean scores on all subscales of TIPS II except for in the skill of interpretation of data and graphic. Overall the program affected pre-service „science teachers’ scientific process skills positively in the third and fourth grade, based on the criteria that the preservice teachers could give a description of an investigation or a problem and identify a suitable hypothesis and decide and select a suitable design for an investigation to test it, determine the independent, dependent, and controlled variables in their hypo-thesis and test their hypothesis and obtain their data, identify a graph, and identify the relationships between variables.

Aydogdu (2015) investigated basic process skills, integrated process skills and overall science process skills of 170 Turkish science teachers in terms of some variables. No significant
differences between basic process skill, integrated process skill and overall skill scores of science teachers regarding their interest levels towards learning science process skills was reported. It was concluded that teachers’ interest levels of science teachers towards science process skills was directly related to their mean scores for science process skill.

**Question generation skill required for STEM thinking**

New K-12 Standards (www.nextgenscience.org), including the Science and Engineering Practices suggests students to develop their scientific knowledge by engaging in practices of scientists and engineers, as well as includes asking questions. Efforts are made, (for example NRC Framework, 2012) to enable students to learn to ask fruitful and researchable questions. Today’s growing areas of the workforce necessitate the critical thinking skills and problem-solving skills that are promoted by question-asking (Minigan, 2017). Science education too often emphasizes answers and ignores the importance of questions. Barnard, Gilbert, and McGregor (1993) in their book about asking questions in biology, consider asking the right questions in the right way to be a fundamental skill in scientific enquiry, however, it receives less attention in scientific training.

Although little is still known about the relationship between curiosity question, asking, and inquiry skills (Jirout & Klahr, 2011), observations so far seem to suggest that learning is impossible without curiosity (Kidd & Hayden, 2015). Hill and McGinnis (2007) defined, curiosity as, “a state of arousal involving exploratory behavior, leads to thinking and thinking culminates in learning” (p. 53). Therefore, learning is a result of the questions we are able to
formulate as the senses are influenced by the surrounding. Thus, the learner’s preferences are tools used to gather and assimilate information. Indicators of interest both designate curiosity about science and demonstrate a willingness to acquire additional scientific knowledge and skills (OECD, 2008; Bybee & McCrae, 2011).

Several researchers have suggested that by exploring students’ self-generated questions, one can better understand what they want to know about a given topic and how they think actively about it (Demirdogen & Cakmakci, 2014). Spontaneous questions and ideas constitute a better measure of students’ interests than their responses to adult-written questionnaires (Baram-Tsabari & Yarden, 2005, 2008, 2009; Falchetti et al., 2007; Yardelen-Damar & Eryilmaz, 2010; Cakmakci et al., 2012).

Graesser and Olde (2003) in their article about testing predictions of a cognitive model of asking questions, referenced many studies where researchers in cognitive science and education routinely advocated learning environments that encourage students to generate questions. They studied existing models of questions with 108 college students in an introductory psychology course. Participants read illustrated texts and breakdown scenarios, with instructions to ask questions or think aloud. They concluded with their confirming with the primary prediction of the PREG model of question asking reported in Otero and Graesser (2001). They reported that deep comprehenders of their device asked good questions when confronted with a breakdown scenario; while shallow comprehenders were not as discriminating when asking questions. They qualified good questions as those that tap plausible faults that explain the symptoms of the breakdown. They did not consider mere volume of questions as a significant reflection of deep
comprehension. They concluded that question asking produced content that was more diagnostic of deep comprehension than did the write-aloud task.

Shaw (2006) explained how questions are generated. A change in the learner’s environment brings about a response. This interaction with the environment brings about perception, i.e., a basic thinking process helping to interpret what we sense. Shaw further explains that when one encounters something also experienced in the past, one’s memory is awakened since this knowledge is stored away. In other words, from old knowledge, curiosity is awakened by the question generated, otherwise, the path ends due to lack of interest. Questions are asked when individuals are confronted with obstacles to goals, anomalous events, contradictions, discrepancies, salient contrasts, obvious gaps in knowledge, expectation violations, and decisions that require discrimination among equally attractive alternatives. The answers to such questions are expected to restore equilibrium and homeostasis (Graesser, 2003). When one encounters the unknown, the thinking process may generate new questions bridging to prior knowledge, thereby arousing curiosity (Loewenstein, 1994).

Baram-Tsabari and Yarden (2005) used a naturalistic approach of question generation by students, instead of having them to respond to a series of prepared questions or topics. They analyzed 1676 science and technology questions submitted by Israeli children to a series of television programs, coding those under: coding schemes: field of interest, motivation for asking the question, type of information requested, country-specific aspects, and source of information. They concluded that the popularity of biology, technology, and astrophysics over other sciences, was a shift in interests with age, and gender-related differences within the sample. They also reported that many children are interested in at least some of the human dimensions of science
and technology; there was a relative lack of interest among the Israeli students responding to the television program with questions; and the findings of this study underscore the need for caution in discussing science and technology as a homogeneous field. In their 2008 study, Baram-Tsabari and Yarden investigated the data from free-choice science learning settings to study if girls’ lack of interest in physics in educational settings is also expressed in non-school settings. The data was three sets of self-generated questions raised by children, adolescents and adults in the fields of biology and physics were used. The outcomes of this analysis show that the pattern of girls’ interest in biology and boys’ interest in physics is also observed in free choice science learning settings. They also reported a difference between the genders in the type of information requested and in the motivation for raising the questions. They recommended using topics that appeal to girls’ interest as the context of science learning could prove beneficial in the process of mainstreaming science education. In their 2009 study, Baram-Tsabari and Yarden investigated nearly 6,000 science questions collected from five different web-based, TV-based and school-based sources, and provided six profiles of K-12 students’ interest in science, based on students’ self-generated questions, dependent on age. They reported to have come up with a comprehensive picture of the interrelatedness of characteristics of the data source, the asker and the question. They analyzed the questions under the categories of: their topic, thinking level, motivation for and level of autonomy in raising the question, the object of interest and its magnitude, and psychological distance of the object in question from the asker. Characteristics of the asker, such as gender, grade level, and country of origin were also considered, alongside characteristics of the data source, such as language, setting, and the potential science-attentiveness of the users. They reported observing a developmental shift in interest from non-
classical to classical school science subjects. They observed that with age development, there was an increase in thinking level, a decrease in organization level and the psychological distance of the object in question.

**Why ask questions?**

Asking questions when working in sciences is an important aspect of student learning (Balzer, Evans, & Blosser, 1973). Graesser and Olde (2003) reported several ways in which learning is affected by question generation: it promotes active learning and construction of knowledge; has the potential for enhancing motivation because information acquisition is student centered; encourages the learners to develop sophisticated metacognitive skills; enables learners to identify their own knowledge deficits, ask question that focus on these deficits, and answer the questions by exploring reliable information sources.

Student-generated questions can be used as a starting point for the development of scientific ideas in the classroom (Yarden et al., 2008). When opportunities are given to students, they are more likely to ask questions for information than raise higher order questions. Harper, Etkina, and Lin (2003) reported that students who ask deeper-level questions also displayed better coherence and application exhibiting higher conceptual achievement. They investigated a large introductory physics course, with about 200 students, where structured weekly journals/reports regularly encouraged students to ask questions about the material. The resulting questions were collected for one 10-week one quarter and coded based on difficulty and topic. Students also took several conceptual tests during the quarter. Relationships among different
types of questions and performance on these tests were explored. The researchers coded questions according to their level of difficulty, aligned with taxonomy including Bloom’s. They considered questions of minimal difficulty by students to seek factual knowledge, low-level questions seek better comprehension; medium-level questions for application or analysis; and reports contained more questions than typically observed in a college classroom, but the number of questions asked was not correlated to any measure of conceptual performance. Deeper-level questions that focus on concepts, coherence of knowledge, and limitations were related to the variance in student conceptual achievement.

Scientific curiosity and asking questions helps to drive research and scientific inquiry. Scientists generate, develop and use their questions to navigate new information. Questions serve a purpose from the onset of an investigation when a scientist must identify or define a problem and hypothesize. Thinking in questions helps investigators assess data, dive deeper into their research, and make conclusions based on gathered evidence (Minigan, 2017). Asking effective questions also has been linked to improvement in students’ problem-solving abilities (King, 1991; Dori & Herscovitz, 1999). Marbach-Ad and Sokolove (2000) reported that independent learning is promoted by having students ask questions. In order to classify student's questions, taxonomy was developed. Two comparable populations of about 250 students were examined. First group comprised of undergraduate students in a large, introductory biology class who were taught in traditional lecture format, and the second group was of students in a similar class taught in cooperative/active learning style. They investigated the type of written questions students ask after reading one or more chapters from their textbook, to gauge the ability of students to improve their questions during the course of a single semester. After the taxonomy was
presented to the active learning class, more students were able to pose better, written questions. Their questions became more insightful, thoughtful, and content-related, and were not easily answered by consulting the textbook or another readily available source. The best questions could be recast as scientific research questions. However, when the taxonomy was presented to students in the traditionally taught class, the quality of student-posed questions was largely unchanged.

3. STEM is challenging for students

Limitations for access to STEM education

Today’s education system does not focus enough on teaching children to solve real world problems and is not interdisciplinary, nor collaborative enough in its approach (DeAngelis, 2014). According to the U.D. Department of Education statistics (U.S ED), only 81 percent of Asian-American high school students and 71 percent of white high school students attend high schools where the full range of math and science courses are offered (Algebra I, geometry, Algebra II, calculus, biology, chemistry, and physics). American Indian, Native-Alaskan, black, and Hispanic high school students have even less access. All children must have the opportunity to be college-ready and to thrive in a modern STEM economy. Only 16 percent of American high school seniors are proficient in math and interested in a STEM career. Even among those who do go on to pursue a college major in the STEM fields, only about half choose to work in a STEM related career. The United States is falling behind internationally, ranking 29th in math and 22nd in science among industrialized nations. Only 29 percent of Americans rated this
country’s K-12 education in STEM subjects as above average or the best in the world. According
the U.S. Dept. of Education, “All young people should be prepared to think deeply and to think
well so that they have the chance to become the innovators, educators, researchers, and leaders
who can solve the most pressing challenges facing our nation and our world, both today and
tomorrow. But, right now, not enough of our youth have access to quality STEM learning
opportunities and too few students see these disciplines as springboards for their careers” (U.S
ED).

**Interest in STEM**

Empirical studies show that interest in science generally drops as students progress
through school (Osborne et al. 2003; 2007). The number of students with interest in STEM
remains substantially low (Chen & Soldner, 2013). This is observed despite the fact that there are
better job opportunities in STEM fields with good salaries. The majority of students who enroll
in STEM-related majors do not graduate with a STEM degree. Correll, Seymour, and Hewitt
(1997), based on their three-year study of students (interviews and enrollment patterns), reported
that about 40 percent of those who enroll in engineering change their programs to non-science
and non-technical majors; 50 percent drop out of physical and biological sciences and 60 percent
drop out of mathematics programs.
Challenges faced due to lack of STEM skills and science process skills

Rillero’s editorial (1998) emphasized that individuals who cannot use science process skills will have difficulty succeeding in daily life in a general sense, as the development at science process skills enables students to gain the skills necessary to solve everyday problems (Kazeni, 2005). Kazeni’s (2005) study aimed to develop and provide validity evidence for a test measuring integrated science process skills competence effectively and objectively in the natural sciences further education and training band; not favoring a particular subject discipline, school type, gender, location, or race. She used a quantitative survey type research methodology. The goal was specific, which was to develop a paper and pencil test of integrated science process skills, referenced to a specific set of objectives for each skill. Further, the test items fell within the accepted range of values for reliable tests. Each of the tests has the characteristics of validity, reliability, item discrimination index, index of difficulty, and readability level. Also, the test could not contain technical and unfamiliar terminology. A pilot study was done with 274 subjects, selected from two rural and two urban schools in South Africa. The selected sample of 769 students for the main study consisted of grade 9, 10, and 11 science learners from different school types, gender, race, and location in the respective schools. The instrument used in the study was a test of integrated science process skills, developed by the researcher along with another test of SPS reported in the literature. One of the conclusions was that there was a significant difference between the performance of learners on the developed test and a standard test (TIPS). The performance of learners was higher on the developed test than on the standard
test used (TIPS), in all grades. The researcher thus argued that foreign developed tests may not always be suitable for South African learners.

Lack of science process skills is an obstacle for science literacy since science literacy in turn requires efficient use of science process skills (Ewers, 2001). The study had two primary purposes: first to compare the effectiveness of two teaching methods (teacher-directed instruction, and the learning cycles) for promoting mastery of the science process skills; and second, to examine the effects of the learning cycles experience on science teaching self-efficacy and outcome expectancy. The participants were junior and senior level elementary education majors enrolled in a science methods class at a US university. Two sections of the semester-long course were used as the study cohorts. The treatment in this study was the approach used to teach the science process skills in the laboratory portion of the course. One cohort was taught using a teacher-directed approach. The other cohort was taught using a learning cycles approach. Pretreatment assessments revealed that the cohorts were similar in terms of mean logical thinking abilities, preference toward classroom environment, and beliefs in science teaching self-efficacy and outcome expectations. However, the two groups significantly differed initially with respect to student age and proficiency in science process skills. Post-assessments were reported to have significant gains in science skill proficiency and teacher efficacy within each cohort. An analysis of covariance was carried out on the posttest scores, using the pretests as covariates, showed no significant differences between the cohorts indicating that the teaching methods were equivalent in producing gains in science process skill proficiency.

Padilla, Cronin, and Twiest’s (1985) study was geared toward developing a valid and reliable multiple choice test of six basic science process skills for students in grades 4 to 8. They
surveyed the basic process skills of 700 middle school students with no special process skill training. They found that only 10% of the students scored above 90% correct, even at the eighth-grade level. Seven criteria were outlined for the test: an emphasis on the six most widely used science process skills (observation, inference, prediction, measurement, communication, and classification); a multiple choice, four-option format; an emphasis on use of pictures and drawings to clarify and enhance items; an average test readability below the fourth grade level; test length that permits completion within one 45 minute-class period; a wide range of difficulty of items addressing each process skill; and content-free items. The first version of the 36-item Test of Basic Process Skills in Science was validated and administered to 133 fourth-, sixth-, and eighth-grade students to establish test reliability and to compute item difficulty and discrimination indices to aid in test revision. A second version was then administered to 684 students. Results show this version to be a reliable and content-valid test appropriate for use with students in grades 4 through 8.

The challenges related to SPS are observed not only in students but also teachers. Studies reported that attitudes of teachers towards learning science process skills were not sufficient (Radford et al., 1992; Miles, 2010). Miles (2010) investigated in-service elementary teachers’ familiarity, interest, conceptual knowledge of, and performance on science process skills, as well as how they relate to each other. The participants were 24 in-service elementary teachers in a master of math and science education degree program participated in this study. Participants completed questionnaires on their familiarity and interest in the science process skills, on a science processes conceptual knowledge test, and a performance test on science process skills. It was reported that these teachers were familiar with the science process skills, but moderately
interested in these skills. Although, teachers performed well on science process skills performance test, they were more interested in learning more about integrated process skills than basic process skills. Teachers possessed very low conceptual knowledge of the science process skills. Significant correlations among the four constructs (familiarity, interest, conceptual knowledge and performance) were only significant between familiarity and interest.

Teacher-trainers should emphasize more on skills acquisition (Akani, 2015). Akani (2015) investigated the levels of possession of science process skills by a sample of 200 final year education certificate students. The instruments for data collection were the science process skills Tests (SPST) and a 28-item Assessment format for science process skills (AFSPS). They saw high level possession of observation, experimentation and measurement skills and low level possession of communication and inference skills by the respondents and gender-related significant difference in level of possession of the skills.

Gultepe (2016) reported that all of the physics teachers and most of the other teachers argued that SPS supported concept learning; however, several teachers thought that these skills hindered concept learning. The activities they performed in classes were intended to enhance concept learning, not particularly the attainment of SPS by students. Other ten teachers claimed that SPS had no effect on or hindered concept learning, as they found SPS a great waste of time in the current education system, arguing that teaching concept knowledge theoretically could be possible and sufficient. The reason for this kind of attitude towards SPS, could be that teachers are not adequately informed about what is suggested in teaching programs about the teaching of SPS along with concepts (Aydogdu, 2015).
Challenges faced due to lack of question generation skill

In typical classroom settings, students rarely ask questions and they are often expected to answer questions (Colbert, Olson, & Clough, 2007). “Students at any grade level should be able to ask questions of each other about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations. For engineering they should ask questions to define the problem to be solved and to elicit ideas that lead to the constraints and specifications for its solution” (NRC Framework, 2012, p. 56).

