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STEM Summer Camps in the US: Knowledge and Context

Amani Qasrawi, University of Texas at San Antonio

Amani Qasrawi is a civil engineer pursuing a Ph.D. in Construction Science and Management at The University of Texas at San Antonio. She completed her undergraduate studies in Civil Engineering at Al Balqa Applied University in Jordan and Construction Science and Management at The University of Texas at San Antonio. Throughout the academic career, she has been involved in research and teaching. She is working as a Graduate Research Assistant and Graduate Teacher Assistant at UTSA.

Dr. Sandeep Langar, The University of Texas at San Antonio

Dr. Sandeep Langar is an Assistant Professor in the Department of Construction Science in College of Architecture, Construction, and Planning at The University of Texas at San Antonio. He received his Ph.D. in Environmental Design and Planning from the Co

Dr. Tulio Sulbaran, The University of Texas at San Antonio

He received his Ph.D. in Civil Engineer from Georgia Institute of Technology with concentration in Construction Management with a minor in Computer Engineering and strong statistical background. He has over 8 years of work experience in the A/E/C (Archite

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Author1 Name , Author2 Name, and Author2 Name
Author1 Affiliation/Author2 Affiliation

Abstract
Summer is an ideal time to expose students to experiences that increase their knowledge about future career choices and awareness. Unfortunately, many students nationwide lack the resources and opportunities to pursue Science, Technology, Engineering, and Mathematics (STEM) careers. In terms of STEM proficiency, the US lags behind other high-performing countries. Among forty-six participating education systems, the US ranked fifteenth for fourth-graders and eleventh for eighth-graders. Further, a STEM-focused workforce is imperative for the nation. Therefore, there is a growing focus on STEM camps at the national and regional levels within the US. This study investigated the implementation characteristics of summer camps in the areas of modality, duration, and measured impacts conducted within the US. The research used three-staged research, which included sample selection, parameter development, and descriptive statistical analysis. Sample selection was dictated by factors such as the ASEE article and publication date. Parameter development included the identification of twelve parameters purposively developed by researchers. The parameters included "population, race, gender, age, targeted population, framework, theories used, context, learning outcome, delivery method, effect, and duration." This study focuses on the seven parameters (framework, theories used, context, learning outcome, delivery method, effect, and duration) that can be identified as characteristics of summer camps. The preliminary data analysis indicates that most camps didn't have an explicitly identified framework to explain their overall design and development. Most of the summer camp activities revolved around Robotics and focused on providing students with exposure to different engineering disciplines. Understanding the used framework and applied knowledge is imperative as it helps to better design and conduct future summer camps to help achieve the identified goals.

Keywords
STEM summer camp, metanalysis, minority and low-income students, framework, outcome

Introduction
Learning does not have to stop when school is on break. Summer camps allow students to gain a unique experience in subjects [1], [2], especially with Science, Technology, Engineering, and Mathematics (STEM). If participating in the summer camps, it is more likely that students' interactions with instructors, staff, and counselors will be more direct and individualized at summer camps than in regular classrooms. This type of environment may boost students' self-confidence when immersed in summer camps [3]. STEM courses are often viewed as complex and sometimes unrelated to reality. Students need to be involved in hands-on STEM activities to make the connection between education and future careers [4]. In addition to academic content, the camp allows students to interact socially and intellectually with others [3], thereby facilitating intellectual growth. Moreover, students can speak with professionals in their free time to fully comprehend the benefits of pursuing this degree and career path [3].

Educators, including those associated with STEM, have used summer camps to facilitate favorable perceptions among high school students and encourage their career choices to be STEM-focused [3]. Although there has been some slight improvement among the younger students, the performance of high school students is worse now than ten years ago [5]. It is safe to say that the day-to-day quality of life and the ability of the youth to serve the world's growing humanitarian and social needs rely on their technological and scientific capacities. In this sense, it is imperative that strategies designed to motivate student involvement in the sciences and then foster success need to be aggressively developed, and the results need to be reported to all stakeholders in the education community [5].

Thus, the research investigates the characteristics of summer camps from the perspective of the use of framework, theories used, context, learning outcome, delivery method, effect, and duration for summer camps conducted between 1998-2017.

