

The Role of Student Passions Inside the Engineering Curriculum

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Abstract— What gap exists between the kind of engineer an engineering program seeks to educate and the ways in which engineering students want their engineering education to engage them? This paper explores such a gap at Colorado School of Mines. Analysis of campus values and student passions through two surveys given in spring 2016 reveal incongruence in campus culture. The students and faculty currently value professional and financial success but aspire to value integrity, ethics and addressing complex problems. Further, surveyed students reported passions outside of engineering. However, just over half of students have been able to develop their non-technical passions at Colorado School of Mines while almost 90% believe developing those passions will make them a better engineer. To explain and rectify this mismatch, results are discussed in terms of three engineering education frameworks: culture disengagement in engineering education, the concept of "engineer and", and calls to include the "whole" student in the learning process.

Keywords— *Student passion; depoliticization; technical/social dualism; engineering values; campus culture*

I. INTRODUCTION

Student persistence in engineering education is highly related to students' identification with engineering [1]. However, such a claim often overlooks "calls for engineering education to produce global engineers" [1]. The need for programs to focus on educating global engineers is complicated by a longitudinal study at four U.S. institutions that found declines in engineering students' concerns for public welfare [2]. Incorporating student passions into the engineering curriculum is one potential method by which to work toward the goal of global engineers with stronger public welfare concerns, and is supported by existing literature. Scholars have identified a need to invite the "whole" student into the classroom [3] and have called on engineering institutions to "include elements that will ignite and sustain student passion" [4]. Inviting students to bring their whole selves to the classroom may foster a culture of engagement and open avenues for better recruitment and retention of students. This paper continues the conversation on the kind of engineer an institution should seek to educate by asking vital questions: What kind of engineers do students want to

become? What kind of engineers do faculty and administrators want students to become?

II. THEORETICAL FRAMEWORK

To understand the need to increase engagement, we first examine disengagement in engineering education. Longitudinal survey data from one study at four U.S. universities found that "students' public welfare concerns decline significantly over the course of their engineering education" [2]. Further, graduates from engineering programs were less interested in their "ethical responsibilities" than when they began [5]. This public disengagement can lead engineers to design systems and technologies that "perpetuate unequal structures and practices for disadvantaged groups" [2]. Two pillars of disengagement shape these decreases in student public welfare concerns. These pillars include *depoliticization*—the belief that the technical aspects of engineering can and *should* be separate from "social" and "political" concerns—and *technical/social dualism*—the tendency of engineers to not only separate the technical from the social but to place value on the realms of engineering that allow for the most extensive marginalization of social considerations [2].

Disrupting the culture of disengagement in engineering education can help programs educate engineers who see and value the interplays between the technical and social spheres of engineering. Further, culturally engaged engineers are more likely to recognize and work to disrupt structural inequalities that intersect with their work [3], [6]. The engineering education frameworks discussed below outline the problem: engineering education programs do not produce engineers who engage sufficiently with the social dimensions of engineering. Further, research into student passions and engineering and social justice suggests a solution: engage student passions *in the classroom* and make explicit connections, such as between passions for social justice and engineering.

Another study investigated the difference between engineers engaged in and not engaged in Engineers Without Borders (EWB) [7]. All engineering students in the study had "equivalent intrinsic motivations to study engineering" [7].

However, those involved with EWB had a “stronger desire to do good and help others as a motivator to study engineering, a wider variety of interests, and stronger personality traits (agreeableness and openness to experience) that are less common to engineers” [7]. In other words, the engaged students had interests in *engineering and X*, where X might be community service or some other passion. Fostering whatever comes after the *and* for engineering students could be a gateway to dismantling the pillars of disengagement. This study examines engagement in one specific institutional context, leading us to wonder how student passions and engagement in other organizations and activities influence motivation and values.

Engaging student passions in the classroom can help assuage the disengagement seen in engineering students. Incorporating passion is supported and called upon by existing studies, such as this one calling on campus leaders to better understand student passion and ask, “What motivates students on your campus to choose an engineering program? What can they be passionate enough about to keep them in an engineering program? Does your program include elements that will ignite and sustain student passion?” [5].

