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BOARD # 208: Interest Development in Engineering: Analysis of an Energy-Focused Engineering Summer Program for High School Students (WIP)

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In this work in progress paper, we present preliminary findings from an engineering technology summer camp for high school students at a southwestern university. This pilot program was designed to trigger situational interest in engineering, with the aim of fostering individual interest—critical for developing a skilled engineering workforce. According to The Engineering Mindset Report, broadening access to engineering is "critical to the future of engineering as a profession" [1]. This study explores how the summer camp broadens access by examining the development of interest in high school students, aligning our findings with the report's call for more inclusive pathways to engineering.

Interest Development

The theoretical framework for this study is Hidi and Renninger's [2] four-phase interest development model, which emphasizes the dynamic and developmental nature of interest, with each phase building upon the prior to support deeper engagement and learning. The model outlines a progression from situational interest, triggered by external factors, to individual interest, characterized by sustained personal engagement and intrinsic motivation. Situational interest is driven more by the activity or task itself, which has implications for instruction. Re-engaging in the content over time builds the content knowledge and skills needed to persevere when challenges arise. Then individual interest develops, allowing students to drive their own learning in the domain. Both types of interest capture and sustain students' attention toward the goal of learning in their chosen area.

The four phases are as follows:

- Phase 1: Triggered Situational Interest: Stimulus in the environment (e.g., classroom activity) that grabs an individual's attention
- Phase 2: Maintained Situational Interest: Sustained situational interest and re-engagement in meaningful tasks
    - Feeling: This study divides maintained situational interest into two subcomponents: feeling and value [3]. The feeling component refers to the emotions associated with specific content
    - Value: Perceiving content as significant beyond the current activity or environment
- Phase 3: Emerging Individual Interest: Development of a lasting inclination to seek out opportunities to reengage with specific content due to positive emotions and perceived value
- Phase 4: Well-Developed Individual Interest: Enduring inclination to reengage with specific content due to stronger positive emotions and greater perceived value [2]

Interest development has a unique trajectory for each individual, however, the early phases can be sparked by engaging activities in the environment. This has particular implications for presenting early opportunities to engage in STEM so that students may progress to individual interest before entering college. Thus, the current study focuses specifically on phases 1-2.

Situational Interest in Engineering

In classrooms, students display a range of engagement levels with the content based on their interest. Interest, a domain-specific motivational construct [2], could look very different in math class than in language arts for a student. As teachers design instruction, they might choose a commonly researched strategy for elevating situational interest, such as novelty, social interaction, meaningfulness, choice, complexity, or hands-on activities [4]. These practices mesh well with engineering content.

Several studies have reported promising findings from interventions designed to generate situational interest in K-12 engineering. For example, Benek and colleagues [5] created a middle school engineering workshop that included hands-on design challenges with practical application to real-world scenarios. Through observations, interviews, and participants' self-reports, researchers found that the activities increased creativity, problem-solving skills, and collaboration. Another study of high school girls gave participants the ability to choose design projects and supported them through the storyboarding or prototyping stage [6]. Notably, the participants' interest in pursuing engineering in college grew from 18% to 51% after this 18-month study. This shows that situational interest can grow into individual interest, particularly in high school students.

Current Study

The current study was designed to better understand the situational interest of high school students participating in a new engineering summer program. Through employing several research-supported strategies to promote engagement and build interest [4] with authentic engineering content, the goal of this program is to create situational interest and provide opportunities for students to explore individual interest. Situational interest, if supported, can develop into long-term pursuit of STEM domains in college and/or careers.

We explored situational interest through the following questions:

1. How do high school students' interest levels change from beginning to end of a weeklong engineering camp in:
    a. Triggered Situational Interest (engagement)?
    b. Maintained Situational Interest-Feeling (enjoyment)?
    c. Maintained Situational Interest-Value (meaning)?
2. How do high school students describe their interest in this program and in engineering in general?

