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DUE S-STEM: Confidence in Academic Ability Among S-STEM Scholars: A Mid-Program Perspective

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Introduction

An important research driver in engineering education is student retention and performance. Many institutions turn towards frameworks like the Social Cognitive Theory (SCT) [1] to provide guidance on such research. Bandura's SCT provides a structure that formalizes human behavior. Particularly applicable to engineering education is the influence of self-efficacy on constructs like motivation, cognitive processes, and life paths [1], [2]. Aligning with SCT, Hunsu et. al found that fostering self-efficacy in sophomore and junior-level engineering students more positively impacted performance over motivation shifting interventions [3]. Another study published in the *Journal of Engineering Education* utilized SCT as a framework guiding qualitative analysis on factors influencing student self-efficacy. The researchers found mastery experiences [1], like internships, most significantly contributed to self-efficacy [4].

Lent et al. adapted the widely regarded SCT framework into Social Cognitive Career Theory (SCCT) to focus on career development. The SCCT expands on factors that shape career and educational development, Figure 1 [5]. Self-efficacy remains a primary component and acts as a predictor of outcome expectations, interests, goals, actions, and performance/attainment [5], [6]. Self-efficacy is derived from four learning experiences: (1) previous personal performance accomplishments, (2) vicarious learning, (3) social persuasion, and (4) physiological and affective states [1], [5]. Person inputs and background contextual affordances (e.g., first-generation college student, low socioeconomic status) are exogenous inputs that can influence learning experiences that can have both positive and negative effects on self-efficacy. Sheu et al. conducted a meta-analysis on the four learning experiences to understand their contribution to the self-efficacy of STEM students and found that all four correlated substantially with their self-efficacy, with the weakest influential factor being vicarious learning [7].

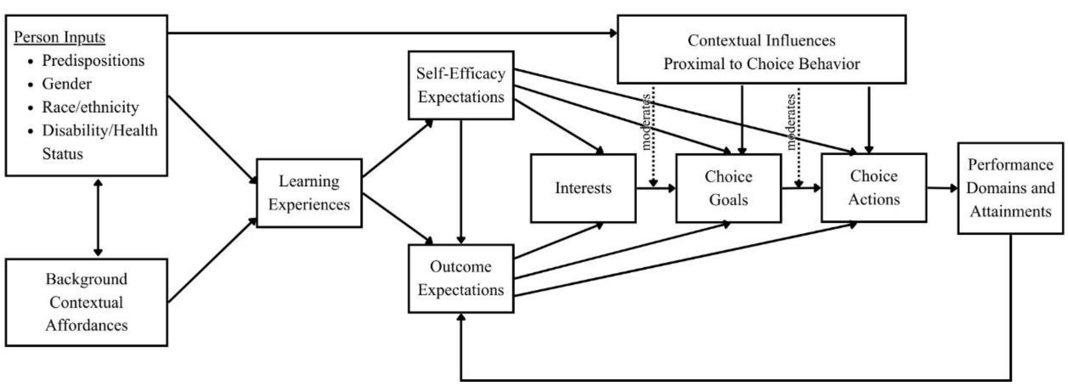

Figure 1. SCCT Framework [5]

For STEM educators who are designing enrichment or intervention programs, recognizing the significant impact of self-efficacy on academic performance is critical. While the inputs of person and background are generally fixed, activities surrounding different learning experiences can be designed to positively impact self-efficacy and customized to the needs of students with specific person and background inputs. This is particularly applicable to projects funded through the NSF S-STEM initiative, which supports academically talented STEM students who have unmet financial need. A primary goal of an S-STEM project is to improve student retention and graduation rates while reducing financial burden and preparing them for the workforce [8]. The article, "The State of SCCT Research in Relation to Social Class: Future Directions," highlights the usefulness of SCCT for people with low socioeconomic status (SES). The researchers recognize that individuals from low SES households often face challenges to their career development and emphasize the need to understand the factors that influence intended versus actual education and career goals. Applying SCCT, the researchers found that self-efficacy served as an informative mediator for the effects of SES status and actual goals and performance [9].

At Louisiana Tech University, two cohorts of low-income students are supported through an NSF S-STEM project called the SUCCESS Scholars Program (SSP), providing financial, academic, and social support while creating opportunities for students' professional growth and career development. This paper provides a mid-program perspective, framed by SCCT, on how students' sense of community with their peers relates to confidence in their academic abilities and career choice, and how these factors influence their desire to continue participating in the SSP.

SUCCESS Scholars Program

The SSP is a five-year initiative that supports two cohorts of students each through four years of study. Cohort 1 (24 students) and Cohort 2 (22 students) entered the program as first-year students in Fall 2022 and Fall 2023, respectively. The student population represents a range of disciplines, including biomedical, chemical, civil, cyber, electrical, industrial, and mechanical engineering, as well as construction engineering technology and instrumentation and controls. At the time of this paper, the students completed their third (Cohort 1) and second years (Cohort 2) years. The academic, social, and career-focused support has evolved over the years of the program to meet the changing needs of the scholars. For more details on the varying support initiatives of the program, reference the papers [10]-[12]. Descriptions of the intensive first-year academic support, cohorting, faculty mentors, peer mentors, social activities, professional development opportunities, and more are described in detail throughout those papers.

