Differences Between Science and Engineering Undergraduate Students' Perceived Support: Exploring the Potential of College Profiles

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***Abstract*—This work-in-progress research paper stems from a larger project where we are developing and gathering validity evidence for an instrument to measure undergraduate students' perceptions of support in science, technology, engineering, and mathematics (STEM). The refinement of our instrument functions to extend, operationalize, and empirically test the model of co-curricular support (MCCS). The MCCS is a conceptual framework of student support that explains how a student's interactions with the professional, academic and social systems within a college could influence their success more broadly in an undergraduate STEM degree program. Our goal is to create an instrument that functions diagnostically to help colleges effectively allocate resources for the various financial, physical, and human capital support provided to undergraduate students in STEM. While testing the validity of our newly developed instrument, an analysis of the data revealed differences in perceived support among College of Engineering (COE) and College of Science (COS) students. In this work-in-progress paper, we examine these differences at one institution using descriptive statistics and Welch's t-tests to identify trends and patterns of support among different student groups.**

Keywords—instrument development, student support, Model of Co-curricular Support, disciplinary differences

I. Background and Theoretical Framework

Most student retention efforts in STEM are addressed at the college level through the offerings of support programs (e.g., living-learning communities, mentoring, etc.). However, theories on student retention traditionally focus on attrition at the institutional level (e.g., [1-5]). Our work addresses this gap between student-retention theory and STEM student-support practice, using the model of co-curricular support (MCCS) as a foundation for the development of an instrument that assesses student's perceptions of the institutional support provided to them. The MCCS is a conceptual framework that models how the academic, social, and professional systems within a college, as well as the overarching university context in which the college is embedded, are integral to the evaluation and subsequent modifications of a STEM learning environment [6], [7]. We grounded the development of our instrument in the MCCS to assist both practitioners and researchers in transforming retention efforts by way of cultivating supportive STEM learning environments for a diverse study body.

The MCCS is based on a qualitative study of student support efforts from four-institution, and it repurposes Tinto's model of institutional departure [2]—an oft-cited student-retention model that explains how a student's interactions with the academic and social systems could influence student retention at an institutional level. The MCCS illustrates more broadly how students that receive co-curricular support benefit when receiving various elements of institutional support at the college level. As used here, elements of institutional support are the essential experiences that students get from interventions (i.e., what you would see if you observed participation) [6], [7]. Using the MCCS as a lens provides a way to deconstruct aspects of *student support* and identify practical experiences that should be facilitated. For example, instead of investigating the impact of peer mentoring programs—which are seldom identical—this lens allows us to investigate the extent to which students receive the support institutions aim to provide via peer mentoring programs without limiting our investigation to a particular source. The MCCS identifies six elements of institutional support: 1) academic performance, 2) faculty/staff interactions, 3) extracurricular involvement, 4) peer-group interactions, 5) professional development, and 6) additional circumstances [8], [9]. For a more in-depth discussion on the MCCS and how that model was developed see Lee and Matusovich [6]. Though the MCCS conceptualizes the six elements of support, we extend MCCS research through our ongoing efforts to validate the instrument we developed for measuring them.

II. Instrument Overview and Description

Our instrument development began with an item bank pertaining to the six constructs of the MCCS. We then leveraged students' open-ended responses toward elements of institutional support (e.g., financial aid, academic advising, etc.) and reviewed existing instruments to develop additional items. We intentionally sought feedback from a diverse group

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of stakeholders (e.g., education researchers, STEM administrators, and marginalized undergraduate and graduate students in STEM) about the items included, the wording used, and overall format of the instrument. For a more in-depth discussion on our instrument development process and validity testing see [10] and [11].

After an extensive instrument development process, we sent a live link via Qualtrics™ software [12] and IRB-approved recruiting scripts to the project partners at University 1, University 2, and University 3. These partners are program directors for several different student support centers at each institution and agreed to distribute the instrument either via mailing list or personal emails. This resulted in distribution of our survey to the College of Engineering (COE) and College of Science (COS) at University 1, the COE at University 2 and the College of Engineering Computing and Applied Sciences at University 3. The pilot instrument had a total of 8 sections: one for each of the six MCCS constructs on student support; a section pertaining to student involvement; and section pertaining to participant demographics. Regarding instrument format, in the sections pertaining to student 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 first two columns on Table I provide sample statements corresponding to each construct in the student support section.

III. Exploratory Factor Analysis (EFA) and Findings Pilot 1.0

To begin to understand how the items developed to measure the six categories of support functioned for students, we conducted an exploratory factor analysis (EFA). EFA is a statistical technique that identifies the underlying structure of a large number of variables without a predetermined expectation of the structure [13]. In our analysis, we examined how the 94 items designed to measure six categories of factors actually measured the underlying constructs. We used a promax rotation and a minimum residuals estimator to test the structure of the data. This rotation allowed for correlations among the underlying data. The minimum residuals estimator produces result similar to maximum likelihood but for non-normal data [14].