Methods

Program

A southwestern university hosted a weeklong summer program for rising 10^{th} through 12^{th} grade students interested in engineering and computing. The program participants (n = 30) ranged in age from 13 to 17. The goal of the program was to build the students' knowledge and interest in engineering and computer science through a series of interactive lessons and activities. The overarching theme of the program was the study of energy, with this broad topic serving as the backdrop for the study of various engineering disciplines. The daily lessons and activities included the following:

- Rolling Energy (Monday): where students built and raced a dragster vehicle that was powered by a small, compressed carbon dioxide gas canister

- Electrical Energy (Tuesday): where students created a variety of circuits and then constructed a flashlight generator and magnetic wire motor.
- Energy Prediction (Wednesday): where students were introduced to Python programming syntax and were then tasked with creating a code to model projectile motion
- Flying Energy (Thursday): where students assembled and flew model aircraft that were powered by rubber bands.
- Harvesting Energy (Friday): where students built model wind turbines and tested them with a box fan. Through measurements of factors such as the fan-produced wind speed and turbine electricity output, students were able to calculate the efficiency of each turbine.

In addition to performing design and building tasks, students were also led through computer programming exercises in both the Arduino and Python programming languages. The Arduino language was used to program microcontrollers for a variety of small projects, including a non-contact, ultrasonic distance sensor and a laser-based object speed sensor. The Python language, meanwhile, was used primarily in the Energy Prediction (Wednesday) module, wherein students were given introductory training in Python then allowed to develop code that predicts the speed evolution of a launched, rolling vehicle as it encounters wind resistance and rolling wheel friction. The culmination of the program was an Open House in which parents and other visitors were invited to visit the working spaces of the academy and observe the projects that the students had developed during the week.

Data Collection and Analysis

This study employed a convergent parallel mixed method design, including a 12-item situational interest survey (adapted from [3]) on the first and final days in addition to written responses to open-ended questions collected throughout the week. The survey measure investigated engineering-specific situational interest in three constructs from the four-phase model [2]: triggered situational interest (TSI), maintained situational interest-feeling (MSI-Feeling), and maintained situational interest-value (MSI-Value). Each subscale was comprised of four questions and rated on a 7-point likert scale from strongly disagree to strongly agree. Quantitative surveys of situational interest were compiled and analyzed in SPSS version 29.0 [7] as paired-samples t-tests. Data met all assumptions for the proposed analysis and a Bonferroni correction was applied ($p < .017$ for significance).

Seven qualitative, open-ended questions were designed to reflect the same three constructs as the survey while digging deeper into participants' experiences. For example, mid-week we asked participants to *describe a time this week when you were particularly excited or fascinated by engineering. Explain why.* Then on the last day, we asked: *Of everything you learned in camp this week, did anything stand out as important (to you personally or to society)? Explain why.* Coding followed a framework analysis procedure [8] to look for instances of TSI, MSI-Feeling, and MSI-Value. The *a priori* framework was applied specifically to engineering as follows: TSI represents when a stimulus or activity in the environment grabs attention, MSI-Feeling is when the individual connects a feeling of enjoyment beyond the activity to the field of engineering, and MSI-Value is finding meaning and significance in engineering beyond current activities to the future self or broader society [2], [3]. Individual interest was also included in our coding in case students expressed it, however we emphasized situational interest due to the short duration of the program.

Results

Paired samples *t*-tests revealed that students' interest increased in TSI, MSI-Feeling, and MSI-Value. See Table 1 for descriptives. TSI significantly increased from pre- to post- with a large effect size as measured by Cohen's *d*, $d = .97$, $t(22) = -4.67$, $p < .001$. MSI-Feeling also significantly increased with a large effect, $d = .84$, $t(20) = -3.86$, $p < .001$, and MSI-Value significantly increased with a medium-large effect, $d = .49$, $t(21) = -2.29$, $p = .016$. This shows that situational interest was maintained throughout the camp and students began to transfer their interest and positive feelings about the camp to engineering as a field and future career.

Qualitative responses were analyzed through a process of framework analysis [4] while staying open to additional emergent themes. Participants' responses provided evidence of TSI, MSI-Feeling, and MSI-Value. TSI was highlighted through a focus on the integrated nature of the activities: "I like building things because I enjoyed seeing how to implement different things such as circuits and coding together." Participants shared that the activities were fun and interesting because they were hands-on and they enjoyed learning something new. For example, "[I enjoyed] making the planes, because it taught me a lot about physics concepts I haven't learned yet." Tackling new and challenging content was brought up by others as well: "Coding [was the most interesting]. I've always wanted to learn how to code, and it provided me the most trouble." Overall, participants reported experiencing TSI when the activities were hands-on, novel, or challenging.