Participants & Method

At the end of each year, the scholars are given a survey that consists of Likert and open-ended questions related to the four direct outcomes (DO) and two indirect outcomes (IO) of the project [10]. The focus of this mid-program perspective is IO.2 Increased Confidence in Academic Ability. The end-of-academic-year (EOAY) survey instrument is the primary source of data for this paper. Specific statements connected to the SCCT framework from the EOAY survey were selected for analysis, Table 1. Students were given each statement and asked to rate them using a 5-point scale ranging from Strongly Disagree to Strongly Agree. Analysis of the statements will be given in two parts: item-level descriptive statistics and an ordinal path analysis.

Table 1. End-of-academic-year survey statements used for analysis

Label	Statement	SCCT
A	The support I received from the SUCCESS Scholars Program has increased my ability to succeed in my STEM classes.	Self-efficacy (academic ability)
B	SUCCESS Scholars Program activities made me feel more confident in pursuing a career in STEM disciplines.	Self-Efficacy (career confidence)
C	I feel a sense of community with my fellow SUCCESS Scholars Program students.	Learning Experiences. (social persuasion)
D	I feel motivated to continue participating in SUCCESS Scholars Program activities.	Choice Goal

Analysis & Results

First, a general overview of the responses including item-level descriptive statistics is provided for each statement parsed out by cohort and academic year (AY), Table 2. Class standing and number of responses are provided along with the average response value (AVG), percent positive (answered either a 4-5 on the Likert Scale), and the overall distribution of responses. Due to attrition from the program and students selecting to opt out of the survey, each academic year contains varying response numbers. It should also be noted that because surveys are answered anonymously, linking an individual's response to each year's survey is not possible.

Table 2. Item-level descriptive statistics for end-of-academic-year survey statements.

Cohort	AY	Class Standing	Responses (N)	AVG	% Positive	Distribution 1 | 2 | 3 | 4 | 5
Statement A: The support I received from the SUCCESS Scholars Program has increased my ability to succeed in my STEM classes.						
1	22-23	1st Year	20	4.8	95	0 | 0 | 1 | 2 | 17
1	23-24	Sophomore	16	5.0	100	0 | 0 | 0 | 0 | 16
1	24-25	Junior	15	4.9	100	0 | 0 | 0 | 1 | 14
2	23-24	1st Year	20	4.8	95	1 | 0 | 0 | 0 | 19
2	24-25	Sophomore	18	4.7	94	1 | 0 | 0 | 2 | 15
Statement B: SUCCESS Scholars Program activities made me feel more confident in pursuing a career in STEM disciplines.						
1	22-23	1st Year	20	4.7	95	0 | 0 | 1 | 5 | 14
1	23-24	Sophomore	16	4.7	100	0 | 0 | 0 | 5 | 11
1	24-25	Junior	15	4.9	100	0 | 0 | 0 | 1 | 14
2	23-24	1st Year	20	4.7	95	1 | 0 | 0 | 2 | 17
2	24-25	Sophomore	18	4.7	94	1 | 0 | 0 | 1 | 16
Statement C: I feel a sense of community with my fellow SUCCESS Scholars Program students.						
1	22-23	1st Year	20	4.8	100	0 | 0 | 0 | 4 | 16
1	23-24	Sophomore	16	4.8	100	0 | 0 | 0 | 4 | 12
1	24-25	Junior	15	4.9	100	0 | 0 | 0 | 1 | 14
2	23-24	1st Year	20	4.8	95	1 | 0 | 0 | 0 | 19
2	24-25	Sophomore	18	4.7	89	1 | 0 | 1 | 0 | 16
Statement D: I feel motivated to continue participating in SUCCESS Scholars Program activities						
1	22-23	1st Year	20	4.8	95	0 | 0 | 1 | 2 | 17
1	23-24	Sophomore	16	4.9	100	0 | 0 | 0 | 1 | 15
1	24-25	Junior	15	4.9	100	0 | 0 | 0 | 2 | 13
2	23-24	1st Year	20	4.8	95	1 | 0 | 0 | 1 | 18
2	24-25	Sophomore	18	4.6	89	1 | 0 | 0 | 1 | 15

Next, directional framing is applied to the survey statements based on their relationship with SCCT constructs. This assessment adds depth beyond simply highlighting how highly the students rated the statements and allows for analysis that does not need person-level tracing with the data. It demonstrates how program experiences translate into goals as well as highlights how the data from the survey aligns with the theoretical framework. Figure 2 overlays the statements from the survey onto the SCCT framework.

