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Research Article

From camps to careers: Analyzing the impact of summer STEM camps on students' career choices

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Amid growing concerns about students' declining interest and proficiency in science, technology, engineering, and mathematics [STEM] subjects, this study underscores the urgent need for innovative educational interventions. It does so by investigating the impact of week-long residential STEM summer camps on the career interests of middle and high school students, using both quantitative and qualitative methods. By employing a tool for assessing responsibility-based education in conjunction with the STEM-CIS, we aimed to identify a shift in interest and a lasting commitment to exploring careers in STEM fields. The results of pre- and post-camp surveys revealed a statistically significant increase in students' career interest, especially in engineering, emphasizing the positive impact of STEM summer camps on shaping students' future career trajectories. Qualitative data also indicated that participation in STEM summer camps enhanced students' interest in STEM-related careers and their understanding of both the practical applications of STEM concepts and the opportunities available in STEM careers. These findings contribute to pedagogical research by demonstrating how informal STEM programs can complement formal education, promote equity, and support career development. We recommend that educators, school leaders, and policymakers invest in and expand access to such programs to cultivate a diverse and skilled STEM workforce, thereby promoting equity and building a workforce that is both diverse and qualified to meet the demands of a technology-driven society.

Keywords: Informal science teaching; Science education; Summer camp

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1. Introduction

STEM summer camps have become a key component of informal education in the United States, providing middle and high school students with immersive, hands-on experiences in science, technology, engineering, and math [STEM] (Kent, 2025; Mohr-Schroeder et al., 2014; Roberts, 2022; Vela et al., 2020). These camps aim to spark curiosity, develop essential skills, and introduce students to real-world applications of STEM concepts, often in ways that traditional classrooms cannot (Kent, 2025; Mohr-Schroeder et al., 2014). The concept of summer camps in the U.S. dates back to the late 19th century, initially having been created to help children escape urban life and reconnect with nature (Nadel & Scher, 2019). Over time, these camps evolved to include educational elements. In the early 2000s, STEM-focused camps began to emerge in response to national concerns about declining student performance in science and mathematics (National

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Research Council, 2015). The formal recognition of STEM education gained momentum in 2001 when the National Science Foundation [NSF] introduced the acronym STEM, replacing the earlier term SMET (Sanders, 2009). This recognition reflected a broader national effort to integrate science, math, engineering, and technology into K–12 education. Subsequent federal initiatives, including the Educate to Innovate campaign and the STEM Education Act of 2015, emphasized the importance of preparing students for STEM careers (National Academies of Sciences, Engineering, & Medicine, 2024). The Every Student Succeeds Act [ESSA] (U.S. Department of Education, 2015), along with other measures, enabled school districts and community organizations to offer afterschool and summer STEM programs, primarily targeting underserved populations (Maier et al., 2017; Neild et al., 2019). More recently, the Federal Strategic Plan for Advancing STEM Education and Cultivating STEM Talent (National Science and Technology Council, 2024) reaffirmed the significance of informal STEM engagement, highlighting lifelong learning, community partnerships, and culturally relevant programming as vital components of a strong STEM ecosystem (Seo et al., 2025).

In this context, the landscape of summer camp experiences prior to the summer of 2020 played a significant role in nurturing STEM interests among young people. With approximately 20 million children in the United States benefiting from these camps (American Camp Association, 2020), they served not merely as recreational outlets but as pivotal platforms for holistic learning, creativity, and the development of critical thinking skills. However, the COVID-19 pandemic cast a long shadow over summer camp enrollment in 2020, resulting in a significant decline in camper registrations (Roberts, 2022). The situation began to improve in the fall of 2021, with 82% of survey respondents indicating that they attended in-person summer camps, marking a promising increase (Summer Camps.com, 2021).

Summer camps, particularly STEM camps, play a unique and invaluable role in the learning journey of K-12 students (Appel et al., 2022; Hynes et al., 2023; Milton et al., 2023; Roberts, 2022). This is especially true for students from disadvantaged backgrounds, for whom these camps offer unparalleled opportunities to engage deeply with STEM activities and concepts that may not be readily available in more formal educational settings (Appel et al., 2022; Hynes et al., 2023). The participation of these students in summer camps, such as STEM camps, may foster their interest in STEM fields and careers (Caspi et al., 2023; Mohr-Schroeder et al., 2014; Vela et al., 2020).

Many students in the U.S. lack interest or proficiency in mathematics and science (Mohr-Schroeder et al., 2014; Vela et al., 2020). Consequently, they are not motivated to pursue careers in STEM fields. If students' interest in STEM increases, their motivation to pursue a career in STEM also increases (Vela et al., 2020). STEM camps serve as a platform to teach students about various STEM fields and degrees, as well as the benefits of STEM careers they may not have been exposed to during formal school education (Vela et al., 2020), thereby addressing the lack of interest in STEM fields among students. Therefore, developing strategies in STEM outreach programming, such as summer programs, is crucial for stimulating students' interest in STEM subjects (Caspi et al., 2023; Vela et al., 2020). This study aimed to determine whether participation in an informal STEM camp could enhance students' interest in pursuing STEM careers, fostering a sense of inclusivity in STEM education. In this context, the University's STEM Camps serve as a model for how informal education can complement formal schooling. The University-run STEM Camps featured in this study exemplify this approach, providing Illinois youth with opportunities to explore engineering design, drone technology, creative media, health sciences, and more. This study investigates the impact of these camps on students' career interests and aspirations, particularly in engineering and health sciences. It explores how such programs can be leveraged to address systemic gaps in STEM education.

2. Literature Review

2.1. Perceived Impacts of STEM Summer Camps

The informal STEM learning incorporated into STEM summer camps may positively impact students' academic achievement (Caspi et al., 2023; King & Pringle, 2019; Mohr-Schroeder et al., 2014; Ortiz et al., 2018). Caspi et al. (2023) emphasized that STEM informal education programs, such as STEM camps, have two distinct objectives: cognitive (developing students' computational skills) and affective (sparking students' interest in STEM topics and careers).

Participation in STEM camps also enhances students' employability skills, including communication, collaboration, and creativity (Vela et al., 2020). It also increases K-12 students' (usually middle-level or high school) interest in STEM fields as they engage in practical activities in these fields (Mohr-Schroeder et al., 2014). By collaborating with other campers during STEM activities, students also benefit from an opportunity to reflect on their learning and the challenges they encounter at the camp (Vela et al., 2020).

The impact of informal STEM outreach programs on underrepresented student populations is significant, as evidenced by Ortiz et al. (2018) and King and Pringle (2019), who highlight how these experiences not only encourage exploration of diverse career paths in STEM but also foster essential employability skills, ultimately enhancing students' perceptions and engagement in STEM fields. However, the impact of STEM summer camps may also depend on the camp curriculum. If the curriculum of STEM camps is designed to offer authentic educational experiences that engage students on a personal level, then students may perceive the experience as meaningful and creative (Bicer et al., 2015; Mohr-Schroeder et al., 2014; Vela et al., 2020). Based on the findings of relevant studies regarding the impact of STEM camp curriculum on student learning, Vela et al. (2020) also concluded that when the curriculum was relevant to STEM professions, students who completed the camps could see themselves pursuing these interests and potentially a career in a STEM field.