According to De Jesus, Teixeira-Dias, and Watts (2003), when students ask questions, only a small proportion of their questions show evidence of genuine intellectual curiosity. Their investigated the general field of learner-centered teaching and learning, with specific reference to undergraduate chemistry. They analyzed student-generated questions, gathered in four ways, as diagnostic of their willingness to engage in classroom interactions. They examined students' capacity to design and present 'quality questions' during phases of their learning and the extent to which these questions are indicative of particular styles of interaction in the classroom, both with tutors and with other students. They collected data collected through written questions posted into a question box, the 'hits' recorded on a computer software system, and through one-to-one interviews with a sample of 32 students. They reported quality of interactions within fairly formalized systems of teaching and learning of chemistry in a university setting.

Rothstein, Santana, and Minigan (2015) quote a teacher about the challenges of question generation, "...getting students to ask questions feels like pulling teeth" (pp. 70). To assume that learners will be vigorous question generators is idealistic (Graesser & Olde, 2003). A vast
majority of learners has trouble identifying their own knowledge deficits (Baker, 1985; Hacker, Dunlosky, & Graesser, 1998) and ask very few questions (Dillon, 1988; Good, Slavings, Harel, & Emerson, 1987; Graesser & Person, 1994).

According to Graesser and Person (1994), a typical student asks only 0.17 questions per hour in a classroom. Thus, it takes about 6–7 hours for a typical student to ask one question in a classroom. One-on-one tutoring session and informal settings encourage more questions. An average student asks 26.5 questions per hour in one-on-one human tutoring sessions (Graesser & Person, 1994). They investigated the questions asked in tutoring sessions on research methods (college students) and algebra (7th graders). Tutoring protocols were collected from 27 undergraduate students at a US university. Questions were classified by (a) degree of specification, (b) content, and (c) question-generation mechanism to analyze their quality. It was reported that student questions were approximately 240 times as frequent in tutoring settings as classroom settings, whereas tutor questions were only slightly more frequent than teacher questions. Student achievement was positively correlated with the quality of student questions after students had some experience with tutoring, but the frequency of questions was not correlated with achievement. They also reported recommendations for tutors and teachers that might improve their question-asking skills.

Another challenge indicated by Graesser and Person (1994) is that very few of the students’ questions reflect deep comprehension, in a classroom environment. Only about 4% of the questions asked by teachers are deep questions (Dillon, 1988; Kerry, 1987). Rothstein et al. (2015) proposed two changes to potentially enable teachers to create classrooms that come alive with questions. First, teachers need to give students both a structure and the opportunity to
practice generating and working with their own questions. The second change is that teachers shouldn't communicate a judgment too quickly about the quality of the students' initial questions. Rothstein and Santana (2011) proposed the QFT process (question formulation technique) to potentially help people develop their ability to ask their own questions in a variety of fields and communities and with adults across a range of educational levels. The full QFT process includes five general steps: (1) produce their own questions, (2) work with and improve their own questions, (3) prioritize their questions, (4) strategize on next steps and how to use the questions, and (5) reflect on what they have learned by working with their questions.

4. Importance of Reflection

What is Reflection in general?

Reflection can be viewed as a process of communication for deep learning and occurs in a variety of forms, such as self-reflection and collaboration (Henderson, Napan, & Monteiro, 2004). Reflection allows learners to review their learning and practice, leading learners to critical thinking for knowledge production and new solutions to problems (Park & Son, 2011). Reflection brings about “growth of the individual – morally, personally, psychologically, and emotionally, as well as cognitively” (Branch & Paranjape, 2002, p. 1187). Reflection is a metacognitive activity and that can serve to inform the learner of his/her developments in concept understanding and lead to deeper understanding (Hodson, 1998; Paris & Ayres, 1994). Reflective learning improves learners’ critical thinking and understanding of what they have
learned (Park & Kastanis, 2009). Learners get benefits from reflective learning in terms of deep understanding of their strengths and weaknesses and identification of underlying values, possible insufficiencies, and areas for improvement (Henderson et al., 2004). Thus, it is imperative to identify and customize each stage of the reflective learning process according to learning objectives and circumstances. It is also important for instructors and learners to adjust the reflective learning process to cater to their needs. Each stage of the process, in particular, needs to be articulated in terms of learners’ engagement and the process customized to fit into it.

However, reflection is often regarded as an annoying interruption and time consuming by learners (CALT Learning Support, 2007). Learners can become more introspective and anxious about their actions, and their lack of experience can affect the quality of their reflective practice (Ajeneye, 2005). This is the reason why “reflective practice requires continual evaluation of beliefs, assumptions and hypotheses against existing data” (Ajeneye, 2005, p. 573), i.e., there is a need to justify the measurement of the process, and reflective learning design should focus on the process of learners’ engagement with, and participation in, reflective practice. Jackling, Natoli, Siddique, and Sciulli (2015) evaluated the capacity of a blog to facilitate reflection among students as part of collaborative group learning. They investigated insights into student attitudes towards blogs as an interactive and reflective learning tool. The assessment task was designed for use in a second-year corporate accounting unit (in a 24-unit undergraduate degree in accounting), in an Australian university; with both local and international students. They reported that, overall, attitudes towards blogs were mixed; factors affecting this could low commitment given the small percentage of marks allocated to the collaborative activity using the blog as an assessment task. The other conclusion was the differences observed between domestic
and international student attitudes towards reflection; international students consistently viewed the use of e-learning tools more positively than domestic students.

**Reflection in STEM**

Reflection and reflective practice are not only gaining ground in new and improved curricula that focus on STEM integration, they have been considered essential in various professional fields, such as the health professions (Ng, 2012). The relatively new focus on integration of disciplines under STEM and engineering challenges also demand to assess students’ learning i.e., to successfully integrate engineering practices with science and mathematics concepts, it is essential to assess how students think critically, problem solve, and make decisions about their engineering designs (Douglas et al., 2018). Students should be provided opportunities to demonstrate evidence of learning through multiple means, including written reflections. Educators can use reflection as a means to help students connect to their own learning, for example to informed design practices. Douglas et al.’s (2018) study explored how students in grades 5 and 7 reflect on what they had learned about engineering design practices in comparison to their previous understandings. Students were provided notebooks for students to demonstrate evidence of their learning through reflection on their own design practices. Reflections have been used for testing common misconceptions science (biology, chemistry) and mathematics courses through reflection sessions, to specifically address the alternative beliefs (Tawde, 2017). The goal of Tawde et al.’s (2017) study was to foster conceptual understanding of course material rather than rote memorization. The study was conducted through in-person,
student-centered, faculty-guided reflection sessions and online reflective exercises, to discover
the correct concepts. They analyzed each other’s erroneous beliefs, and in the process, they
recognized and corrected errors.

Reflections have been adopted in a Makerspace to improve the confidence and ability of
primary education students in STEM education (Blackley et al., 2017). Makerspace opportunities
have been identified as informal science programs and intentionally different to more traditional
approaches (Krishnamurthi & Rennie, 2013). Makerspace in STEM requires the drawing
together of skills and knowledge from the areas of science, technology, engineering, and
mathematics to create, construct, and critique a product or artifact (Cooper, 2013). The goal of
Blackley et al.’s (2017) study with Makerspace was to frame the project with the goal of
scaffolding the PSTs to develop their personal identity and professional identity as a STEM
educator by collaboration and reflection. It used an activity-based, learning-by-doing approach
that the PSTs reported as an effective way to improve their STEM knowledge and skills. The
preservice teachers also completed a series of reflections to encourage PSTs to consider how the
activities have improved their STEM and pedagogical skills and knowledge, how their prior
beliefs or experiences have been challenged, and how they would modify their actions in the
future.

Reflections were used for group/team development in university level computer
engineering courses, from the perspective of organization behavior theory, specifically
Tuckman’s model of the stages of group development (Kearney et al., 2015). The thought behind
the study was that as much as there is a high demand for technical engineering skills, people
skills such as interpersonal communication, conflict management, and group and team leadership
are also critical for success. The study was conducted through linguistic analysis of student reflection essays, and through focus group interviews to find what ways are group/team development processes and characteristics outlined in the field of organizational behavior identifiable within an academic computer engineering lab. The study reported that evidence existed to support different group development stages as the semester progressed.

Reflections were used to analyze how research-intensive and immersive experiences, such as practicums, internships and field experiences, impact the practice of teaching in the natural sciences (Felege et al., 2018). The data collected was end-of semester reflections from students and their faculty mentor, and was reported to indicate a need to formalize and further develop an understanding of both students' self-identity and the cultural attitudes of the students and the mentor.

**Online Reflections**

One of the important requirements of STEM camps in this research, is for campers to reflect at least once a day, on the online portal, an educational social networking site (SNS or ESNS) Edmodo; both for the purposes of camp evaluations and research. The reflections are geared towards campers’ daily successes, challenges or what they learnt about themselves. This reflective practice included generating questions pertaining to the hands-on projects. Only the generated questions were analyzed for this dissertation study. The reflections were not expected to be comprehensive; to hopefully not deter campers from reflecting due to the length of reflections.
Role of Social Networking Sites (SNS) for Reflection

A SNS is cyberspace where people share information and stories and network each other, and where various human-to-human interactions take place (Boyd & Ellison, 2007). The nature of SNSs is sharing and connecting through interpersonal interactions that support sociability (Ryberg & Larsen, 2008). Thus, creating an SNS is equivalent to signing into the social network with others and consenting to be a participant in the online community (Boyd & Ellison, 2007).

When reflective writing is designed for collaboration on an SNS, it is necessary to integrate the reflective learning process and the writing process into the SNS, taking into account the learner’s background and circumstance (Park & Son, 2011). However, studies have concluded that use of SNSs are not appropriate for reflective learning; deeming SNSs as mere personal log books lacking reflective learning elements such as individual reflection and collaboration (Park & Son, 2011; Park & Kastanis, 2009). Park and Kastanis (2009) identified three major obstacles in adopting SNSs for reflective learning: (1) insufficient time for reflective learning; (2) technical difficulties in using various media formats; and (3) insufficient integration of the reflective learning process and characteristics of SNSs.

Park and Kastanis’s (2009) survey study reported that when students were asked why they were dissatisfied with social network site-based reflective learning, the issues indicated were: technical difficulties, such as uploading and manipulating various media files; not enough time to do other than completing their projects; and no opportunity for them to interact with peers. They also reported that the social network site-based reflective learning journal was not very useful in terms of students’ time management and quality of learning. Only 21 percent of
the respondents thought it was effective. About 63 percent of the respondents focused on their own journal rather than engaging in social interactions with others. 52 percent of respondents answered ‘Average’ to using social network sites for their reflective learning.

Park and Son (2011) reviewed the reflective learning process and the public writing process on SNSs and looked at the similarities and differences between the two processes from pedagogical perspectives. It has proposed the expression process and the connection process on SNSs and explained that the connection process assists each stage of the expression process in an iterative design cycle. When reflective writing is designed for collaboration on an SNS, it is necessary to integrate the reflective learning process and the writing process into the SNS, taking into account the learner’s background and circumstance. Reflection is more than self-critical thinking that can be a form of mutual communication with others (Park & Son, 2011). Herrington and Oliver (2002) point out that “socially-mediated reflection is enhanced considerably by collaboration” (p. 315) and collaboration on task maximizes reflective practice and enhances its process (Herrington & Oliver, 2002). SNSs can be used in teaching and learning environments, particularly for reflective learning, with the view that the characteristics of SNSs support the reflective learning process of individuals and collaboration (Furberg, 2009; Griffith & Liyanage, 2008; Herrington & Oliver, 2002). As pointed out by Hai-Jew (2008), the participatory and reflective learning via SNSs enhances learners’ engagement and helps learners balance between work and study. To integrate the reflective learning process and the writing process into SNSs for social networking, it seems clear that reflective learning has to be embedded into collaborative learning and connection activities on SNSs.
Strauss’ (2008) writing process focused on the individual writer’s perspective. Park and Son (2011) proposed their web-based reflective learning (WBRL). They considered Strauss’ (2008) model to not take into consideration the values of reflective learning in line with communication and interaction that require writers to have a mind of active participation and collaboration. They consider their framework enabled students to view the overall process of WBRL by linking expression and connection to the quality of their reflective learning. Park and Kastanis (2009) reported findings that the key challenge of usage of social network sites for reflective learning should be how to design learning content and activities while retaining all the benefits of social network sites, and, how to strategically and systematically encourage students to actively participate in their learning through interactive social interaction.

Barab and Hay (2001) investigated how middle school science teachers supported both reflection-in-practice (within the activity) and reflection-on-practice (following the activity) during the camp, and how an electronic notebook was also leveraged to support both types of reflection. They reported the experiences of 24 middle school learners in a 2-week long camp with scientists engaged in scientific research. The notebook was an on-line database for the participants to collect their ideas, scientific data, illustrations, digital images, and reflections on their work in the labs, and to pose questions to the scientists using the apprenticeship notebook. They concluded that the use of electronic notebook can make apprenticeships more accessible to classroom learners, promote interaction and dialogue between learners and the scientist. These discussions frequently led to debates among team members, as is the case in the example discussion on phase information above.
Schwartz, Lederman, and Crawford’s (2004) study included the use of reflective journals when investigating the developments in nature of science, NOS, conceptions during a science research internship course for preservice secondary science teachers. The participants were secondary preservice science teachers enrolled in a fifth-year, MAT teacher preparation program in a US university. The course included seminars, along with journal assignments. Interns kept detailed records in journals and responded to sets of focus questions in the reflection section. The purpose of the focus questions was to facilitate the interns’ abilities to make connections between the research experiences and aspects of NOS. Journal questions also served to drive seminar discussions. They identified three factors important for NOS developments during the internship: (1) reflection, (2) context, and (3) perspective. Reflective journal writing and seminars had the greatest impact on NOS views. The science research component provided a context for reflection. The interns’ role perspective appeared to impact their abilities to effectively reflect. Interns who assumed a reflective stance were more successful in deepening their NOS conceptions. Those who maintained a scientist’s identity were less successful in advancing their NOS views through reflection.

Hay and Barab’s (2001) study also included the use of reflective journals, when they investigated the comparison of two summer camps, one traditionally considered as constructivist, and the other consistent with more camper participation. They analyzed the two summer camps in terms of theoretical assumptions, community and groups, participant roles, practices, and other evidence of learning. The constructivist camp was a 1-week summer camp for high school students at a US university campus, where campers worked on academically diverse projects. The other camp had six groups of inner-city, middle school students who selected an
apprenticeship in which they worked with one practicing K–12 science teacher and one mentor scientist. Students were presented with an authentic research problem and had hands-on experience with state-of-the-art instrumentation and equipment. In this apprenticeship camp, in a secondary but related role, campers engaged in active and planned reflection on the experience they had in the laboratories, where they reflected 3 times: prelab, postlab, and creation of final project. The learners uploaded the digital photographs they had taken, entered information (data, graphics, notes, etc.) into the digital logbook, and discussed the experience in a teacher lead groups. From the comparison study they concluded that the differences in the two approaches lie in whether the learning environment has a community-centered focus or a learner-centered one. Also, both environments share authenticity of practices and goals, ownership of the environment by the learners, and a focus on project outcomes rather than tests.

5. STEM camps supporting STEM thinking

Camps teach important skills

Camps can help to connect curriculum-based science concepts and real world scenarios and applications. Camps can introduce and help develop 21st century learning skills (Little, Wimer, & Weiss, 2008; Eguchi, 2016).

Inquiry

Scientific inquiry is the formulation of a question that can be answered through investigation (Kennedy & Odell, 2014). Standards, including the Next Generation Science Standards (NGSS) reflect the importance of developing students’ inquiry skills to better prepare
students to succeed in their careers and in college. Naizer, Bell, West, and Chambers (2003) reported an improved understanding, confidence and attitudes in teachers toward teaching inquiry-based science based on their pre- and post-assessment scores, after attending a 3-week professional development program for preservice and inservice elementary teachers to engage in hands-on, inquiry-based science learning and then apply their learning by working with students in the concurrent science summer camp. The researchers used an adaptation of the Science Teaching Efficacy Belief Instrument (STEBI-B), with open-ended questioning, open-ended student assignments, and the assessment of open-ended assignments, to measure general beliefs and attitudes about science and science teaching. The teachers reported increase in their science content knowledge, confidence in science teaching and in their understanding of inquiry-based science teaching increased. The teachers expressed more intention to teach active, inquiry-based science lessons more frequently in their classrooms.

**Interdisciplinary approach and skills**

Recent emergent disciplines of science require the need for extensive changes than those promoted by traditional reform efforts (Hurd, 2002). “In the interdisciplinary literature that touches on everyday science learning, the disagreement seems to focus on the role of everyday experiences in children’s developing scientific thinking” (Bell et al., 2009, p.106). The most evolved science is interdisciplinary in nature and requires students, as well as science teachers to be able to integrate ideas from several topic areas. Recent calls for reform are pointing to changes in the foci and progression of K-12 science, in a cross-disciplinary manner (Stevens,
Shin, Delgado, Cahill, Yunker, & Krajcik, 2007). American Association for the Advancement of Science’s (AAAS) Benchmarks for Science Literacy, highlights the importance of helping students understand the interconnectedness of knowledge and the impact of recent developments in science on society (AAAS, 1993).