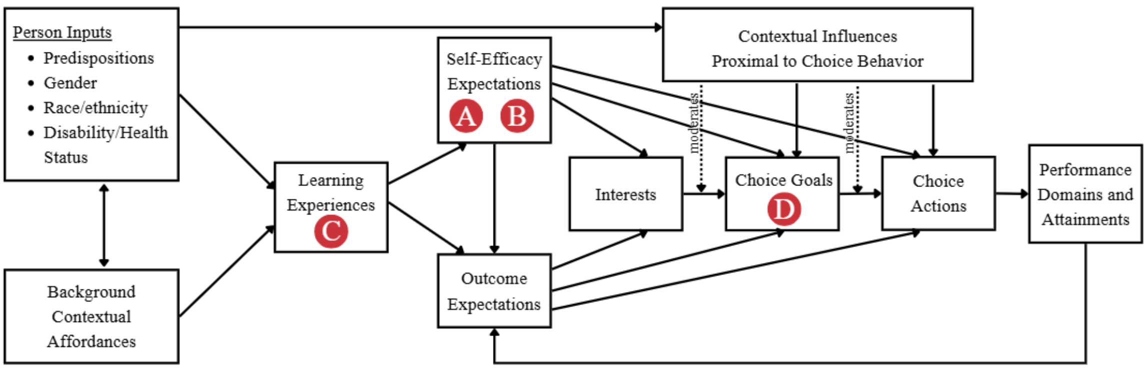

Figure 2. SCCT Framework [5] with end-of-academic-year survey question overlayed.

Using an ordinal path analysis helps understand the strength and direction of the relationships for the variables: A (Self-Efficacy: Academic Ability), B (Self-Efficacy: Career Confidence), C (Learning Experiences), and D (Choice Goals). The model is estimated using WLSMV (Weighted Least Squares Mean and Variance adjusted) to account for the ordered categorical variables and the non-normal distribution of the data. The structural plan tests whether A is predicted by C (A ~ C + Controls), whether B is predicted by C (B ~ C + Controls), and whether D is predicted by both A and B (D ~ A + B + Controls), with cohort and academic year included as control variables in each equation. Mediation is tested by looking at the indirect effect of C on D through A and B along with the total effect of C on D. The results of the ordinal path analysis are found in Table 3.

Table 3. Summary of ordinal path analysis (N=89).

Path	Description	Unstd. (B)	SE	p-value	Std. (β)
Direct Effects					
C → A	Learning Experiences to Self-Efficacy (Academic Ability)	0.999	0.480	0.037*	0.562
C → B	Learning Experiences to Self-Efficacy (Career Confidence)	1.183	0.437	0.007**	0.603
A → D	Self-Efficacy (Academic Ability) to Choice Goals	0.906	0.161	<0.001***	0.768
B → D	Self-Efficacy (Career Confidence) to Choice Goals	0.497	0.108	<0.001***	0.465
Indirect Effects					
C → A → D	Via Self-Efficacy (Academic Ability)	0.905	0.353	0.010*	0.431
C → B → D	Via Self-Efficacy (Career Confidence)	0.588	0.245	0.016*	0.280
Total Effect					
C → D	Total Path	1.493	0.378	<0.001***	0.711

*Note: Significance levels: *p < .05, **p < .01, ***p < .001. All control variables (Cohort, Year) were non-significant (p > .05).*

Discussion

For each path analyzed, the results are strong and statistically significant, and the controls (cohort and academic year) both showed no statistical significance. This supports the proposed SCCT framework application for the variables being assessed. The learning experience (C) significantly predicts self-efficacy factors (A and B), and both self-efficacy factors significantly predict the choice goal (D). Therefore, community with their peers in the SSP influenced their self-confidence in their academic ability and career choice which also impacted their choice goal of continuing participation in the SSP. The strongest path is A to D with $\beta = 0.768$ and $p < 0.001$, indicating self-efficacy in academic ability is the primary driver, out of the two assessed, impacting their choice goal of continuing participation in the SSP. Additionally, both indirect paths assessed have statistical significance; thus, confirming that A and B are mediators that bridge C and D. Furthermore, when combining both paths to assess total effect, statistical significance was found. Thus, the students' learning experience (C) has a substantial impact on their choice goal (D). The large standardized total effect value ($\beta = 0.711$) suggests that the intervention being measured is highly effective at shaping student choice goals, which is continuing participation in the SSP.

It is worth noting, that a limitation of this study is the small sample size (N=89) which can cause noise in the fit. The variance for D was found to be -0.068, indicating a Heywood Case [13]. Accordingly, results should be interpreted with caution and viewed as preliminary; however, the primary structural paths and indirect effects were statistically significant and substantively large, suggesting the proposed relationships warrant further investigation with a larger sample.

Conclusion

Table 2 shows that student responses to all four questions in this study were overwhelmingly positive, a trend that remained throughout each academic year. This speaks to the overall positive experiences and perspectives that the students have when reflecting on the SSP. When layering the survey question on the SCCT framework, more information can be gleaned beyond the general statistics of the survey results. Using an ordinal path analysis, statistical significance was found on the pathways assessed. Recognizing how learning experiences, such as a sense of community with peers, shape self-efficacy and, in turn, choice goals helps to understand the impact of the SSP activities. Thus, academic focused initiatives that foster community with peers can positively impact students' desire to continue in such programs. This informs best practices and helps with the future of this and other initiatives.

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