The literature on informal STEM camps suggests that participation can enhance students' affective and cognitive development. In light of this suggested developmental influence, the present study aimed to examine the perceived impact of STEM summer camps on students' interest in careers in STEM-related fields.

2.2. Assessing the Impact of Camp Programs on STEM Interest with the STEM-CIS

Only a handful of recent studies (e.g., Baucum, 2022; Tedeschi, 2023; Tekbiyik et al., 2022) have examined the perceived impact of informal learning environments on enhancing students' STEM-CIS, an evaluation system developed by Kier et al. (2014). Drawing on social cognitive career theory, the STEM-CIS contains four subscales: science, technology, engineering, and mathematics (Kier et al., 2014). STEM-CIS is appropriate for measuring the outcomes of summer camps because informal science learning programs focus on short-term outcomes (e.g., interest, attitudes, and program-specific knowledge) and intermediate outcomes, such as persistence in STEM through future degrees (Wilkerson & Haden, 2014).

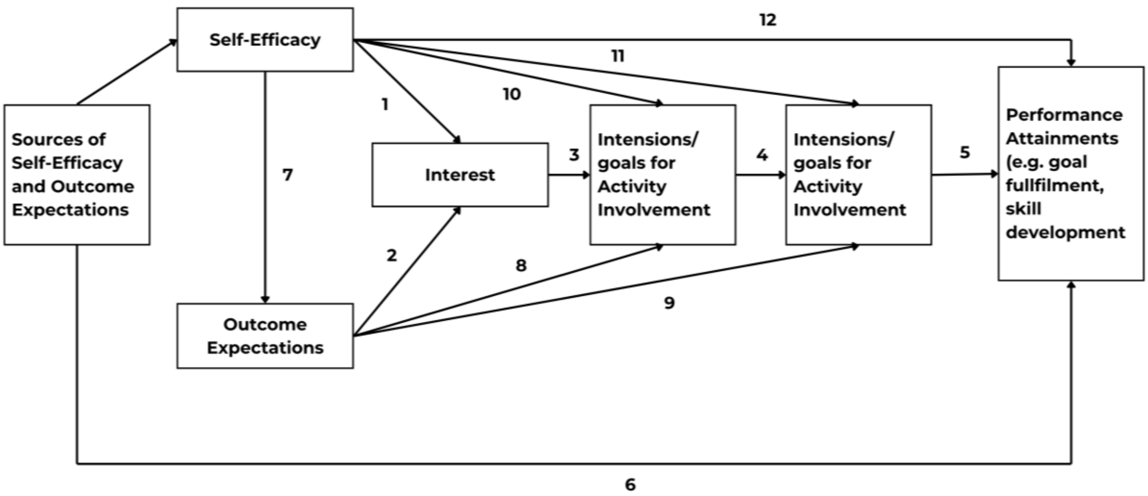
Using a STEM career interest survey to examine the perceived impact of online and traditional face-to-face [FTF] STEM camps, Baucum (2022) reported the results from a paired-sample t-test on selected items of the STEM-CIS, such as interest in STEM careers; the results indicated that the FTF camp significantly improved students' likelihood of having a STEM role model, and the online camp significantly improved students' comfort in talking to STEM professionals. Tekbiyik et al.'s (2022) study, which examined the perceived impact of summer robotics camps, revealed that students' interest in a career in engineering increased significantly. However, the change in interest in careers in science, technology, or mathematics was not statistically significant.

Tedeschi (2023) examined the effect of a seven-day informal learning camp on the self-efficacy and interest in STEM of underrepresented minority middle school students, measuring the camp's outcomes using the STEM-CIS survey. Since all four subject areas showed small to significant effects, Tedeschi (2023) concluded that the summer camp exposure had a significant impact on the students due to their interactions and engagement with professionals in STEM. The survey results also demonstrated a significant increase in interest in technology careers.

3. Theoretical Framework

Since STEM-CIS items are based on social cognitive career theory [SCCT] (Tedeschi, 2023), the present study adopted this framework. Albert Bandura's (1986) social cognitive theory serves as the foundation for SCCT, which examines how self-efficacy, outcome expectations, demographic factors, and contextual experiences influence an individual's career interests and choices (Lent et al., 1994, 2002). SCCT examines the intricate relationship between individuals and their career environments, highlighting the cognitive and interpersonal factors that influence career behaviors (see Figure 1).

Figure 1
Diagram of Social Cognitive Career Theory (SCCT)



Note. Adopted from Lent et al. (1994, p. 88)

The goal of SCCT interventions is to enhance self-efficacy regarding career choices, address challenges in decision-making, and clarify personal objectives to broaden interests. Self-efficacy pertains to beliefs about one's capability to perform actions that result in specific performance outcomes (Bandura, 1986). It is informed by four primary sources: personal achievement, mediated learning, social motivation, and physiological and mental traits (Bandura, 1997; Lent et al., 2002). Achievements in specific tasks generally enhance self-efficacy, making personal successes a crucial source of confidence. Goals are essential in empowering individuals to control their behaviors (Lent et al., 2002). Additionally, through mediated learning, educational experiences can strengthen self-efficacy. The expectations individuals have regarding their professional outcomes arise from assessing past rewards (social motivation), observing others, and self-generated results (e.g., personal satisfaction, Lent et al., 2002). Outcome expectations include beliefs about the external rewards and self-directed consequences associated with engaging in activities.

SCCT further investigates the relationship between career-related interests, choices, and performance, underscoring how interests motivate skill acquisition and the significance of experiential and cognitive factors in shaping adolescents' career interests. Feedback and modeling enhance self-efficacy and outcome expectations related to activity participation, significantly affecting the development of career interests. SCCT identifies self-efficacy as connected to career decisions and barriers to success, aiding in the definition of personal goals (Miles & Naidoo, 2016; Wang & Lent, 2022). For instance, Miles and Naidoo (2016) highlighted the importance of SCCT in evaluating high school students' confidence in making career decisions.

Other research (e.g., Tedeschi, 2023; Zhou & Shiraz, 2025) further validates the application of

SCCT in understanding STEM career development among youth. Tedeschi (2023) examined the impact of a seven-day informal STEM camp on underrepresented minority middle school students and found that students' self-efficacy and career interest significantly increased after camp participation. Zhou and Shirazi's (2025) systematic literature review of 159 studies on STEM career aspirations among youth aged 11–23, particularly among underrepresented groups such as girls and minoritized students, emphasized that self-efficacy was a critical motivator for students. These studies reinforce the theoretical foundation of SCCT and support the current study's design, which integrates hands-on learning, mentorship, and reflective practices to foster self-efficacy and career interest in STEM among diverse student populations.

4. Methodology

4.1. Research Design

This study was designed to investigate the impact of participation in informal STEM summer camps on the career interests of middle and high school students, with a particular focus on engineering and the health sciences. Grounded in Bandura's (1986) social cognitive theory [SCT] and its extension into social cognitive career theory (Lent et al., 1994, 2002), the study explores how students' beliefs about their capabilities (self-efficacy), expectations of outcomes, and personal goals are shaped through immersive STEM experiences.

Bandura's concept of self-efficacy, the belief in one's ability to succeed in specific tasks, was central to the study's design. The camp activities were intentionally structured to provide mastery experiences (e.g., building robots, editing media, conducting health science simulations), which are known to enhance self-efficacy. Additionally, students interacted with STEM professionals and instructors, offering vicarious experiences and social modeling, both of which Bandura identified as key sources of self-efficacy development.

