ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #24912

# Toward a Measurement of Co-Curricular Support: Insights from an Exploratory Factor Analysis

**Mrs. Janice Leshay Hall, Virginia Tech**

Doctoral candidate in Engineering Education at Virginia Tech. Her research interests center on broadening participation of underrepresented groups, particularly women of color (WOC), in engineering. Specifically, her doctoral work focuses on exploring the early-career experiences of WOC in engineering industry.

**Ms. Dina Verdín, Purdue University-Main Campus, West Lafayette (College of Engineering)**

Dina Verdín is a Ph.D. Candidate in Engineering Education and M.S. student in Industrial Engineering at Purdue University. She completed her B.S. in Industrial and Systems Engineering at San José State University. Dina is a 2016 recipient of the National Science Foundation's Graduate Research Fellowship and an Honorable Mention for the Ford Foundation Fellowship Program. Her research interest focuses on changing the deficit base perspective of first-generation college students by providing asset-based approaches to understanding this population. Dina is interested in understanding how first-generation college students author their identities as engineers and negotiate their multiple identities in the current culture of engineering.

**Dr. Walter C. Lee, Virginia Tech**

Dr. Walter Lee is an assistant professor in the Department of Engineering Education and the assistant director for research in the Center for the Enhancement of Engineering Diversity (CEED), both at Virginia Tech. His research interests include co-curricular support, student success and retention, and diversity. Lee received his Ph.D in engineering education from Virginia Tech, his M.S. in industrial & systems engineering from Virginia Tech, and his B.S. in industrial engineering from Clemson University.

**Dr. David B Knight, Virginia Tech**

David B. Knight is an Associate Professor and Assistant Department Head of Graduate Programs in the Department of Engineering Education at Virginia Tech. He is also Director of International Engagement in Engineering Education, directs the Rising Sophomore Abroad Program, and is affiliate faculty with the Higher Education Program. His research tends to be at the macro-scale, focused on a systems-level perspective of how engineering education can become more effective, efficient, and inclusive, tends to be data-driven by leveraging large-scale institutional, state, or national data sets, and considers the intersection between policy and organizational contexts. He has B.S., M.S., and M.U.E.P. degrees from the University of Virginia and a Ph.D. in Higher Education from Pennsylvania State University.

**Dr. Allison Godwin, Purdue University-Main Campus, West Lafayette (College of Engineering)**

Allison Godwin, Ph.D. is an Assistant Professor of Engineering Education at Purdue University. Her research focuses what factors influence diverse students to choose engineering and stay in engineering through their careers and how different experiences within the practice and culture of engineering foster or hinder belongingness and identity development. Dr. Godwin graduated from Clemson University with a B.S. in Chemical Engineering and Ph.D. in Engineering and Science Education. Her research earned her a National Science Foundation CAREER Award focused on characterizing latent diversity, which includes diverse attitudes, mindsets, and approaches to learning, to understand engineering students' identity development. She has won several awards for her research including the 2016 American Society of Engineering Education Educational Research and Methods Division Best Paper Award and the 2018 Benjamin J. Dasher Best Paper Award for the IEEE Frontiers in Education Conference. She has also been recognized for the synergy of research and teaching as an invited participant of the 2016 National Academy of Engineering Frontiers of Engineering Education Symposium and the Purdue University 2018 recipient of School of Engineering Education Award for Excellence in Undergraduate Teaching and the 2018 College of Engineering Exceptional Early Career Teaching Award.

# Toward a Measurement of Co-Curricular Support: Insights from an Exploratory Factor Analysis


## Abstract

The purpose of this work-in-progress paper is to share insights from current efforts to develop and test the validity of an instrument to measure undergraduate students' perceived support in science, technology, engineering, and mathematics (STEM). The development and refinement of our survey instrument ultimately functions to extend, operationalize, and empirically test the Model of Co-curricular Support (MCCS). The MCCS is a conceptual framework of student support that demonstrates the breadth of assistance currently used to support undergraduate students in STEM, particularly those from underrepresented groups. We are currently gathering validity evidence for an instrument that evaluates the extent to which colleges of engineering and science offer supportive environments. To date, exploratory factor analysis and correlation for construct validity have helped us develop 14 constructs for student support in STEM. Future work will focus on modeling relationships between these constructs and student outcomes, providing the explanatory power needed to explain empirically how co-curricular supports contribute to different forms of student success in STEM. We hope that operationalizing the MCCS through this survey will shift how we conceptualize and offer student support, enabling college administrators and student support practitioners to evaluate their portfolio of student support efforts.


