The Relationship between Mental Health, Professional Identity, and Perceptions of Inclusion in Project-Based Engineering Programs

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Abstract

Background: This research paper extends previously reported work on engineering stress culture (ESC) in the context of project-based learning engineering programs. Our previous work, which mirrored a study conducted by Jensen and Cross on this topic, showed that students in project-based engineering programs report less stress and depression, stronger personal vision of an engineering career, more positive perceptions of department caring and diversity, and greater pride in their department compared to the student population in the original study. No statistically different effects were found for reported anxiety or engineering identity between the two populations in our previously reported work.

Purpose: Our goal is to continue the comparative replication of Jensen and Cross's study by establishing a baseline correlation between mental health, professional identity, and perceptions of inclusion among students in entirely project-based engineering and computer science programs.

Design/Method: We gather data from students pursuing engineering and computer science degrees delivered in entirely project-based learning environments. We use the validated instrument developed by Jensen and Cross as well as methodology informed by their original study. In doing so we establish baseline correlations between mental health, professional identity, and inclusion in the context of project-based learning environments in engineering and computer science.

Results: We present results from statistical analyses reporting correlations between measures of mental health, professional identity, and perceptions of inclusion among students working towards undergraduate engineering degrees in project-based learning environments. We compare these correlations with those found in the original Jensen and Cross study. Our results show that although students in our project-based programs experience less stress and depression overall than the population studied by Jensen and Cross, there is a significant difference in correlation between these two factors, as well as between stress and anxiety when comparing the two populations. Results also indicate a significant difference in correlation between department diversity and department caring among project-based students population when compared with the Jensen and Cross population, and similarly with the correlation between engineering career and engineering identity.

Conclusions: Some correlations between mental health, engineering identity, and and department inclusion measures are significantly different in the project-based student population than in the population studied by Jensen and Cross. These results, especially when interpreted in the context of our previous work, may have implications for further research into how the structure of project-based learning programs influence these correlations and related overall outcomes.

Background and Perspectives from the Literature

This research extends the understanding of engineering stress culture (ESC) in undergraduate project-based engineering and computer science programs. The intent is to continue to establish a benchmark for comparing the ESC experiences of project-based student engineers to those in traditionally operated programs.

The three programs studied in this paper are in the same college of the same institution. Further, the cultures of engineering and computer science are similar [1][2][3]. Thus, we consider the cultures of the two engineering programs and the computer science program to belong to a shared context.

Previous studies demonstrate the stressful nature of engineering and engineering education culture. Heavy workloads, high expectations, rigorous assignments, smart students, and fierce competition for grades are typical descriptors of engineering programs [4] [5] [6]. Student suffering and a bootcamp-like approach where individuals are torn down to be rebuilt and only the strong survive contribute to the stressful culture [7] [8] [9]. Perceptions and experiences of exclusion [10] [11], especially for women [12] and people of color [13], are additional contributors to stress.

This research is a continuation of our recent results that were based on Jensen and Cross's [14] approach to studying the ESC of undergraduate level engineering programs. The ESC they investigated examined stress, anxiety, and depression; engineering identity; and perceptions of inclusion in undergraduate engineering programs. The engineering programs studied by Jensen and Cross were not project-based programs.

To explore the relationship between levels of stress, anxiety and depression; levels of inclusion; and social identity Jensen and Cross deployed a validated quantitative instrument to engineering students at three three large U. S. public universities. Their work indicated there were relationships between the studied constructs – specifically, that reported feelings of stress, anxiety, and depression statistically decreased with increasing reports of inclusion [14].

For this research we replicated the work of Jensen and Cross by deploying the same instrument they used in our project-based context. Using this instrument, we collected quantitative data on:

- Mental health: self-reported stress, anxiety, and depression
- Professional identity: engineering identity and engineering career
- Inclusion: department caring, department pride, and department diversity

In previous reported work [15] we followed Jensen and Cross's approach to study students in our

three entirely project-based programs. Using their data collection and analysis techniques, we found that students in the project-based programs reported less stress and depression and a stronger vision of an engineering career than students in the Jensen and Cross study, while the project-based program students reported anxiety and professional identity comparable with the original Jensen and Cross results. Those results were commensurate with previous work [15] that demonstrates some of the benefits of entirely cohort-based, project-based engineering programs. Those documented benefits include improved recruitment of non-traditional student, more engaged learning, and improved retention of all students.