Ahrenkiel and Worm-Leonhard (2014), reported a narrative approach of a one-week interdisciplinary forensic science camp for high school students in Denmark. The goal of the camp was to introduce the participants to the nature of science and what scientists do as the students experience easily understandable real-world scenarios. The camp used forensic science and simulated crimes theme as a common foundation for teaching the theory and practice of concepts in chemistry, physics, and medicine or biology. From the survey and free responses form campers, the researchers concluded that the camp had a positive effect on the participants’ attitudes toward science in general, and that the participants enjoyed working with science in an interdisciplinary context, and that they gained both concrete knowledge of the subjects taught and scientific literacy in general. 54% of the participants agreed while 14% agreed somewhat, that their experiences from the camp were useful in respect to their ordinary education and everyday life.

Fields (2009) concluded that camps can successfully be used to encourage interdisciplinary approach to learning and practicing science, as well as practicing general skills of working as a team. This study explored views of 10 of the 33 high school campers in a summer astronomy camp, about their views of the benefits of a summer astronomy camp. It was reported that the youth were allowed to decide about choosing, researching, and interpreting their projects, which was useful to them to first-hand experience of practicalities and hardships
associated with scientists’ work. The campers talked a lot about friendships with their peers and how this was one of the strengths of the camp. This was reported as an evidence for the idea of ‘affinity spaces’ which gives individuals having a common interest, to work with other individuals of various skill levels, organizing through interaction, developing and sharing of specialized knowledge, and allowing participation of sorts. Thus, science camps not only motivate students to get excited about the theory and practice of science, camps also fulfil the goal of acquiring 21st century learning and work skills.

**Apprenticeship camps allowing interactions between participants and “real” scientist**

Barab and Hay (2001) reported experiences of 24 middle school students in a 2-week long Science Apprenticeship Camp (SAC), which was reported to be different from other traditional camps as the students worked with real scientist in the School of Science at a university, and got experience of some real research. The middle school science teachers supported both reflection-in-practice and reflection-on-practice during the camp using an electronic notebook. The data was reported to be collected through multiple methods, including interviews, field notes, videotape analyses, learner debriefing, and referential materials and was triangulated. The study concluded that although students only worked with scientists for 2 hours a day, students were able to engage in authentic science.

Leblebicioglu, Metin, Yardimci, and Cetin (2011) also reported a study where young campers interacted with scientists both formally and informally with the goal to be introduced to the nature of science and scientists. The researchers wanted to determine the change in twenty-
four 6th and 7th graders’ images of scientists throughout a 10 day science camp at which they interacted with scientists both formally and informally and met with scientists. The team of scientists consisted of elementary science education researchers, as well as scientists, who worked and stayed with the children throughout the science camp. One of sessions of the science camp, had the young campers’ images of scientists interviewed, analyzed and challenged by introducing campers to three non-stereotypical scientists. Draw a Scientist Test (DAST), both as pre-and post-test was used to research the change in the children’s images of scientists; which was reported to indicate a 6% decrease of frequency of old scientists in the post-test. Most of the scientists drawn in the post-test were young (44%) or middle-aged (44%). It was an interesting reporting that the stereotypical images of scientists, working in laboratories were rare, with only 4% in the pre-test and 3% in the post-test. Only 8% in the pre-test and 6% in the post-test were scientists drawn as working in external environments. Fields’ (2009) research explored American high school students’ views of the benefits of a summer astronomy camp, also concludes that the camp supported that idea that constructionist and cognitive apprenticeship learning models work together in a single informal science program. Thus, science camps play a pivotal role, in introducing science to young learners, in a way that not only sparks their interest in learning more about things around them, but can also guides their college and career paths.
Studies have considered how questions asked by students influenced and modified the content and structure of ongoing classroom discourse (Aguiar et al. 2010) and how teachers can encourage students to raise questions (Chin, 2004; Colbert et al., 2007; Rosenshine, Meister, & Chapman, 1996). The results of these studies suggest that classroom interactions initiated by students’ questions of wonderment have potential to stimulate active intellectual engagement in classrooms, which can impact upon the subsequent development of the classroom discourse and foster a ‘culture of inquisitiveness’ in science classrooms (Chin 2004).

Most research studies are about student question generation in formal classroom settings. Colbert et al. (2007) investigated the use of Web-based discussion boards (WebCT course management tool) in a second semester introductory undergraduate biology course, to encourage students to pose questions about course content. The same provided for the instructor to answer the questions outside of class time which were accessible to all students in the course. They reported that approximately 80% of the enrolled students asked at least one question about course content during each of three semesters during which this approach was implemented. About 95% of the students who posted questions reported reading the instructor’s response to their questions. Approximately 75% of the students reported reading questions posted by other students in the class. Approximately 60% of the students reported that the Web-based question asking activity contributed to their learning of biology. Graesser and Olde (2003) studied existing models of questions with 108 college students in an introductory psychology course. Participants read illustrated texts and breakdown scenarios, with instructions to ask questions or think aloud. They conclude with their confirming with the primary prediction of the PREG...
model of question asking (Otero & Graesser, 2001). They reported that deep comprehenders of their device asked good questions when confronted with a breakdown scenario; while shallow comprehenders were not as discriminating when asking questions. They qualified good questions as those that tap plausible faults that explain the symptoms of the breakdown. They did not consider mere volume of questions as a significant reflection of deep comprehension. They concluded that question asking produced content that was more diagnostic of deep comprehension than did the write-aloud task. Rosenshine et al. (1996) reviewed 26 empirical studies that compared question generation conditions with appropriate controls using the impact of question asking on learning in their meta-analysis. In all these studies students were taught to generate questions during or after reading or listening to passage. Their purpose was to evaluate the effectiveness of this cognitive strategy, and to use this research to learn how to teach cognitive strategy. The outcome measures in these studies included standardized tests, short answer or multiple-choice questions prepared by experimenters, and summaries of the texts. They pointed out several instructional elements, or scaffolds to support student learning, including procedural prompts or facilitators, such as providing a simplified version of the task, providing modeling and thinking aloud, anticipating student difficulties, regulating the difficulty of the material, providing cue cards, and using a checklist.

Now looking at question generation in informal and nonformal environment, a student asking a question is directly related to the degree to which they feel secure (Watts et al., 1997) and the classroom atmosphere does not necessarily provide an environment where students can ask about whatever they wish to learn (De Jesus, Teixeira-Dias, & Watts, 2003). Only about 4% of the questions asked by teachers are deep questions (Dillon, 1988; Kerry, 1987). It is difficult
to gather students’ questions that provide evidence of genuine intellectual curiosity in a classroom environment because students may ask rhetorical questions, suggestive questions, or questions intended primarily to please their teachers (Dillon, 1988; De Jesus et al., 2003).

According to Graesser and Person (1994), a typical student asks 0.17 questions per hour in a classroom, thus, it takes about 6–7 hours for a typical student to ask one question in a classroom; due to large class sizes. Also, very few of the students’ questions reflect deep comprehension, in a classroom environment. Self-generated questions asked in an informal and a formal setting have different patterns (Cakmakci et al., 2011). A free-choice science-learning environments (e.g., web-based) might help boost student confidence (Wallace, Kupperman, Krajcik, & Soloway, 2000), yielding a more accurate picture of students’ needs and interest since students are self-directed and self-motivated (Falk & Dierking, 2002) in these settings. Teachers might benefit from the electronic archive of informal learning environments and identify what students want to know more about. Damirdogen and Cakmakci’s (2014) recommendation to Popular science magazines, educational TV and radio programs, and web-based science learning environments was that they may contribute to research on science learning by designing their ‘‘Ask-A-Scientist’’ sections. They may encourage the questioner to provide all demographic details (e.g., gender, age, and school) and information about why they need to know about the topic of interest. Raising a question in an informal setting is a self-regulated act that is mainly intrinsically motivated—doing something because it is inherently interesting or enjoyable (Mitchell, 1993; Ryan & Deci, 2000). Since students’ spontaneous questions are self-regulated acts, these self-generated questions could be a better measure of their interest in science (Falchetti et al., 2007; Chin & Osborne, 2008; Baram-Tsabari & Yarden, 2009).
Although more research about question generation is in a classroom or formal settings, there are studies about the same in nonformal settings including camps. For example, Barab and Hay (2001) reported a study where campers posed questions to scientists. They reported the experiences of 24 middle school learners in a 2-week long camp with "real" scientists engaged in "real" research. They described how middle school science teachers supported both reflection-in-practice (within the activity) and reflection-on-practice (following the activity) during the camp, and how an electronic notebook was also leveraged to support both types of reflection. Using the electronic notebook, participants entered data (including pictures and field notes), posed questions to scientists using a chat interface, searched online for relevant data, read scientists' notes, and worked on their final presentations.

In a more informal, non-camp setting, Cakmakci et al. (2011) investigated Turkish primary school students’ interest in science by using their self-generated questions. Two different sets of data were collected from primary school students: self-generated questions asked in an informal setting and a formal setting. 826 questions were submitted to a popular science magazine called Science and Children (informal). While 739 students in classrooms (formal) were asked to write a question that they wanted to learn from a scientist and as a result 878 questions were gathered, from 13 different schools at 9 cities in Turkey. Various gender-related and age-related patterns and the pattern of self-generated questions asked in an informal and a formal setting are also searched among the field of interest and the level of the question. They reported that self-generated questions asked in informal and formal settings have different patterns. Most of the questions were about properties and that was followed by the questions requesting comparisons or causal relationships between variables. Students tended to ask for
higher order information as they got older—more causal relationship questions were asked by older students. The results also indicated that older students tended to ask more prediction, methodological and factual types of questions, whereas younger students tended to ask general requests and explanatory types of questions. In another informal setting, Demirdogen and Cakmakci (2014) investigated Turkish students’ (age 15 or older) interest in chemistry by analyzing 1027 of their self-generated chemistry-related questions, which had been submitted to a popular science magazine. These questions were classified based on the field of interest, the cognitive level of the question, and the stimulating impetus for asking the question. The researchers noted that males asked overwhelmingly more questions than females in an informal setting. While Cakmakci et al. (2011) observed that more girls asked science related questions in an informal learning setting than in a formal setting.

6. Learning outcomes of STEM camps

Most camps are driven by the wish to activate and engage students in learning. The goal is to convince learners through fascinating experiments, laboratory work and the contact with experts to an education within science, technology and health (Lindner & Kubat, 2014). According to Henderson (2018) camp research is almost a century old. Around the 21st century, camp research in general, while specifically toward youth development outcomes and for improvement of camp practice, have resurged. The literature reports indicators of gain from attending STEM camps and how these learning outcomes are measured. The learning outcomes or learning gains are measured via research instruments or tools, including pretest/posttest,
A commonly reported measurable learning outcome of STEM camps is increased interests in STEM disciplines and careers. Motivation for learning STEM in adolescents happens through programs that allow hands-on learning and peer mentoring (Farber & Bishop, 2018). The learning outcome of igniting the spark for STEM careers in girls including interest and confidence in STEM fields, decision to pursue STEM curricula, and future career plans, measured via postcamp surveys, was also reported (AAUW, 2014). Students with reportedly no interest in STEM prior to attending a STEM camp were shown to have positively benefited from the STEM mentoring opportunity (Reid-Griffin, 2019). Reid-Griffin (2019) collected data through a self-efficacy scale and career inventory of perceptions, learning and academic interests, as well through mentor/mentees interviews. There are studies that have attempted to correlated participation in STEM camps to campers’ performance on standardized testing, such as the SAT test (e.g., Boedeker, et al., 2015).

Similar outcomes of igniting the spark for interest in engineering careers, and content knowledge in select science and mathematics content areas, in middle school students was also reported. It was measured through pre-post survey to gauge campers’ self-reported engineering-related self-efficacy, knowledge of engineering careers, and motivation to pursue future engineering classes and careers (Martinez Ortiz et al., 2018). Impact studies show increased motivation and confidence in science, as well as gaining of knowledge among high school students (Marle, et al., 2014), increase in mathematical and scientific vocabulary knowledge (Bicer, Boedeker, Capraro & Capraro, 2015), and enhanced creativity, communication and collaborative skills (Ravitz, et al., 2012).
Other commonly measured outcomes are self-regulation and self-efficacy; which are reported to lead to measurable outcomes of higher retention, progression and graduation rates using pre-post surveys and other qualitative measures (Wheeler & Wischusen, 2014). Camp participants exhibited higher self-efficacy, self-regulation, and final grades than their non-camper peers. Camps, in general, have campers working on hand-on inquiry projects, as practiced in project-based learning (PBL). In PBL students gain knowledge and skills by investigating an engaging and complex question, problem, or challenge (BIE, 2012). PBL can also increase students’ interest, self-confidence and self-efficacy in STEM (Baran & Maskan, 2010), as well as positive attitudes toward learning, team communication and collaborative behavior (e.g., Dominguez & Jaime, 2010); increased problem-solving during project frameworks, (Barron, et al., 1998; Boaler, 1998).

7. Use of Social Networking Sites in Education

SNSs are defined as web sites which provide opportunities for users to increase levels of communication and sharing personal content, the essentials of online communities (Boyd & Ellison, 2008 Buss & Strauss, 2009), showcase their creativity, and get rapid feedback from their friends (Wheeler, Yeomans, & Wheeler, 2008). According to Junco and Mastrodicasa (2007), SNSs are a comfortable way to connect in a disconnected world.

SNSs have been referred to as ESNSs, educational social networking sites (Cankaya et al., 2013). For example, Edmodo, Ning, Elgg, are innovative educational environments with social networking capabilities. Thus, just like formal and informal education, social network sites
can also be categorized into formal and informal category. Formal SNSs, are mostly used in educational activities, and Informal SNSs be used for both educational and social activities (Sohaei & Iahad, 2014). Apparently, there are many more studies on SNSs in formal education (than regarding informal education), at both middle/secondary school (e.g., Wendt & Rockinson-Szapkiw, 2014 & 2015) and undergraduate level (e.g., Al-Said, 2015; Çankaya et al., 2013). The appearance of social networks focused on teaching and learning allow students and educators to minimize the privacy and safety concerns (Kevin, Lori, & Bethany, 2010).

The main reason given for the current trend of SNSs in formal education is the omnipresence of technology (Prensky, 2001) and the way digital natives are raised with technology in toys and exposure of television, computers, iPads and iPhones. The technology has allowed for constant communication from behind screens and the expectation of instant access to information (Olson, 2014). The importance of SNSs, such as Facebook, Twitter, etc., is immense in the everyday life of digital natives (e.g., Özmen & Atıcı, 2014). The ability to access information through the digital world is unparalleled to any other time in history (Olson, 2014). At the same time with the political and administrative push, and due to the theoretical reflections and empirical studies (e.g. Pilkington & Kuminek, 2004; Pilkington & Walker, 2003; Bell et al., 2010; Park & Son, 2011) for technology in classes, teachers who work in a challenging, ever-changing environment, have been devising ways to engage the digital native student body in curriculum. Studies reporting research and new theories conclude that the way individuals learn has shifted over time, giving way to multiple-intelligences, project based learning, learner-centered environment, etc. (Balasubramaniam et al., 2014).
Another reason reported for the popularity of SNSs has been the lack of social element in the learning management systems (LMS). They tend to be overly structured (Brady, Holcomb, & Smith, 2010), making some students reluctant to use these platforms (more recently reported by, e.g., Aghili et al., 2014; Divall & Kirwin, 2012). They provide less student communication, satisfaction and motivation when compared to the face-to-face classroom environment from the perspective of students (more recently reported by, e.g., Aghili et al., 2014; Thoms & Eryilmaz, 2014). LMSs also tend to be instructor centric and instructors primarily use these platforms for information sharing (Mott, 2010). SNS are more popular because of factors, such as encouragement of communication (Rozac et al., 2012), student engagement (Aghili et al., 2014), motivation, personal interaction and collaboration (Veletsianos, Kimmons, & French, 2013; Veletsianos & Navarrete, 2012). With the growing incorporation of SNSs or ESNSs in formal education, it would be interesting to see the role ESNSs can play in furthering the goals of non-formal education. The themes of this review include students’ positive perception of use of ESNSs, and the issues with the use of Edmodo for educational purposes.

Research Gap

There are many camp studies that have measured for campers’ improvement in various aspects (detailed in the literature review section). For example, increase in understanding, confidence and attitude in teachers toward teaching inquiry-based science (Naizer et al., 2003); change in attitudes toward science (Ahrenkiel & Worm-Leonhard, 2014); and change in attitude toward interdisciplinary approach for learning and doing science (Fields, 2009). Also there are
studies on in-classroom reflections (Blackley et al., 2017; Douglas et al., 2018; Kearney et al., 2015; Tawde, 2017; and many more) and question generation by students, however, fewer studies have used an educational social networking sites, ESNS, for question generation as part of reflections in informal and nonformal settings, specifically in STEM summer camps.

