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STEM Enrichment and Career Development: Analysis of NSF's Young Scholars Program

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Abstract: This paper examines data collected from in-depth interviews with 20 participants of the Young Scholars Program (YSP), a STEM enrichment initiative for middle and high school students in the U.S. that was funded by the National Science Foundation from 1988 to 1996. Using social cognitive career theory (SCCT) as the guiding framework, the analysis considers how the students' motivation, self-efficacy and sense of identity may have been influenced by the YSP experience and how these constructs may have been connected to the development of their careers. Applying epistemic network analysis (ENA) to the data, it was found that greater levels of STEM motivation, identity and opportunities were central to the career development of individuals who ultimately remained in STEM-related professions.

Introduction

Various STEM enrichment programs in K-12 settings have been implemented over the years to increase student knowledge, skills and interest in STEM topics and subjects. A key aim of such programs, particularly those funded through public resources, has been to support and encourage the entry of individuals into STEM-related academic disciplines and ultimately into the STEM workforce. However, whether a young participant eventually decides to pursue and sustain a career in a STEM-related field has been difficult to evaluate. The long-term retrospective study of the Young Scholars Program (YSP) is an effort to address this challenge. The YSP was a federally-funded STEM enrichment initiative that was carried out across the U.S. between 1988 and 1996. Designed for middle and high school students, the YSP sought to: (1) enhance participants' knowledge of and exposure to STEM fields; (2) foster interest in STEM education and research; (3) increase awareness of academic for STEM careers; (4) gain familiarity with universities and research institutions; and (5) enhance confidence in making career-related decisions (National Science Foundation, 1993). With more than twenty-five years having elapsed since the end of the program, the current age of YSP participants range from late 30s to early 50s. Through surveys and interviews of the YSP participants, the retrospective study seeks to examine the impact that the YSP may have had in the subsequent academic and professional trajectories of the young students.

In this context, this paper examines data collected from in-depth interviews with 20 YSP participants. Guided by social cognitive career theory (SCCT), this paper considers how the students' motivation, self-efficacy and sense of identity may have been influenced by the YSP experience as well as how these constructs may have been connected to the development of their careers. Building on Bandura's (1986) social cognitive theory, SCCT focuses on the role of self-efficacy and outcome expectation in mediating interests and goals that lead to choice behavior (Lent et al., 1994). It provides a framework for understanding the relationship and interactions among constructs affect career-related decision-making processes (Lent, Brown, & Hackett, 1994). SCCT also accounts for environmental factors and individual learning experiences in addition to personal attributes, such predispositions and demographic information (Lent et al., 2000). Through the notion of an iterative and dynamic feedback loop, SCCT recognizes the effect that previous career-related actions can have in subsequent decisions (Lent et al., 1994). While not an explicit component of SCCT, the importance of identity formation in career development has been emphasized, particularly in adolescents. In the process of identity formation, adolescents seek to gain a deeper understanding of their own beliefs, values and emotions as well as a sense of their interests and abilities (Gushue et al., 2006). A key component of this process is career exploration, whereby students begin to develop their own vocational or career identity (Macht Jantzer et al., 2009).

Methods

This paper analyzes data collected from semi-structured interviews of 20 YSP participants. Convenience sampling was utilized, as comprehensive lists of participant names and contact information were not retained for many of the YSP projects. The professional fields of YSP participants included in this analysis were split evenly between roles that are STEM-related and those that were not (see Table 1). Both groups of interviewees consisted of individuals from diverse demographic backgrounds.

Table 1
Summary of participants by professional field, gender and race/ethnicity

	Current Professional Field	
	STEM Field	**Non-STEM Field**
Gender		
- Female	5	8
- Male	5	1
- Non-binary	0	1
Race/Ethnicity		
- American Indian/Native American	0	1
- Asian	1	1
- Black/African American	2	2
- Hispanic/Latinx	1	1
- Pacific Islander	1	0
- White/Caucasian	5	3
- Other/Not specified	0	2
Total	**10**	**10**
Sample Professional Roles	Research Scientist / Administrator, Science Teacher, Professor (STEM), Aerospace Engineer, Computer Network Engineer	Artist/Writer, Designer, Judge, Professor (Non-STEM), Business Executive, Higher Education Administrator

Interviews were carried out using an online video conferencing platform. The first part of the interview focused on the experiences of participants during their involvement in the YSP while the subsequent portion concentrated on the development of their academic and professional careers and the influence of YSP in this process. The recorded interviews were transcribed and segmented by sentence. The data was coded independently by two raters using a codebook comprising a total of 13 codes organized around four categories: (a) topic/field; (b) self-reflective constructs; (c) description of YSP experience; and (d) career-related factors (see Table 2). Codes in categories a and b were applied to both sections of the interview data; codes in categories c and d were each applied to interview sections one and two, respectively. For each dataset, two coders reached agreement on the final coding through a process of social moderation (Herrenkohl & Cornelius, 2013).