Literature Review

STEM courses are often perceived as complex and unrelated to reality, and STEM-based summer camps can help establish a connection with future careers, should students decide to participate [3]. Students planning majors in engineering or science often switch to other fields of study or fail to complete their degree altogether, according to a study conducted by the University of California at Los Angeles (UCLA) [6], [4]. The motivation to learn science can lead students to scientific literacy—to understand scientific knowledge, identify critical scientific questions, draw evidence-based conclusions, and make decisions about how human activity affects the natural world. The motivation to learn science can also lead students to AP science courses, college science majors, scientific careers, and perhaps, to remarkable scientific discoveries [7].

Motivating students to pursue careers in science has been an abiding concern in American education. Compared to students in other industrialized countries, their American counterparts have been performing significantly less in math and science. Fewer students are choosing science as a major, not to speak of as a career. Their math and science scores in standardized tests have been falling among secondary students [8], [3]. This is worrisome as the world is rapidly moving toward knowledge-based economies with a high quotient of science and math. With fewer science graduates, America risks becoming less competitive and economically less powerful [9], [3].

To provide accessible opportunities for more students to experience doing science, engineering, and mathematics (SEM) in authentic and exciting communities of practice, regularized partnerships could be developed to link schools to places of SEM practice like community colleges and universities, hospitals, museums, and technical laboratories. Such programs could allow students to individually explore identity connections to science [10].

In some summer camps, students use designed thinking and inductive reasoning to process what they learned there with what they already knew [11]. Design thinking is often mentioned as a useful tool for implementing summer camps, but there is little discussion about how well participants comprehend the topics covered or how this comprehension affects their perceptions of engineering [11]. Other summer camps used Cognitive Apprenticeship (CA) as a framework for creating the camp [12]. Students should be immersed in STEM-based activities as early as possible. Immersing in a guided environment is necessary but insufficient to develop scientific reasoning. Explicit instruction is required for all ages to develop reasoning skills successfully [12].

Students construct their identities in relation to their communities as they develop knowledge, competence, and meaning from these interactions [10]. As part of a situated learning approach, students' lived experiences and interactions at home, school, and the wider community shape their science identities. Participating in science allows students to think about how they view themselves and how others perceive them [10].

Several studies look at the camp itself and what participants may learn. Participants may benefit from science camps in terms of their skills and perspectives [1]. In different qualitative studies, the camps have been perceived to benefit students personally as well as scientifically, as well as improving students' creativity, active learning, and understanding of science and interdisciplinary topics [13], [14]. The results from one summer camp cannot be transferred (and replicated) to another summer experience without a theoretical framework, especially when the summer experience focuses on a different knowledge or context. The SumEx-TLC addresses the lack of a "Theoretical Framework" used to develop activities for construction summer experiences that target specific "Knowledge" in a particular "Context" desired by the educator (Figure 1) [15].

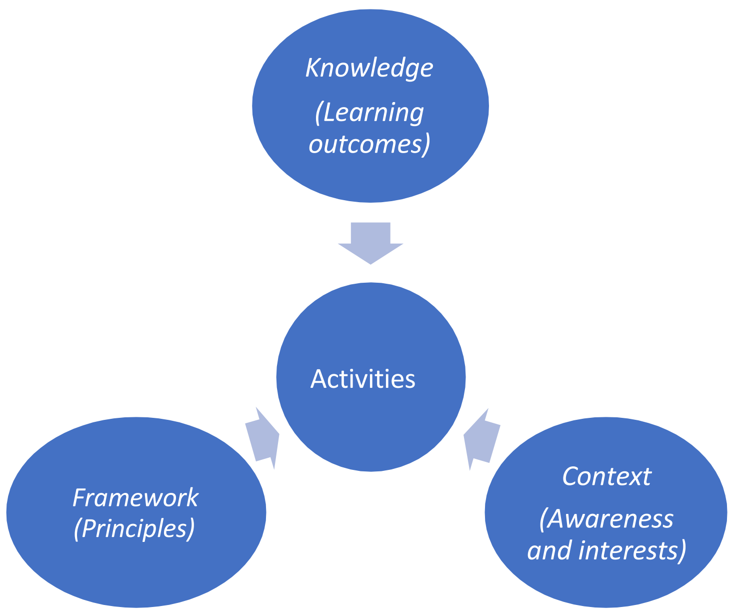

Figure 1. SumEx-TLC Overview

Many academic institutions offer summer camps to introduce students to areas and fields of study they might be interested in. Based on the literature and the importance of framework, context, and knowledge (learning outcomes), the research on how these three were implemented for summer camps. In addition, the research investigates the summer camp characteristics (modality, duration, and measured impacts) from 1998 – 2017.