Responses reflecting MSI-Feeling similarly shared engaging experiences, but focused on the interaction of activity and self, such as "I think tinkering with ways to improve my build was the most interesting because I enjoy innovation." Many participants hinted at enjoyment beyond the current activity, "…Just building things, and tweaking them is my favorite. I've always enjoyed that. That's why I love robotics so much, seeing the intricacies of what makes things physically function is the most appealing thing." This makes sense given students' willingness to attend an engineering summer program. A past experience where TSI occurred, such as robotics for this participant, can spur re-engagement in similar activities, such as this summer program.

Finally, MSI-Value was expressed in the program activities as related to self and society. In particular, high school participants were thinking about their future majors and careers: "I enjoy learning the ins and outs of mechanical wiring and laws, because it will be helpful later in my career." Additionally, some of the activities were perceived as useful in daily life, such as "…soldering, I feel like it's a very useful skill." Beyond themselves as individuals, participants also shared that the activities connected to their broader worldviews, such as "I would say the way we use energy is very important as a society. We learned how it is manipulated different ways for our needs which is important to know..." Additionally, some responses hinted at individual interest, which goes beyond situational interest. For example, one student's response, "I really want to know more about engineering overall, and in particular I want to gain experience in a variety of types of engineering, so I know what I want to do in the future," showed a higher level of motivation and indicated that attending this summer program was just a small step in their overall development.

Discussion

This study's findings provide preliminary evidence that a weeklong engineering summer camp can effectively trigger situational interest and support the development of more sustained interest in engineering among high school students. Using Hidi and Renninger's [2] four-phase model of interest development as a framework, the increases in triggered situational interest (TSI), maintained situational interest-feeling (MSI-Feeling), and maintained situational interest-value (MSI-Value) observed in this study suggest that brief but targeted interventions can successfully initiate the early phases of interest development. This agrees with findings of other similar engineering design interventions with positive outlooks on increasing situational interest (e.g., [5]), with our study showing growth quantitatively as well as qualitatively. Our findings that situational interest could significantly increase through the short duration of one week highlights that the intensity of this program made a difference in students' engineering interest. Supported by qualitative findings, students noted that this was due to the variety of novel and known situations providing challenges that could be solved independently or with support.

High school is a critical period for shaping students' interests, as decisions about post-secondary education and career paths are often made during this time. The hands-on and interactive nature of the camp provided participants with opportunities to engage with engineering concepts in meaningful ways, fostering connections between the activities, their personal goals, and societal applications. Qualitative responses further support these findings, with students expressing enjoyment in building and innovating, as well as recognizing the relevance of energy and engineering to societal challenges. These results highlight the potential of such interventions to influence students' perceptions of engineering as a future academic and career option.

Additionally, this work aligns with *The Engineering Mindset Report* [1], which emphasizes the importance of broadening participation in engineering to ensure the future vitality of the field. Programs like this camp serve as an inclusive pathway to introduce diverse groups of students to engineering. By offering accessible and engaging experiences, these initiatives create opportunities for students who might otherwise have limited exposure to the field. As a result, the camp's structure and outcomes align with broader calls to expand access to engineering education and promote diversity within the profession.

Future Directions

Future directions for this WIP study include repeating the survey with larger samples and including interviews with participants to more deeply understand the mechanisms of the camp that facilitate interest. Expanding the qualitative component of the study is essential to learning when and how participants are developing interest in engineering.

Several participants also shared that they were interested in pursuing engineering and looking into college engineering programs on the first day of the program. The current study is limited by the number of participants and the short amount of time they are on campus. However, if any program participants become students at our university or even come back to the summer program in subsequent years, there may be longitudinal research opportunities. A strength of this study is that our measures are brief and they could reasonably be repeated over time. Through analyzing secondary students' interest in engineering over a longer period of time, we could capture more phases in their interest development progression. It is through this type of research that we can hope to understand and facilitate interest toward STEM careers.

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Table 1: Descriptive Statistics from Pre- and Post-Surveys of Situational Interest

	Pre-Survey Mean (SD)	**Post-Survey Mean (SD)**
TSI	20.16 (3.26)	23.27 (2.79)
MSI-Feeling	23.67 (3.29)	24.64 (3.08)
MSI-Value	22.44 (2.99)	23.68 (3.01)