This study employed a mixed-methods research design to secondarily analyze previously collected data, examining the influence of a summer STEM camp on students' career interests. The qualitative method was used in conjunction with a quantitative study and was embedded between the pretest and posttest (Creswell & Plano Clark, 2011). The purpose of the embedded mixed-methods design was to incorporate qualitative data to address the secondary research questions within the predominantly quantitative study and to further integrate and associate the results of both studies. To collect data, the study employed the STEM Career Interest Survey [STEM-CIS], which aligns with SCCT's domains of science, technology, engineering, and mathematics interest. The survey was conducted both before and after camp to assess changes in career motivation and attitudes. Furthermore, daily reflections and TARE-based observations were used to capture qualitative evidence of self-efficacy, outcome expectations, and career-related behaviors, which are the core components of SCCT.

Embedding SCT and SCCT into the study's structure allows not only an investigation into shifts in STEM interest but also an examination of the psychological factors, such as self-efficacy, that drive career development. The following research questions were developed to explore how students' beliefs about the benefits and rewards of STEM careers evolve through exposure to professionals and real-world applications, as well as to investigate the influence of vicarious learning and social reinforcement, which are the key mechanisms in SCCT.

RQ 1) To what extent do students' outcome expectations about STEM careers change after participating in the camp?

RQ 2) What role do social interactions and modeling (e.g., with instructors and STEM professionals) play in shaping students' career-related goals and aspirations?

4.1.1. Research setting: University STEM summer camps

The University-run STEM Camps were designed as one-week summer day camps for Illinois middle and high school students. The STEM Camps offered a variety of experiences for students to participate in, stimulating their interest in STEM. The middle school camps offered activities related to engineering design, exploring drones, creative media, augmented and virtual reality, photography, and Minecraft. The high school camps provided an overview of health and engineering careers. Other high school camps offered opportunities to design video games with Game Maker and Unity. The camps ran from 9:00 am to 4:00 pm for five days and included complimentary breakfast, lunch, dinner, and evening activities for the campers. When the study was conducted in 2022, 140 students from 19 different Illinois counties and three other states (Missouri, New York, and Wisconsin) participated in the STEM camps.

While the study focused on students who participated in STEM summer camps, it is essential to note that these camps were explicitly designed to offer STEM-focused programming. Students did not have alternative camp tracks available within the seven-day summer camp they initially selected. However, we acknowledge that students (or their parents/guardians) may have self-selected into the camp based on their children's pre-existing interest in STEM, which could influence the baseline levels of motivation and career interest. To address this, the study employed pre-camp surveys to capture initial attitudes and interests, allowing for a comparison of growth over the course of the camp.

4.1.2. Summer camp curriculum details and subject representation

The university STEM Camps offered a range of interdisciplinary STEM modules designed to provide hands-on, experiential learning. These camps emphasized applied science and technology, offering students opportunities to develop STEM-related skills and to explore career pathways. The curriculum was designed to foster self-efficacy and career interest through mastery experiences, consistent with the principles of SCCT.

While the summer camps emphasized hands-on engagement through lab-based activities, it is important to clarify that campers were first introduced to key STEM concepts through structured lectures and guided instruction before entering the labs. This instructional component ensured that students had a foundational understanding of the subject matter, which enhanced their ability to engage meaningfully with the practical tasks. The integration of theoretical elaboration with experiential learning is essential for evaluating the educational impact of the camps, as it reflects a pedagogical approach that supports both cognitive and affective development. By combining conceptual instruction with hands-on application, the camps provided a comprehensive learning experience that aligns with best practices in informal STEM education.

Although the camps did not include formal instruction in physics or chemistry, students engaged with STEM concepts through various thematic programs such as Engineering Design, which involved activities like robotics and bridge building; Drone Technology, which introduced flight simulation and coding; Creative Media, focusing on film editing and sound engineering; Game Design, where students used platforms such as Game Maker and Unity; Virtual and Augmented Reality, exploring immersive digital environments; and Health Sciences, which included hands-on experiences such as cow eye dissection and nursing simulations.

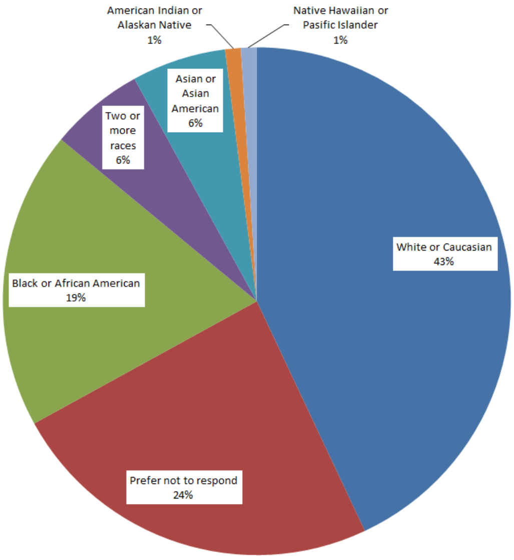
Among the various high school camps, the Health Sciences Careers Camp stands out for its unique focus on audiology, featuring a dedicated lab experience where students delve into ear health, learn about diagnostic procedures, and interact with audiologists. Through activities such as observing hearing tests, understanding the anatomy of the ear, and discussing career pathways in audiology, students gained valuable insights into the field. This module not only introduced them to biology and applied health sciences but also reinforced their understanding of STEM in real-world contexts. In addition to the specialized audiology experience, students also engaged with a variety of other STEM concepts through different camps.

4.1.3. Research participants

Before registering for the camp, parents provided information about their socio-economic status, including their education level and whether their children qualified for free or reduced lunch. We did not collect direct socio-economic indicators like household income. Analyzing the educational attainment data reveals that the largest group of respondents (38%) reported not having completed high school. Those with a high school diploma or some college experience make up 16%, while 7% hold an associate degree, 17% have a bachelor's degree, and 14% hold a master's degree. Only 8% of respondents have earned a doctorate or professional degree. This distribution indicates that most students come from underserved groups. Regarding eligibility for free or reduced lunch, 48% of respondents answered "yes," 43% answered "no," and 9% chose not to respond.

The campers' demographics regarding race are presented in Figure 2. Of the students who responded, male students represented 49% and female students represented 47%. As for students' grade level, 26 (or 30%) were middle school students and 61 (or 70%) were high school students.

Figure 2
Camper Demographics



4.2. Data Collection

Institutional Review Board approved the proposal to analyze secondary data on January 23, 2025 (Protocol #HS25-0182). Because the STEM camps' outcomes required seeking and defining evidence of challenging outcomes, various approaches were used to assess the impact of summer camps, such as pre- and post-camp surveys from 87 students out of 140 who completed both surveys, daily reflections on summer camp experiences, and observations (see Figure 3), resulting in a 38% non-response rate. The final sample was determined based on complete survey responses, which were necessary for conducting paired-sample statistical analyses. While all students were invited to participate in both surveys via Google Classroom, the low response rate was primarily due to early departures from the camp for COVID-related or other reasons. Figure 3 outlines the research framework and timeline of the STEAM camp study. The pre-camp survey was administered on Day 2 (Monday), followed by four days of hands-on STEM activities, structured observations using the TARE protocol, and daily reflections submitted via Google Classroom. The post-camp survey was conducted on Day 5 (Friday). This framework illustrates the integration of quantitative and qualitative data collection methods to assess shifts in students' STEM attitudes and career interests.