In this paper we deepen the analysis of our three programs using additional methods presented by Jensen and Cross. Here we specifically analyze the correlation between mental health, engineering identity, and perceptions of inclusion. (For the Jensen and Cross original results, see Table 9 in [14].) Using this approach, we have been able to create an analysis of student experience in project-based engineering and computer science programs that serves both as a baseline for future work and as an initial comparison between student experiences in entirely project-based programs and programs which are not.

Methods

Emulating the methods employed by Jensen and Cross [14], we used their previously published and validated instrument. The basis this was a quantitative survey in three main parts: Mental health (self-reported stress, anxiety, and depression), Professional identity (engineering identity, engineering career), and Inclusion (department caring, department pride, department diversity).

Methods: Research Questions

We set out to answer the following research question and test the corresponding hypothesis:

> **Research Question**: How do mental health, engineering identity, and perceptions of inclusion in our student population compare with the relationships reported in the original Jensen and Cross study?
> **Hypothesis**: *There are no correlations between the scores of self-reported stress, anxiety, and depression, engineering identity, engineering career, department caring, department pride, and/or department diversity between the two student populations.*

Methods: Measures

The survey method used by Jensen and Cross [14] was based on 56 questions. These items are spread across three categories:

- Mental Health
- Professional Identity
- Inclusion

To assess **Mental Health** we used the Depression Anxiety Stress Scales (DASS-21) (which is a short form of the full Lovibond and Lovibond DASS instrument [16]) to measure student levels of stress, anxiety, and depression. The survey included items such as, "I was worried about situations in which I might panic and make a fool of myself." Measurements were taken using a Likert scale that asked participants rank how frequently each item applied to their own experience. The twenty-one component survey elements were spread evenly across three mental health components: stress, anxiety, and depression. The scores for each component were summed and assigned a resulting severity level that ranged from "normal" to "extremely severe."[16].

Also in emulation of Jensen and Cross, we applied the Identification with Academics sub-scale adapted to engineering [17] to assess student levels of **Professional Identity** with engineering. An example survey item in this category was, "It matters to me how I do in engineering." Similarly, we addressed "engineering career" by including survey elements that measured student beliefs that their career post-graduation would be related to engineering. Ratings for both elements were gathered using a Likert scale that varied from 1 to 7 ("Strongly disagree" to "Strongly agree").

Continuing to emulate previously used methods, we applied the Engineering Department Inclusion Level Survey (EDIL) to assess student perception of **Inclusion**. The sub-scales in this section of the instrument measured department caring, department pride, and department diversity. A Likert scale from 1 to 7 (Strongly disagree to Strongly agree) was also used here[18].[1]

Methods: Demographic Information and Open Response for Future Work

We also asked students to report demographic information that included age, academic major, gender, race/ethnicity, socioeconomic status, first-generation college student status, and whether English is the primary spoken language. Students were also asked, "Is there anything else you would like to share that was not included in this survey?" (None of the data collected in this category was used in this study. This component of the collected data will be used in future work.)

Data Collection

Only students who were currently enrolled in one of the three programs being studied, and who agreed to participate, were included in our data set. We distributed invitations to participate to all students who were validated as currently enrolled. The survey was administered asynchronously and online, and no monetary or other rewards for participation were offered. The work was done under IRB approval (IRBNet ID 1797019).

