A Better Life for the People Around Me: The Affective Layers of High School Students Perceptions of STEM Club

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[Fundamental]

Abstract

Broadening participation in engineering necessitates that educators take a learning-oriented stance to explore and understand the ways that learners from marginalized communities experience STEM. Students' affective experiences (e.g. feelings of difficulty and enjoyment) are critical pieces in their access to STEM learning in general, and engineering education specifically. In addition, their beliefs about the importance of STEM and its relevance to their families and communities are also important. Research on the connections between students' beliefs and affective experiences of STEM would contribute to our understanding about the ways that place-based affective and value-based understandings of STEM interact. This study explored the how high school students who pursue extracurricular STEM experience STEM in affective dimensions and what they believe about the importance of STEM to their families and communities. Findings from this study revealed consistent connections between the difficulties faced by students in STEM programs as related, and even valuable, aspects of what is also enjoyable about STEM. The study also revealed that students perceived the importance of the technologies (e.g. robotics, renewable energy) to their communities but they perceived that this value was not necessarily visible to members of their communities.

Purpose

Broadening participation in engineering necessitates better understanding of the ways that learners from marginalized communities experience STEM. Students' affective experiences (e.g. feeling of difficulty and enjoyment) are critical pieces in their perceptions of access to STEM learning in general, and engineering education specifically. In addition, their beliefs about the importance of STEM and its relevance to their families and communities are also critical [3]. Research on the connections between students' beliefs and perceptions is needed to understand the ways that place-based affective and cognitive understandings of STEM interact [4].

The research questions that frame this study examine *high school students who self-select into extracurricular STEM.*

(1) What is the affective nature of STEM experience for students who seek out STEM experiences?
(2) What are the beliefs about the importance of STEM in their families and communities among students who seek out STEM experiences?

Background

Fredrickson's [X] Broaden and Build Theory of Positive Emotions define emotions as a subset of affective phenomena where affect

> refers to consciously accessible feelings" (p. 2) but are also present within attitudes, moods, and other phenomena. The Broaden and Build Theory suggests that positive emotions play a critical role in broadening "people's momentary thought-action repertoires and [also] build their enduring personal resources, ranging from physical and intellectual resources to social and psychological resources. (p. 3)

The positive feelings of high school students about STEM must play a critical role in their retention in STEM and persistence on STEM workforce pathways. This study was informed by the Broaden and Build Theory and examined the positive feelings of a group of high school students who self-selected into extracurricular STEM to understand how their positive feelings toward STEM served their broadening of STEM beliefs in their school-based and home-based lives.

Methodology

This mixed methods study drew on two data sources: (1) the Common Instrument Suite-Student (CIS-S) survey, and the (2) Green STEM Community Questionnaire. The former is a self-report survey designed for out-of-school and in-school STEM programs that includes STEM attitudes and 21st Century and social emotional skills. The latter is an open-ended questionnaire that elicits respondents' perceptions about their STEM experiences and connections between STEM, sustainability, and their community. The survey was developed by Noam and colleagues [5] and is an established survey that has been used to conduct research and evaluation with out-of-school programs. The questionnaire was developed by the authors and has been used in previous studies [6]. The questionnaire elicited open ended responses to questions about the challenges students faced in programming, the aspects that were enjoyable, and the connections and value of program skills and technologies to their homes and communities.

Analysis

Codes were developed inductively in three iterations. First, the first author developed an initial set of codes that described three questionnaire items. These items were: (1) *Tell us about your STEM experience, what has been fun or enjoyable? (2) Tell us about your STEM experience, what has been difficult? (3) Think about your neighborhood and family. How important is STEM and green energy to the people you live with and around?* These reflected students' perceptions of the most enjoyable aspects of their STEM experiences, the most difficult, and their beliefs about the relevance and importance of STEM to their families and communities. The first author conducted analyses at two separate time points and intra-rater agreement was achieved first. The other authors then conducted their own analyses using the codes generated by the first author

initially, which were then refined. Discussion among raters resolved several instances of disagreement until inter-rater agreement was established.