Table 1 outlines the logistical and procedural details of the University STEM Camps. The camps were conducted over five consecutive days (Monday through Friday, 9:00 am to 4:00 pm). Data collection included a pre-camp survey administered on Day 2 via Google Classroom using the STEM Career Interest Survey [STEM-CIS] developed by Kier et al. (2013, 2014), and a post-camp survey administered on Day 5. A total of 87 students completed both surveys. Observational data were collected during four days of camp activities using the Tool for Assessing Responsibility-Based Education [TARE] protocol (Wright & Craig, 2013).

Figure 3
Research Process

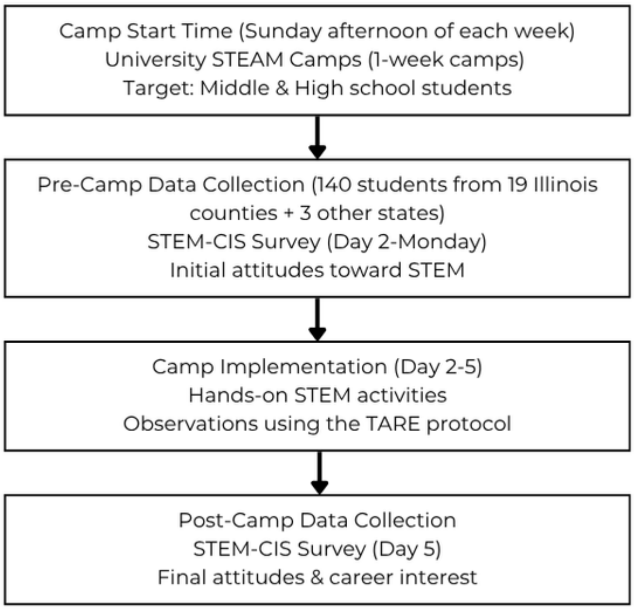


Table 1
Timeframe and Data Collection References

Aspect	*Details*
Camp Duration	5 days (Monday–Friday, 9:00 am–4:00 pm)
Pre-Camp Survey	Administered on Day 2 (Monday) via Google Classroom using the STEM-CIS instrument (Kier et al., 2014),
Post-Camp Survey	Administered on Day 5 (Friday),
Participants	87 students completed both surveys
TARE Observation (during four days)	Wright and Craig (2013)

Table 2 presents the key instruments used and their application. We administered the 44-item STEM Career Interest Survey (Kier et al., 2014) before and after the camps to assess changes in students' interest in science, using Google Classroom prepared for each camp.

Table 2
Key Points of the Instruments Used

Instrument	*Purpose*	*Structure*	*Scale*	*Application*
STEM-CIS	Measure students' interest in STEM careers	44 items across Science, Technology, Engineering, Mathematics	Likert-type (1 = Strongly Disagree to 5 = Strongly Agree)	Pre- and post-camp surveys
TARE 2.0	Observe instructor and student behaviors	60-minute observations rated every 3 minutes	Scale: 0 (Absent) to 4 (Very Strong)	Daily camp observations
Daily Reflections	Capture student experiences and insights	Open-ended questions on Google Classroom	Qualitative coding using SCCT constructs	Daily submissions

(a) Pre-Summer Camp Survey. On Monday, the second day of camp, each camper was asked to complete a pre-camp survey with questions to gauge their attitude toward STEM and career motivation.

(b) Post-Summer Camp Survey. On the last day of camp, Friday, each camper was asked to complete a post-camp survey with questions to gauge campers' science/engineering skills, attitudes toward STEM, and career motivation. The results of the pre-camp and post-camp surveys are presented in Table 3.

4.2.1. Observations

We also conducted 60-minute observations in each camp, observing both the camp instructors' strategies and the students' behaviors. The observations followed the Tool for Assessing Responsibility-Based Education 2.0 observation protocol (Wright & Craig, 2013). This protocol evaluates a set of behaviors and strategies rated at three-minute intervals on a five-point scale (0 = absent through 4 = very strong), indicating the strength of implementation for teacher behaviors and level of enactment for student behaviors.

4.2.2. Reflections

Campers were encouraged to use Google Classroom as a social platform. They could use it at their discretion during the day to promote communication and collaboration, and submit their responses to daily reflection questions.
The following questions were posted daily:

Q 1) What was your favorite activity, and why?

Q 2) What STEM activity did not go as planned, and how did you attempt to solve the issue?

Q 3) What was the most interesting thing you learned today, and why did it capture your interest?

4.3. Data Analysis

The study employed a mixed-methods approach, integrating quantitative and qualitative data to assess the impact of STEAM summer camps on students' career interests. Quantitative data were analyzed using descriptive statistics, paired-sample t-tests, and mixed-design ANOVA to examine changes in STEM-CIS scores from pre- to post-camp. The STEM-CIS instrument included 44 Likert-type items across four domains: science, technology, engineering, and mathematics. The analysis focused on changes in mean scores and statistical significance across these domains, with particular attention to differences by grade level and gender. Qualitative data from daily reflections were analyzed using content analysis with a priori coding based on the SCCT framework. Themes such as self-efficacy, career interest, and experiential learning were identified through frequency coding and keyword analysis.

5. Results

5.1. STEM-CIS Results

STEM-CIS results showed positive changes in campers' motivation to explore various STEM careers; the sample means for items related to STEM career interest were higher at the posttest than at the pretest, especially for engineering and art careers. The item choices were on a Likert-type scale, with "1" as "strongly disagree" and "5" as "strongly agree." The survey results showed positive changes in campers' motivation to explore various STEM fields, as indicated by the sample mean differences for all items being higher in the post-camp survey, particularly for engineering and math. Moreover, there was a statistically significant difference between pre-camp (M = 3.48; SD = .68) and post-camp mean scores (M = 3.65; SD =.76) (see Figure 4). Table 3 provided the results of paired samples t-test, showing there was a statistically significant difference for engineering (t (86) = −23, p < .05). However, the effect size for engineering career interest in this analysis (d = 0.24) was negligible (Cohen, 1988), but it was still higher than the effect size for the items.