One program used storytelling to stimulate student interest and engage their passions. Students were not only more interested in the course, but stories helped build ethical values and build basic engineering principles “intuitively” [8]. Other programs use service learning and project based learning to anchor the attractiveness, social relevance, and connectedness of engineering [9]. One program that integrated service learning into a first engineering course found that students were more challenged and motivated by the project. Moreover, students believed it was a valuable experience that should be incorporated into more engineering courses. These studies offer a glimpse into methods used to engage students and enhance their engineering education.

Engineering programs should strive to engage students in their education and further emphasize both the contribution of engineers to public welfare and the responsibility of engineers to design with social justice in mind [6], [10]. Yet the only way to know how to begin engaging student passions inside engineering education is to understand student perspectives. Although it is unrealistic to expect to engage all student passions, it is vital to first know more about the nature of student passions, whether students perceive engineering education as providing opportunities to develop one or more of those passions, and whether students think developing such passions will make them a better engineer or scientist.

III. METHODS

This study seeks to discover how engineering programs can begin to foster engagement, make room for whatever comes after *engineering “and,”* and dismantle technical/social dualism. We examine one potential axis on which to dismantle the pillars of disengagement in engineering education: incorporating student passions. In doing so, we corroborate the existence of technical/social dualism at this institution and explore a potential remedy.

Two surveys, a Campus Values Survey (CVS) and a Student Passions Survey (SPS), were administered in spring 2016 at Colorado School of Mines. Besides one degree in economics and business, Mines only offers degrees in engineering and applied science fields, so the CVS was administered electronically to all faculty and students on campus, while the SPS was sent electronically to all students on campus. The CVS—sponsored by the Faculty Senate, an elected body that represents faculty interests on campus—gauged what students and faculty believe the institution’s community currently values and what they believe they should value. The CVS received 441 responses, 157 of which were undergraduate students, 95 of which were graduate students and 189 of which were faculty/administration. The student response rate was 8.82% and faculty/administration response rate was 52.5%. Students were not asked to specify their enrollment level beyond graduate vs. undergraduate. Appendix A includes the CVS questions.

The SPS—administered by one of the authors—gauged the interests and passions of the institution’s students. Participants provided their major, minor, year in school, the three organizations or activities they are most involved in on campus and what they hope to do after graduation. Then, participants could answer three optional questions that asked about their passions beyond engineering:

- Question 1: Beyond engineering/science, what are you passionate about?
- Question 2: Have you been able to develop your passions while you’ve been at Mines? What has Mines done to foster your passions?
- Question 3: Do you think the time you’ve spent fostering those passions will make you a better engineer/scientist? If so, how? If not, why not?

The SPS was administered via email and received 137 responses from 123 undergraduates (27 freshmen, 34 sophomores, 33 juniors, 29 seniors) and 14 graduate students with 130 of those students completing the optional questions. The overall response rate is low, at 2.7%. Responses to optional questions were coded into strongly agree, somewhat agree and disagree as illustrated in Table I. Appendix B includes the full SPS.

TABLE I. CRITERION USED TO CLASSIFY RESPONSES TO QUESTIONS 2 AND 3

	Student Response		
	<i>Strongly Agree</i>	<i>Somewhat Agree</i>	<i>Disagree</i>
Question 2	Student has been able to develop passion at institution	Student has been able to develop passion in some ways, but not as much as they would like	Student has not been able to develop passion at institution
Question 3	Student believes that fostering their passions will make them a better engineer	Student is unsure if fostering their passions will make them a better engineer	Student does not believe fostering their passions will make them a better engineer

IV. FINDINGS

Findings are discussed in three phases: looking at the CVS, SPS, and a third section looking at the surveys' intersections.

A. Campus Values Survey

If findings from the two surveys could be summarized in a single phrase, it would be *Keep the challenge but engage the passions*. The CVS data does not call for an “easier” engineering curriculum. In fact, students—even more so than faculty—believe hard work and professional success are currently and should remain core values in an engineering program. As noted in Table II, 56% of students not only expect to work hard and handle high workloads but also believe this should be a core piece of the engineering education experience. However, only 28% of faculty believes this should be a core value. Despite such figures, faculty control the classes that cause the high workloads. This may indicate differing definitions of “high workloads” or differing perspectives of “core values”.