Seventeen survey items aligned to their feelings about STEM experiences. The Likert scale of the survey on this section of items was between 1 and 4 where 4 indicated *strong agreement* and a 1 indicated *strong disagreement* relative to statements like *I am interested in STEM inventions* and *I like to participate in STEM projects*. These were analyzed in two ways. First, the sum of their ratings on this section were used to create a single score indicative of their overall feelings about STEM experiences. In addition, the items were grouped into three affective categories: enjoyment, excitement, and curiosity. These categorizations were based on the language in the items. For example, the statement *I like to participate in STEM projects* was categorized as enjoyment due to the word "like". The statement *I am interested in STEM inventions*, was categorized as curiosity due to the word "interest". Items in each of these three categories were then averaged and used to describe the enjoyment, excitement, and curiosity expressed by each student.

Findings

RQ1 What is the affective nature of STEM experience for students who seek out STEM experiences?

Consistent with mixed methods, a blending process was conducted to explore the affective nature of participants' STEM experience. Specifically, their feelings about STEM relative to how they described the positive aspects of STEM and the difficult aspects of STEM were explored. This comprises the analyses tied to the first research question where their feelings of enjoyment, excitement, and curiosity are described as well as codes related to positive and difficult aspects of STEM alongside their feelings toward STEM.

The enjoyment, excitement, and curiosity indicators on the survey demonstrate that these students, who self-selected into an extracurricular STEM program, held generally positive feelings toward STEM. The survey Likert scale defined 4 as indicative of strong agreement and a rating of 3 indicated agreement. Among 31 students, the average enjoyment score was a 3.28; the average excitement score was 3.34, and the average curiosity score was 3.23. Participants total ratings of their feelings about STEM were also summed and examined against their responses to the questionnaire items *Tell us about your STEM experience, what has been fun* and *tell us about your experience; what has been difficult*. Four codes were generated to describe responses to both questions and these are shown in Table 1 and are accompanied by their definitions and examples.

Table 1

Codes generated from questionnaire for positive and difficult aspects of the experience

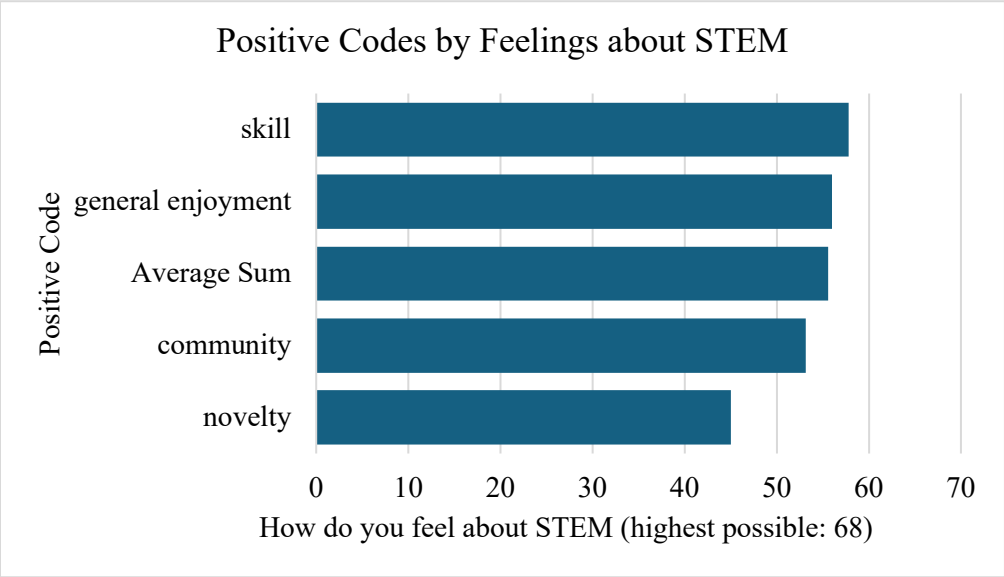
Code category	Code (# instances)	Definition	Example
Positive	Skill	Developing a STEM skill centers the program experience positively.	My [program name] experience has been great so far. I've been able to understand coding and robotics better.
	General enjoyment	The program is generally fun. No specific explanation or examples provided.	It has been very fun. The activities have been fun to work on.
	Community	Either peer or neighborhood experience centers the program experience positively.	[program name] was a fun experience because we got to explore about our community using technology.
	Novelty	The positive nature of the experience relates to exposure to novelty. No specific examples are provided.	It has been fun because I get to a lot of new things.
Difficulty	Skill	Difficulty is focused on a specific skill.	Learning new programming languages.
	Social	Interpersonal difficulties during STEM projects.	When someone talks too much about the work etc.
	Nothing	Student states that no difficulties or challenges arose.	I don't believe anything was difficult. The instructions simplified every project, and our teamwork made us work quickly.
	Challenge	Student acknowledges difficult aspects of the experience but perceives them as positive.	The most difficult part was learning new things about devices, but it was challenging in a good way