## Introduction

Financial, physical, and human capital resources are used to provide additional efforts intended to support undergraduate students in STEM, particularly underrepresented racial, ethnic, gender groups in certain disciplines [1]-[3]. With U.S. demographic projections indicating a growth in diversity of the population, we can anticipate an increasingly diverse population of undergraduate students. In preparation for this shift in demographics and in response to historical issues of diversity in STEM, it is important that we begin to rethink our offerings of student support.

The larger project in which this paper is situated aims to help colleges improve their student support investments by developing and testing the validity evidence for an instrument that assesses the magnitude of perceived support provided to undergraduate students in STEM, thereby providing practitioners with a diagnostic instrument for effectively allocating resources that enable/provide student support. The utility of such an instrument can aid STEM educators and college administrators in several ways, including (1) identifying unmet needs in local environments; (2) monitoring progress as it relates to supporting students, and (3) providing data-driven evidence of interventions for target populations.

Our project presents a radically different approach for student support practitioners; rather than focusing on individual interventions, results from this instrument will provide colleges with a comprehensive look across their portfolio of support offerings and on student perceptions of the support provided by their respective institutional contexts. Such data will enable practitioners to identify the types of support that students receive and areas that represent a missed opportunity

to better support students. Disaggregated data will also inform practitioners on how support varies across subpopulations. The purpose of this paper is to introduce this diagnostic instrument to student support practitioners and share the most recent insights from our efforts to test the validity of the instrument to measure undergraduate support in STEM.

## Model of Co-Curricular Support

Student retention in STEM is typically addressed through efforts such as mentoring programs or living-learning communities implemented at the college level (e.g., [4]-[6]); however, theories on student retention traditionally focus on attrition at the institutional level (e.g., [7],[8]). Thus, there is a gap between student-retention theory and STEM student-support practice, which is why the development of our instrument is grounded in the recently developed model of co-curricular support (MCCS).

The MCCS is a conceptual model that provides a lens to examine the most essential elemental experiences of institutional support. By deconstructing student support and revealing the latent experiences that should be facilitated, the MCCS highlights the use of co-curricular support in STEM and is uniquely situated to assist both researchers and practitioners [1],[9]. The model suggests that the professional, academic, and social systems operating within a college (e.g., College of Science or College of Engineering), in addition to the overarching university context in which the college is embedded, are factors that should be considered when evaluating the support offered within STEM learning environments [1],[9].

The MCCS repurposes Tinto's model of institutional departure [8], a commonly cited student-retention model that operates at the university level. Whereas Tinto's model explains how interactions of a student with academic and social systems could influence student retention at an institutional level [8], the MCCS explains how students' interactions with professional, academic and social systems could influence their success more broadly in an undergraduate STEM degree program. The MCCS systematically conceptualizes the learning environment by illustrating the benefits to students who have received co-curricular support across multiple possible elements of institutional support simultaneously. We hope that the use of MCCS to improve STEM learning environments serves as a foundation for better understanding of how to build institutional capacity for supporting diverse undergraduate students in STEM.

According to the MCCS, elements of institutional support are viewed as the essential experiences that students get from interventions [1],[9]. Without limiting our investigation to a particular intervention (e.g., impact of peer mentoring programs), the MCCS lens allows us to investigate the extent to which students receive the support institutions aim to provide. To date, research concerning the MCCS has identified six elements of institutional support: 1) academic performance, 2) professional development, 3) faculty/staff interactions, 4) extracurricular involvement, 5) peer-group interactions, and 6) additional circumstances (for more details on these dimensions see [1]). Although the MCCS provides a way to identify elements of support conceptually, subsequent research is needed to measure these areas. Our work aims to address these gaps.

## Instrument Development

The goal of this research project is to develop and test the validity of an instrument grounded in the MCCS framework that will assess the magnitude of institutional support effectively provided to undergraduate students in STEM. The development and collection of validity evidence as it relates to the instrument can be summarized in five rounds of development. Because the purpose of the project centers around identifying institutional support related to marginalized populations in STEM, we aimed to achieve maximum variation within the students included during the development and revision phases of the instrument, paying close attention to representation across engineering and science disciplines, gender identity, race/ethnicity, and transfer student status.