Our results revealed that the originally hypothesized six categories of support actually measured 13 categories of support and the number of items was reduced from 94 to 54 (see Table I column three for new constructs). While analyzing the data for perceived differences in support across various demographics, we found statistically significant differences in how students majoring in engineering perceived certain elements of support compared to the other STEM majors in the pilot sample. The items still measured the same underlying 13 areas of support, but the mean responses on these items varied.

TABLE I. Examples of Student Support Construct Labels and Associated Items Before and After EFA

Constructs Before EFA (# of items)	Sample Statements	Corresponding Constructs After EFA (# of items)
Faculty Interaction (13)	*“My instructors were available to meet with me if needed”* *“I had a STEM faculty member who I consider a role model”*	Faculty Academic Support (3) STEM Faculty Connections (4)
Peer Interaction (18)	*“I met STEM students who are now my friends”* *“I could access a peer study group if needed”*	STEM Peer Connections (5) Academic Peer Support (2)
Academic Support (12)	*“I was regularly around other STEM students who took school seriously”* *“I received helpful guidance on registering for classes”*	Academic Peer Support (4) Academic Advising Support (2)
Professional Development (21)	*“There were opportunities for me to attend career fairs relevant to my major”* *“I received assistance with preparing for interviews”* *“I discussed opportunities for pursuing a graduate degree outside of my major”*	STEM Career Development (7) Engaging with Professionals (3) General Career Development (3)
Additional Support (16)	*“I received assistance from disability services”* *“I received help in applying to scholarships and/or fellowships”* *“I received information on the importance of diversity for STEM”*	Personal and Student Affairs Support (2) Cost-of-Attendance Support and Planning (6) Diversity and Inclusion Support (4)
Extracurricular Support (14)	*“I received notifications about events related to STEM”* *“I was encouraged to be involved in the local community outside of the university”*	Extracurricular Information (4) Developing a Local Network (5)
Total (94)		**Total (54)**

Because the research team was intrigued by preliminary findings regarding students majoring in engineering vs. other STEM majors, we use this WIP to focus on a single university, reducing the variability of the institutional context. Although it is too soon to make concluding remarks about how the instrument may measure perceived differences in support among STEM majors, we end with a discussion of potential reasons for these perceived differences

IV. Institutional Context- University 1

The institution selected for this study represents a large public land-grant university. The institution type is technical and based on student body demographics the university is a predominately white institution, with undergraduate enrollment exceeding 27,000 students. This context is particularly useful for exploring the experiences of STEM students from underrepresented and underserved groups.

Recognized nationally for its premiere engineering programs this institution also enrolls a large number of first-time COE students each year, approximately 2,000, which presented the opportunity to survey a larger sample representative of the engineering student population nationally. At about half that size the COS enrolls approximately 1,100 first-time college students. Other noteworthy differences, the COS undergraduate enrollment was majority female (53.1% female, 46.8% male, 0.1% not reported), whereas COE was male dominated (22.1% female, 77.7% male, 0.08% not reported).

A. *Sample Participants*

A total of 542 Students completed the survey with a percentage participation breakdown by college of 78% COE and 22% COS. Sample demographics are similar to the respective college populations in terms of majority race and gender distribution with the exception that women's perceptions of student support are slightly overrepresented for both colleges. For a summary of the remaining demographics (i.e., race/ethnicity, gender identity, residency, first generation college student status and class standing) see Table II.

B. *Descriptive Statistics*

We explore group mean differences of COS and COE students using Welch's t-tests. A Welch's t-test accounts for populations with unequal variance. Because we ran 13 different t-tests, we also corrected for Type I error using a false discovery rate *p*-value correction. In the next section, we show results from our in-depth university profile and the differences we found between COE and COS students.

C. *College Profiles Mean Comparisons*

The results from the Welch's t-tests, see Table III, show statistically significant differences with moderate effect sizes (i.e., 0.2 < Cohen's d < 0.5) regarding perceptions of support pertaining to STEM Peer Connections; STEM Career Development; and Engaging with Professionals. The remaining ten constructs of support functioned similarly for COE and COS students. In the next section we discuss possible reasons why we may be finding differences in particular areas of support for these two different STEM fields