Epistemic network analysis (ENA) was then used to model the connections between the codes present in the interview data. ENA is a tool in quantitative ethnography, applies statistical and visualization techniques to identify patterns in discourse (Shaffer, 2017). Specifically, connections among codes are modeled in ENA by quantifying their co-occurrences in the recent temporal context (Siebert-Evenstone et al., 2017). The unit of analysis was defined as a participant and a conversation was specified to be the set of lines contained within a section of an interview. A moving window of size 4 was used to model the co-occurrences of codes between a given line and three preceding lines in the same conversation. For each section of the data, subtracted ENA networks were created to compare the patterns of discourse in the reflections of YSP participants currently in STEM-related professional fields and those working in other sectors.

Table 2
Codebook of constructs included in the analysis

Category	Code	Description
Topic/Field	STEM	Direct reference to a STEM-related discipline, field, area or topic
	Non-STEM	Direct reference to a discipline, field, area or topic that is not STEM-related
Self-reflective constructs	Motivation	Gaining interest, desire or intent to pursue further action toward a goal; setting goals/expectations (to propel forward) or a having a sense of direction for the future
	Self-efficacy	Confidence, pride or sense of accomplishment in themselves; belief in one's own ability to complete a task, achieve a goal or succeed; expectation of positive change in their abilities
	Identity	Reference to sense of self, sense of independence or a sense of belonging; reference to permanent or long-term characteristic, ability or state the participant attributed to self
Description of YSP experience	Knowledge Acquisition	Gaining of knowledge or skills by the speaker; description of learning processes in which the speaker took part
	New Experiences	Reference to a new or eye-opening experience for the speaker; description of experiences that enabled the speaker to broaden their perspective

	Peer Interaction	Interactions, exchanges or relationships with peers in social and academic contexts; references to the development of interpersonal/social skills with other participants
	Engagement	Reference to active participation and involvement in an task, project or activity
	Positive Affect	Experience described through explicit expressions of joy, fun, excitement, positive regard
	Negative Affect	Experience described through explicit expressions of stress, sadness, anxiety, regret
Career-related factors	Career Opportunities	Reference to opportunities offered to the speaker for academic and professional development or advancement
	Career Challenges	Reference to academic, professional and personal challenges confronted by the speaker (challenges can refer to obstacles, loss of opportunities, failures, etc. that hinder advancement or development in a particular field, area or career path)