The goal of this study was not to analyze for the effectiveness of the use of ESNS, Edmodo, in this unique camp setting. Edmodo was incorporated as part of camp activities, as it made it easy for uploading and manipulating various media files, as well as interacting with their peers, for example, by being able to text, and upload their project progress details. However, the effectiveness of the use of ESN in this unique camp setting was not analyzed. Campers were provided a dedicated hour for reflections. These steps were taken to eliminate the three major obstacles in adopting SNSs for reflective learning were identified as: (1) insufficient time for reflective learning; (2) technical difficulties in using various media formats; and (3) insufficient integration of the reflective learning process and characteristics of SNSs (Park & Kastanis, 2009).

This study not only attempts to assess increases in campers’ SPS, but also assesses the relationship between increases in SPS and the increase in level of question generated by the campers as part of daily reflections using Edmodo, in a very specific setting of several one-week long camps of various STEM themes, on a university campus, for middle and high school-students.
CHAPTER 3

METHODOLOGY

The following are the research questions that determined the specific methodologies, data collection and analyses in this research. For each quantitative question, a null and alternative hypothesis is presented.

Research Question 1. Was there a change in science process skills of campers from the beginning to the end of the camp, in accordance with the Science Process Skills Inventory (SPSI)? Was there an effect of gender, grade, ethnicity, and their interactions on the change of science process skills of campers?

Research Question 1. Null Hypothesis. There is no change in science process skills of campers from the beginning to the end of the camp, in accordance with the Science Process Skills Inventory (SPSI)? There was no an effect of gender, grade, ethnicity, and their interactions on the change of science process skills of campers.

Research Question 1. Alternative Hypothesis. There was a change in science process skills of campers from the beginning to the end of the camp, in accordance with the Science Process Skills Inventory (SPSI)? There is an effect of gender, grade, ethnicity, and their interactions on the change of science process skills of campers.

Research Question 2. Is there a progression in campers’ question generation about their camp projects; as part of daily reflection on the ESNS, Edmodo?
Research Question 2. Null Hypothesis. There is no progression in campers’ question generation about their camp projects; as part of daily reflection on the ESNS, Edmodo.

Research Question 2. Alternative Hypothesis. There is progression in campers’ question generation about their camp projects; as part of daily reflection on the ESNS, Edmodo.

Research Question 3. Is the change in campers’ survey scores related to the progression in their level of their generated question?

Research Question 3. Null Hypothesis. The change in campers’ survey scores is not related to the progression in their level of their generated question.

Research Question 3. Alternative Hypothesis. The change in campers’ survey scores is related to the progression in their level of their generated question.

The research questions detail an effort to look for possible increase in science process skills (SPS) after a one-week camp, as well as for the progression in the level of camper generated questions. This chapter describes the research methodology and instruments for data collection, analysis procedures,, internal and external validity, and reliability. Although both quantitative (survey data) and qualitative data (camper generated questions as part of daily reflection) were collected, all data were analyzed quantitatively.
Data collection methodology

Study Context

The population from which the sample for this study was drawn was middle and high school students attending a Midwestern public research university’s STEM (Science, Technology, Engineering and Mathematics) summer camps. These were camps of various STEM themes, all one-week long, with campers staying on university campus.

For the past several years, the university’s STEM Outreach department has offered STEM summer camps, of several STEM themes, for students in middle and high school. Through engaging in hands-on project-based activities, and interdisciplinary learning experiences, campers explore STEM concepts, develop skills, and learn about possible STEM career. As afore mentioned these STEM camps allow campers to engage in project-based learning through guided inquiry; with the requirement of team work and communication with team members. An example of such a project-based camp activities, with guided inquiry, included creating a batter capable of powering a car. The expectations were that the campers would investigate the concepts related to batteries, create a battery, and test the same. Another activity, called games and puzzles, required campers to learn to build an escape room using math problems (a puzzle). The camp counselors provided examples where needed, however, it was the responsibility of campers to investigate throughout the project to create a final product and then test the product.
Selection of Participants

More than 400 campers attended the camps and were invited to participate in this research. Of those who agreed to participate, 362 campers submitted both the presurvey and the postsurvey. The sample \( (N = 362) \) for this study was nonprobabilistic, convenience sample. The camp enrollment is open to local and international students. The university Outreach department’s website allows parents to register their students by a certain date. When the camps are full, registration is closed. The participants were middle and high school students, attending the university’s STEM summer camps of various STEM themes. Most campers attend one camp but a few may enroll in more than one camp. A few campers were returning campers, who have attended repeatedly within the past 3-5 years. The consent process for participation in this project was composed of two parts: consent by the parent/guardian and consent by the camper.

Participants

Each camp had either middle or high school campers. The middle school campers, between the ages of 11-14 years, were enrolled in sixth- eighth grade. The high school campers, between the ages of 14-18 years, were enrolled in ninth - twelfth grade. The campers had diverse demographic features and other individual features such as gender, residence (also have international campers), exposure to STEM camps/activities, type of schooling, and ethnicity. These features contributed to establishing notions of external validity.
Research Question 1 regarding presurvey and postsurvey

Conduct of Study/Data Collection

Quantitative data came from the presurvey and postsurvey scores. There was only one construct, the Science Process Skill (SPS), where change was computed as the difference between the presurvey and the postsurvey scores. Each camp was one week in duration; therefore, students were involved in the study for the week that they attend their camps. At camp orientation, each camper was asked to complete a paper-pencil presurvey. The survey was a 10 item Likert scale, the Science Process Skills Inventory (SPSI; Arnold, Bourdeau, & Nott, 2013). On the last day of each camp, each camper was asked to complete the same survey as the postsurvey.

Instrument: SPSI

The basic and integrated SPS skills (AAAS) are the items of SPSI, the survey tool used as the presurvey and postsurvey in this dissertation study. Studies have reported using the SPSI survey (Arnold et al., 2013; Soomro, Qaisrani, & Uqaili, 2011) or similar surveys (e.g., Okey and Dillashaw’s (1980) Test of Integrated Process Skills (TIPS); Myers et al., 2004). “[SPSI] may provide a clear profile of student development of inquiry skills because it assessed a variety of specific scientific inquiry practices of students in the classroom” (Danipog, 2018, p. 102). Its items represent the important steps of a complete inquiry process (Arnold et al., 2013). Because
SPSI focuses on assessing the process of science, and not the students’ learning of science content, this study adds to literature, as a focus study of campers’ (attending a short duration STEM camp) perception of their SPS, and not their science content improvement after attending the camp. Despite its strength as a survey instrument, studies such as those by Danipog (2018) criticize SPSI, that “[SPSI] could not offer ways to assess students’ learning of science content because its main focus is on the process of science only” (p. 102). Danipog reported that not many studies could be found using SPSI as a survey tool, and specifically as a comparative survey tool, as a presurvey and post survey. Several other similar survey tools for SPS are available (Donipog, 2018), but most were not used as a comparative tool (comparing presurvey and postsurvey), unlike this dissertation study.

**Study Constructs/Measures**

This study was an attempt to assess the change in Science Process Skills (SPS) in a STEM camp setting. The American Association for Advancement of Science (AAAS) provides the comprehensive list of SPS, classified into two categories based on operational difficulties and intellectual demands. These categories with their component skills are: the basic science process skills: include; observing, measuring, inferring, classifying, predicting, and communication; and the Integrated science process skills, include; formulating hypotheses, identifying variables, defining variables operationally, designing investigations, experimenting, analyzing data, indicating causes and effect relationship and formulating variables/models. The gradual approach of SPS refers to the skills that may depend on grade (Akgün et al., 2014). Younger, elementary
school students can be thought of as achieving basic process skills; whereas middle and/or upper secondary school students can be thought of as achieving integrated process skills. Since this dissertation study involved middle and high school students, both basic and integrated SPS can be intended to be attained.

In this study, an increase in science process skills is identified as change in scores from presurvey to postsurvey using the Science Process Skills Inventory (SPSI; Arnold et al., 2013).

The SPSI survey was used with the intent of measuring overall ability of students to understand and use the range of skills related to the cycle of science inquiry. These skills include forming scientific questions, designing scientific procedures, collecting and recording data, analyzing results, using models to describe results and creating scientific presentations (Arnold & Bourdeau, 2013). The SPSI consists of ten items, each associated with five Likert response options from 1 = *strongly disagree* to 5 = *strongly agree*. Total scores for each camper were computed as the sum of the item scores. Arnold and Bourdeau (2013) reported the Principal Components Analysis (PCA) to assess the structure of SPSI scales and to determine if the set of items were measuring a single construct made up of science process skills. For this dissertation study, Cronbach’s alpha coefficient for presurvey and postsurvey scales was 0.86 (presurvey) and 0.89 (postsurvey), suggesting good internal consistency reliability. The results of the psychometric testing of the SPSI indicated the instrument is reliable and measures a cohesive construct called science process skills, as reflected in the items that make up this group of skills.

The SPSI items were:

1. I can Use scientific knowledge to form a question.
2. I can Ask a question that can be answered by collecting data.
3. I can Design a scientific procedure to answer a question.

4. I can Communicate a scientific procedure to others.

5. I can Record data accurately.

6. I can Create a visual presentation to communicate my data using digital media.

7. I can Analyze the results of a scientific investigation.

8. I can Use science terms to share my results.

9. I can Use models to explain my results.

10. I can Use the results of my investigation to answer the questions I asked.

**Data Analysis**

The analysis of the quantitative data gathered aimed to identify statistically significant differences in the change in science process skills during the one-week camp period. A Mixed Design ANOVA was used to compare the construct, science process skills, from each camper’s presurvey and postsurvey scores. This analysis also investigated the effects of gender, grade level, and ethnicity. SPSS Statistical Software Version 16 was used for statistical analysis. To facilitate analysis, grade levels were aggregated into two groups (middle school and high school), and ethnicity was recoded into two groups (White vs. non-White). Science process skills (SPS) were assessed at two different times: before the start of camps on the orientation day, and on the last day of camp. Eta squared ($\eta^2$) was computed as a measure of effect size. Other statistical tests included the $t$-tests (paired and independent) and Cohen’s $d$ was computed as a measure of effect size.
### Table 1
Summary of procedure.

<table>
<thead>
<tr>
<th>Data Collected</th>
<th>When</th>
<th>How</th>
<th>Guidelines provided</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presurvey</td>
<td>First day of camp</td>
<td>Paper/pencil presurvey were collected from each camper, during the introductory session.</td>
<td></td>
<td>ANOVA</td>
</tr>
<tr>
<td>Postsurvey</td>
<td>Last day of camp</td>
<td>Paper/pencil presurvey were collected from each camper, during the last camp session.</td>
<td></td>
<td>ANOVA</td>
</tr>
<tr>
<td>Daily generated questions as part of daily reflections</td>
<td>From first to last day of camp</td>
<td>On the ESN, Edmodo. Each camper created an account on Edmodo and posted camper-generated questions every day. A camper’s generated questions were not visible on Edmodo to other campers.</td>
<td>The prompt provided for daily questions generation, as part of daily reflection was: “Based on the concepts you learned today and the work you did, if given the opportunity, what other 1-2 project-related questions would you like want to pursue?”</td>
<td>Manually coded generated question using PREG Model categories. Generalized Linear Multilevel Model</td>
</tr>
</tbody>
</table>

### Research Question 2 regarding camper generated questions

**Conduct of Study/Data Collection**

At the camp orientation, each camper was provided written instructions to create an individual Edmodo account. The camp counselors led this process and described the features of
Edmodo that were to be used for camps, mainly the “Posting” feature, for anytime postings and comments, the “Assignment” feature for daily camper generated questions, as part of daily reflections. Camper postings were not part of the analysis for this research study. Campers were encouraged to use Edmodo as a social platform, at their discretion, at any time during the day. The postings and comments in Edmodo were visible to other participants in the group, however the questions generated, as part of daily reflections completed under “Assignment” were only be accessible to the researcher. The campers generated questions, as part of the daily reflections, at any time each day of the camp, as well as during the dedicated time provided for doing the same. The prompt provided for daily questions generation, as part of daily reflection was: “Based on the concepts you learned today and the work you did, if given the opportunity, what other 1-2 project-related questions would you like want to pursue?”

**Instrument: PREG model**

In the PREG Model, “PREG” is part of the Spanish word “pergunta,” meaning question. Otero and Graesser (2001) define the model as:

[PREG is] a conceptual model of human question asking. The model contains a set of production rules that specify the conditions under which children and adults ask questions when they read expository texts. The essence of PREG's question-asking mechanism is the existence of discrepancies between the representation of text information and the reader's world knowledge, with a mediating role of pragmatics and metacognition. Both the explicit text and the world knowledge are represented in the form of a conceptual graph structure. Comparisons between text representations and readers' knowledge are carried out by examining the 3 components of conceptual graph structures: words, statements, and links between statements. (p. 143)
Otero and Graesser (2001) considered PREG to be a comprehensive analytical model of question asking that incorporated the mechanisms that have been identified in education, psychology, discourse processing, and artificial intelligence reported. The PREG model adopts a theory of knowledge representation and a production rule formalism. It was reported that the model not only accounted for nearly all of the questions produced by the students, it could also identify the conditions in which particular classes of questions are either generated or not. They reported introducing a new methodology for empirically testing a complex analytical model of question asking after having applied to the questions collected by Costa (1997). The questions in this corpus included all questions that were generated by two or more students in either 8th grade or 12th grade. The model was able to account for 95% of the 20 observed frequent questions. For their second analysis the PREG model could account for 21 out of the 23 frequent questions about this text, which constitutes a hit rate of .91.

Based on previous research, Otero and Graesser (2001) admitted that additional variables, such as reader goals and idiosyncratic dimensions of context, may have also influenced question asking. In the 2001 paper they reported the extent to which these models mirror human cognition. According to the authors, “The primary goal of the research reported here is to reduce the large gap that exists between the precise computational models in artificial intelligence and the empirical research in education and psychology.”

For the purposes of this study, the PREG model was considered appropriate for use in coding students’ generated questions. The model was reported as valid and reliable. It has been used in several other studies pertaining to predictions of question generation (e.g., Otero & Graesser, 2001; Graesser & Olde, 2003). PREG and its derivative models have been reported to
be used for predicting question arising on the basis of cognitive disequilibrium, which drives the asking of sincere information-seeking questions; and not the questions, which are generated just as part of conversation among speech participants. For this study the model has been extended further than how the model has been utilized in other studies; even extended further than other models based on PREG model, such as the Graesser-McMahan model (Graesser & McMahan, 1993). The model was not used for predicting questions by learners, involved in relatively ill-structured problem solving. For the purposes of this study, the model was used to code/rank campers’ questions generated throughout the camp duration; while those campers were working relatively well-structured project-based activities. This model has been extended in this study to code students’ generated questions in a unique setting of a Midwestern state university’s STEM one week summer camps for middle and high school students. Also, it is beyond the scope of this dissertation to provide a complete evaluation of PREG. Instead, the higher level categories (and not the subcategories) of this model have been used for the qualitative coding of the questions generated by each camper, i.e., Word- Level, Statement-level and Link-level. The goal was to see the progression in the level of question asking over the duration of the camp. According to Graesser and Olde (2003), learners ask questions when confronted with obstacles to goals, anomalous events, contradictions, discrepancies. The equilibrium is restored by finding the answers to those questions. Graesser and Olde’s research participants had to read illustrated texts and breakdown scenarios, with instructions to ask questions or think aloud. The participants were then subjected to a device-comprehension test, and tests of cognitive ability and personality, to gauge for deep comprehension through the quality of questions. For this dissertation study, campers’ development of deeper comprehension, possibly because of immersion in hands-on
STEM activities over the one-week camp duration, was to be gauged through their possible progression from word, to statement, to link level of questioning.

Before deciding upon the PREG Model for coding of campers’ generated questions, a few other rubrics/coding systems were examined. Most rubrics/coding systems had categories that were too broad for the analysis of camper generated questions. Others were closer to the preferred coding scheme. For example, Baram and Yarden (2005) reported the results of an analysis of close to two thousand science and technology questions submitted by children to a series of television programs. The analysis of questions led to generation of five coding schemes to provide a variety of perspectives regarding the children’s interests in science and technology: factual, explanatory, methodological, evidential, open-ended, application. Each coding scheme was subdivided as necessary. Although, these categories appeared appropriate, there was much overlap, making it challenging for coding questions and assessing progression. Another coding system that was considered was from Baram-Tsabari and Yarden (2009), who used a modified typology, based on those by Dillon (1984) and Brill and Yarden (2003), to classify questions according to a gradual increase in the cognitive level required to answer them. The categories were (1) “properties”—answers to questions in this category describe the properties of the subject in question; (2) “comparisons”—answering questions in this category requires a comparison between the subjects outlined in the question; and (3) “causal relationships”—answering questions in this category requires finding the relation, correlation, conditionality, or causality of the subjects in question.
Analysis of generated questions using PREG model

The qualitative part of the study was based on the analysis of campers’ question generation level progression over the course of the 1 week camps. The social networking site or the educational portal Edmodo was used by campers to upload social postings, as well as their generated questions as part of their daily reflection. However, do the purposes of this dissertation, only the generated questions were analyzed using the PREG Model. At the camp orientation, each camper was provided with written instructions to create individual Edmodo account. The campers were given codes to join their camp group on Edmodo. The camp counselors lead through this process and described the features of Edmodo that were used for camps, mainly “Posting” for anytime postings and “Assignment” for daily reflections, including camper generated questions. Campers were encouraged to use Edmodo as a social platform, at their discretion, any time during the day. The postings and comments in Edmodo were visible to other participants in the group, however the reflections completed under Assignment were only accessible to the researcher. The reflections were completed at participants’ discretion at any time each day of the camp. The reflection question that was analyzed for this dissertation was about question generated by each camper on each day of the camp based on the work that they did that day: “Based on the concepts you learned today and the work you did, if given the opportunity, what other 1-2 project-related questions would you like want to pursue?” The analysis was based on using the PREG model’s levels of generated questions. This coding revealed about the progression in each campers’ question(s) asked from the start to the end of the camp. The categories of the PREG model used to code are explained in Table 2.
PREG model is based on, firstly, knowledge representation, which are the hands-on camp projects that campers worked on throughout the camps, and secondly, production rules of PREG model that identified the particular conditions that produce certain questions. Production rules of PREG were used as the categories to code the campers’ generated questions; and not in a computational program as did Otero and Grasser (2001). The three main categories of the models are explained as follows.