Figure 4
STEM Career Interest Survey Results

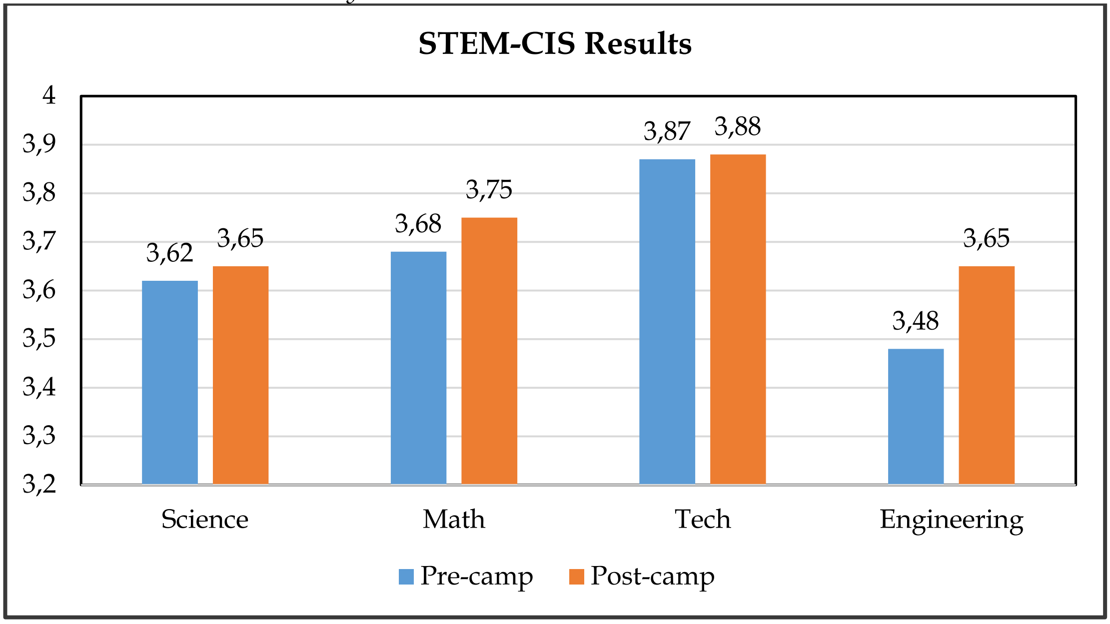


Table 3
Paired Samples Test

Paired Tests		*Mean*	*SD*	*t*	*df*	*p-value*
Pair 1	Science	−.02612	.57961	−.420	86	.675
Pair 2	Math	−.07210	.47302	−1.422	86	.159
Pair 3	Tech	−.00836	.48456	−.161	86	.873
Pair 4	Eng	−.16928	.68637	−2.300	86	.024

Mixed-design ANOVA analysis revealed significant differences in math scores from pretest to posttest by age level, controlling for gender ($F(1, 80) = 4.434$, $p = .038 < .05$; Table 4). With only 26 middle school participants, further disaggregated analysis across STEM domains (e.g., science, technology, engineering) is constrained by statistical power. It may not yield reliable or generalizable results.

Table 4
ANOVA Results by STEM Domain

STEM Domain	*F value (df)*	*p-value*
Science	$F(1, 80) = 0.883$	.417
Math	$F(1, 80) = 4.434$	.038
Technology	$F(1, 80) = 0.051$	.822
Engineering	$F(1, 80) = 0.122$	.728

In terms of the impact of the summer camp on preparing the campers either for college or their future careers, 86% of students said that the summer camp program was effective in preparing them for college, and 85% of students indicated that the summer camps were effective in preparing them for their future careers. As for satisfaction with the summer camp program, 90% of students said that they were satisfied with the greetings of the staff upon arrival at the classroom; 85% of students noted that they were "satisfied" or "very "satisfied" with the activities offered during the summer camps; and 92% of the students expressed satisfaction with the classrooms where the camp sessions were held. When asked about their satisfaction with the interactions they had with camp instructors and counselors, 91% of the campers rated their interactions with instructors as "good" or "excellent," and 92% of the campers rated their interactions with counselors as "good" or "excellent."

5.2. Observations

Observational findings revealed that students exhibited behaviors outlined in the TARE protocol to varying degrees. The behaviors most commonly enacted included participation, showing respect, engagement, and expressing one's voice. The findings also revealed that the camp instructors strongly employed effective and powerful strategies, such as modeling respect, setting clear expectations, providing opportunities for success, and offering choices and voice. The frequently observed behaviors and strategies were sufficient to show that students were exposed to diverse types of instruction and engaged in the behaviors that fostered active learning.

5.3. Reliability in Observations

As Escarti et al. (2015) suggested, we analyzed the TARE protocol by conducting intra-class correlation Coefficient [ICC] analyses in conjunction with standard error of measurement [SEM] studies to assess the inter-rater reliability of the teacher observation section and the student observation section of TARE. Observational data were evaluated using the TARE 2.0 protocol, with inter-rater reliability assessed via intra-class correlation coefficients and standard error of measurement [SEM]. Table 5 shows all observed variables from the TARE's teacher and student observation sections. Reliability coefficients between 0.61 and 0.80 are considered significant, while those above 0.80 are considered almost perfect, according to Landis and Koch (1977). The teacher observation variables, such as modeling respect, setting expectations, and providing opportunities for success, show a range of means, indicating different average levels of observed behaviors, ranging from 0.01 to 3.96. The higher means indicate that the camp instructors demonstrated those behaviors more frequently than those with lower mean scores. The ICC values also vary significantly, with some variables, such as “Assigning tasks” and "Leadership," showing almost perfect reliability (ICC close to 1.00), while others, like “Modeling respect,” have relatively low reliability (ICC = 0.287). The SEM values are generally low, indicating some minor measurement errors across these observations. The p-values indicate the statistical significance of the ICCs, with most variables showing significant reliability except for “Transfer life skills.”

Table 5
Inter-rater reliability: Mean and SD for each observed variable, Intra-class Correlation Coefficients (ICC), p values, Standard Error of Measurement (SEM), and p values.

Variables	*M*	*SD*	*ICC*	*SEM*	*p*
Teacher Observation					
Modeling respect	3.96	0.195	0.287	0.012	.023
Setting expectation	3.81	0.483	0.753	0.029	< .001
Opportunity for success	3.72	0.556	0.773	0.033	< .001
Fostering social interactions	1.27	1.562	0.927	0.093	< .001
Assigning tasks	0.01	0.084	1.000	0.005	< .001
Leadership	0.02	0.179	0.941	0.011	< .001
Giving Choices and Voices	2.62	1.370	0.941	0.082	< .001
Teacher Role in Assessment	0.04	0.302	0.96	0.018	< .001
Transfer life skills	0.03	0.245	0.826	0.015	< .001
Student Observation					
Participation	3.89	0.354	0.543	0.021	< .001
Engagement	3.74	0.536	0.516	0.032	< .001
Showing respect	3.83	0.406	0.153	0.024	.166
Cooperating with peers	1.62	1.622	0.939	0.097	< .001
Encouraging others	0.37	0.868	0.749	0.052	< .001
Helping others	0.48	0.981	0.91	0.059	< .001
Leading	0.03	0.214	0.758	0.013	< .001
Expressing voice	2.41	1.356	0.857	0.081	< .001
Asking for help	0.88	0.950	0.775	0.057	< .001

Student observation variables, such as participation and engagement, also exhibit a range of mean scores and variability, indicating which behaviors were most frequently observed during the observations. The ICC values here also vary, with "helping others" and "leading" showing very high reliability, whereas "showing respect" has relatively low reliability (ICC = 0.299). The p values mostly show significant results except for "Showing respect" (see Table 5).