The codes that describe how students experience STEM in ways that feel positive are shown in terms of their self-reported survey data about their feelings about STEM in Figure 1. Although

participants who associated skills development with positive STEM experiences had the highest self-reported positive feelings about STEM overall, no statistical or practically significant differences are observable in this data. This is a meaningful finding as it suggests that there are several types of perceived experiences that signify positive STEM experience for students. Students may value different aspects of STEM experience and still have overall positive feelings about their engagement.

Figure 1

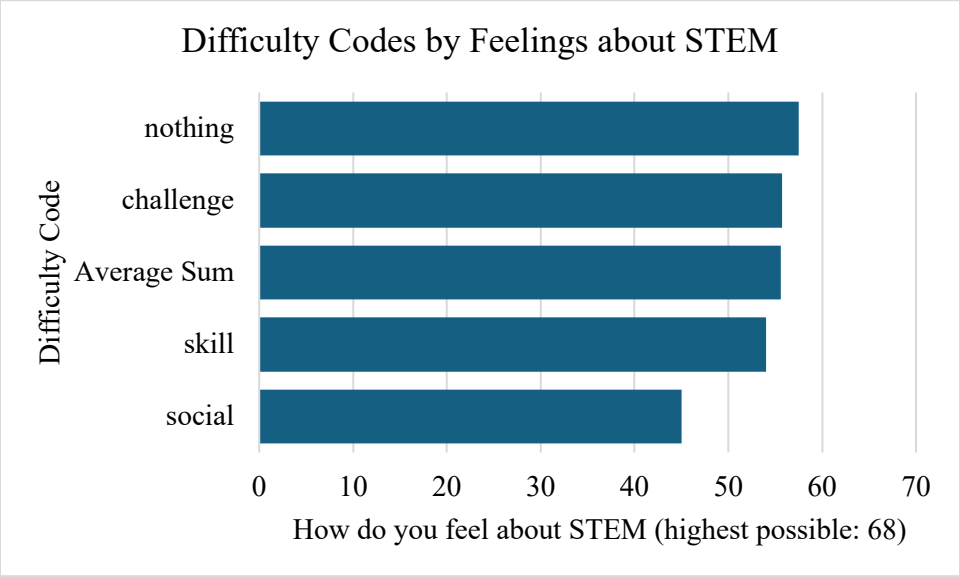
Positive codes (questionnaire data) shown by the average sum rating for feelings about STEM (survey data)



The codes that describe how students experience STEM in ways that feel difficult are shown in terms of their self-reported survey data about their feelings about STEM in Figure 2. Although the number of participants with codes in each category are similar, most commonly participants reported that *nothing* in particular was difficult in the afterschool program. Near in number to *nothing* was *challenge,* which coded statements that described STEM as challenging/hard/difficult but that even that challenge was ultimately positive and part of the experience they enjoyed. Specific skills like coding in robotics and the frustrations that accompany working in teams comprised the other two codes.