TABLE II. SAMPLE PARTICIPANT DEMOGRAPHICS

Demographics	COE (%)	COS (%)
Gender Identity[a]		
Woman	38.3	72.6
Man	57.6	19.7
Gender Nonbinary or Agender	<1	<1
A gender Not Listed	<1	-
I Prefer Not to Answer	1.2	2.5
Race/Ethnicity		
White	90.8	70.1
Asian (South,East,Southeast)	13.6	9.4
Hispanic or Latino/a/x	3.1	3.4
Black/ African American	2.8	1.7
Middle Eastern/North African,	1.4	1.7
Race/Ethnicity Not List	1.4	-
Native Hawaiian/Pacific Islander,	<1	-
American Indian/Alaska Native	<1	-
Class Standing		
First-year/Freshman	19.3	17.1
Sophomore	26.1	27.4
Junior	24.7	29.1
Senior	28.2	25.6
Other	1.2	-
Residency		
U.S. Citizen	91.5	96.6
A permanent resident of the U.S.	2.6	-
A student with a temporary U.S. Visa	4.0	2.6
Other	<1	-
I Prefer Not to Answer	<1	-
First Generation College Student	9.6	9.4
Total Participation % (n=542)	**78**	**22**

[a] Students could mark all gender identities with which they identified.
[b] Students could mark all race/ethnic identities with which they identified

V. DISCUSSION

Our goal in this discussion is to provide suggestions that explore why we may be seeing differences in perceptions of STEM support among COS and COE students in the following areas: STEM Peer Connections, STEM Career Development, and Engaging with Professionals. The following section describes how differences between participants of COE and COS at the student level, as well as professional vs non-professional degree programs could be contributing to differences in students' perceptions of institutional support.

A. *Student Level Differences*

1) Gender: The longstanding gender disparity in STEM has led researchers to identify obstacles and differences in experiences that make it harder for women to pursue STEM [3], [9], [15]. They have found that gendered socialization shapes the educational experiences of men and women where women are socialized to be help seekers and givers and more collaborative concerning academics [17]. Thus, variables like *STEM peer support* have been shown to mediate the participation, identity (e.g. sense of belongingness), and pursuit of STEM careers for girls and women throughout their academic careers [15-17]. Especially in engineering, where the gender disparity is more pronounced, peer interactions were a noteable source of influence for women's commitment to engineering [17]. Contrarily, the male model of academic success socializes them to be more self-reliant and to have competitive and aggressive relations with peers [17]. Given that COS at this institution has a majority female enrollment 53.1% and an overrepresentation in our sample 72.6%, the perception of strong institution support for STEM Peer Connections from COE students could be a result of targeted support offered by COE for its minority female population which is also overrepresented in our sample 38.3% . This is just one way that perceived differences in STEM support can be attributed to differences at the student level.

2) Classification by Credit Hours: While the majority of participants from COS and COE identified as juniors and seniors, in total the upper-division COE students accounted for 41.5% of the whole sample, which could be a potential reason for the higher perception of institutional support among COE for areas related to professional development and preparing to enter the workforce (e.g. *STEM Career Development* and *Engaging with Professionals)* . These upper-division students may be more career oriented given their tentative graduation and thus support geared toward professional development may be more engaged and sought after.

B. Professional and Non-professional Degree

Taking the student-level differences, the institution's reputation for engineering, and the professional nature of the engineering baccalaureate degree, it is understandable that an emphasis to prepare and develop professionals engineers has had an influence on support offerings (e.g., engineering focused career fairs) at this particular institution. An engineering baccalaurate degree is considered the first professional degree or standard degree for practice in the field whereas baccalaurate degrees from COS programs typically are non-professional degrees [18]. It follows that students getting ready to enter their field of practice would perceive support related to STEM Career Development and Engagement with Professionals differently than students who are seeking non-professional degrees. Because the standard degree of practice for COS majors is attained at the post-graduate level of education, perhaps a comparison between COS majors and engineering subfields where the master's degree has become the standard for practice (e.g., environmental, structural and geotechnical) [18] warrants more exploration. For a more in-depth discussion on how the various dimensions of an institution's context (i.e., structural differences at the college level, liberal arts versus technical orientation) can account for differences in undergraduate student perceptions of STEM support, see [11].

C. Next Steps

This analysis was preliminary and exploratory. In future work, we will examine measurement invariance testing to ensure that the measurement is the same between groups and determine where differences are occurring in the measurement (i.e., is it something inherent to how COE and COS students are responding to question wording or true mean differences in the samples). We are deploying a second version of our instrument in the spring of 2019. Once construct validity has been further refined we will be able to develop mean construct scores so that upon using our instrument an institution will be able to review which areas (broadly) they are doing well in (e.g., a mean above 3) and areas that could benefit from additional oversight, funding, planning, execution (e.g. a mean below 3). The instrument would also provide a more in-depth look into which elemental aspects of a construct are not perceived to be supporting for students. This information can be parsed out by interest group (e.g. minority women, first generation students, and international students), classification, major, etc. Our instrument will help educators identify areas where perceived support or resources are lacking or sufficient and for whom. This can aid colleges and institutions effectively build capacity for diverse undergraduate students in STEM