1. **Word-Level Questions.** It is lowest level question in the PREG model. Otero and Graesser (2001) define it as:

   A word-triggered question is generated when a reader is uncertain about the meaning of a particular word in the text. This may happen because the word is completely unknown to the reader or because no referent is found for it, even when the meaning is known. Thus, there may be a discrepancy between a word in the text and (a) the lexicon of word knowledge, or (b) the referent of the word in the situation model. (p. 153)

   It has three categories, each have the same value (1) on the coding scheme used for coding questions generated by the campers.

   i. **Unknown Word:** If a content word X (noun, main verb, or adjective) in the text is not known.

      Then Ask: What does X mean? Example, “What does the work homogenous mean?”

   ii. **Unknown Referent:** If Referent of a noun or pronoun X is not known

      Then Ask: What X? Example, “What is pollution?”

   iii. **Ambiguous Referent:** If Referent of a noun or pronoun X is ambiguous

      Then Ask: Which X? Example, “What are the bonds that link oxygen to hydrogen?”

   The campers’ generated questions that feel in this category were codes as “1.”
2. **Statement-Level.** It is middle level question in the PREG model. Otero and Graesser (2001) define it as:

Questions at the statement level directly depend on the reader's world knowledge. Such knowledge may be stored in episodic representations or in semantic representations that have been formalized as schemata and generic knowledge structures. (p. 154)

It has two categories, each have the same value (2) on the coding scheme used for coding questions generated by the campers.

i. **Incomprehensible Statement:** If Statement X cannot be represented at the situation model level. According to Otero and Grasser (2001), “…when a reader is unable to create a referent or situation model representation for a statement in the textbase” (p. 154).

Then Ask: What does X mean? or How X?

Example: "Some gases ... are soluble liquids. What does it mean for a gas to be soluble in a liquid?" and "the solubility of oxygen in water ... How is oxygen dissolved in water?"

ii. **Discrepant Statement:** If Statement X clashes with world knowledge and no incoming consequence or implies link feeds into X in the textbase structure. According to Otero and Grasser (2001):

Questions are asked when an explicit statement in the text is discrepant with a reader's explicit knowledge or implicit knowledge. A clash between an explicit text statement and prior explicit knowledge is easiest to detect and specify theoretically….Clashes with implicit knowledge are sometimes subtle, particularly when the central foundation lies in metacognition and in opaque features of language and discourse. (p. 155)
<table>
<thead>
<tr>
<th>Word-Level</th>
<th>Statement-Level</th>
<th>Link-Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coded as: 1</strong></td>
<td><strong>Coded as: 2</strong></td>
<td><strong>Coded as: 3</strong></td>
</tr>
<tr>
<td><strong>Unknown Word</strong></td>
<td><strong>Incomprehensible Statement</strong></td>
<td><strong>Incomprehensible Consequence or</strong></td>
</tr>
<tr>
<td></td>
<td>If Statement X cannot be represented at the situation</td>
<td><strong>Implies Link</strong></td>
</tr>
<tr>
<td></td>
<td>model level</td>
<td>If Consequence or implies link L connecting statements X and Y is not comprehensible</td>
</tr>
<tr>
<td></td>
<td>Then Ask: What does X mean?</td>
<td>Then Ask: Why Y, How X L Y?</td>
</tr>
<tr>
<td></td>
<td><em>E.g.:</em> What does &quot;breakwater molecules&quot; mean?</td>
<td><em>E.g.:</em> Why does pollution cause a decrease in oxygen?</td>
</tr>
<tr>
<td><strong>Unknown Referent</strong></td>
<td><strong>Discrepant Statement</strong></td>
<td><strong>Incomprehensible Manner Link</strong></td>
</tr>
<tr>
<td></td>
<td>If Referent of a noun or pronoun X is not known</td>
<td>If Manner link L connecting statements X and Y is not comprehensible</td>
</tr>
<tr>
<td></td>
<td>Then Ask: What X?</td>
<td>Then Ask: How X L Y?</td>
</tr>
<tr>
<td></td>
<td><em>E.g.:</em> What is pollution?</td>
<td></td>
</tr>
<tr>
<td><strong>Ambiguous Referent</strong></td>
<td><strong>Discrepant Consequence or</strong></td>
<td><strong>Discrepant Manner Link</strong></td>
</tr>
<tr>
<td></td>
<td>If Referent of a noun or pronoun X is ambiguous</td>
<td>If Consequence or implies link L connecting statements X and Y clashes with world knowledge</td>
</tr>
<tr>
<td></td>
<td>Then Ask: Which X?</td>
<td>Then Ask: Why Y or How X L Y?</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Then Ask: How X? or How X L Y?</strong></td>
</tr>
</tbody>
</table>
Otero and Grasser (2001) identified six specific conditions to better express the discrepancies that are detected and trigger questions. However for this dissertation work, the six conditions were not differentiated.

Then Ask: Why X? or How X?

Example: “why do fish breathe in water and people do not? Why is there pollution? Why are oxygen and hydrogen linked by strong bonds? Why can fish not break the water molecule?

The campers’ generated questions that feel in this category were codes as “2.”


One reason that link questions are complex is because the comprehensibility of a link depends on the comprehensibility of the statements involved in the link......Link-triggered questions result from a discrepancy between activated world knowledge structures and links existing in the text. (p. 159)

Two types of link-triggered questions may be asked:

i. Incomprehensible Links are observed when readers are incapable of translating the textbase formulation into a situation model representation of a link. This is the case for many causal or implicational links that readers do not understand, but for which they have no discrepant knowledge. An incomprehensible consequence link sometimes triggers "how" questions, so the reader can create an appropriate causal chain that connects an explicit cause to a consequence. For example: "When the quantity of oxygen dissolved in water decreases because of a polluting process ... How do toxic waste, garbage ... all polluters of water use up oxygen in it?"
ii. Discrepant Links are observed when the situation model level may clash with readers' world knowledge. Example: "These droplets fall down very slowly because of air friction and the turbulence existing in clouds. If there is air friction and turbulence in clouds, shouldn't droplets fall down faster?" The form of the question implies that this reader believes that air friction and turbulence are causally linked to a faster falling of droplets, not to a slower fall. Discrepancies may be found between world knowledge and all kind of links. For example, some students reading the "Dissolved Oxygen" text asked about a set membership link: "Some gases, like oxygen, nitrogen, carbon dioxide, or ammonia, are soluble in liquids. What allows these gases and not others to be soluble in water?"

Each of these above categories have two sub categories:

a. Consequence or Implies Link: "The consequence link designates a causal relation between two events, between an event and a resulting state, or between a state and an event. The consequence link is directed, such that the first event or state precedes the resulting event or state in time. The Implies link is similar to the consequence link, except for the temporal constraints that exist between the source node and the end node.

b. Manner links specify the speed, style, or other dynamic characteristics of an event.

For purposes of coding for this dissertation, the link triggered questions were broadly analyzed as either incomprehensible or discrepant, without further subcoding as consequence or manner link. The campers’ generated questions that feel in this category were codes as “3.”
Data Analysis

For the purposes of this dissertation, only the Edmodo entrees of campers’ generated questions were hand open-coded using PREG Model categories (Otera & Graesser, 2001). To ensure interater reliability, the author and another researcher (a college educator and a STEM expert) first independently reviewed the entire dataset of campers’ generated questions and open-coded using PREG model categories of, word-level questions, statement–level questions, and link-level questions. The data were then analyzed for areas of disagreement. In addition, these discussion sessions were used to ensure that the data aligned with our research questions and related research on question generation. Cohen's \( \kappa \) was run to determine if there was agreement between the author and the other researcher, about the ranking of campers’ questions generated over the entire camp duration; the rankings being word-level, statement-level, or link-level. There was substantial agreement between the author and the other researcher (\( \kappa = .775, p < .001 \)).

After the coding process, the ratings were analyzed via Generalized Linear Multilevel model to check for the progression in the level of campers’ question generation (research question 2), as well as the correlation of the progression in the level of campers’ question generation with change in campers’ survey scores (research question 3).
CHAPTER 4
RESULTS

Participants

This dissertation study participants were middle and high schoolers attending STEM summer camps at a Midwestern university from late June to early August (Figure 1 and 2). These are camps of various STEM themes, all one week long, with campers staying on campus. Each camp had either middle school students or high school students. Most camps were offered to both middle and high school students, however, a few were not; for example, camps such as Chemistry and Electricity and Magnetism, Engineering Amusement, Lego Robotics, were only offered to middle school student; while, Health, Life Sciences, Physical Sciences, Science, and Video Game Design camps were only offered to high school students (Figure 1). The enrollment by gender was not uniform between camps (Figure 2). For example, middle and high school Art and Health camps were mostly attended by female campers, while camps such as Electricity and Magnetism, Engineering, Lego Robotics, and Video Game design were mostly attended by male campers. The campers were of diverse demographic, gender, ethnicity, geography (local and international campers), with varying exposure to STEM camps/activities, type of schooling, etc.
Research Question 1

“Was there a change in campers’ Science Process Skills (SPS) from the beginning (presurvey) to the end (postsurvey) of the camp, in accordance with the SPS Inventory (SPSI)? Was there an effect of gender, grade, ethnicity, and their interactions on the change of SPSs of campers?”

Methods

The quantitative survey data were collected through the SPSI survey administered to each camper, at the beginning of the camp as presurvey, at the end of the camp as postsurvey (each camp was approximately one week in duration). At camp orientation, each camper was asked to complete a paper-and-pencil presurvey, the SPSI (Arnold et al., 2013). On the last day of each camp, each camper was asked to complete the postsurvey. The presurvey and postsurvey scores were used to assess for a change in SPS of campers. A total of 148 females and 214 males completed both the presurvey and postsurvey.
Figure 1. Distribution of campers’ gender by camp theme.

Figure 2. Distribution of campers’ ethnicity by camp theme.
Descriptive Statistics

Table 3 shows descriptive statistics for the SPSI scores, (presurvey and the post survey scores); Table 4 shows the same by gender, grade, and ethnicity. For these data, Cronbach alpha coefficient for the presurvey and postsurvey scores ranged from 0.86 to 0.89, suggesting good internal consistency reliability. Both presurvey and postsurvey scores show negative Skewness. While the presurvey scores are kurtotic, postsurvey scores are not.

Table 3  
Descriptive statistics for SPSs Scores

<table>
<thead>
<tr>
<th></th>
<th>Presurvey Scores</th>
<th>Postsurvey Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>362</td>
<td>362</td>
</tr>
<tr>
<td>N</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean</td>
<td>38.10</td>
<td>40.20</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>5.83</td>
<td>5.95</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.58</td>
<td>-0.41</td>
</tr>
<tr>
<td>S.E. of Skewness</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>0.99</td>
<td>0.02</td>
</tr>
<tr>
<td>S.E. of Kurtosis</td>
<td>0.26</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Table 4  
Descriptive Statistics for SPSI Scores by Groups

<table>
<thead>
<tr>
<th>Gender Grade</th>
<th>Ethnicity</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>PreSurvey</td>
<td>Female High School</td>
<td>Asian</td>
<td>35.70</td>
<td>4.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Black</td>
<td>38.67</td>
<td>6.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Latina/Latino/Hispanic</td>
<td>38.17</td>
<td>5.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>43.33</td>
<td>3.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>White</td>
<td>39.57</td>
<td>7.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>38.81</td>
<td>6.10</td>
</tr>
<tr>
<td>Middle School</td>
<td>Asian</td>
<td></td>
<td>34.17</td>
<td>5.61</td>
</tr>
<tr>
<td></td>
<td>Black</td>
<td></td>
<td>32.00</td>
<td>5.29</td>
</tr>
<tr>
<td></td>
<td>Latina/Latino/Hispanic</td>
<td></td>
<td>41.40</td>
<td>5.77</td>
</tr>
</tbody>
</table>

(Continued on following page)
Table 4 continued

Descriptive Statistics for SPSI Scores by Groups

<table>
<thead>
<tr>
<th>Gender</th>
<th>Grade</th>
<th>Ethnicity</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>High School</td>
<td>Other</td>
<td>41.00</td>
<td>.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>White</td>
<td>36.29</td>
<td>5.06</td>
<td>21</td>
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<tr>
<td></td>
<td></td>
<td>Total</td>
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<td>Total</td>
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<td>White</td>
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<td>4.11</td>
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<td>Total</td>
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<td>5.47</td>
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<td>Total Middle School</td>
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<td>Other</td>
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<td>White</td>
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<td>6.37</td>
<td>82</td>
</tr>
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<td></td>
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<td>36.37</td>
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<td></td>
<td></td>
<td>Latina/Latino/Hispanic</td>
<td>39.63</td>
<td>5.18</td>
<td>8</td>
</tr>
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<td></td>
<td></td>
<td>Native American</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
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<td>White</td>
<td>39.38</td>
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<td>Total</td>
<td>37.91</td>
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</tbody>
</table>
(Continued on the following page)
### Table 4 continued

*Descriptive Statistics for SPSI Scores by Groups*

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<tr>
<th>Gender</th>
<th>Grade</th>
<th>Ethnicity</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
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</thead>
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<tr>
<td></td>
<td>Middle</td>
<td>Total</td>
<td>40.61</td>
<td>5.30</td>
<td>94</td>
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<tr>
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<td>Total</td>
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<td>School</td>
<td>Asian</td>
<td>39.03</td>
<td>6.26</td>
<td>36</td>
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<tr>
<td></td>
<td></td>
<td>40.00</td>
<td>6.64</td>
<td>8</td>
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<tr>
<td></td>
<td></td>
<td>Black</td>
<td>41.00</td>
<td>7.62</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Latina/Latino/Hispanic</td>
<td>37.67</td>
<td>5.51</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Native American</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>40.25</td>
<td>7.59</td>
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<td></td>
<td>White</td>
<td>41.64</td>
<td>5.64</td>
<td>45</td>
</tr>
<tr>
<td></td>
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<td>Total</td>
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<td>School</td>
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<td>7.67</td>
<td>12</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Latina/Latino/Hispanic</td>
<td>41.42</td>
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<td></td>
<td>Other</td>
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<td></td>
<td>White</td>
<td>39.67</td>
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<td></td>
<td>Total</td>
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<td>117</td>
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<tr>
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</tr>
<tr>
<td></td>
<td>School</td>
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<td>6.17</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Black</td>
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<td>50</td>
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<td>Latina/Latino/Hispanic</td>
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<td>6.00</td>
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<td></td>
<td></td>
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<td>White</td>
<td>40.80</td>
<td>5.68</td>
<td>211</td>
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<td>School</td>
<td>Asian</td>
<td>38.42</td>
<td>6.75</td>
<td>59</td>
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<tr>
<td></td>
<td></td>
<td>39.58</td>
<td>9.03</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Latina/Latino/Hispanic</td>
<td>42.37</td>
<td>6.72</td>
<td>8</td>
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<tr>
<td></td>
<td></td>
<td>Native American</td>
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<td>.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>40.20</td>
<td>6.57</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>White</td>
<td>41.52</td>
<td>5.69</td>
<td>66</td>
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<td></td>
<td></td>
<td>Total</td>
<td>40.11</td>
<td>6.58</td>
<td>151</td>
</tr>
</tbody>
</table>
Figure 3 shows the histogram and box plots for the presurvey and postsurvey scores. The visual inspection of the histograms shows negative skewness for both presurvey and postsurvey scores; more so for the postsurvey scores. Box plots for both presurvey and postsurvey scores for the presurvey scores shows an extreme value for case number 251. The value was truncated for further analysis by changing the score value to a value that was equal to the next-smallest presurvey score).