Members of the research team used purposive sampling to recruit a diverse group of students from two universities. Participants were compensated $15-20, depending on the round of stakeholder feedback and commensurate to the time commitment required. We plan to expand our recruitment efforts in 2019 to increase survey participation/completion numbers from marginalized students. In the remainder of this section, each step of the instrument development process is summarized briefly. For a more detailed description of the process see [10].

## Theoretical Constructs and Item Bank Development

The initial item bank was based on the MCCS, which was developed from a multi-site case study of student support practitioners and students involved in six different student support centers serving STEM students across four U.S. universities [1],[9]. For the development of an item bank, we leveraged the theoretical constructs of the MCCS along with responses collected from students using open-ended surveys along each of the six dimensions of institutional support. This primary round of instrument development allowed us to create a set of items that spanned the full set of theoretical dimensions of student support and to adjust the wording used for each item based on students' feedback; we then began the process for establishing content and face validity for the instrument [11].

The resultant instrument was then revised based on a review of existing instruments suggested to us by our advisory board, collaborators from our institutional partners and otherwise related to our project purpose [10]. The goal was to develop and include questions or statements that captured the extent of student involvement in a variety of programs, activities, or services as well as demographic information more inclusive than typically recorded in educational research. To focus on the underserved sub-populations of particular interest for this project, our demographic questions capture student diversity on a spectrum and includes aspects such as gender identity, race and ethnicity, socioeconomic status, institution, academic major, and transfer student status [12]-[14].

The initial item bank underwent two rounds of feedback with the entire research team. Based on the expertise of the research team, the feedback received consisted of the following: removing questions that were not consistent with the goals of the project; providing suggestions of areas that had not yet been captured by the current questions; providing suggestions of questions that needed expanding or rewording; collapsing questions that were redundant, and dividing

questions that were double or triple barreled. The development phase of this project also included multiple rounds of stakeholder feedback as described below.

**Advisory Board and Stakeholder Feedback**

Once the initial set of items had been vetted by the research team, we sent the resulting instrument to the project advisory board as well as gatekeepers from our respective institutional partner sites. The collective expertise of our three advisory board members spans the areas of qualitative and quantitative research, student support, diversity in STEM, and workforce development. We used the feedback received from the educational research experts and practitioners on our Advisory Board to modify the instrument items for subsequent piloting.

Members of the research team helped recruit a diverse group of students via purposive sampling. The total number of participants selected for interviews and focus groups per institution was based on availability of students meeting our selection criteria. In total we solicited feedback from 46 participants (38 students and 8 administrators). A summary table of the number of participants at each round of stakeholder feedback can be found in Table 1.

*Table 1. Participation of Stakeholder Feedback for Instrument Development*

| **Feedback Round** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| Stakeholders | *Undergraduate Focus Groups* | *Undergraduate Cognitive Interviews* | *Graduate Researchers* | *Administrator Feedback Forms* |
| Number of Participants | 16 | 8 | 14 | 8 |

As this project aims to identify institutional support as it pertains to underrepresented and underserved populations in colleges of engineering and science, we sought representation across various student and personal demographics (e.g., race, gender) during all rounds of revisions and instrument development.

**Student Focus Groups & Cognitive Interviews**

In fall 2017, four focus groups were held, each having four to six undergraduate science and engineering students for a total of 16 participants. For the first round, the focus groups were aimed at identifying high-level issues with the survey (i.e., the applicability of the questions and students' initial reactions to the instrument). Questions aimed at the participants in the focus group ranged from reflecting about the different experiences of student support, whether those experiences were captured in the instrument and identifying any student support experiences that were not represented among available answers. Additionally, participants were asked to look carefully at how the questions are constructed and the wording used in the instrument. The students described how they interpreted questions and gave suggestions to improve question wording. The feedback gained from these focus groups was then used to add new items and response options to the instrument as well as revise existing items for clarity.