TABLE III. DIFFERENCES IN PERCEIVED STUDENT SUPPORT

Student Support Construct	Mean Comparisons Across COE and COS				
	COE ***(M ± SD)***	***COS*** ***(M ± SD)***	**t-*stat***	***Corrected*** **p-*value***	***Cohen's* d**
Academic Advising Support	4.94 ± 0.93	4.74 ± 1.04	1.82	0.140	-
Academic Peer Support	4.58 ± 0.87	4.35 ± 0.91	2.36	0.057	-
Extracurricular Information	4.90 ± 0.79	4.82 ± 0.88	0.94	0.523	-
Developing a Local Network	4.47 ± 0.87	4.41 ± 0.88	0.60	0.656	-
STEM Peer Connections	**4.95 ± 0.93**	**4.60 ± 1.00**	**3.30**	**0.0047****	**0.243**
STEM Career Development	**4.86 ± 0.92**	**4.07 ± 1.06**	**7.31**	**<0.0001*****	**0.493**
General Career Development	3.39 ± 1.37	3.49 ± 1.23	-0.76	0.593	-
Cost-Of-Attendance Support & Planning	3.97 ± 1.00	4.03 ± 1.13	-0.41	0.743	-
Diversity & Inclusion Support	4.70 ± 0.96	4.43 ± 1.10	2.28	0.0571	-
Engaging with Professionals	**4.27 ± 1.19**	**3.39 ± 1.37**	**6.33**	**<0.0001*****	**0.439**
Stem Faculty Connections	4.12 ± 1.16	4.13 ± 1.22	-0.06	0.953	-
Faculty Support	4.89 ± 0.75	5.00 ± 0.73	-1.45	0.256	-

** significant at $p < 0.005$; *** significant at $p < 0.001$.

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REFERENCE

[1] J. P. Bean and B. S. Metzner, "A conceptual model of nontraditional undergraduate student attrition," *Rev. Educ. Res.*, vol. 55, no. 4, pp. 485–540, 1985.

[2] V. Tinto and others, "Constructing Educational Communities: Increasing Retention in Challenging Circumstances.," *Community Coll. J.*, vol. 64, no. 4, pp. 26–29, 1994.

[3] C. Allen, “Wiser women: Fostering undergraduate success in science and engineering with a residential academic program,” *J. Women Minor. Sci. Eng*., vol. 5, no. 3, 1999.

[4] D. Dickerson, F. Solis, V. Booth Womack, T. Zephirin, and C. S. 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.

[5] W. C. Lee “Help me help you: Building a support network for minority engineering students,” In Proceedings of the ASEE Annual Conference and Exposition, Vol. 23, pp. 1-23, 2013.

[6] W. C. Lee and H. M. Matusovich, “A Model of Co-Curricular Support for Undergraduate Engineering Students,” J. Eng. Educ., vol. 105, no. 3, pp. 406–430, 2016.

[7] W. C. Lee, “Providing Co-Curricular Support: A Multi-Case Study of Engineering Student Support Centers,” Virginia Polytechnic Institute and State University, 2015.

[8] 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, ASEE, 2001.

[9] C. Samuelson, “Living, Learning, and Staying: The Impact of a Women in Engineering Liv-ing and Learning Community,” in Proceedings, ASEE, 2014.

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

[11] J.L. Hall, D. Verdín, W.C. Lee, D. Knight, and A. Godwin, “Toward a Measurement of Co-Curricular Support: Insights from an Exploratory Factor Analysis,” in Collaborative Network for Engineering and Computing Diversity (CoNECD) Conference, 2019.

[12] Qualtrics, “Qualtrics.com,” Provo, UT, USA, 2017.

[13] 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.

[14] J. French and W. Revelle, "R: Exploratory Factor analysis using MinRes (minimum residual)...", Personality-project.org, 2017. [Online]. Available: https://www.personality-project.org/r/html/fa.html. [Accessed: 30- Mar- 2019].

[15] M. Soldner, H. Rowan-Kenyon, K. Kurotsuchi Inkelas, J. Garvey and C. Robbins, "Supporting students' intentions to persist in STEM disciplines: The role of living-learning programs among other social-cognitive factors", The Journal of Higher Education vol. 83 no. 3, p. 311-336, 2012. [Online]. [Accessed: 30- Mar- 2019].

[16] R. Robnett, “The role of peer support for girls and women in STEM: Implications for identity and anticipated retention,” International *Journal of Gender, Science and Technology,* vol. 5, no. 3, p. 232-253, 2013.

[17] R. J. Burke, “Women and minorities in STEM: A primer,” *Women and minorities in science, technology, engineering and mathematics: Upping the numbers,* 2007, p. 3-27.

[18] J. S. Russell, B. Stouffer and S. G. Walesh, “The first professional degree: A historic opportunity,” *Journal of Professional Issues in Engineering Education and Practice,* vol. 126, no.2, p.54-63, 2000.