5.4. Reflections

Daily reflections provided qualitative data. Content analysis is a structured, repeatable method that condenses significant texts into concise content categories using defined coding rules (Cohen et al., 2017; Krippendorff, 2013). It enables researchers to analyze extensive data systematically through coding that involves categorizing and describing data units that are descriptively indistinguishable, allowing for analysis in clearly defined terms (Krippendorf, 2013; Strauss, 1998). Within mixed-method research, content analysis includes frequency coding (Krippendorff, 2013). An example includes analyzing the frequency with which a specific topic appears in a document or multiple documents (Krippendorff, 2013). In this study, a priori coding was implemented. Priori coding establishes categories before analyzing the data, typically based on a pre-existing theory (Cohen et al., 2017). The SCCT interest model emphasizes how career-related interests influence choice behaviors and skill development. It also considers the experiential elements, such as various activities in their social surroundings, and cognitive factors, like engineering-related tasks, that shape adolescents' career-related interests. Utilizing the SCCT framework for priori coding, the researchers independently analyzed some of the data (see Table 6). After an initial screening of the data from the summer of 2022, researchers compared codes for consistency and agreement. Once this had occurred, the primary researcher continued to categorize the data.

The qualitative data revealed that participation in the camps opened doors to future STEM careers in Illinois and beyond for middle and high school students, enabling them to develop STEM-based awareness, competence, and confidence, as reflected in their responses. After the potential themes were analyzed in depth, three themes emerged: (a) the power of self-efficacy in overcoming challenges, (b) empowering future innovators through STEM camps, and (c) strengthening understanding through modeling and experiential learning.

5.4.1. Theme 1: The power of self-efficacy in overcoming challenges

As mentioned earlier, self-efficacy is believing in one's ability to succeed in specific situations. Self-efficacy is crucial in STEM because students with high self-efficacy believe they can find solutions, a belief that persists even when they face challenges. In daily reflections, many responses or aspects of them exemplify the students' high self-efficacy. For example, one of the students in the Film Camp said, "I think editing and re-watching [my film] and having a successful product is very liberating." This statement shows how self-efficacy can foster a sense of accomplishment.

A student in the Engineering Camp shared:

> One activity that did not go as planned was building our robot today, using cardboard and the hummingbird kit. We used hot glue to put it together. Many of the parts we put onto the robot kept falling off. We solved the problem by re-gluing and adding tape to the pieces to prevent them from falling off.

As seen from the quote, the experience of building a robot showcased the importance of resilience and problem-solving. Although the project did not proceed as planned, the response to the challenge, including re-gluing and taping the parts, reflected a strong sense of self-efficacy.

Another student reflected on their achievements, saying, "Looking back, I am very accomplished with the bridge we built. We had many challenges, but we overcame them all." In this case, acknowledging past successes, particularly after overcoming challenges, reinforced belief in one's abilities, encapsulating the essence of self-efficacy.

Table 6
Initial Priori Coding and Preliminary Themes

Potential Themes from the Constructs of SCCT	*Priori Coding*	*Examples*
Self-efficacy (Choice behavior)	Codes: Competency belief; Perceived ability • Keywords for the code "Competency belief": "proud," "accomplished," successful," and "liberating." • Keywords for the code "perceived ability": learned," "understood," and "able."	"Editing was quite difficult and not the most enjoyable activity. I think editing, followed by re-watching, can lead to a successful product, which is liberating."
STEM concepts and careers (Skill/Knowledge development)	Direct or indirect exposure to careers • Keywords for "Career Success": "career-related words" • Keywords for STEM: "engineering," "science," "technology," and" math concepts."	"My favorite activity in engineering was snapping blocks on the computer." "My favorite activity today was touring the engineering building because I got to see the labs that students and faculty use and met some of the faculty and students involved within the programs offered in engineering."
Modeling, Experiential, and Cognitive Learning	Experiential Learning/Educational Support • Keywords for the Code "Educational support or experiential learning": "activity/hands-on experience," "observed," "words related cognitive elements (e.g., critical thinking and memory," and "demonstrated."	"When we had an activity related to engineering, we could not get the rotator to work. We watched an instructional video to fix it, and it worked."

Collaboration during the writing process further emphasized this theme. One of the students in Creative Media Camp said, "Today, I was writing a short story with my film crew. I am proud of myself because we were all bouncing off ideas, and no one was left out in the brainstorming process." As the quote shows, the collaborative spirit fostered creativity and built a supportive environment where everyone's contributions were valued, strengthening collective self-efficacy.

In conclusion, self-efficacy was a potent force that shaped how students approached challenges, collaborated with others, and reflected on their achievements. It empowered creativity, resilience, and a sense of accomplishment, underscoring the importance of believing in one's abilities to navigate the complexities of creative projects and beyond.

5.4.2. Theme 2: Empowering future innovators through STEM camps

The STEM camps' students highlighted learning about innovative STEM activities and the connection between education and career opportunities. They shared how they could explore diverse pathways in STEM fields. For instance, one of the campers mentioned, "The most interesting thing I learned was that liquid nitrogen makes ice cream. That interested me because I never once wondered how ice cream was made." This statement demonstrates that scientific concepts can be applied in fun and engaging ways, sparking interest in STEM fields among individuals who may not have previously considered them.

Another student reflected, "My favorite activity was to collaborate with the people in my team about writing for our film. This activity was my favorite because I got to talk to people for our film." As can be assumed from the statement, collaboration in film writing requires critical thinking, creativity, and teamwork skills. These are essential skills in many STEM careers where collaboration is key to problem-solving and innovation. Another student shared, "The most interesting thing I learned today was how to change how a voice sounds after recording it." A similar response was provided by one of the students, who said, "Before doing this, I did not know that this editing tool was part of our program. This will also be useful when using this program in the future." One of the students in the photography camp shared, "The most interesting things I learned today were the photographing terms we learned, such as 'rule of thirds' and 'frames within a frame.' I liked learning more about the photography world. Understanding these concepts may enhance skills in visual communication, which is increasingly important in STEM fields, especially in data visualization and presentation. "I learned the difference between graphics and aesthetics, and that although graphics are important, aesthetics are more important and are what make the game so memorable." As seen from the responses to the reflection questions, learning about photography techniques helped students see the intersection of art and technology.

Students who participated in the Health Sciences careers camp shared their experiences about the possibility of pursuing a career in health sciences. One student said, "I am proud that I made a video game, and I love that I put all this effort into it. After that presentation, I am curious about becoming a doctor to be an oncologist." Several other students also discussed how the summer camp helped them consider many careers:

> I am proud of exploring new things that I had not done before, like audiology, medical lab science, biomedical engineering, and more. The camp and the professionals we met during the camp helped me narrow down my future STEM major in college.
>
> I was very interested in pet therapy. It intrigued me because I did not realize how extensive the process was for a dog and its trainer to become certified as a therapy dog. My interest in pet therapy involves understanding the rigorous training and certification process for therapy dogs and their handlers. I also liked learning about the differences between service animals, therapy animals, and emotional support animals.
>
> I liked visiting the audiologist's office and learning about ear health. I also liked seeing the different kinds of tests they performed. I never considered becoming an Audiologist, but now I am interested in the field.

The quotes from daily reflections highlight a strong interest in hands-on, experiential learning within the context of various medical and therapeutic fields. The individual expresses intrigue in pet therapy, particularly the certification process for therapy animals, which reflects a desire to understand complex systems and training methodologies. The exploration of audiology also showcases a newfound passion for ear health, driven by engaging activities that provide insight into the field. Overall, these experiences empower individuals to explore innovative paths in healthcare and beyond.