The choice to pool students from these three programs for study was motivated by available sample size. The relatively small sample size of each project-based program makes it difficult to draw significant conclusions when examined independently. However, pooling the results allows the drawing of conclusions about project-based programs holistically at the expense of being able

[1]For this portion of the survey, Jensen and Cross's original study used a Likert scale that spanned from 1 to 6, not 1 to 7. We re-scaled for accurate comparison.

to make statements at the resolution of individual project-based programs. Because the project based students represent a different population than the one initially studied by Jensen and Cross, Cronbach alpha was used to ensure the instruments remained reliable in the new context. All Cronbach alpha values exceed 0.6 indicated a reasonable level of reliability. (See Table 3.)

A total of 58 responses - 25 from one engineering program (E1), 22 from the other (E2), and 11 from computer science (CS) - were collected. All respondents were validated as being eligible to participate in the study. The result was that **54.2 percent** of the eligible student population participated.

Thirty-six (36)% of participants reported being first generation and twenty-four (24)% of participants reported having poor or working class backgrounds.

Results and Discussion

We compare the correlations found between descriptive statistics for stress, anxiety, depression, engineering identity, engineering career, department caring, department pride, and department diversity within each of our three programs, and overall. We also compare our results with those reported by Jensen and Cross [14] with our own results, all per the experimental hypotheses laid out above in Section 2.1.

For ease of reference, we share here Jensen and Cross's "Table 9, Correlations (r_s) between mental health, engineering identity, and perceptions of inclusion", from page 381 of [14].

	Stress	**Anxiety**	**Depression**	**E ID**	**E Career**	**Caring**	**Pride**	**Diversity**
Stress	1							
Anxiety	0.725*	1						
Depression	0.663*	0.609*	1					
Engr Identity	0.055	0.023	-0.08	1				
Engr Career	-0.038	-0.034	-0.039	0.491	1			
Dept Caring	-0.158*	-0.127*	-0.292*	0.311	0.125	1		
Dept Pride	-0.102*	-0.100*	-0.268*	0.415*	0.286*	0.667*	1	
Dept Diversity	-0.059	-0.086	-0.141*	0.198*	0.073	0.418*	0.369*	1

Table 1: **Table 9 from Jensen and Cross:** Correlations (r_s) between mental health, engineering identity, and perceptions of inclusion

E ID = Engineering Identity, E Career = Engineering Career, Caring = Department Caring, Pride = Department Pride, Diversity = Department Diversity, Engr = Engineering, Dept = Department

*Significance at $p < 0.05/28 = 0.001786$ (two-tailed) on Bonferroni correction for 28 comparisons

	Stress	**Anxiety**	**Depression**	**E ID**	**E Career**	**Caring**	**Pride**	**Diversity**
Stress	1							
Anxiety	0.822*	1						
Depression	0.708*	0.722	1					
Engr Identity	-0.041	-0.074	-0.222	1				
Engr Career	-0.017	-0.09	-0.099	0.402*	1			
Dept Caring	-0.414	-0.263	-0.446	0.236	-0.012	1		
Dept Pride	-0.329	-0.242	-0.482	0.38*	0.239	0.633*	1	
Dept Diversity	-0.359	-0.239	-0.433	0.1887	0.133	0.617*	0.64*	1

E ID = Engineering Identity, E Career = Engineering Career, Caring = Department Caring, Pride = Department Pride, Diversity = Department Diversity, Engr = Engineering, Dept = Department

Table 2: Correlations (r_s) between mental health, engineering identity, and perceptions of inclusion across three project-based programs combined

*Significance at $p < 0.05/28 = 0.001786$ (two-tailed) on Bonferroni correction for 28 comparisons

Chronbach's alpha values for each measure used in the study are provided below in Table 3. All the Chronbach's alpha values exceed 0.6, indicating acceptable reliability.