The CVS identified a chasm between current and aspirational campus values. In fact, the top four values that students and faculty perceive as currently engaged and the top four values students and faculty believe should propagate throughout campus (Table II) share only one common value: challenge, addressing difficult or complex problems. Faculty strongly believe engagement, intellectual curiosity and creativity should be valued in an engineering program. Integrating student passions into the classroom could do exactly that. The addition of empathy, ethics, integrity and the other high scoring values could create more dynamic and engaged scientists and engineers.

TABLE II. PARTIAL STUDENT AND FACULTY/ADMINISTRATION RESPONSES TO “TO WHAT EXTENT DO THE FOLLOWING CURRENTLY DEFINE THE CORE VALUES OF THE MINES COMMUNITY?” (“CURRENT”) AND “TO WHAT EXTENT SHOULD THE FOLLOWING CURRENTLY DEFINE THE CORE VALUES OF THE MINES COMMUNITY?” (“SHOULD”).

Value	Percent strongly agree			
	Student “Current”	Faculty “Current”	Student “Should”	Faculty “Should”
Hard work, handling high work loads	88	75	56	28
Professional success, contribution to industry	84	66	58	50
Financial success, high salaries	72	48	25	18
Challenge, addressing difficult or complex problems	64	41	90	87
Intellectual curiosity, engagement	45	31	88	95
Creativity, innovation	35	23	87	87
Integrity, honesty, trustworthiness	27	22	85	94
Ethics, doing the right thing	26	17	85	87

Value	Percent strongly agree			
	Student “Current”	Faculty “Current”	Student “Should”	Faculty “Should”
Empathy, understanding others	9	6	53	53

B. Passions Survey

Distinct student perspectives emerged from the SPS. Overall, the data indicate that students who responded value non-technical passions and yearn to develop them.

The SPS identified shortcomings in the institution’s educational approach consistent with the findings in the CVS. Table III indicates that over 90% of students believe their passions are relevant to engineering, but only slightly over half have been able to develop those passions while at Mines (Table III). Further, 48.2% of students reported a passion for social justice, humanitarian work, service, education or access to education. Of these students, 98.5% view their passion as highly relevant to engineering. This corroborates the CVS, revealing that students not only have passions outside of engineering, but they are passionate about engineering and X (where X may be social justice, humanitarian work, service, etc.). The SPS results also accentuate that students value the intersections between the technical and social and desire opportunities to foster passions that will make them better engineers or scientists.

TABLE III. STUDENT RESPONSES TO QUESTION 2 (N=130) AND QUESTION 3 (N=129) ON PASSION SURVEY

	Coded Student Responses		
	Strongly Agree	Somewhat Agree	Disagree
Have you been able to develop your passions at Mines?	56.92%	23.85%	19.23%
Do you think the time you’ve spent fostering those passions will make you a better engineer/scientist?	88.37%	4.65%	6.97%

Students rely heavily on structures *outside* of the technical curriculum to develop their passions. Of the 130 students who answered question 2, all but four students cited some non-technical outlet that has allowed them to develop their passions at Mines. (Of the 130 responses, 32 could not be classified as technical/non-technical.) These students mentioned the McBride Honors Program in Public Affairs and the Humanitarian Engineering Program as well as on-campus clubs, organizations and the people on campus as the reason they have been able to develop their passions. One student, passionate about “being a well-rounded citizen who is capable of clear communication and well-informed about current events,” captures this realization in a response, saying he or she feel that his or her efforts to develop passions are “outside the core values” of Mines, existing “in spite of engineering, and do not describe Mines fostering my passions.” Harkening back to the CVS, this makes sense. In a culture defined by tackling high workloads, it is not surprising that students feel

they have insufficient time for their personal, non-technical passions. In this student's case, their passions might fall under categories like "addressing difficult or complex problems" and "ethics, doing the right thing," both of which are currently valued significantly less than handling high workloads.