Figure 3. Histogram and box plots for the presurvey and postsurvey scores. Continued on the following page.
Figure 3. Continued from previous page.
Results

A. Mixed Design ANOVA. Mixed design ANOVA was used for assessment of campers’ change in SPS (change in presurvey to postsurvey score), as well as how gender (male, female), grade level (high school, middle school) and ethnicity (white, nonwhite) moderated this change. SPSS Statistical Software Version 16 was used for statistical analysis. The between-subject factors were gender, grade level, and ethnicity, while the within-subject factor was time. Grade level consisted of two groups, middle school and high school. Gender consisted of males and females. Due to small cell sizes for ethnicity, the five categories (White, Black, Asian, Latino, and Others) were aggregated into two groups (White and Nonwhite). The outcome variables were the pretest and posttest SPS scores. Box’s test for mixed ANOVA model was not significant \( (p = .228) \); therefore, the equality of variance and covariance assumption was met for the model.
Mixed design ANOVA revealed that the change in SPSI scores with time (from pretest to posttest), was statistically significant $F(1,354) = 45.81, p < .001, \eta^2 = .11$ (large effect; see Table 5), as well as the interaction effect of gender and ethnicity on this change in SPSI scores over time $F(1,354) = 6.99, p = .009, \eta^2 = .02$ (small effect; see Table 5).

There was no statistically significant main effect of gender or grade on the SPSI scores (presurvey to postsurvey; see Table 6). However, there was a significant main effect for ethnicity, $F(1, 354) = 11.98, p = .001$ (see Table 6). The effect size was however, small ($\eta^2 = .030$) indicating that the effect of ethnicity explained only 3% of the overall variance in SPS.

There was also a significant interaction effect of gender and grade on SPS scores, $F(1, 354) = 12.32, p = .001$ (Table 6). The effect size was small, indicating that the interaction effect of gender and graded explained a small amount of the overall variance in SPS.

### Table 5

Tests of Within-Subject Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>$F$</th>
<th>$p$</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>749.52</td>
<td>1</td>
<td>749.52</td>
<td>45.81</td>
<td>&lt;.001</td>
<td>.11</td>
</tr>
<tr>
<td>Time × Gender</td>
<td>37.92</td>
<td>1</td>
<td>37.92</td>
<td>2.32</td>
<td>.129</td>
<td>.01</td>
</tr>
<tr>
<td>Time × Grade</td>
<td>15.75</td>
<td>1</td>
<td>15.75</td>
<td>0.96</td>
<td>.327</td>
<td>.00</td>
</tr>
<tr>
<td>Time × Ethnicity</td>
<td>0.54</td>
<td>1</td>
<td>0.54</td>
<td>0.03</td>
<td>.855</td>
<td>0.00</td>
</tr>
<tr>
<td>Time × Gender × Grade</td>
<td>49.60</td>
<td>1</td>
<td>49.60</td>
<td>3.03</td>
<td>.083</td>
<td>.01</td>
</tr>
<tr>
<td>Time × Gender × Ethnicity</td>
<td>114.34</td>
<td>1</td>
<td>114.34</td>
<td>6.99</td>
<td>.009</td>
<td>.02</td>
</tr>
<tr>
<td>Time × Grade × Ethnicity</td>
<td>6.54</td>
<td>1</td>
<td>6.54</td>
<td>0.40</td>
<td>.528</td>
<td>0.00</td>
</tr>
<tr>
<td>Time × Gender × Grade × Ethnicity</td>
<td>1.59</td>
<td>1</td>
<td>1.59</td>
<td>0.10</td>
<td>.756</td>
<td>0.00</td>
</tr>
<tr>
<td>Error</td>
<td>5791.76</td>
<td>354</td>
<td>16.36</td>
<td></td>
<td></td>
<td>.86</td>
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</table>
Table 6  

Tests of Between-Subject Effects

<table>
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<tr>
<th>Source</th>
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<th>Mean Square</th>
<th>F</th>
<th>p</th>
<th>η²</th>
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</thead>
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<tr>
<td>Gender</td>
<td>18.50</td>
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<td>18.50</td>
<td>0.74</td>
<td>0.391</td>
<td>0.00</td>
</tr>
<tr>
<td>Grade</td>
<td>27.44</td>
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<td>27.44</td>
<td>1.10</td>
<td>0.296</td>
<td>0.03</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>299.93</td>
<td>1</td>
<td>299.93</td>
<td>11.98</td>
<td>0.001</td>
<td>0.03</td>
</tr>
<tr>
<td>Gender × Grade</td>
<td>308.47</td>
<td>1</td>
<td>308.47</td>
<td>12.32</td>
<td>0.001</td>
<td>0.00</td>
</tr>
<tr>
<td>Gender × Ethnicity</td>
<td>7.23</td>
<td>1</td>
<td>7.23</td>
<td>0.29</td>
<td>0.591</td>
<td>0.00</td>
</tr>
<tr>
<td>Grade × Ethnicity</td>
<td>17.78</td>
<td>1</td>
<td>17.78</td>
<td>0.71</td>
<td>0.400</td>
<td>0.00</td>
</tr>
<tr>
<td>Gender × Grade × Ethnicity</td>
<td>4.92</td>
<td>1</td>
<td>4.92</td>
<td>0.20</td>
<td>0.658</td>
<td>0.93</td>
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<tr>
<td>Error</td>
<td>8860.77</td>
<td>354</td>
<td>25.03</td>
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<td></td>
</tr>
</tbody>
</table>

Figure 4 shows a plot of SPSI scores by ethnicity over time. As can be seen, the mean scores were higher for white campers than for non-white campers. Figure 5 shows the change in SPSI scores by gender and grade, illustrating a disordinal interactive effect of these variables on the outcomes. Here, among high school students, females showed a higher mean score than males; however, among middle school students, males showed a higher mean score than females. Figure 6 shows the change in SPSI scores by gender and ethnicity, illustrating the significant interactive effect of these variables on the outcomes. Here, for non-white students, the growth in SPSI scores was similar for females and males; however, among white students, females showed greater growth than males.
Figure 4. Change in SPSI scores by ethnicity.

Figure 5. SPSI scores by gender and grade level.
Figure 6. Change in SPSI scores by gender and ethnicity.

Residual Analysis. Figure 7 shows the standardized residual plots and Q-Q plots of presurvey and postsurvey scores, based on the mixed ANOVA analysis. Both Kolmogorov-Smirnov and Shapiro-Wilk tests for the standardized residual plots were significant; indicating that assumptions of normality are not met (Table 7).

Table 7

Tests of Normality for Standardized Residuals of Presurvey and Postsurvey Scores

<table>
<thead>
<tr>
<th></th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>df</td>
</tr>
<tr>
<td>Standardized Residual: Presurvey scores</td>
<td>.07</td>
<td>362</td>
</tr>
<tr>
<td>Standardized Residual: Postsurvey scores</td>
<td>.09</td>
<td>362</td>
</tr>
</tbody>
</table>

a Lilliefors Significance Correction

A visual inspection of the standardized residual plots (Figure 7) for the presurvey and postsurvey residuals also showed some departure from a normal distribution. Both histograms are negatively skewed; the postsurvey scores more so than the presurvey scores. Descriptive
statistics for these residuals (Table 8) showed that the standardized residuals of presurvey scores are skewed. The standardized residuals postsurvey scores are also skewed but not kurtotic. However, given the large sample size in this study, the mixed-design ANOVA was robust to this non-normality.

Figure 7. Standardized residual and standardized residual Q-Q plots of presurvey and postsurvey scores.
Table 8
Skewness and Kurtosis for Standardized Residual of Presurvey and Postsurvey Scores

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Standardized Residual: Presurvey scores</th>
<th>Std. Error</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.00</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.36</td>
<td>0.13</td>
<td>-2.80</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.13</td>
<td>0.26</td>
<td>-0.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Standardized Residual: Postsurvey scores</th>
<th>Std. Error</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.00</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.41</td>
<td>0.13</td>
<td>-3.23</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>0.02</td>
<td>0.26</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Figure 8 shows Box plots for standardized residuals for presurvey and postsurvey scores were approximately symmetric.

Figure 8. Box plots for standardized residuals of presurvey and postsurvey scores.

B. t-Tests

i. Paired t-test. Paired samples t-tests (Table 9) were carried out to compare the
presurvey and postsurvey scores between nine different groups: all campers, all middle school (MS) campers, all high school (HS) campers, all male campers, all female campers, all middle school male campers, all middle school female campers, all high school male campers, all high school female campers. Results from the paired-samples $t$-tests indicated that for each of the nine comparison groups, the mean postsurvey score was significantly higher than the mean presurvey score. The effect size (Cohen’s $d$) indicated small to medium effects.

Table 9
**Paired Samples Test**

<table>
<thead>
<tr>
<th>Pair</th>
<th>ALL Presurvey – ALL Postsurvey</th>
<th>MS Presurvey – MS Postsurvey</th>
<th>HS Presurvey – HS Postsurvey</th>
<th>Male Presurvey – Male Postsurvey</th>
<th>Female Presurvey – Female Postsurvey</th>
<th>MS Presurvey Male – MS Postsurvey Male</th>
<th>MS Presurvey Female – MS Postsurvey Female</th>
<th>HS Presurvey Male – HS Postsurvey Male</th>
<th>HS Presurvey Female – HS Postsurvey Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Error</td>
<td>95% Confidence Interval of the Difference</td>
<td>$T$</td>
<td>$df$</td>
<td>$p$</td>
<td>Cohen’s $d$</td>
<td>Effect size</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-2.04</td>
<td>5.96</td>
<td>0.31</td>
<td>-2.66</td>
<td>-1.43</td>
<td>-6.53</td>
<td>&lt;.001</td>
<td>0.34 Medium</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>-2.21</td>
<td>5.98</td>
<td>0.49</td>
<td>-3.17</td>
<td>-1.24</td>
<td>-4.53</td>
<td>&lt;.001</td>
<td>0.37 Medium</td>
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</tr>
<tr>
<td>3</td>
<td>-1.93</td>
<td>5.95</td>
<td>0.41</td>
<td>-2.74</td>
<td>-1.12</td>
<td>-4.71</td>
<td>&lt;.001</td>
<td>0.32 Medium</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-1.82</td>
<td>5.69</td>
<td>0.39</td>
<td>-2.59</td>
<td>-1.06</td>
<td>-4.68</td>
<td>&lt;.001</td>
<td>0.32 Medium</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>-2.37</td>
<td>6.32</td>
<td>0.52</td>
<td>-3.39</td>
<td>-1.34</td>
<td>-4.55</td>
<td>&lt;.001</td>
<td>0.37 Medium</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>-1.57</td>
<td>6.00</td>
<td>0.61</td>
<td>-2.78</td>
<td>-0.36</td>
<td>-2.57</td>
<td>.012</td>
<td>0.26 Medium</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>-3.35</td>
<td>5.83</td>
<td>0.79</td>
<td>-4.94</td>
<td>-1.76</td>
<td>-4.23</td>
<td>.53</td>
<td>0.58 Medium</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>-2.03</td>
<td>5.44</td>
<td>0.50</td>
<td>-3.03</td>
<td>-1.04</td>
<td>-4.04</td>
<td>&lt;.001</td>
<td>0.37 Medium</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>-1.80</td>
<td>6.55</td>
<td>0.68</td>
<td>-3.14</td>
<td>-0.46</td>
<td>-2.66</td>
<td>.009</td>
<td>0.27 Small</td>
<td></td>
</tr>
</tbody>
</table>

Presurvey and postsurvey scores comparison: ALL = ALL Campers; MS= Middle School; HS= High School.
ii. **Independent t-test.** Independent samples t-tests were carried out to compare females’ and males’ pretest and posttests scores, both overall, and within high school and middle school. The independent t-tests indicated that, when considering all the campers, the differences between the presurvey scores of males and females, and the difference between postsurvey scores of males and females were not statistically significant (each $p > .05$; Table 10). In contrast, when considering middle school campers, the presurvey scores of males and females did differ significantly, $t(149) = 3.76, p < .001$, with a moderate effect size (Cohen’s $d = .62$, Table 10).

### Table 10
**Independent t-tests for Difference between Male and Female Skill Scores**

<table>
<thead>
<tr>
<th></th>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error Mean</th>
<th>$t$</th>
<th>Df</th>
<th>$p$</th>
<th>Cohen’s $d$</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ALL Presurvey</strong></td>
<td>Male</td>
<td>214</td>
<td>38.33</td>
<td>5.61</td>
<td>0.38</td>
<td>1.09</td>
<td>360</td>
<td>0.277</td>
<td>0.12</td>
<td>small</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>148</td>
<td>37.65</td>
<td>6.13</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ALL Postsurvey</strong></td>
<td>Male</td>
<td>214</td>
<td>40.15</td>
<td>6.01</td>
<td>0.41</td>
<td>0.21</td>
<td>360</td>
<td>0.834</td>
<td>0.02</td>
<td>small</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>148</td>
<td>40.01</td>
<td>6.16</td>
<td>0.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MS Presurvey</strong></td>
<td>Male</td>
<td>97</td>
<td>39.18</td>
<td>5.47</td>
<td>0.56</td>
<td>3.76</td>
<td>149</td>
<td>&lt;.001</td>
<td>0.62</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>54</td>
<td>35.63</td>
<td>5.71</td>
<td>0.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MS Postsurvey</strong></td>
<td>Male</td>
<td>97</td>
<td>40.74</td>
<td>6.06</td>
<td>0.62</td>
<td>1.58</td>
<td>149</td>
<td>0.116</td>
<td>0.26</td>
<td>small</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>54</td>
<td>38.98</td>
<td>7.35</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HS Presurvey</strong></td>
<td>Male</td>
<td>117</td>
<td>37.62</td>
<td>5.65</td>
<td>0.52</td>
<td>-1.46</td>
<td>209</td>
<td>0.145</td>
<td>-0.20</td>
<td>small</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>94</td>
<td>38.81</td>
<td>6.1</td>
<td>0.63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HS Postsurvey</strong></td>
<td>Male</td>
<td>117</td>
<td>39.66</td>
<td>5.95</td>
<td>0.55</td>
<td>-1.21</td>
<td>209</td>
<td>0.229</td>
<td>-0.17</td>
<td>small</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>94</td>
<td>40.61</td>
<td>5.3</td>
<td>0.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Presurvey and postsurvey scores comparison: ALL = ALL Campers; MS= Middle School; HS= High School

The middle school males had a higher average presurvey score than middle school females. The middle school gender difference in posttest scores, however, was not statistically significant
\[ t(149) = 1.58, p = .116 \]. For all of the remaining between-groups comparisons, there were no statistically significant group differences in pretest or posttest scores.

**Research Question 2**

"Is there a progression in campers’ question generation about their camp projects; as part of daily reflection on the ESNS, Edmodo?"

**Camper generated questions**

The social networking site or the educational portal Edmodo was used by campers to upload social postings, as well as their daily reflection. At the camp orientation, each camper was provided with written instructions to create individual Edmodo account. The campers were given codes to join their camp group on Edmodo. The camp counselors lead through this process and described the features of Edmodo that were used for camps, mainly “Posting” for anytime postings and “Assignment” for daily reflections, including camper generated questions. Campers were encouraged to use Edmodo as a social platform, at their discretion, any time during the day. The postings and comments in Edmodo were visible to other participants in the group, however the reflections completed under Assignment were only accessible to the researcher. The reflections were completed at participants’ discretion at any time each day of the camp.

The reflection question that was analyzed for this dissertation concerned questions generated by each camper on each day of the camp based on the work that they did that day;
“Based on the concepts you learned today and the work you did, if given the opportunity, what other 1-2 project-related questions would you like want to pursue?” The analysis was based on using the PREG model’s levels of generated questions. This coding reflected progression in each campers’ question(s) generated from the start to the end of the camp.

**PREG Model**

The PREG model is based on knowledge representation and production rules. In this research knowledge generation will be represented by the camp projects that campers will be working on throughout the camps. Production rules of PREG identify the particular conditions that produce particular questions. This aspect was used as the categories were used to code the questions and not use in a computational programs, as did Otero and Grasser (2001).

Otero and Graesser (2001) considered PREG to be a comprehensive analytical model of question asking that incorporated the mechanisms that have been identified in education, psychology, discourse processing, and artificial intelligence reported. It was reported that the model not only accounted for nearly all of the questions produced by the students, it could also identify the conditions in which particular classes of questions are either generated or not. They reported to have introduced a new methodology for empirically testing a complex analytical model of question asking after having applied to the questions collected by Costa (1997). Based on previous research, they admitted that additional variables may have also influenced question asking, such as reader goals and idiosyncratic dimensions of context. This research team continued research using the PREG model. Otero and Graesser reported the extent to which these
models mirror human cognition, “The primary goal of the research reported here is to reduce the large gap that exists between the precise computational models in artificial intelligence and the empirical research in education and psychology” (p. 145).

As aforementioned, for this purposes of this study the PREG model was extended further from its reported application. For this study, the model was not used for predicting questions while solving rather ill-structured problem solving. The model was used for ranking questions generated by campers, who were involved in relatively well-structured project based. The categories of this model have been used for the qualitative coding of the questions generated by each camper (N=362; Table 10). The goal was to look for any change/progression the level of question asking from over the length of the camp. The three different levels of progression are explained in Chapter 3: (1) Word- Level, (2) Statement-level, and (3) Link-level. The categories of the PREG model used to code are explained in Table 2.