Round two focused on individual students' understanding of specific items via cognitive interviews with eight science and engineering undergraduate students. During the cognitive interviews participants were asked to complete the survey "thinking aloud" about their interpretation of each item and how each area of support connected to their own experiences. The purpose of this round was to explore the alignment of students' interpretations and the researchers' interpretations. The cognitive interviews progressed with minimal interruption from the interviewer, apart from instances where students stopped thinking aloud. These cognitive interviews helped to provide evidence of face validity for the survey. Based on the information given by interviewees, we revised survey items that were unclear or had varying interpretations.

**Administrator Forms & Graduate Research Feedback**

In addition to the student focus groups and cognitive interviews, we also received feedback from eight administrators. We sought out administrators based on their expertise working with STEM students at various institutions. We sent administrators a copy of the instrument, along with a feedback form that requested commentary related to institutional appropriateness and instrument use, question format, length, and comprehension of items used on the instrument.
Prior to deploying the instrument, the last phase of development involved feedback from engineering education graduate students who work with the Principle Investigators and Senior Personnel on other projects. Including graduate students from engineering education was done to catch grammatical errors and provide additional expertise related to survey development and implementation, education research, and perspectives of underrepresented groups. The revisions put forth by the graduate researchers were among the final changes made before the pilot instrument was deployed for testing.

**Finalized Pilot Instrument**

The resulting version of the instrument (version 1.0) consisted of eight sections: 1) academic support, 2) faculty-interaction support, 3) extracurricular support, 4) peer-interaction support, 5) professional-development support, 6) additional support, 7) student involvement, and 8) demographics. On sections about various types of support, students were asked their level of agreement to several statements on an anchored numeric scale from 1 - "Completely Disagree" to 5 - "Completely Agree." Students were also given an option of "Does Not Apply to Me." The student involvement section captured students' self-reported involvement in student organizations, co-ops and internships, study abroad, learning communities, and other out- of-class experiences that may have provided opportunities for the perceived supports captured in earlier sections. The demographics section asked information about university affiliation, degree programs, start year, parents' level of education, citizenship status, and a number of identity related questions (e.g., LGBTQ+, disability, gender, race/ethnicity etc.).

**Pilot Instrument Deployment-Spring 2018**

The three institutions included in the initial piloting of the instrument represent three public, research-intensive, land-grant universities. These predominantly white institutions also enroll a large number of engineers each year (~2,000 at University 1, ~2,300 at University 2 and ~1200 at University 3). After the extensive instrument development process, a live link via Qualtrics

TM software [15] and IRB approved recruiting scripts were sent to project partners at each institution. These partners are program directors for several different engineering student support centers who agreed to send the instrument to students at their university either via mailing list or personal emails. The survey was available March-May 2018 and was completed by approximately 700 students across all participating institutions. A summary of the participant demographics across all 3 university sites can be found in Table 2.

*Table 2. Institutional Context and Participant Demographics for Instrument Deployment*

| | *University 1* | *University 2* | *University 3* |
|---|---|---|---|
| **Total Participation** | 598 | 51 | 123 |
| **Gender** | | | |
| Women | 414 | | |
| Men | 283 | | |
| Genderqueer/Non-binary | 7 | | |
| Transgender | 5 | | |
| Agender | 3 | | |
| Gender not listed | 6 | | |
| Prefer not to answer | 11 | | |
| **Race/Ethnicity** | | | |
| American Indian/ Native American/Alaska Native | 9 | | |
| Black/African American | 31 | | |
| Hispanic/Latino/-a | 40 | | |
| South Asian | 46 | | |
| East Asian | 62 | | |
| Southeast Asian | 25 | | |
| Middle Eastern/North African | 22 | | |
| Native Hawaiian/Pacific Islander | 9 | | |
| White | 544 | | |
| Another Race/Ethnicity | 11 | | |

**Exploratory Factor Analysis**

We used an exploratory factor analysis (EFA) to determine the factor structure for the set of variables; this method allows for early exploration of whether the model is useful in providing a parsimonious description and relationship between the observed variables [16]. The observed variables within each factor provide estimates of strength and direction of influence of measured items onto an underlying factor; these estimates are known as factor loadings [17]. Brown [18] outlines four steps when analyzing data using an EFA: 1) factor extraction, 2) factor selection, 3) interpreting factors and evaluating quality of solution, and 4) re-run factor analysis until final factor solution is achieved.