Research Methodology

The research team used three stages of research for this study: sample selection, parameter development, and descriptive statistical analysis. The team selected a sample of articles for analysis, guided by predetermined factors, including: a) publishing dates between 1998 – 2017; b) publication in ASEE as it is one of the most prominent education avenues. From a pool of 729 identified articles, the research team randomly selected 24 articles relevant to 38 summer camps conducted within the US.

In the second stage, the researchers developed a comprehensive list of twelve parameters, including "population, race, gender, age, targeted population, framework, theories used, context, learning outcome, delivery method, effect, and duration," which are integral components of any summer camp. Seven parameters were selected for analysis, as they could be associated with determining the "knowledge, context, and framework" of a summer camp. The purposively selected parameters included "camp framework, camp theories used, camp context, camp learning outcome, camp delivery method, camp effect, and camp duration."

In the final stage, the research team analyzed the data using descriptive statistical analysis to determine the implementation characteristics of STEM summer camps. They examined the compiled data along the seven parameters to gain insights into the knowledge, context, and framework associated with summer camps conducted within the US.

Results and Discussion

Planning, implementing, and evaluating summer camps can be guided by theoretical frameworks. Theoretical frameworks are essential because they offer a clear and tested foundation for creating summer experiences with repeatable outcomes while allowing different educators to customize the content and setting of their own construction summer experiences activities to produce the same outcomes [15]. Without a theoretical framework, transferring and replicating findings from one summer camp experience to another can be difficult, especially if the summer camp experience focuses on different knowledge and/or context [15]. In some cases, the engineering design process is used as a theoretical or conceptual framework to teach students skills such as problem-solving, critical thinking, and collaborative work. Using the process, students learn to design, build, and test solutions to real-world problems [16]. Many summer camps implicitly implied the engineering design process approach. The engineering design process is a series of steps that engineers follow to develop solutions to problems. For instance, in Robotics camps campers were asked to build robots to perform specific tasks. To complete this task, campers would need to follow the steps of the engineering design process. Identifying the problem, possible solutions, and designing and testing prototypes are all part of this process. The analysis found that most of the analyzed summer camps lacked a framework (Table 1).

STEM concepts may be taught in school, but the opportunities to explore and experience hands-on activities are usually limited in terms of extensive and elaborate laboratories and site visits. The time spent at different locations offers a variety of perspectives on engineering for the campers. Most summer camps were conducted face-to-face on school/university campuses or field trips (Table 2).

Table 1. Existence of a framework for summer camp

Summer camps explicitly identifying framework	Summer camps implicitly referring to the possibility of framework	No framework identified	Total summer camps
2	27	9	38

Online summer camps offer a multitude of benefits for K-12 students, including the ability to motivate and engage students, expand access, provide high-quality learning opportunities, be flexible for students and instructors, and improve administrators' efficiency [17]. At the same time, some of the disadvantages of online summer camps can be the extra screen time which can lead to behavioral problems such as social, emotional, and attention issues, sleeping problems, and a decline in academic performance [18]. Therefore, to conclude given the background the research also aimed to determine what number of summer camps were conducted online. In this regard, the study found the majority of summer camps conducted between 1998-2017 were face-to-face.

Table 2. Summer camps delivery format

Online	Face-to-face	Hybrid
0	37	1

The term "Context" refers to the "meaning and knowledge application to increase awareness and interest among the students" [15]. Majors in analyzed STEM summer camps included biology, physics, and engineering (such as civil, mechanical, chemical, biomedical, electrical & computer engineering, industrial and systems engineering). Most camps focused on exposing students to various engineering disciplines (Figure 2).