5.4.3. Theme 3: Strengthening understanding through modeling and experiential learning

This theme underscores the significance of hands-on activities and real-world applications in the learning process, highlighting how experiential learning can foster student engagement and comprehension across diverse disciplines, including healthcare engineering. By incorporating practical experiences into the curriculum, students were able to connect theoretical knowledge with tangible practice, fostering deeper understanding and skill development. For example, one student reflected on their experience with a specific activity as follows:

> My favorite activity of the day was drawing blood from a fake arm after the nurses showed us. It was enjoyable to gain firsthand experience in a medical setting. I was nervous to do it, and I know I messed up because it was my first time doing it. It was not easy, but it was fun at the same time. Learning the new technique was an incredible experience for me.

As seen from the student's reflective statement, the experience of drawing blood from a fake arm exemplifies experiential learning, which emphasizes learning through hands-on activities. Practice of a medical skill helps bridge theoretical knowledge with practical application.

Other students who participated in health science careers camps also shared their experiential learning experiences. Here are some of their responses to daily reflection questions:

> The most interesting thing I did today was dissect a cow's eye, following the instructions. At first, I felt disgusted because I was not used to dissecting anything. It was a new experience, and since it was new, it was also exciting. I honestly did not know what to expect. It was the most interesting because I had never done anything like it. I enjoyed it, even though I did get a little grossed out.
>
> My favorite activity was the nursing program. It was my favorite because I preferred hands-on learning over listening. I enjoyed going into the audiology rooms because I enjoyed the interactive part.

Students' reflections revealed that their understanding of STEM concepts was deepened through a combination of hands-on activities, instructor modeling, and cognitive engagement. For example, one student shared, "My favorite activity of the day was drawing blood from a fake arm after the nurses showed us. It was fun to have firsthand experience when doing something medical." These experiences reflect the power of experiential learning to make abstract concepts tangible and memorable. Beyond physical engagement, students also demonstrated cognitive learning through problem-solving and critical thinking. One camper described troubleshooting a malfunctioning rotator by watching an instructional video and successfully resolving the issue. This example illustrates how students employed both observational and cognitive strategies to overcome challenges. Additionally, students frequently used terms like "demonstrated," "observed," and "hands-on" in their reflections, indicating the importance of modeling and guided practice in their learning process. Together, these experiences show how modeling, experiential, and cognitive learning worked in tandem to enhance students' confidence, curiosity, and competence in STEM. The integration of these learning modes aligns with SCCT's emphasis on mediated learning and outcome expectations, reinforcing the value of informal STEM programs in fostering meaningful and lasting educational experiences.

In conclusion, participation in STEM summer camps significantly enhanced students' interest in pursuing careers in science, technology, engineering, and mathematics by providing them with practical, hands-on experiences that reveal the real-world applications of STEM concepts. This increased interest motivates students to explore diverse career paths and cultivates a deeper understanding of the relevance and importance of STEM fields today. The findings highlight the crucial role that inclusive STEM educational programs, such as summer camps, play in promoting a sense of belonging and support among underrepresented groups. By creating accessible and engaging learning environments, these camps not only bridge the STEM education gap but also empower all students, particularly those from disadvantaged backgrounds, to pursue their passions in STEM fields. The informal learning opportunities provided by STEM summer camps significantly contribute to developing essential skills, including communication, collaboration, and creativity, among participants. As students engage in practical activities and teamwork, they enhance their employability skills and build confidence in their abilities to tackle complex problems, preparing them for successful futures in STEM careers.

6. Discussions

The findings related to the research questions demonstrated that the summer camp experience increased participants' knowledge of STEM content and skills in STEM subjects, as evidenced by the survey results and the quotes from reflections. Responses to the questions about satisfaction with the summer camp also showed that students were satisfied with their overall experience. Moreover, the findings provided substantial evidence of how students experienced various STEM camps during the summer, through STEM activities they selected based on their interests. The evidence of STEM career interest was supported by either survey item responses (an increase in the mean scores of all STEM subjects post-camp), quotes from reflections, or findings from observations. Adolescents are constantly exposed to various activities, both directly and indirectly. This exposure, coupled with various forms of reinforcement such as modeling and feedback, played a significant role in shaping their career interests, enhancing their self-efficacy, and forming expectations about the outcomes of their actions. Thus, the students' career interests were directly influenced by their belief in their abilities (self-efficacy) and their expectations regarding the outcomes of their activities. Therefore, self-efficacy and outcome expectations may have played a pivotal role in determining individuals' goals and the degree of effort they invested in achieving them.

The demographic survey and the STEM-CIS results indicate that students from varied backgrounds participated in the camp, which is significant for fostering an inclusive environment that enhances self-efficacy. According to Lent et al. (2002), the expectations of outcomes derived from educational experiences can be crucial in shaping self-efficacy beliefs. In this context, the positive feedback from campers regarding the summer camp's effectiveness in preparing them for college and future careers—86% and 85%, respectively—demonstrates a strong sense of outcome expectation, which can enhance their confidence and motivation to pursue STEM careers.

Additionally, the increased motivation for exploring STEM careers, particularly in engineering and mathematics, suggests that students recognized the potential rewards (social motivation) associated with these fields and experienced self-approval for their engagement and improvement. The statistically significant increase in engineering interest from pre-camp to post-camp indicates that students experienced tangible benefits from their participation, reinforcing their confidence in their capabilities. This aligns with Lent et al.'s (2002) idea that positive evaluations of past experiences contribute to elevated self-esteem and expectation of future successes in similar tasks.

Furthermore, student satisfaction ratings regarding interactions with instructors (91%) and counselors (92%) indicated that they were rated as "good" or "excellent", reflecting the social reinforcement aspect of outcome expectations. The supportive environment created by staff likely enhanced the students' perceptions of earned rewards through engagement, bolstering their self-efficacy. The instructors' effective strategies, such as modeling respect and providing opportunities for success, align with Lent et al.'s (2002) observations on the influence of others' results, which help foster a positive learning experience.

The qualitative reflections reveal strong self-efficacy, a key construct in SCCT. Students described overcoming challenges, collaborating, and envisioning a future career, mirroring findings from recent literature (e.g., Caspi et al., 2023; Tedeschi, 2023), which concluded that the summer camp exposure had a significant impact on the students due to their interactions and engagement with professionals in STEM. The survey results also demonstrated a significant increase in interest in technology careers. As students engaged in hands-on STEM activities and had opportunities to be exposed to different STEM careers through lab tours, their perceptions of STEM careers improved. This finding aligns with the findings of a study by Vela et al. (2020), which reported that campers' perceptions of a STEM career improved after attending the camp, primarily due to the engaging STEM experiences, such as lab tours and talking to STEM professionals.

In summary, the data supports the idea that the campers' positive expectations about the outcomes of their learning experiences—characterized by satisfaction, engagement, and perceived program effectiveness—act as a strong catalyst for increased self-efficacy and motivation to pursue STEM careers, as outlined by Lent et al. (2002). This connection highlights the importance of offering enriching educational experiences that can significantly enhance students' confidence in their abilities and future success. For example, comparing pre- and post-camp surveys shows alignment with the SCCT framework’s mediated learning concept, demonstrated by the career-related interests that influence choice behavior and skill development. The educational activities in STEM summer camps, mainly mediated learning, contributed to heightened self-efficacy in STEM subjects. We can speculate that the variety of activities in interpersonal settings and STEM-related tasks helps develop adolescents’ career-related interests. Our findings also support Zhou and Shirazi’s (2025) findings, which showed that exposure to STEM professionals and role models in informal environments might increase students’ confidence (considering the impact of gender and ethnicity) in their ability to succeed in STEM fields and help break down systemic barriers by fostering learning and self-belief. In our study, most campers came from diverse backgrounds and reported a sense of belonging in STEM after being exposed to different careers.