In this study, we used a maximum likelihood factor extraction method, which allows researchers to compute a wide range of fit indexes, test the statistical significance of factor loadings, calculate correlations among factors, and compute confidence intervals for these parameters.

This method is appropriate with normally distributed data; in our study, the data were within recommended ranges of kurtosis less than seven and skew less than positive or negative two [19].

A scree plot and parallel analysis were used to determine the number of factors. A scree plot provides a visual representation of the number of factors to be extracted, and parallel analysis uses the eigenvalues from the obtained data and comparing these values to a random sample generated by the statistical software. Eigenvalues from the obtained data should be higher than those generated by the software [18], [19]. We used an oblique rotation in this analysis, which "provides a more accurate and realistic representation of how constructs are likely to be related" [19, p. 282], by allowing them to be correlated. Interpreting factors and evaluating the quality of the solution requires several considerations: there should be more than two observed variables loaded onto each factor, all factor loadings should be above .32, variable communalities should be between .40 to .70, and variables should not load onto two or more factors (i.e., cross-loading [18], [20], and [21]). Observed variables that violated any one of these considerations were removed from the analysis. After removing poorly behaving variables, EFA was re-run to until a factor solution that met all the criteria was achieved.

**Findings of EFA and Further Revision**

After we analyzed each construct and its associated items for factor loadings, we saw some differences among responses from college of science (COS) and college of engineering (COE) students' perceptions of support. For example, the items under construct Peer-Interaction loaded into two separate factors for engineering students but only one factor for students in colleges of science. Upon examination of the wording, the resultant factors for engineering students appear to relate to socializing with peers and peer collaboration. Engineering students had a tendency to perceive interactions with peers differently depending on context. Where items like, *"I regularly meet with a study group for my STEM courses,"* loaded similarly with other items related to collaboration or advancing academic work, items like, *"I regularly socialized with students in my major outside of class,"* loaded separately with other items related to spending time and meeting-up with friends. In the discussion section, we explore possible reasons for these differences in factor loadings for these two groups (e.g., COS and COE students).

The data collected provided an opportunity to test the validity of our newly developed instrument. We used our pilot data to test for construct validity using a maximum likelihood exploratory factor analysis and correlation analyses. These results informed the latest revision of our instrument. After data analysis, we went from 6 anticipated to 13 actual constructs, and the total number of items went from 94 to 89.

An overview of changes in construct names and number of items per construct from before and after EFA are detailed in Table 3. After analysis of the preliminary data, the resulting factors were given tentative construct names. These tentative construct names and associated items were the focus for the second round of revisions to the instrument. We consulted with content experts (e.g., academic advisors) and referred to existing instruments to generate new items. The revised survey (e.g., construct labels and added items) was then sent out for feedback from our stakeholders.

To date, we have received input from all of our Advisory Board members and Institutional Partners on the revised construct names as well as newly added items. In late Fall 2018, we also conducted eight virtual interviews with undergraduate students to get participant feedback on comprehension of newly added items, the order that items appear, and the tentative construct names. The revised construct names can be found in the second column of Table 3. Based on stakeholder feedback we have made the following changes to the instrument: we expanded or re-worded items, reordered items following a logical progression (e.g., peer, faculty, university), categorized newly formed items in existing constructs, and altered language used in survey instructions to encompass more student experiences.

*Table 3. Changes to Student Support in STEM Survey Constructs and Corresponding Number of Items Before and After Exploratory Factor Analysis (EFA)*

| Original Instrument: Construct Names Based on MCCS | Current Instrument: Tentative Construct Names Post EFA Analysis |
|---|---|
| · Faculty-Interaction (13)<br>· Peer-Interaction (18)<br>· Academic Support (12)<br>· Professional Development (21)<br>· Extracurricular Support (14)<br>· Additional Support (16)<br>· | · Faculty Academic Support (9)<br>· STEM Faculty Connections (7)<br>· Academic Peer Support (6)<br>· STEM Peer Connections (5)<br>· Academic Advising Support (8)<br>· STEM Career Development (7)<br>· Non-STEM Career Development (6)<br>· Out-of-Class Opportunity Awareness (6)<br>· Out-of-Class Encouragement (5)<br>· Engaging with Professionals (5)<br>· Cost-of-Attendance Support and Planning (8)<br>· Personal and Student Affairs Support (7)<br>· Diversity and Inclusion (10) |
| **Total Items (94)** | **Total Items (89)** |

## Discussion

Although we observed differences in perceived support among COE and COS students, it is too soon to derive concluding remarks. Our goal in this discussion is to provide suggestions that explore why we may be seeing these differences in perceptions of STEM support among COS and COE students. The following sections describe how differences between COE and COS at the micro, meso, exo, and macro levels may be contributing to differences in students' perceptions of support.