**Results**

The generated questions of the 362 campers who completed both the presurvey and postsurvey were analyzed. Campers’ generated questions were compiled in an Excel spreadsheet. Using the categories of the PREG model, discussed above, each entry was coded by hand. It was found that a large number of campers did not ask question(s) as part of the daily reflection process, Monday through Thursday, i.e., 130, 149, 183, and 202 campers did not ask question(s), respectively (Table 11).
Table 11
Frequency of Questions by Level for Each Day

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>130</td>
<td>29</td>
<td>150</td>
<td>54</td>
</tr>
<tr>
<td>2</td>
<td>149</td>
<td>43</td>
<td>153</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>183</td>
<td>19</td>
<td>130</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>202</td>
<td>11</td>
<td>113</td>
<td>36</td>
</tr>
</tbody>
</table>

**Coding of camper generated question**

1. **“Word-Level” questions.** Questions that fell under the first (lowest) level of question asking are “Word-Level” questions. These are the word-triggered questions, generated when encountered by rare words and expressions; not asking about words that are familiar to the camper. The reflection entries were subcoded under the three subcategories of the word level, unknown word, unknown referent and ambiguous referent, explained above. However, all these were coded as Level 1. These questions followed the format "What does X mean?" The word level questions increased from Monday to Tuesday and then decreased until Thursday (Table 10). The expectation was that as the campers go through camp projects from Monday to Thursday, they demonstrate their progression of understanding of the project, as well as a progression of their SPSs, which would be demonstrated by a progression in the level of questions generated by each camper, as part of the daily reflection. The expected trend was that the frequency of these word level (lowest level) questions would decrease from Monday to Thursday and the camper would be asking higher level, “statement level” (coded as “2”) and link-level (coded as “3”) questions. Missing questions were coded as “0.”
2. “Statement-Level” questions. Questions that fell under the second (medium) level of question asking, “Statement-Level” questions directly depend on the reader's world knowledge, as explained above. The reflection entries were subcoded under the two subcategories, incomprehensible and discrepant, following the question format: What does X mean? or How X?, and Why X? or How X?, respectively, explained above. However, both were coded as Level 2. It was counted that the frequency of statement level (middle level) questions was almost the same on Monday and Tuesday and then decreased from then until Thursday (Table 10). The expected trend was that the frequency of these statement-level (lowest level) questions would decrease from Monday to Thursday and the camper would be asking higher, link-level questions (coded as “3”).

3. “Link-Level” questions. Questions that fell under the third (highest) level of question asking, “Statement-Level” questions, are complex as these result from “a discrepancy between activated world knowledge structures and links existing in the text,” as explained above. Thus, the categories had four main subcategories: Incomprehensible Consequence or Implies Link, Incomprehensible Manner Link, Discrepant Consequence or Implies Link, and Discrepant Manner Link. However, all camper-generated questions were coded as “link-level,” (Level 3). The frequency of link-level (highest level) questions had no discernible trend, i.e., most link level questions were asked on Monday, while the least were asked on Tuesday. The frequency increased and stayed almost the same on Wednesday and Thursday (Table 10; Figure 9). The expected trend was that the frequency of these word level (lowest level) questions would
increase from Monday to Thursday. The campers would progress through, first asking “word level questions, in the start of the camp, to then statement-level questions, and eventually asking higher, link-level questions (coded as “3”), toward the end of the camps.

There was no discernible trend in the frequency of 3 levels of questions over four days as seen in Table 11. It was evident that a large number of campers did not ask question(s) as part of the daily reflection process and that was the only observed trend, as the number increased throughout the camp. The possible reasons are discussed in the next chapter.

![Figure 9. Frequency of questions by level for each day.](image_url)
Analysis of progression in question generation over time using Generalized Linear Multilevel Model

The results of the analysis of the progression in campers’ scores for question generation scores with time using a generalized linear multilevel model (GLMM) are shown in Table 12. An ordinal link function was used, and the time points (days) were clustered within individuals. Gender, grade, and ethnicity were level-2 covariates. The missing questions were analyzed as “missing data,” followed by codes of “1” for word level, “2” for statement level, and “3” for link level.

Table 12

GLMM Analysis for the Progression of Scores of the Generated Questions: Missing Questions Coded as “missing data”

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Std. Error</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>0.09</td>
<td>0.07</td>
<td>1.26</td>
<td>.210</td>
</tr>
<tr>
<td>Gender-Female</td>
<td>0.07</td>
<td>0.22</td>
<td>0.31</td>
<td>.757</td>
</tr>
<tr>
<td>Ethnicity-Non-White</td>
<td>-0.49</td>
<td>0.21</td>
<td>-2.31</td>
<td>.021</td>
</tr>
<tr>
<td>Grade-HS</td>
<td>0.18</td>
<td>0.22</td>
<td>0.82</td>
<td>.410</td>
</tr>
</tbody>
</table>

There was no statistically significant change over time in the rating scores of the generated questions ($z = 1.26, p = .210$). High school grade did not have a significant effect on the change in ratings over time ($z = 0.82, p = .410$). Non-white ethnicity ($z = -2.31, p = .021$) had a negative significant effect on survey scores, while female gender did not have a significant effect ($z = 0.31, p = .757$).
Research Question 3

Is the change in campers’ survey scores (from presurvey to postsurvey) related to the progression in the level of their generated question as part of daily reflection?

GLMM analysis

Tables 13 shows the results for the generalized multilevel model (with random intercept and random slope for the effect of time), predicting the progression in scores for the generated questions from the survey change scores, and using gender, grade, and ethnicity as level-2 covariates. The missing questions were coded as missing data, with codes of “1” for word level, “2” for statement level, and “3” for link level.

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Std. Error</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>0.09</td>
<td>0.09</td>
<td>1.09</td>
<td>.277</td>
</tr>
<tr>
<td>Difference in Survey Scores</td>
<td>0.00</td>
<td>0.04</td>
<td>-0.05</td>
<td>.959</td>
</tr>
<tr>
<td>Gender-Female</td>
<td>0.08</td>
<td>0.23</td>
<td>0.36</td>
<td>.718</td>
</tr>
<tr>
<td>Ethnicity- Non-White</td>
<td>-0.51</td>
<td>0.22</td>
<td>-2.26</td>
<td>.024</td>
</tr>
<tr>
<td>Grade-High School</td>
<td>0.16</td>
<td>0.23</td>
<td>0.69</td>
<td>.488</td>
</tr>
<tr>
<td>Time x Difference in Survey Scores</td>
<td>0.00</td>
<td>0.01</td>
<td>0.39</td>
<td>.700</td>
</tr>
</tbody>
</table>

There was no statistically significant association between the change in survey scores and the rating of the campers’ generated questions \( (z = -0.05, p = .959) \), nor any significant effect of
the change in survey scores on the change in ratings over time ($z = 0.39, p = .700$). Female gender ($z = 0.36, p = .718$) and high school status ($z = 0.69, p = .488$) had no significant effect. Nonwhite ethnicity ($z = -2.26, p = .024$) had significant negative effect.
CHAPTER 5
SUMMARY OF RESULTS

This dissertation study is based on a unique STEM summer camps, at a Midwestern university. So it adds to the literature as a study about a relatively small sample size ($N = 362$) of campers, using a survey instrument (SPSI) that has seldom been used. There were more male campers, 214, altogether, than females campers, 148. Camps were attended by both national and international students, although most campers were local to the state.

The goal of this study was to analyze the impact of STEM summer camps in a unique setting, focusing on the progression in SPS and question generation and the correlation between the two. The theoretical framework for this study was the Experiential Learning Model (Kolb et al., 2001). Knowledge, including STEM knowledge and SPS, as per Experiential learning occurs through direct engagement with the subject matter, interaction with others, and detailed observation (Dillivan & Dillivan, 2014). STEM camps provide campers the opportunity for hands-on experience, to utilize their prior knowledge, and develop new skills.

This study’s data was collected using SPSI presurveys and postsurveys (Arnold et al., 2013), and through campers’ generated questions, as part of daily reflections posted on Edmodo, an educational social networking site (ESNS). The goal of this research was to assess for a possible progression in campers’ SPS after attending the camp. This was measured by the change from presurvey to postsurvey scores. The camper generated questions were coded using categories of the PREG model (Otera & Graesser, 2001). Correlational analysis was also
performed to discern the relationship between the potential progression in campers’ SPS and the potential progression in the level of questions generated by the campers.

For the first research question, mixed design ANOVA revealed that the outcome variable, i.e., change in SPS, which is the difference between presurvey and postsurvey scores was statistically significant. Thus, it can be said that the campers’ perception of their science process improved during the course of the camp. As aforementioned, SPS are important to discuss when discussing STEM thinking and STEM education. SPS have been identified in the science education literature as an effective inquiry method of teaching science. Chiappetta (1997) states, “the acquisition and frequent use of these skills can better equip students to solve problems, learn on their own, and appreciate science” (p. 24). Danipog (2018) reported that not many studies could be found using SPSI as a survey tool, and specifically as a comparative survey tool, as a presurvey and post survey. Several other similar survey tools for SPS are available (Donipog, 2018), but most were not used as a comparative tool (comparing presurvey and postsurvey). Most studies used other content testing/assessment comparative tool. Those studies were not discussed here as this dissertation did not involve camper’s content testing; but only their perception of their SPS before and after the camp.

Among the studies that have used the SPSI or similar surveys, most have not used it as a comparative tool (comparing presurvey to postsurvey; e.g., as discussed in Chapter 2, Myers et al., 2004; Akani, 2015; Gultepe, 2016). This dissertation uses the SPSI as a comparative tool. Arnold et al. (2013), who reported constructing and validating the SPSI survey tool, used the survey to compare the SPS level of students of 6th, 7th, and 8th grade, but not comparing presurvey to postsurvey. They reported that the SPSI had the ability to measure increases in skill
level regardless of the student’s pre-program skill level. They concluded that all three grade
groups reported stronger use of science processing skills at the end of camp, with those in 8th
grade having the strongest skills.

Soomro et al. (2011) conducted a comparative study and used the SPSI to measure the
ability of 40 tenth grade students in using SPS in physics. They compared the students’
development of SPS, in the experimental group with a learning environment that used the 5E
teaching model, to the control group with a learning environment that used traditional teaching
methods. The 5E is a learning cycle model that is used to facilitate learning in science and
involves the components: Engagement, Exploration, Explanation, Elaboration and Evaluation.
Each component is unique and asks for clear role of the teacher, and more importantly the for the
role of the learners’ in gaining better understanding of science knowledge, attitudes, and skills
(Bybee et al., 2006). The history of development and details of 5E is found in literature (e.g.,
Bybee, 2006). Soomro et al., (2011) briefly mention that:

In 5Es Leaning Cycle Model all the students work in groups or individual performance
accepts the challenges and find the alternative solutions and use previous knowledge and
experience which makes them new knowledge and experience. Organize science process
skills change in their attitude and their thought; demonstrate higher cognitive activities and
deep scientific understanding. Learning is an internal mental and purposeful, teachers role is
facilitate learning by observing and collect data on changes in individuals actual behavioral
or hidden performance and capture individuals attention and activate their motivation to learn
and connect relevance concepts with students interests, real situation and classroom
environment. (p. 2284)

The traditional method was described as teacher centered, where the teacher imparted knowledge
from a physics content textbook, encouraging rote learning of physics. “It contains only passage,
some figures showed their activities, problems in exercises their equation and formulas to solve
those exercises” (p. 2282). They used SPSI in a pretest-posttest control group research design.
Based on the results of SPSI, they reported that the 5E teaching model was more effective in improving students’ attitudes towards SPS in physics than the traditional teaching methods. The recent research in teaching and learning, and the standards such as NGSS, require students to take an active role in learning process. Learning cycles, such as 5E, allow for an effective way to help students enjoy science, understand content and apply scientific situation. STE camps allow for the same kind of learning, which puts the responsibility of learning on the learners and makes teachers the facilitators. In this dissertation study, the understanding is that the presurvey responses were based on campers’ personal belief of their capabilities. The postsurvey was completed after the campers had experienced the opportunity to work hands-on, throughout the camp, and develop a new personal belief of their skills. Bandura’s Theory of Self-Efficacy (1997) is based on a person’s beliefs concerning their capabilities to organize and implement actions necessary to learn or perform behaviors at designated levels. These beliefs are not the same as their actual ability, but they are closely related. If a person has a low self-efficacy regarding a certain task or concept, their performance in that area is expected to be low (Bandura, 1997). The opposite is also true, that an increase in self-efficacy and hence an increase the level of performance, are a result of higher ability levels.

As reported in prior studies, science camps provide a hands-on opportunity for inquiry, thus leading to the campers’ perceived development of their SPS. The results of this study indicate a statistically significant difference between the postsurvey and presurvey scores, indicating that the campers did experience a greater belief in their capabilities. As detailed in Chapter 2, camps provide an environment of enhancing cognitive abilities and learning skills (Little et al., 2008; Eguchi, 2016), scientific inquiry (Nazir et al., 2003), interdisciplinary
approach and skills (Ahrenkiel & Worm-Leonhard, 2014; Fields, 2009), and encourage ability to ask questions (Barab & Hay, 2001) through camps, including apprenticeship camps (Barab & Hay, 2001; Leblebicioglu et al., 2011).

This study found no significant main effect of gender, grade, or ethnicity on the change in SPSI scores. Regarding between subject effects, while there were no significant main effects of gender and grade level on SPSI scores, there was a significant main effect of ethnicity. Specifically, white campers showed higher scores in general compared to the ‘Non-white’ group. For those of white ethnicity, females showed greater growth in SPS than males, while this was not the case for those of nonwhite ethnicity. The nonwhite ethnicity group actually consisted of four ethnicities (Asians, Latina/Latino/Hispanic, Black, and Other).

Also pertaining to research question 1, a paired samples $t$-test indicated that, when considering all campers, the difference between presurvey and postsurvey scores was statistically significant. This analysis, unlike the ANOVA analysis, did not control for ethnicity, gender, and school-level differences. Additionally, a set of paired samples $t$-tests for nine different comparisons (all campers, all middle school campers, all high school campers, all male campers, all female campers, all middle school male campers, all middle school female campers, all high school male campers, all high school female campers), indicated that the difference between presurvey scores and the post survey scores, for each of the nine groups, was statistically significant. This indicates that campers’ perceived level of their SPS did improve after attending the camps. This can be explained by Bandura’s Theory of Self-Efficacy (1997) and the theory of constructivism which is the theoretical framework of this dissertation study. As detailed in the first chapter, according to the theory of constructivism, learners construct knowledge based on
their own experiences, perspectives, conceptions, and social interactions (Scott, 2013). STEM camps allow campers opportunities, such as using hands-on experience, using their prior knowledge, and acquiring new knowledge which is internalized through previously established experience or knowledge. According to von Glaserfeld (1984), effective learning occurs when it happens within a meaningful and authentic situation in which experience and knowledge are shared and adapted collectively. STEM camps allow campers to work in a nonformal educational environment, with other learners with similar interests, working on hands-on inquiry based projects, in a collaborative manner. Edmodo allows for interactions and sharing of ideas. The effect size was moderate for all comparisons. Thus, it can be said, there was a meaningful increase in the SPS of campers from the start of the camp (presurvey) to the end of the camp (postsurvey) for this particular sample of campers in this unique STEM camp setting. As aforementioned, this study instrument does not gauge for STEM content level change of the campers, but only their perception of their SPS before and after the camp.

Also pertaining to research question 1, independent samples t-tests indicated that the gender difference in the overall presurvey scores, as well as the gender difference in overall postsurvey scores, was not statistically significant. In contrast, the gender difference in presurvey scores among middle school students was statistically significant, where males had a higher mean presurvey score than females. Among the middle school students, there was no statistically significant gender difference in postsurvey scores. Among high school campers, the gender difference in presurvey scores as well as postsurvey scores was not statistically significant. These are interesting observations, as there are several studies reporting the gap among males and females in STEM education and careers (e.g., Clark Blickenstaff, 2005; Hyde, & Mertz, 2009;
Beede, Julian, Langdon, McKittrick, Khan, & Doms, 2011; Cheryan, Siy, Vichayapai, Drury, & Kim, 2011). It was therefore expected that there would be statistically significant difference in the change in SPSI scores between males and females. However, the purposeful sampling of this study that might have led to a sample of female high school campers with high initial perceived levels of SPS, which may have limited their growth potential; and the same could apply to the male campers. On the other hand, it could be pointing to the fact that these STEM camps did allow the all campers to develop a good perception of their SPS.