When comparing our findings with those of Baucum (2022), several notable differences emerged concerning the perceived impact of camp types (online vs. traditional face-to-face) on students’ career aspirations. The Mixed Design ANOVA results for the STEM-CIS indicated that responses to career choice questions (e.g., “I plan to use STEM in my future career”) across various domains—science, technology, engineering, and mathematics—did not show significant differences by camp type as all reported p-values exceeded the alpha level of .05. This distinction emphasizes the need to explore multiple dimensions of student experience beyond career aspirations alone, as different camp formats may cultivate varying skills and attitudes toward STEM. However, our finding aligns with the results of Tekbiyik et al. (2022), which examined the perceived impact of summer robotics camps. The study revealed that students' interest in pursuing a career in engineering increased after the camp, even though changes in interest in careers in science, technology, or mathematics were not statistically significant. Similarly, our study found that interest in engineering items rose post-camp, with a small effect observed in this category. The effect size for other domains was not statistically significant, consistent with Tekbiyik et al.’s (2022) study. Moreover, our findings partially agree with Tedeschi’s (2023) study that examined the effect of a residential summer camp on the self-efficacy of underrepresented minority middle school students using the STEM-CIS survey. In Tedeschi’s (2023) study, students reported the positive influence of having role models and professionals from the STEM field involved in the summer camp. Our survey results revealed that exposure to the summer camp had a significant impact on the students, primarily due to their interactions and engagement with STEM professionals.

6.1. Implications

The findings of this study have important implications for STEM education, particularly in the context of informal learning environments such as summer camps. First, the statistically significant increase in students’ interest in engineering, along with the overall positive shift in STEM career interest, underscores the effectiveness of immersive, hands-on experiences in shaping career trajectories. These results support the broader educational goal of fostering STEM engagement among middle and high school students, especially those from underrepresented backgrounds.

Second, the study highlights the role of self-efficacy and outcome expectations, key constructs in SCCT, in motivating students to pursue STEM careers. The qualitative reflections revealed that students not only gained technical skills but also developed confidence in their ability to solve problems, collaborate, and envision themselves in STEM professions.

Third, the demographic diversity of the camp participants demonstrates the potential of informal STEM programs to promote educational equity. By offering accessible, culturally relevant programming, these camps help bridge gaps in STEM exposure and opportunity, particularly for students who may not have access to such experiences in formal school settings. These camps support federal initiatives like the 2024 Federal Strategic Plan for Advancing STEM Education, which emphasizes informal learning as a key strategy for cultivating a diverse and skilled STEM workforce.

Finally, the integration of qualitative and quantitative data in this study offers a comprehensive understanding of how informal STEM education impacts student development. The use of the STEM-CIS survey, TARE observations, and daily reflections allowed for a nuanced analysis of student growth in both cognitive and affective domains. These insights can inform future program design, emphasizing the importance of experiential learning, mentorship, and inclusive practices in STEM outreach.

6.2. Conclusion

This study provides compelling evidence that informal STEM education programs, such as the University-run STEM summer camps, can significantly enhance students' interest in STEM careers, particularly in engineering and mathematics, while also fostering self-efficacy, collaboration, and career exploration. The integration of quantitative and qualitative methods enabled a comprehensive understanding of how students engaged with STEM content and how these experiences impacted their career aspirations.

Although the program is referred to as a STEM camp, the structure and content of some activities involved creative media, game design, and photography, centering on artistic expression and design thinking. Few students engaged deeply with artistic concepts and how these experiences shaped their understanding of design and creativity, the skills that are increasingly valued in interdisciplinary STEM fields. However, the study does not provide a direct comparison of changes in student attitudes toward engineering versus the arts.

Future research should investigate how different disciplinary emphases within informal learning environments impact student motivation and career aspirations. Future researchers may also consider conducting longitudinal studies to track whether the increased interest in STEM careers persists over time and translates into actual academic or professional choices. Additionally, expanding the sample to include a broader geographic and demographic range would help assess the generalizability of the findings. Researchers may also investigate the impact of specific camp components, such as mentorship, project-based learning, or exposure to STEM professionals, on various student populations. Comparative studies of virtual and in-person STEM camps could also yield valuable insights into the effectiveness of different delivery models.

While the relevant research (e.g., Appel et al., 2022; Hynes et al., 2023) highlights the importance of informal STEM programs for disadvantaged students, it did not collect data on direct socio-economic indicators such as household income. The term "disadvantaged" was used in alignment with the camp's outreach goals, which prioritized recruitment from rural counties, underrepresented racial/ethnic groups, and schools with limited STEM resources. Students were invited through partnerships with school districts and community organizations known to serve historically marginalized populations. However, because socio-economic data were not systematically collected, the study cannot make definitive claims about the impact on specific subgroups. Future research should incorporate demographic and socioeconomic variables to assess equity outcomes and tailor programming more effectively to meet the needs of diverse learners. Therefore, educators and program designers should prioritize culturally responsive, hands-on learning experiences that align with students' interests and real-world applications. Incorporating structured reflection, mentorship, and exposure to diverse STEM professionals can further enhance the impact of such programs. Policymakers and school leaders are encouraged to invest in informal STEM initiatives, particularly in underserved communities, to promote equity and workforce readiness.

6.3. Limitations

While this study offered valuable insights, it is not without limitations. The sample size, though diverse, was limited to students who self-selected into the program, potentially introducing selection bias.

Second, the two parts of the STEM Career Interest Survey (STEM-CIS) were administered only four days apart, at the beginning and end of the five-day camp. While a more extended follow-up period would have provided more substantial evidence of lasting impact, this was not feasible due to the nature of the study. Participants returned to their home communities immediately after the program concluded, making post-camp data collection beyond the final day logistically impractical.

Third, although 140 students participated in the camp, only 87 completed both the pre- and post-camp surveys, resulting in a non-response rate of approximately 38%. The final sample was determined based on complete survey responses, which were necessary for conducting paired-sample statistical analyses.

Fourth, the camp structure itself may have contributed to self-selection bias. Students enrolled in STEM-focused modules, such as engineering, drone technology, creative media, and health sciences, had no alternative non-STEM tracks to choose from. As such, participants likely had a pre-existing interest in STEM, which may have influenced their baseline levels of motivation and career interest. Future studies should consider including a control group or comparing outcomes across different types of camps to better isolate the effects of STEM-specific programming.

Despite these limitations, the study's strengths lie in its mixed-methods design, which allowed for triangulation of data and a richer understanding of student experiences. The use of validated instruments (STEM-CIS and TARE), combined with daily reflections, provided both breadth and depth in assessing outcomes. The study also contributes to the growing body of literature emphasizing the importance of informal STEM education in promoting equity, engagement, and career development.

In conclusion, this research underscores the transformative potential of informal STEM programs in shaping students' academic and professional trajectories. By continuing to refine, expand, and study these initiatives, educators and researchers can play a pivotal role in building a more inclusive and innovative STEM future.

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