Figure 2

Difficulty codes (questionnaire data) shown by the average sum rating for feelings about STEM (survey data)



RQ2 What are the beliefs about the importance of STEM in their families and communities among students who seek out STEM experiences?

The blending process that was conducted to examine the participants' belief about the importance of STEM to their families and communities drew on *relevance* and *importance* codes that were developed from the questionnaire item *think about your neighborhood and family. How important is STEM and green energy to the people you live with and around.* Three analyses were conducted to explore the second research question. The codes were developed to describe whether they believe STEM is relevant to their family and what the nature of its importance is to them. The codes were also blended with the data of their feelings about STEM. Specifically, their enjoyment of STEM was blended with the codes to explore whether patterns are suggested by the data. Thirdly, among students who reported whether English was the language spoken at home; the distribution of relevance and importance codes were examined.

Three codes were generated to describe whether STEM was believed to be relevant to participants' families: *relevant, irrelevant,* and *unsure.* These are defined in Table 2 and examples from the questionnaire are provided. Five codes were developed iteratively, in a process similar to that used to address the first research question, to describe their beliefs about the importance and what the nature of that importance is to their families. These codes and associated examples are provided in Table 2. Their beliefs indicate empathies with their families and communities that illustrate local tensions. For example, the *health* code was generated with responses that described the challenges for older people in their family and the factories and pollutants in their communities.

Table 2

Codes generated from questionnaire for the relevance and importance of STEM and green energy to their families and communities

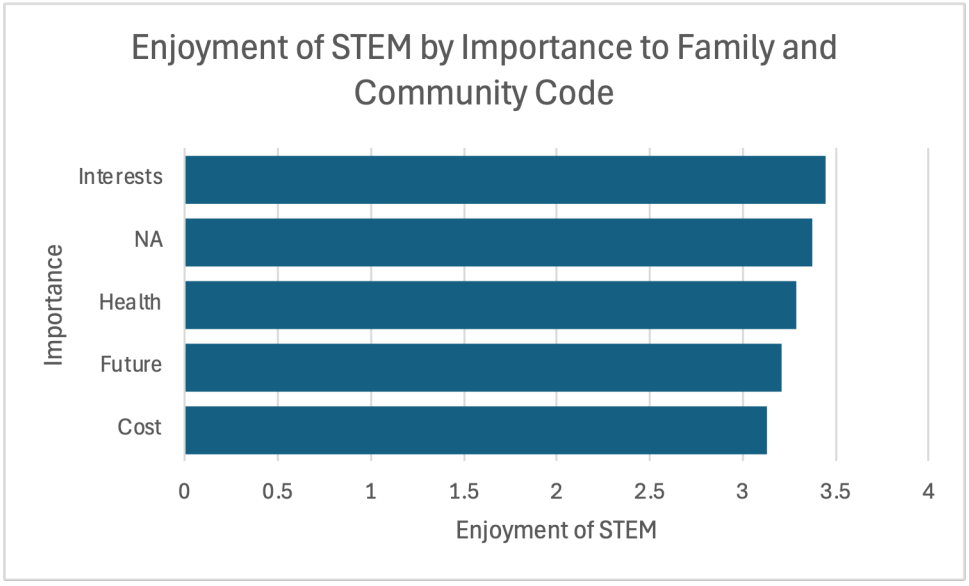
Code category	Code (# instances)	Definition	Example
Relevance	Relevant (26)	Developing a STEM skill centers the program experience positively.	STEM is very important to my family and community. Even as technology continues to advance, green energy must be interconnected with those advancements which will affect them.
	Irrelevant (3)	STEM is not viewed as relevant to their family or community.	It's not really important in their lives.
	Unsure (2)	Student claims neither relevance or irrelevance of STEM for their family or community	I don't know.
Importance	Health (9)	Either age or pollution related illness are the focus of the importance	It can help the old people when labor gets hard to do the hard jobs humans can't/we live near a factory so it's important to protect the environment.
	Cost (5)	The importance to their family or community is centered on saving money	It gives safe energy and lets my family and neighbors save money in the long run.
	Future (7)	The relevance to their family or community is focused on the near or distant future	It is very important to use STEM because we need to improve it for the future generations.
	Interests of Family (2)	Student acknowledges difficult aspects of the experience but perceives them as positive.	Due to hobbies. My cousins play a lot of videogames (Fortnite, Minecraft, free fire) so it matters to them.
	Not Applicable (8)	Response ascribes no importance of STEM within their family or neighborhood	It is important to people around me. Some have solar panels on their roofs. My own family that I live with [though] don't really

