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Engineering Stress Culture in Project-based Engineering Programs

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Abstract

Background: This research paper examines engineering stress culture in the context of project-based learning engineering programs at the university level. Multiple authors have reported that the culture of engineering and engineering education can be stressful and exclusive. A study conducted by Jensen and Cross [1] found that measures of inclusion such as ”Department Caring” and ”Department Pride” were negatively correlated with stress, anxiety, and depression. We used the approach developed by Jensen and Cross to examine stress culture in the context of three project-based learning engineering programs.

Purpose: Our goal was to establish a baseline of measures of mental health (stress, anxiety, and depression), professional identity, and inclusion among students in entirely project-based engineering and computer science programs.

Design/Method: Our study used the instruments developed by Jensen and Cross to gather data from the perspective of students pursuing integrated engineering and computer science degrees in entirely project-based learning environments. Data collection and analysis for this study were informed by the methodology used by Jensen and Cross, allowing us to establish baseline measures for stress culture within the context of project-based learning environments in engineering and computer science.

Results: We present results from statistical analyses reporting measures of mental health (stress, anxiety, depression), professional identity, and perceptions of inclusion among students pursuing engineering and computer science degrees in entirely project-based learning environments. 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. The anxiety and professional identity results were comparable with the original Jensen and Cross results.

Conclusions: Although the sample size for this study is smaller than that of the original Jensen and Cross study, the results show the strong potential impact of project-based engineering programs. Future work will examine performance changes as a function of time and population size, as well as triangulating and supporting quantitative results with qualitative data.

Background and Perspectives from the Literature

We undertook this research in order to examine engineering stress culture (ESC) within the context of three project-based programs. Two of the programs are project-based undergraduate engineering programs and the third is a project-based computer science program. Our primary goal was to create a baseline that would allow us to begin to compare our students' experiences with student populations in other programs whose education environments are not primarily organized around project-based learning.

As all three programs are in the same college at our institution, we are considering student culture collectively as belonging to a shared context. Other authors have documented the similarities between engineering and computer science cultures[2][3][4]. For the purpose of this paper, the computer science program is considered to have an engineering culture.

Multiple authors have documented that the culture of engineering and engineering education can often be stressful. The stressful culture includes experiences of student suffering and shared hardship or a bootcamp mentality [5] [6] [7]. Undergraduate engineering programs have been described as having heavy workloads, high expectations, rigorous assignments, smart students, and fierce competition for grades [8] [9] [10].

Additional stress can also arise from perceived and experienced exclusion from participation [11] [12], especially for women [13] and people of color [14].

We are particularly focused, as a basis for our work, on how Jensen and Cross [1] described 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. Jensen and Cross collected data from student populations at three large U. S. public universities.

Jensen and Cross hypothesized that levels of stress, anxiety, and depression would vary by social identities and that levels of inclusion and engineering identity would vary by social identities. Further, they hypothesized that the relationships among these constructs would also vary across social identities. To answer these research questions, Jensen and Cross collected data using a validated, quantitative survey that had one open-ended item. Their findings suggested that perceptions of inclusion and engineering identity are related to student mental health. Specifically, they found that measures of inclusion such as "Department Caring" and "Department Pride" were negatively correlated with stress, anxiety, and depression.

With this research we approach the question of how these effects may be different in engineering and computer science programs that are structured as entirely cohort-based, project-based learning experiences. Benefits of this style of program include improved retention of students, more engaged learning, and improved recruitment of non-traditional students. These benefits have been shown within our project-based engineering programs [15] [16] [17] [18] [19] and are anticipated to bear out with equal success in our relatively new computer science program [20].

We used the approach and instruments developed by Jensen and Cross to examine the experience of stress culture among the students in our three programs. In doing so, we were able to create a

baseline analysis of student experience in project-based engineering and computer science programs that both yields an initial understanding of how project-based learning affects student experience and provides a useful baseline for future investigation.

Methods

Following the methods practiced by Jensen and Cross [1], we employed a quantitative survey built on previously published scales. We used this survey to measure:

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

Methods: Research Questions

We set out to answer the following research questions (RQs) and test the corresponding hypotheses:

> RQ1: How does mental health in our student population compare with that in the original Jensen and Cross study?
> **Hypothesis 1.** *There is no difference in the mean score of self-reported stress, anxiety, and depression between the two student populations.*
>
> RQ2: How does professional identity in our student population compare with that in the original Jensen and Cross study?
> **Hypothesis 2.** *There is no difference in the mean score of engineering identity and engineering career between the two student populations.*
>
> RQ3: How do feelings of inclusion in our student population compare with that in the original Jensen and Cross study?
> **Hypothesis 3.** *There is no difference in the mean score of department caring, department pride, and diversity between the two student populations.*

Methods: Measures

Four existing surveys were used to measure our target constructs of mental health, professional identity, and inclusion, as well as demographic information. Together the survey included the same 56 items[1]that were used by Jensen and Cross [1] and which can be found in their Appendix(Table A1).

[1]A typographical error that was discovered after our data was collected unfortunately invalidated the usability of one of the survey questions.