Measure	**Chronbach's alpha**
Stress	0.81
Anxiety	0.64
Depression	0.80
Engr Identity	0.70
Engr Career	NA (single question)
Dept Caring	0.90
Dept Pride	0.67
Dept Diversity	0.79

Table 3: Chronbach's alpha values for each measure used in the study

By comparing Tables 1 and 2, we can examine differences in correlations between measure values for the students in our entirely project-based programs *vs.* those studied by Jensen and Cross. We compared the correlation coefficients using Fisher's z transformation for the correlation coefficients from the two tables. The results of the comparison can be seen in Table 4 below, which indicates the results of calculating the probabilities of the correlation coefficients being different between the two studies. Comparing only results that are statistically significant within each of Tables 1 and 2, and then additionally applying a 95% threshold of probability for the significant differences in correlations between pairs (in bold in Table 4), we find that the correlations between measures that are significantly different between the project-based population and the Jensen and Cross baseline are: Anxiety-Stress, Depression-Stress, Engineering Career-Engineering Identity, and Department Diversity-Department Caring.

	Stress	**Anxiety**	**Depression**	**E ID**	**E Career**	**Caring**	**Pride**	**Diversity**
Stress	NA							
Anxiety	**1**	NA						
Depression	**0.996367**	1	NA					
Engr Identity	0.001208	0.00108	2.14E-06	NA				
Engr Career	0.746531	0.037905	0.028443	**0.000219**	NA			
Dept Caring	3.47E-19	3.87E-06	8.01E-09	0.005213	6.9E-06	NA		
Dept Pride	2.05E-14	1.85E-06	1.17E-15	0.094623	0.055436	0.031428	NA	
Dept Diversity	7.7E-24	3.29E-07	1.56E-24	0.38016	0.972283	**1**	1	NA

E ID = Engineering Identity, E Career = Engineering Career, Caring = Department Caring, Pride = Department Pride, Diversity = Department Diversity, Engr = Engineering, Dept = Department

Table 4: Fisher z transformation results comparing correlation coefficients in Tables 1 and 2 (probabilities), Significance differences tested at 95% on both tails are highlighted in bold.

In our previous work [15] we found that students in the project-based programs reported less stress and depression than students in the Jensen and Cross study, but comparable levels of anxiety. With these results we now find that although students in our project-based programs experience less stress and depression overall, there is a significant difference between the correlation between these two factors in the project-based student population compared to Jensen and Cross's population. There is also a significant difference in correlation between stress and anxiety between the two populations.

In our previous work [15] we also found that students in project-based programs reported a stronger belief that their post-graduation career would be engineering-related than students in the Jensen and Cross population, but a comparable level of professional identity as an engineer. Our current results additionally indicate that there is a significant difference between the engineering career and engineering identity measures when comparing the project-based student population with the population studied by Jensen and Cross.

Finally, in our original work we [15] found that the project-based students studied perceived their departments as more caring and diverse than those in the Jensen and Cross study, as well as reporting more pride in their departments. With these new results we find a significant difference between the correlation between department caring and department diversity when comparing the original Jensen and Cross population with the project-based students.

Conclusions and Future Work

The results of this research motivate a important future lines of inquiry into the causes of the significantly different correlations we found between mental health, engineering identity, and department inclusion factors among our project-based students when compared with the student population studied by Jensen and Cross. What aspects of the project-based environment lead to these results, and how might these differences in correlation relate tp the overall outcomes we found in our original work of lower stress and depression and a stronger sense of department caring for the project-based population?

These results also motivates future work in understanding if and how choices around engineering

pedagogy influence students' development of an identity as an engineering and choice of engineering career.

One limitation of this work is our small sample size, both absolutely and in comparison with that of Jensen and Cross. Even with small N, however, these results show that student perceptions of the relationships between aspect of mental health, professional identity, and department inclusion vary across the contexts studied by Jensen and Cross [14] and our three project-based programs. As the programs studied here grow and evolve, our future work will examine changes in outcomes as a function of time and population size, as well as triangulating and supporting quantitative results with qualitative data.

Another limitation of this study that could be addressed in future research is non-respondent selection bias. Additional future work also includes further exploration of the similarities and differences between the stress cultures in project-based engineering programs and project-based computer science programs.

An additional limitation of the study is that the pandemic was a significant change between the data collection of the Jensen and Cross [14] study and the data collected for this study. Thus, more work is needed to fully establish if the differences in correlation results from program type or temporal/historical context.

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