Another research question investigated the progression in campers’ question generation as part of daily reflection. The process of experiential learning is complex as it requires that learners connect and make meaning of the new knowledge and their existing one (Dennehy et al., 1998). Learning involves dissonance between the existing and new knowledge. This leads to question generation and reflection by the learners (Otero & Graesser, 2001; Gunstone & Champagne, 1990). Reflective observation includes activities such as discussion and reflective questions that require students to reflect on their hands-on experiences. In this study, the daily, project-related reflections and question generation by the campers, allowed them to ponder on the progression of their project. As detailed in Chapter 2, asking questions is an essential skill as part of the SPS, and of scientific inquiry in general. Asking questions promotes learning through construction of knowledge, enhancement of motivation, development of metacognitive skills, identification of knowledge deficits, and answering questions by exploring reliable information sources (Graesser & Olde, 2003). Asking questions is the starting point for the development of scientific ideas in the classroom (Yarden et al., 2008). Asking effective questions also has been linked to improving students’ problem-solving abilities (King, 1991; Dori & Herscovitz, 1999),
independent learning (Marbach-Ad & Sokolove, 2000), stimulating active intellectual engagement in classrooms, (Chin, 2004), and helping teachers in modifying the content and structure of ongoing classroom discourse (Aguiar et al., 2010). Not asking questions ends the process of curiosity, which is awakened by questioning the knowledge one has possessed in the past (Loewenstein, 1994). The literature also reports asking questions, which is assumed to be a natural, process following reading, observing, and concluding (NRC Framework, 2012), is not very prevalent (Good et al., 1987; Dillon, 1988; Graesser & Person, 1994; Colbert et al., 2007). Studies reported gaps in asking questions, evidenced as, limited genuine intellectual curiosity (De Jesus et al., 2003), trouble identifying their own knowledge deficits (Baker, 1985; Hacker et al., 1998). A more recent study found that out of six scientific inquiry practices analyzed, only engaging in questioning and generating questions showed a significant positive relationship with students’ chemistry achievement (Danipog, 2018).

Although a majority of research studies concern student question generation in a classroom or formal setting (e.g., Marbach-Ad & Sokolove, 2000), there are studies based on informal and nonformal settings including camps, where campers posed questions to scientists (Barab & Hay, 2001) or, for example, Turkish primary school students who generated questions and submitted to a science magazine (Cakmakci et al., 2011). This dissertation study focuses on the use of an ESNS, Edmodo, for question generation as part of daily reflection, in an informal/nonformal setting, specifically in STEM summer camps at a Midwestern university. The ability of campers to use Edmodo for posting comments, allowed for more online social interaction. While the postings were visible to other campers, the reflections and generated questions were not. Before camper reflected and generated questions, they have had a chance to
collaborate through postings of their ideas related to their hands-on project. Thus, before the campers’ completed their daily, project-related reflections and asked questions, they had the opportunity to ponder on the progression on their projects. Park and Kastanis’s (2009) suggestions were kept in mind to make sure that while the ESNS retains all its benefits of social network sites, it is also utilized to strategically and systematically encourage students to actively participate in their learning through interactive social interaction. For this purpose, the present study attempted to remove the major obstacles to adopting SNSs for reflective learning, as identified by Park and Kastanis, i.e., providing enough time for reflections/question generation, and dealing with technical difficulties by providing devices. This study attempted to improve ESNS user satisfaction by eliminating technical difficulties through the use of an ESNS. Edmodo allows uploading and manipulating various media files, giving campers the ability to interact with their peers, for example, by enabling texting and uploading camper project progress images. The goal was to improve campers’ experience of learning in a community setting through the use of an ESNS for constant communications, as well as daily reflection, involving question generation.

This dissertation study assumed that the campers will be vigorously asking questions because of being immersed in a full day and full week of hands-on STEM activities, employing the SPS. However, that turned out to be an idealistic expectation, a concern expressed in other studies in various settings (Graesser & Olde, 2003). In typical classroom settings, students rarely ask questions and they often are expected to answer questions (Colbert et al., 2007). A large number of campers did not ask questions as part of the daily reflection process on each day of the camp. (See Table 11). Also, the trend was different from expected, as the level of generated
questions did not improve with time. There could be several reasons for this trend: the campers’ lack of interest in generating questions because of perceived redundancy of the daily reflection question; the campers’ lack of understanding of the question prompt; the campers’ lack of understanding of the question generation process; the campers’ perception that there was no need for asking questions; or in general, a lack of incentive for generating question or reflecting. The reasons reported in literature for such deficiency (Graesser & Olde, 2003), and genuine intellectual curiosity (De Jesus et al., 2003), include: students not being able to identify their own knowledge deficits (Baker, 1985; Hacke et al., 1998); preference for one-on-one tutoring session and informal settings (Graesser & Person, 1994); classroom setting being a hindrance to reflections; and teachers attitude, as well as lack of guidance and quick judgment towards students’ questions (Rothstein et al., 2015). Studies, such as those of Rothstein and Santana (2011), also provide guidelines, which they call their five step QFT process (question formulation technique) to potentially help people develop their ability to ask their own questions in a variety of fields and communities and across a range of educational levels. There are studies that use ESNS for mobile learning, mostly in a formal or classroom setting (which is not the focus of this study), that mention cognitive and technical hindrances, such as: low perception level toward mobile learning (Serin, 2012), low battery life of mobile phones (Al-Said, 2015), and others discussed in Chapter 2. These don’t seem to be the issue in the camp setting discussed in this study. The campers were given a dedicated time and freedom to use their personal electronic devices or devices provided by the camp counselors, to reflect and generate questions at any time during the day. Another reason that the afore mentioned hindrances were not the reason for lack of questions generated, is because campers were constantly and enthusiastically
using the ESNS, Edmodo, for communication with other campers, posting details and pictures of the project-based activities, uploading posts, and using other features of Edmodo.

Questions are asked when individuals are confronted with obstacles to goals, anomalous events, contradictions, discrepancies, and gaps in prior knowledge (Graesser & Olde, 2003). Thus, it is interesting to note that the campers did not show much interest in asking questions, despite working on project-based camp activities and having ample opportunities engaging in new knowledge that would create disequilibrium between the new and the prior knowledge. The lack of interest in generating questions could be due to the fact that the campers were discouraged by the routine nature of reflecting and generating questions.

To address the second research question, the PREG model’s categories first were used to the code/rank the question generated by the campers throughout the camp duration. The categories were: 1) word level, 2) statement level, and 3) link level. The missing questions were marked as “missing”. Then the analysis of the progression was done through comparative generalized multilevel model (GLMM) analysis. Harper et al.’s (2003) study ranked questions generated by students as: 1) minimal difficulty questions as those seeking factual knowledge, 2) low-level questions as those seeking better comprehension, and 3) medium-level questions for application or analysis. This could be considered to be similar to the PREG model categories used in this study. Even earlier studies, such as those of Marbach-Ad and Sokolove (2000) distinguished the different categories of questions students might ask. They build a semi-hierarchical taxonomy, and in the process, discussed other existing taxonomies that couldn’t work for their study, including Bloom's taxonomy (Bloom, 1984). The taxonomy included eight categories of student questions. The use of this elaborate taxonomy was possible because of the
nature of their longitudinal study in a formal classroom. When compared to the study at hand, those categories would not be applicable.

In this study, questions that fell under the lowest level of question asking, word-level questions were the word-triggered questions. The word-level questions increased from Monday to Tuesday and then decreased until Thursday, instead of the expected trend of decrease from Monday to Thursday, as the campers would be asking higher level questions, statement-level (coded as “2”) and link-level (coded as “3”). There could be several reasons for this trend. Because the word-level questions increased from Monday to Tuesday, it could be that campers were initially learning new material and asked low-level questions. As the camp progressed, campers were able develop a better understanding of their project and ask higher level questions, and therefore a decrease in word-level questions was observed as the camp week progressed.

Questions that fell under the second (medium) level of question asking, statement-level showed a frequency that was almost the same on Monday and Tuesday and then decreased from that point until Thursday (see Table 11). The expected trend was that the frequency of these statement-level (medium level) questions would decrease from Monday to Thursday and the camper would be asking higher-level, link-level questions. However, the link-level questions did not increase as expected. In fact, link-level questions were the least frequent of the generated questions throughout the camps. The frequency of link-level questions had no discernible trend, i.e., most link level questions were asked on Monday, and the least were asked on Tuesday. Then the frequency increased and stayed almost the same on Wednesday and Thursday. As mentioned before, the expected trend was that the frequency of these word level (lowest level) questions would increase from Monday to Thursday. That is, it was expected that the campers would
progress, initially asking “word level questions,” then progressing to statement-level questions, and eventually asking higher, link-level questions toward the end of the camps. This expectation again was based on Bandura’s Theory of Self-Efficacy (1997) and other aforementioned studies that posit that hands-on activities founded in the constructivist method of learning can help learners develop higher efficacy, to perceive higher level of SPS; one of those SPS is asking questions as well as questions generation at higher level. There was no discernible trend in the frequency of the three levels of questions over the four days. It was evident that a large number of campers did not ask question(s) as part of the daily reflection process, and this was the only observed trend, as the number of missing questions increased throughout the camp. This could be interpreted as lack of camper interest in asking questions about their work. The campers were given a dedicated time to work on reflection questions, so lack of time during the camp day was not the reason for this occurrence. It could also be interpreted as campers not thinking of questions beyond their current understanding of their work. Although the word-level (lowest level) questions eventually decreased in frequency from Monday to Thursday, this did not lead to an increase in the frequency of statement level (middle level) questions – which occurred with similar frequency on Monday and Tuesday and then decreased from that time until Thursday – nor in the frequency of link level (highest level) questions – which showed highest frequency on Monday, the least frequency on Tuesday, then increased and remained at almost same frequency on Wednesday and Thursday. This qualitative analysis of campers’ generated questions indicates that, for the second research question pertaining to the progression of campers’ question generation about their camp projects, the conclusions are not clear cut. Although there were a larger number of statement-level/level 2 questions, compared to word-level/low level questions,
there was not a larger number of link-level/level 3 compared to the statement-level/level 2 questions.

GLMM analysis for progression in scores for the campers’ generated questions concluded that when the missing questions were analyzed as missing data, followed by codes of “1” for word level, “2” for statement level, and “3” for link level, there was no statistically significant change in the ratings of the questions over time. There was no statistically significant change over time in the rating scores of the generated questions. The only significant effect was a negative one, for the non-white ethnicity group. The female gender did not have a significant effect. Here, the same assumptions could be used as in explaining the trend observed in the first research question, where the gender difference in presurvey scores and postsurvey scores was not statistically significant. The assumptions being that the purposeful sampling of this study might have led to a sample of female campers with high initial perceived levels of SPS, which may have limited their growth potential; or that these STEM camps did allow the all campers to develop a good perception of their SPS.

To address the third research question, GLMM analysis was carried out to discern the relationship between each camper’s change in SPSI score, and each camper’s change in level of their generated questions, using gender, grade, and ethnicity as level-2 covariates. The missing questions were analyzed as missing data, followed by codes of “1” for word level, “2” for statement level, and “3” for link level. There was no statistically significant association between the change in survey scores (from presurvey to postsurvey) and the rating of the campers’ generated questions, nor was there any significant effect of the change in survey scores on the change in ratings over time. Other studies, such as those by Harper et al. (2003) reported that
deeper-level questions that focus on concepts, coherence of knowledge, and limitations to the change in student conceptual achievement, were measured from the difference in pretest/posttest scores. In this dissertation study, the progression in the level of questions asked by each camper throughout the camp was correlated to the camper’s difference in survey scores from presurvey to postsurvey. According to Harper et al., “questioning behavior of students is not related to their acquisition of conceptual understanding only, but rather the total package of successfully applying concepts to solve simple problems” (p. 789). So, for this dissertation study, does it mean that campers did not progress in asking higher level questions because they didn’t acquire conceptual knowledge, nor applied concepts to solve problems? Because this study did not check for content acquisition using a pretest/posttest method, the reason for lack in progression of level of campers’ questions cannot be based on Harper et al.’s conclusion. Harper et al., also advised that encouragement of high-level questioning involving coherence and limitation, leads to better conceptual understanding; while simply encouraging students to ask questions on a regular basis does not result in learning. But Harper et al. were not certain if discouraging the minimal-level questions and/or encouraging the higher-level questions would relate to better scores on more difficult problem solving tasks.

Limitations

The main limitation to this study is that the generalization of these findings is limited because of the clinical nature of this study and the relatively small purposive, accessible sample, very specific to a Midwestern university outreach department’s STEM camps. Further research is
needed to understand the phenomena under study and to attempt generalization through replication of findings, also over longer camps’ durations. Using the same survey (SPSI) as presurvey and postsurvey just over a period of a week might not be enough time to see evidence of change in campers’ SPS.

Another limitation could be the use of quantitative presurvey and postsurvey data without triangulation with other quantitative or qualitative data (i.e., observation, interview, and rubric, etc.) to support the survey data for analyzing the increase in campers’ SPS by attending the camp. The qualitative data for camper generated questions was specific to measuring the progression in the level of questioning (questions coded using PREG Model categories), and not for the purpose of triangulation of survey data. A majority of SPS studies employ at least two varied data collection tools, shedding additional light and providing data triangulation to enhance reliability and validity evidence of the data (Yıldırım et al., 2016). For example, Aydoğdu (2006) used observation and multiple-choice questions (as data collection tools) to ensure the reliability and validity of the data and findings. Because SPS involves cognitive and psychomotor skills, measuring these skills is a limitation to the study. This calls for complementary data collection tools to validly and reliably measure and evaluate SPS (Yıldırım et al., 2016).

**External Validity**

Because the selected sampling method is purposive and nonprobabalistic, the traditional notions of external validity that rely on probability cannot be used to establish generalizability. The study dealt specifically with subjects in a Midwestern university outreach department’s
STEM summer camps. In addition to describing this as a limitation of the proposed study, the proximal similarity model (Cook & Campbell, 1979) is used. Under this model, different generalizability contexts are considered and a theory is developed about which contexts are more like our study and which are less so. When different contexts are placed in terms of their relative similarities, this implicit theoretical is called a gradient of similarity. Once this proximal similarity framework is developed, generalization can be assumed. That is, it can be concluded that generalization of the results of a study can be done to other persons, places or times that are more like (that is, more proximally similar) to that study. The proximal similarity model describes external validity by first establishing a strong description of the study context, including times, places, settings, people, and places. In this study, this was accomplished by providing description of the setting, the demographic information, and relevant information from the qualitative inquiry. In Cook and Campbell’s framework, generalizations of the study results are then applied to other contexts based on their “proximal similarity” to the study context on four characteristics, time, people, places, and settings.

**Educational implications of results**

The findings provide important implications not only for the camp administrators, but also for STEM teaching, STEM teachers’ professional development, and future research. This study offers further insight into the role of camps in nonformal education. The role of question-asking for scientific inquiry and improvements to students’ critical thinking has already been
established and discussed in detail in Chapter 2. STEM summer camps provide the opportunities for inquiry-based activities that can help foster the question generation skill.

This study adds to the field of nonformal STEM education through summer camps. Although this study was based on a unique setting for STEM summer camps, at a university campus, the results can help further research in the field. The aim of this study was to assess a possible progression in SPS after attending a week long STEM camp. The instruments used in this study for collection of data are very user friendly in a nonformal setting. Apart from the survey tool, the study incorporated the use of an educational social network, Edmodo, easily accessible to campers using their devices. Edmodo allowed for the collection of valuable qualitative data to support the quantitative data from the surveys. The study may therefore be considered as an improvement on similar instruments that might currently be presenting challenges. Use of the survey helped campers in gauging the perception of their SPS at the start of the camp and then after going through a one week immersion into hands-on STEM activities. Although, the camp duration is short, the immersion process allowed for campers to assess their perception of their SPS, versus some other long formal or nonformal STEM experience void of practical work, due to lack of resources, overcrowded large classes, ill-equipped laboratories, unqualified or under qualified science educators, etc. The campers were completely immersed in the content learning, and more importantly application of interdisciplinary STEM principles. That, along with other things, enables language facility and familiarity with technical words that may affect learners’ demonstration of competence in SPSs.
Recommendations for further research

One aspect of this study was correlating the increase in SPS to the progression in question generation level in campers’ generated question. This relationship potentially could improve by implementing longer duration camps and corresponding longitudinal studies on these camps. This study was based on a small purposive, accessible sample, from a very specific setting of limited external validity. It could be extrapolated, by studying this correlation (between the increase in SPS, and the progression in question generation level in campers’ generated question) in formal and other settings too. This would help to identify the SPS inherent in certain curricula material; determine the level of acquisition of SPSs in a particular unit; establish SPSs competence by science teachers; or to compare the efficacy of different teaching methods in imparting SPSs to learners. Researchers could also use? the survey instrument tool, SPSI, as it has not been used frequently. SPSI is not a widely used assessment for inquiry-based learning. But the advantage of using the SPSI is that it may provide a clear profile of student development of inquiry skills because it assessed a variety of specific scientific inquiry practices of students in the classroom (Donipog, 2018). This is evident in the composition of its items, which represent the important steps of a complete inquiry. The survey data should be triangulated by other quantitative or qualitative data (e.g., observation, interview, and rubrics).
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