	community. Or indicates their family does not value STEM.	do any practices contributing to green energy, sadly.

The blending of the *importance* codes with the data of their feelings of enjoyment about STEM indicate that for this group of 31 participants they held a variety of different beliefs that are potentially unrelated to their feelings of enjoyment about STEM. Figure 3 illustrates the average enjoyment ratings by code where a 3 indicates agreement with enjoyment indicators and a 4 indicates strong agreement.

Figure 3

Importance of STEM codes (questionnaire data) shown by the average Likert ratings for feelings of enjoyment about STEM (survey data)



Approximately half of participants were multilingual, and the afterschool program was conducted in the home language of students in instances where their English language fluency was still developing. Participants were also asked on the questionnaire and survey whether English was the language spoken within their families. They were able to indicate if they preferred not to answer. Nineteen participants provided a response, and the breakdown of the importance codes and relevance codes are shown in Table 3. No inferences can be made due to the small numbers, but it is an area in need of future research that among participants whose home language was not English that they exclusively held beliefs that STEM was relevant to their families and that their affective feelings about STEM were an average 7.7 points lower than students whose home language was English.

Table 3

Relevance and importance of STEM codes by home language (n=19)

English at home? (#)	Importance to family (#)	Relevance to my family (#)	Average of STEM Feelings
No (8)	Cost (1)	Relevant (1)	42
	Future (2)	Relevant (2)	46
	Health (2)	Relevant (2)	56.5
	Interests of Family (1)	Relevant (1)	68
	NA (2)	Relevant (2)	57.5
No English at Home (8) Average of STEM Feelings			53.75
Yes (11)	Cost (2)	Relevant (2)	61
	Future (3)	Relevant (3)	64
	Health (4)	Relevant (3)	60
	NA (2)	Irrelevant (1)	54
		Unsure (1)	68
		NA Total (2)	61
English at Home (11) Average of STEM Feelings			61.45

Discussion and Conclusions

This study reveals consistent connections between the difficulties faced by students in STEM programs as related, and even valuable, aspects of what is also enjoyable about STEM. Murphy et al.'s [7] review of STEM motivation literature describes self-concept, self-efficacy, and task value as key factors in STEM motivation. The value of STEM experiences and self-belief in their abilities to persist may underlie why difficult feelings of challenge in STEM also contribute to positive feelings about STEM. The study also revealed that students perceived the importance of the technologies (e.g. robotics, renewable energy) to their communities but whether their families and communities also believed in that importance was unclear. Further research that untangles

whether there are relationships between the importance that family and communities ascribe to STEM relate to, or underlie, young people's beliefs about the importance of STEM is needed.

Among students who self-select into extracurricular STEM programs, their feelings about STEM are unsurprisingly positive overall. The underlying nature of that positivity relates to the sense of accomplishment that developing STEM skills fosters, the opportunity to engage with peers and their community through STEM, and a general sense of fun that accompanies STEM challenges. It may also explain, or otherwise relate to, their beliefs about the importance of STEM to their families and communities.