### Micro (Student) Level

At the micro (or student) level, cultural differences in gender and racial/ethnic representation across engineering and science affect how students perceive and experience these fields [22]-[24]. Women represent approximately 20% of engineering bachelor's degrees in the United

States [25]. This number is similar to female enrollment in physics and computer science [26]. However, other science fields, such as biology and chemistry, have much higher representation of women [23]. Additionally, gender representation is not the same across all of engineering. Some disciplines (e.g., environmental and biomedical engineering) have reached parity, yet other disciplines (e.g., computer, aerospace, electrical, and mechanical engineering) lag far behind [25]. Black men and women and Asian men are more likely to choose electrical engineering at the beginning of college. In general, Black students and Asian and Hispanic men are also more likely to enroll in computer engineering relative to other engineering disciplines, although at lower rates than electrical engineering [27]. These differences between engineering and science and within engineering disciplines highlight particular areas of interest to explore with this research on students' perceived support in their degree programs.

Another factor to consider at the micro level is the socialization used for engineering students from the beginning of their undergraduate studies to begin their acculturation to the field (e.g., being referred to as engineers despite having obtained a degree or licensure).This practice is not typical for COS students who are not commonly addressed as physicists or scientists more broadly so early in their academic careers. Thus, students' engineering identity and subsequent perceptions of belonging to the field may be cultivated or more heavily emphasized than their other STEM counterparts influencing their perceptions of support [28].

**Meso (College) Level**

At the meso (or college) level, structural differences and organizational standpoints may dictate out-of-class learning opportunities and access to resources to extend learning beyond the classroom. These college -differences in offerings may impact perceived support on behalf of undergraduate STEM students. In a study on organization of university hierarchies, Hammond [29] outlines the impact of a university's organization of basic units (e.g., departments), which form its colleges or schools, on university decision making processes and outcomes. Hammond [29] examines the impact of structure on decision making to include how top-level administrators perceive problems that need attention, how possible solutions/interventions are constructed for consideration, and how final decisions are implemented. In terms of grouping departments into colleges, a common principle is to group departments based on the requirement of professional training, (i.e., combining all disciplinary departments in engineering into a single College of Engineering). Many departments are categorized according to professional and non-professional colleges/schools.

Once the formal structure has been identified the impact of that structure on university decision-making can be determined. As Hammond [29] proposes, different organizational structures may process the same data in different ways based on the type of information collected. For example, requests provided by academic advisors and department heads to provide career development opportunities for undergraduate students would likely result in different outcomes for a COE versus a COS at the same university. In terms of providing career development support for students in STEM, the way the departments are combined (e.g., professional versus non-professional) could dictate the values of top-level administrators and influence how they construct possible solutions/interventions and how final decisions are implemented. The professional nature of the engineering field may have a sizable impact on the extent to which

college administrators decide to create an engineering-specific career fair to provide access to internship opportunities in the same way a college of science may prioritize undergraduate research to prepare its students for graduate studies or other professional schooling.

**Exo (Institutional) Level**

At the exo (or institutional) level, the type of institution (e.g., liberal arts vs. research intensive) may operationalize the undergraduate experience differently because the educational focus of a university can create different learning environments and impact how students feel supported. That is to say, an engineering program at a Liberal Arts College may aim to provide a broad and well-rounded undergraduate education, whereas an engineering program at a research university may focus more so on preparing students for specific career paths or industries. Taking engineering at Smith College as an example of a Liberal Arts College, Smith requires its engineering students to take at least one course in each of the seven general areas of knowledge (e.g., literature, historical studies, social science, natural science, mathematics and analytic philosophy, the arts, a foreign language). Given that the college has no core curriculum, engineering students at Smith are the only majors required to have this breadth in education [30]. Because of differences in educational objectives by type of institution (as well as program size), the support offered to STEM students as well as student perceptions of that support can vary. Student support and resources at a liberal arts college may place a high value on providing students in STEM majors with flexibility of curriculum to explore their personal artistic or technical interests (e.g., Rock Climbing with Physics as part of Passionate Pursuit program at Olin College [30]). At more technically oriented research universities, student support for STEM majors may encompass curriculum that restricts students to using the tools and language specific to their respective disciplinary industries as a form of acculturation to the field.