Methods: Mental Health

Student levels of stress, anxiety, and depression were assessed using the Depression Anxiety Stress Scales (DASS-21), which is the shorter form of the full Lovibond and Lovibond DASS instrument [21]. Some example survey items include, "I found it difficult to work up initiative to do things" and "I was worried about situations in which I might panic and make a fool of myself." Participants were asked to indicate the frequency with which they experienced each item over the past week, using a Likert scale from (1) "Did not apply to me at all" to (4) "Applied to me very much, or most of the time." Of the 21 survey elements, seven were associated with each of the three mental health components that were measured (stress, anxiety, and depression). The scores for each component were totaled and assigned a severity level (normal, mild, moderate, severe, extremely severe) [21].

Methods: Professional Identity

Student levels of professional identity with engineering were measured using the Identification with Academics subscale adapted to engineering [22]. Three of the items included were:

- "Being good at engineering is an important part of who I am."
- "Doing well on engineering tasks is very important to me."
- "It matters to me how I do in engineering."

Each item was rated on a Likert scale from (1) *Strongly disagree* to (7) *Strongly agree*.

Methods: Inclusion

Student perception of inclusion was measured using the Engineering Department Inclusion Level Survey (EDIL). The subscales used include Department Caring (*e.g.* "I feel welcome in this department"), Department Pride (*e.g.* "I take pride in the fact that I am a student in this department"), and Department Diversity (*e.g.* "This department is committed to promoting diversity" and "All students feel welcome in this department"). Each item was rated on a Likert scale from (1) *Strongly disagree* to (7) *Strongly agree* [23][2].

Methods: Demographic Information and Open Response

Participants were asked to report their age, major, gender, race/ethnicity, socioeconomic status, first-generation college student status, and whether they speak English as their first language. At the end of the survey, students were also invited to share in response to the prompt: "Is there anything else you would like to share that was not included in this survey?" (Neither demographic nor open response data were used in this study. This data will be retained for use in future work.)

[2]For these inclusion constructs, Jensen and Cross's original study used a Likert scale that spanned from 1 to 6, not 1 to 7. Thus the data required scaling for comparison.

Data Collection

Institutional Review Board approval was obtained to conduct the study within our three programs (IRBNet ID 1797019). The criteria for inclusion was students who were currently enrolled in one of the three programs being studied, and who agreed to participate. Invitations to participate were distributed to all those who were validated as currently enrolled. The survey was administered asynchronously and online. No monetary participation rewards were offered.

A total of 58 responses (11 from computer science (CS), 25 from one engineering program (E1), and 22 from the other (E2)) were collected, all of which were validated as being eligible to participate. The response rate was **54.2 percent** of the eligible student population.

Results and Discussion

We compared the descriptive statistics for stress, anxiety, depression, engineering identity, engineering career, department caring, department pride, and department diversity as reported by Jensen and Cross [1] with our own results, per the experimental hypotheses laid out above in Section 2.1.

For ease of reference, we share here Jensen and Cross's "Table 2, Descriptive statistics for constructs", from page 378 of [1].

Construct	*N*	Minimum	Maximum	Mean	SD
Stress	1008	0	42	13.93	9.264
Anxiety	1008	0	42	8.30	8.505
Depression	1008	0	42	11.41	10.023
Engr Identity	1000	1	7	5.83	1.212
Engr Career	1003	1	7	5.84	1.628
Dept Caring	1005	1	6	4.31	0.904
Dept Pride	1005	1	6	4.88	0.974
Dept Diversity	1004	1	6	4.68	0.976

Table 1: **Jensen and Cross's Table 2**: Descriptive statistics for constructs
Abbreviations: Dept, department; Engr, engineering, SD, standard deviation

This table compares the **mean and standard deviation values** reported by Jensen and Cross for each of the seven constructs analyzed against each of our three programs.

Construct	JC M	JC SD	CS M	CS SD	E1 M	E1 SD	E2 M	E2 SD
Stress	13.93	9.264	9.36	7.089	12.84	5.444	11.81	7.007
Anxiety	8.3	8.505	9.45	8.042	9.44	5.370	8.18	6.162
Depression	11.41	10.023	9.18	5.880	9.6	5.627	9.72	7.004
Engr Identity	5.83	1.212	5.18	1.047	5.67	0.752	5.83	1.058
Engr Career	5.84	1.628	5.45	1.809	6.6	0.763	6.72	0.550
Dept Caring	4.31	0.904	5.23	0.707	5.20	0.560	5.25	0.672
Dept Pride	4.88	0.974	5.37	0.645	5.16	0.786	5.30	0.795
Dept Diversity	4.68	0.976	5.49	0.648	5.33	0.641	5.37	0.646

Table 2: Mean (M) and standard deviation (SD) construct values, Jensen and Cross vs. our three programs (CS, E1, E2)

At a 95% confidence level the students enrolled in our three project-based programs showed less self-reported stress and depression but not anxiety than those assessed by Jensen and Cross. Project-based students were not statistically different with respect to engineering identity but did more strongly envision an engineering career. Also, the project-based students perceived their departments as more caring and diverse than those in the Jensen and Cross study. They also took more pride in their departments.

Conclusions and Future Work

Limitations of this work include the small sample size. Additionally, the unique nature of the programs studied limits transference to other populations. Although our N is small these results show the strong potential impact of project-based engineering programs. The programs in this study are still growing and evolving, so future work will examine performance changes 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. We plan to extend the current work to look at additional comparisons with elements of Jensen and Cross's original results not explored in this paper, including relationships between mental health, professional identity, inclusion, and demographics factors. Finally, additional work is needed to explore the similarities and differences between the stress cultures in project-based engineering programs and project-based computer science programs.

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