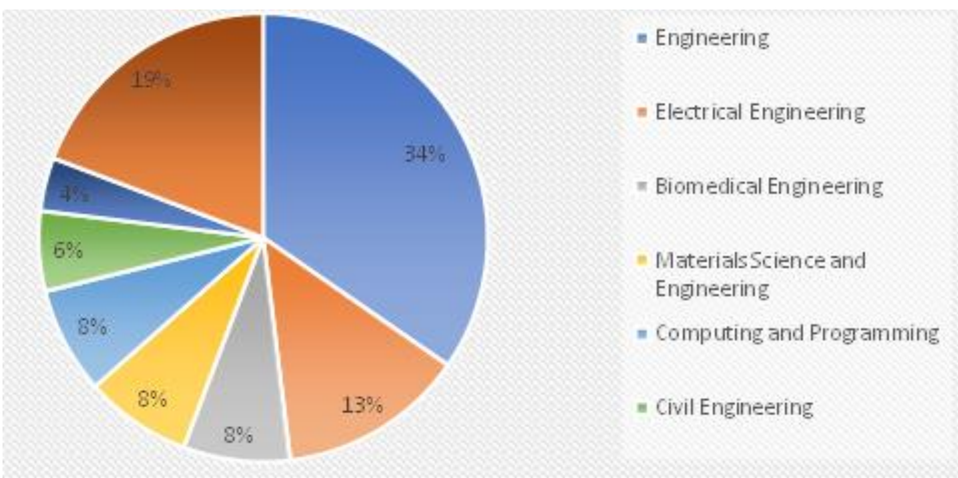

Figure 2. The context in which the summer camps were conducted.

The term "Knowledge" refers to "subjects that the students are expected to learn in the activities of the construction summer experience" [15]. Most summer activities revolved around Robots. Robotics summer camp is an alternative to the traditional learning environment in schools and can be a venue for the students to apply their knowledge of physics as they build simple robotic machines (Figure 3).

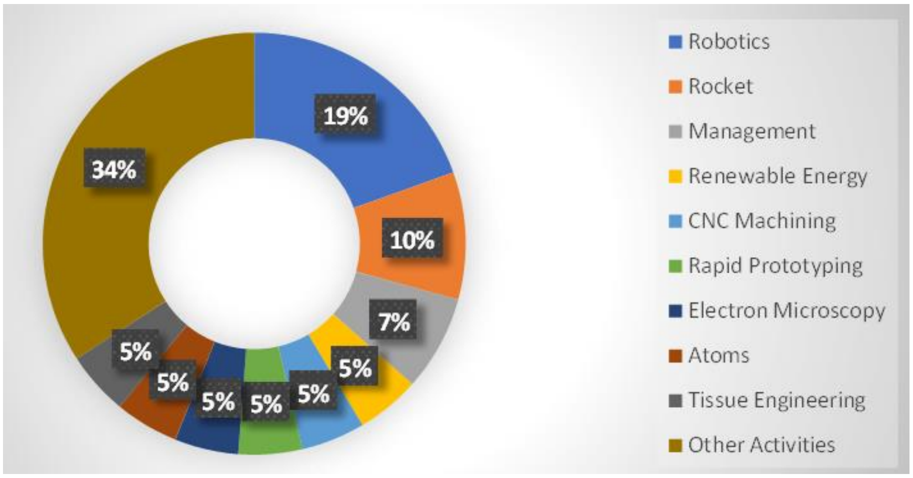

Figure 3. Knowledge (Learning Outcomes) of the summer camps analyzed.

The information and data presented in this paper result from data gathered from articles published in ASEE during 1998-2017. The most used knowledge and the years when the knowledge is applied (Table 3). Students' learning activities and subjects have become more focused over the years.

Table 3. Domain knowledge of summer camps and years applied.