**Macro Level**

At the macro level, engineering and science disciplines have different socio-cultural backgrounds that have shaped their respective curricula [28]. The emphasis on engineering sciences and the importance of theory and mathematics in U.S. engineering can be traced back to European influences and Cold War politics [28]. More recent cultural shifts have emphasized a stronger connection to the profession, which is reflected in many of today's engineering program objectives requiring that the development of professional skills appear somewhere in the curricula. Disciplinary culture not only impacts curricula, but there have also been studies suggesting that disciplinary cultures are associated with perceptions of engagement, educational values and norms in science and engineering students [31]. Differences in disciplinary culture have been found to account for why students in social sciences prize individual assertion, classroom participation, and interest in ideas; in contrast, science and engineering students are described as placing more value on participation that fosters quantitative competencies through individual and collaborative efforts [31].

Depending on an institution's definition of STEM (e.g., broad enough to encompass social sciences) and the organizational structure of its colleges as well as the educational objectives (e.g., liberal versus technical) of the institution, it is plausible that the differences we are seeing among students' perceived support in STEM is a result of a combination of these components.

While engineering educators traditionally group STEM subjects together, a more nuanced understanding of how science fields and engineering fields provide different kinds of support is an area of future work in this grant. As we deploy the instrument a second time, we will pay special attention to how responses differ among COS and COE students.

## Concluding Remarks and Future Work

To summarize our work so far, we sampled from three predominately white, land-grant public institutions. The goal of the first phase of this study was to examine how well the instrument functioned for undergraduate students. Our results showed that students in Colleges of Engineering responded differently to items than students in Colleges of Science. All of the items functioned well for students, but the factor structure of the instrument was different for these groups. We acknowledge that our sampling may reflect students' experiences at particular types of institutions, and we plan to gather a wider sample of institutional types and student experiences when we deploy the fully developed survey.

We plan to distribute the most current version of the instrument to a broader set of students in spring 2019. Our target sample for this part of the research is 2,000 students, so we will survey 8,000 students based on a 25% anticipated response rate. We will use incentives and our campus contacts to ensure we reach a diverse and adequate sample to reach the response total necessary for statistical analyses. Following data collection, we will use confirmatory factor analysis to continue establishing construct validity and report on the stability of constructs emerging from our piloting on a new student sample, which will also include students from institutions beyond the institutions reported in this paper. To date we have at least 4 institutions that have committed to distributing the Student Support in STEM instrument for data collection in spring 2019. We also plan to investigate differences across these constructs by subpopulations of students.

## Acknowledgements

The authors would like to thank the anonymous participants for their involvement in the research as well as their research teams at Virginia Tech, GUIDE Research Group and the DEEP Lab, and at Purdue University, STRIDE. This work is supported by the U.S. National Science Foundation award # 1704350. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

## References


[1] W. C. Lee and H. M. Matusovich, "A model of co-curricular support for undergraduate engineering students," *Journal of Engineering education,* vol. 105, pp. 406-430, 2016.

[2] B. E. Rincon and C. E. George-Jackson, "STEM intervention programs: funding practices and challenges," *Studies in Higher Education,* vol. 41, pp. 429-444, 2016.

[3] B. L. Yoder. (2012, Going the Distance: Best Practices and Strategies for Retaining Engineering, Engineering Technology and Computing Students. 32. Available: https://www.asee.org/retention-project

[4] C. Allen, "Wiser women: Fostering undergraduate success in science and engineering with a residential academic program," *Journal of Women and Minorities in Science and Engineering,* vol. 5, 1999.

[5] D. Dickerson, F. Solis, V. Booth Womack, T. Zephirin, and C. Stwalley, "Can an engineering summer bridge program effectively transition underrepresented minority students leading to increased student success," in *ASEE Annual Conference, Indianapolis, IN. https://peer. asee. org/20142*, 2014.