Results

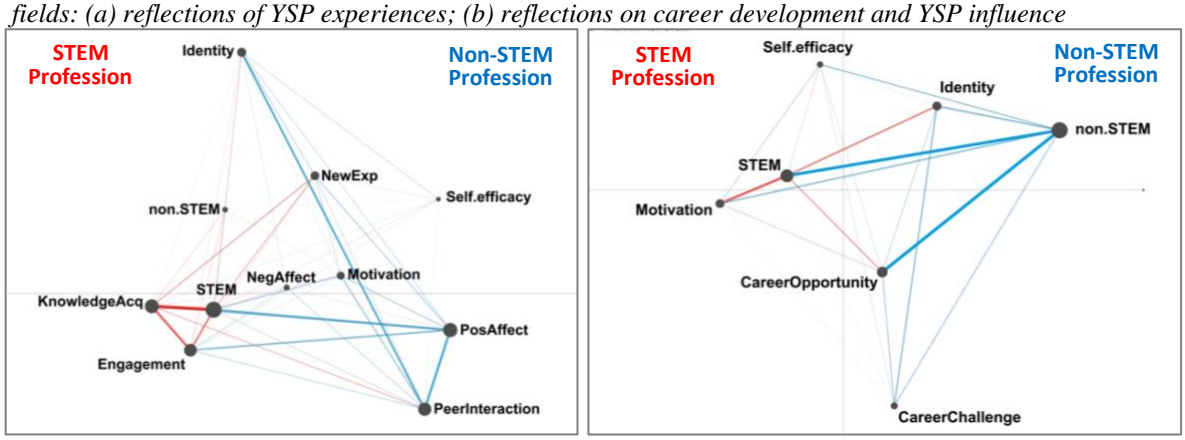
Reflections of YSP experiences

The first analysis explored the differences in the reflections of participants about their YSP experiences (see Figure 1a). For participants who are currently STEM professional fields, their discourse patterns exhibited relatively stronger connections among STEM, KNOWLEDGE ACQUISITION and ENGAGEMENT. This suggests that the active involvement in the learning of STEM content during the YSP left a strong imprint in their minds. As one participant in this group noted: "…prior to the program, I had just a basic, most basic, rudimentary understanding of what science, engineering and math meant in the real world and this very much concretized my ideas, expanded my ideas" (Participant 13).

On the other hand, stronger associations between POSITIVE AFFECT and both PEER INTERACTION and STEM as well as between PEER INTERACTION and IDENTITY can be observed for participants in non-STEM professional fields. This points to the emphasis given to the sense of enjoyment and belonging that these students felt while being with each other and working on STEM-related activities. This connection was articulated in the following manner by a participant in this group: "Yeah, for me, it was just a sense of belonging and that what might have made a person cool or popular or approachable at school didn't really need to cross over into that particular space because we all knew that we were nerds like that. That was kind of like, you know, the baseline. So it's like, we [are] good…we don't have to compete" (Participant 2).

Figure 1

Subtracted ENA models for the discourse patterns of YSP participants in STEM and non-STEM professional fields: (a) reflections of YSP experiences; (b) reflections on career development and YSP influence



(a) (b)

Reflections on career development and YSP influence

Examining the differences in the reflections about career develop and the impact of the YSP, participants working in STEM-related fields displayed relatively stronger connections between STEM and the constructs of MOTIVATION, IDENTITY and CAREER OPPORTUNITY (see Figure 1b). This is indicative of the mutually reinforcing nature of gaining interest, finding opportunities and enhancing one's sense of belonging within the STEM domain. The linkages between STEM topics, identity, motivation and self-efficacy were captured in the comments by a participant in this group: "I think that having YSP and along with some of the other STEM programs that I

participated in, I think all contributed to my love... I mean, number one, my love of science, but number two, that I could do it" (Participant 16).

For individuals who ultimately pursued other professional fields, the reflections placed greater emphasis on the connections between NON-STEM and CAREER OPPORTUNITY as well as between NON-STEM and STEM. The first association is likely to be indicative of the opportunities garnered from other fields that may have eventually led them to their current profession. At times, it was being in the right place at the right time. Reflecting on the shift that he had been asked to make at his company, one participant in this group reflected: "They didn't have somebody to head up product management and brand management and market management. So they asked me to kind of create and manage and develop a team for all of that globally. So I'm now over the product management and brand teams…" (Participant 11). Second, scientific thinking and reasoning continues to benefit participants despite their transition from STEM-related fields. Another participant described how she was able to apply scientific approaches to her first job: "I started that job a week after I graduated college, but there was something about again being thrown into, like this is how STEM is in the real world that I think just helped me be like…well, just take it one step at a time. You know, like, have a hypothesis" (Participant 6).

Discussion

This analysis focused on the interlinkages among motivation, self-efficacy and sense of identity contained in the reflections of YSP participants. Examination of key differences in the reflections of participants currently in STEM-related versus other professions revealed some interesting findings. First, participants working in STEM fields placed greater emphasis on the depth of STEM learning during the YSP, which was followed by higher levels of STEM motivation, STEM identity and STEM opportunities in the development of their careers. This may be reflective of the iterative feedback loop described in SCCT (Lent et al., 1994), whereby their YSP participation may have served as the first career-related action toward a STEM profession. Second, participants in non-STEM fields highlighted the role of peer interactions in enhancing their sense of identity and enjoyment with STEM topics during the YSP. Although they were drawn to other sectors by various opportunities, they nevertheless maintained a connection to the scientific approaches they had learned. Building on this preliminary analysis, further work should seek to investigate the how the three social cognitive constructs relate to career development at the individual level.

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