Knowledge	Number of Camps	Years in which they were conducted
Robotics	8	2003-2016
Rocket	4	2011-2013
Management	3	2007-2015
Renewable Energy	2	2015
Electron Microscopy	2	2015
CNC Machining	2	2015
Rapid Prototyping	2	2015
Atoms	2	2006-2010
General Engineering Topics	8	1998-2005

The summer camp surveyed participants to obtain feedback regarding the camp's success as an outreach activity designed to increase student interest in STEM topics. The results of the measured "Effects" of the intervention in the form of the Summer Camps were significantly positive (Figure 4).

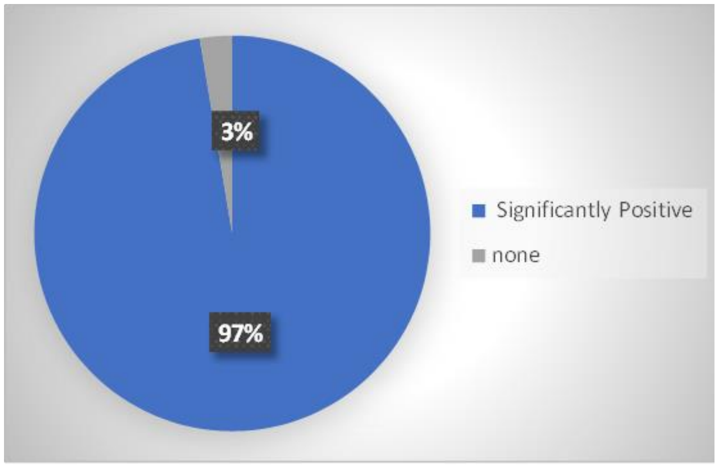

Figure 4. Measurement of summer camp effects.

For the analyzed articles, summer camp duration ranged from one to three weeks, allowing students to work on meaningful hands-on projects while covering a wide range of STEM topics. At the same time, a significant percentage (70%) of camps were one-week, followed by 27% that lasted two weeks (Figure 5). Only 3% of the camps lasted for three weeks.

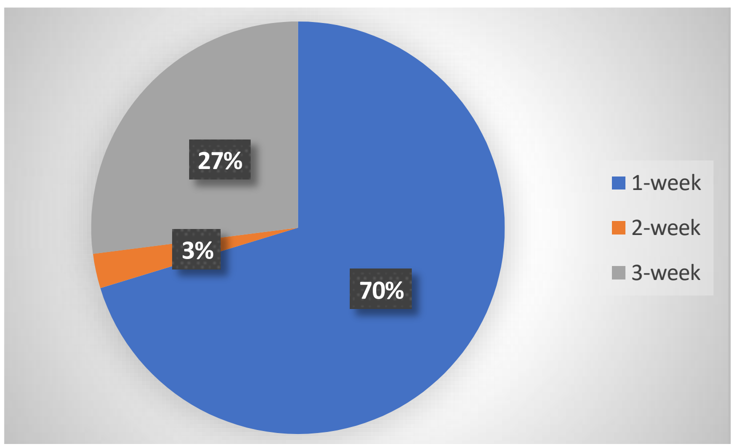

Figure 5. Summer Camp Durations.

Conclusion

There is no better time than summer to increase children's awareness of careers and their knowledge about them. The lack of resources and opportunities prevents many nationwide students from pursuing STEM careers. As part of this study, the outcomes of 1-week or longer summer camps are examined, as well as the context, application methods (face-to-face, online, or hybrid), theories used, and camp framework. Summer camps are valuable and can be counted as one of many important factors when high school-aged students choose an education path and discipline of study.

The camps included various learning environments, from traditional classroom teaching with little interaction to group discussions about concepts and hands-on demonstrations. Many activities were conducted to increase general awareness of different STEM aspects and to increase the awareness of students and parents of the specific opportunities available to study different engineering disciplines. Significant trends were observed among the thirty-eight camps that are important to note include:1) The majority of summer camps did not explicitly provide a framework; 2) Most summer camps focused on providing students with general exposure to different engineering disciplines; 3) The Robotics lab is the most conducted activity.

Limitations and Future Research.

This study had a couple of limitations. First, most of the camps focused on providing students with some exposure to different engineering disciplines, they were generic, and not precise to a certain discipline. Second, the "Summer Camps Effects" were only opinions, maybe a follow-up with the participants and if they pursued a degree in STEM.

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