[6] W. C. Lee and K. J. Cross, "Help me help you: Building a support network for minority engineering students," age, vol. 23, p. 1, 2013.

[7] J. P. Bean and B. S. Metzner, "A conceptual model of nontraditional undergraduate student attrition," Review of educational Research, vol. 55, pp. 485-540, 1985.

[8] V. Tinto, "Constructing Educational Communities: Increasing Retention in Challenging Circumstances," Community College Journal, vol. 64, pp. 26-29, 1994.

[9] W. C. Lee Jr, "Providing co-curricular support: A multi-case study of engineering student support centers," Virginia Tech, 2015.

[10] W.C. Lee, L. Moyer, A. Godwin, and D. Knight,"Instrument Development: Measuring Undergraduate Students' Perceived Support in STEM," in 48th Annual Frontiers in Education (FIE) Conference, San Jose CA, 2018.

[11] S. L. Fletcher, D. C. Newell, L. D. Newton, and M. R. Anderson-Rowland, "The WISE summer bridge program: Assessing student attrition, retention, and program effectiveness," in Proceedings, American Society for Engineering Education, 2001.

[12] T. Fernandez, A. Godwin, J. Doyle, D. Verdin, H. Boone, A. Kirn, et al., "More comprehensive and inclusive approaches to demographic data collection," 2016.

[13] T. Shealy, A. Godwin, and H. Gardner, "Survey Development to Measure the Gap Between Student Awareness, Liter-acy, and Action to Address Human-caused Climate Change," in ASEE Annual Conference proceedings, 2017.

[14] Office Assessment and Research "Arizona State's Sample of Demographic Questions," 2011.

[15] Qualtrics, "Qualtrics.com," ed. Provo UT, 2017.

[16] B. Everitt and T. Hothorn, An introduction to applied multivariate analysis with R: Springer Science & Business Media, 2011.

[17] L. R. Fabrigar and D. T. Wegner, Exploratory Factor Analysis Understanding Statistics: Oxford University Press, 2011.

[18] T. A. Brown, Confirmatory factor analysis for applied research: Guilford Publications, 2014.

[19] L. R. Fabrigar, D. T. Wegener, R. C. MacCallum, and E. J. Strahan, "Evaluating the use of exploratory factor analysis in psychological research," Psychological methods, vol. 4, p. 272, 1999.

[20] A. B. Costello and J. W. Osborne, "Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis," Practical assessment, research & evaluation, vol. 10, pp. 1-9, 2005.

[21] B. Tabachnick, "Using multivariate statistics," ed: Boston: Pearson.

[22] S. G. Brush, "Women in science and engineering," American Scientist, vol. 79, pp. 404-419, 1991.

[23] C. Hill, C. Corbett, and A. St Rose, Why so few? Women in science, technology, engineering, and mathematics: ERIC, 2010.

[24] D. Verdín, A. Godwin, and M. Ross, "STEM Roles: How Students' Ontological Perspectives Facilitate STEM Identities," Journal of Pre-College Engineering Education Research (J-PEER), vol. 8, p. 4, 2018.

[25] B. L. Yoder, "Engineering by the Numbers," in American Society for Engineering Education, 2017, p. 37.

[26] NSF and NCSES, "Digest: Women, Minorities, and Persons with Disabilities in Science and Engineering," ed. Arlington VA, 2017.

[27] S. M. Lord, R. A. Layton, and M. W. Ohland, "Multi-institution study of student demographics and outcomes in electrical and computer engineering in the USA," IEEE Transactions on Education, vol. 58, pp. 141-150, 2015.

[28] M. C. Paretti and L. D. McNair, "Analyzing the intersections of institutional and discourse identities in engineering work at the local level," Engineering Studies, vol. 4, pp. 55-78, 2012.

[29] T. H. Hammond, "Herding Cats IN University Hierarchies: The Impact Of Formal Structure On Decision-Making," 2002.

[30] D. Grasso and J. J. Helble, "Holistic engineering and educational reform," in Holistic Engineering Education, ed: Springer, 2010, pp. 81-92.

[31] T. A. Litzinger, L. R. Lattuca, R. Hadgraft, and W. C. Newstetter, "Engineering Education and the Development of Expertise," Journal of Engineering Education, vol. 100, pp. 123-150, 2011