C. Survey Intersections

Combing the two survey results reveals that many students want more from their engineering education than four years of non-stop work funneling them into high-paying industry jobs. They want to be engineers and applied scientists who devote their formative college years to developing technical skills/abilities *and* their passions—engineers and scientists who care about addressing complex problems and doing the right thing. Recall that 48.2% of students are passionate about social justice, humanitarian work, service, education or access to education – all passions centered on addressing complex problems and doing the right thing. The desire for a shift in education raises questions about how engineering programs can better engage student passions in their engineering education. These results add to the call on institutions to address the mismatch in campus values and the desire to expand the engineering culture to include non-technical passions that students perceive to be inherent in their technical work.

V. DISCUSSION

Overall, these data suggest that students believe their passions are relevant to engineering, but they welcome more support in developing them. Nearly every student who did not strongly agree that they had been able to develop their passions at Mines cited a *lack of time* as the reason. Students spend so much time engulfed by their technical work that their passions are left to sit on a shelf, collecting dust. A sophomore in Mechanical Engineering noted that it is "really easy to push off all of your extracurricular and passions here if you let yourself only focus on school." She further noted that it takes a "conscious effort to get out and focus on the other things you are passionate about."

Some may argue that while students have passions that fall into the social realm and perceive them as relevant to engineering, they are not actually relevant to technical courses like fluids or mechanics of materials. This concern can be addressed by Figure 1, which gives a visual representation of student responses to Question 1. The larger the word, the more students gave that response. Figure 1 shows that music, art, climbing, and traveling are among the most common student passions.

Though developing these passions can make better engineers, technical courses may not be the best place for that development to occur. However, if professors can recognize and mention connections to music or art when they are germane to the content, students may begin to see those passions—and more broadly, the development of the whole person—as valued inside their technical courses and inside the engineering profession.

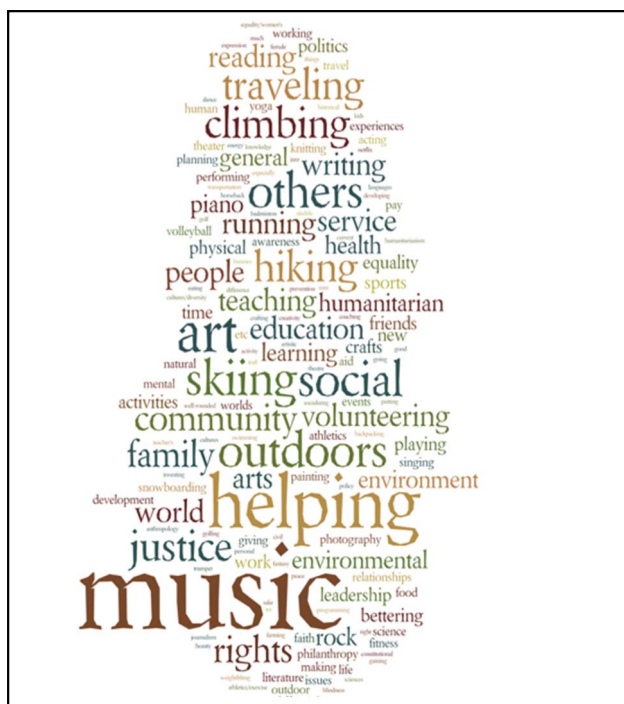


Figure 1 - Visual representation of student responses to Question 1. The larger the word, the more it was used in responses. Responses were reduced to key elements. Created via wordle.net.

On the other hand, words like helping (others), humanitarian, justice and environment/environmental recur among student passions. These passions are directly relevant to engineering. In fact, they are emphasized in the oath that engineers take at the end of their education in order to join the Order of the Engineer. Engineers vow to "serve humanity by making best use of the Earth's precious wealth" – implicitly emphasizing humanitarian work and environmental justice – and to give their skill and knowledge "without reservation for the public good" – emphasizing helping others, public welfare, and justice [9]. At its core, the engineering profession values these passions. So why must students look outside their core courses to develop them? It seems the clear answer is the technical curriculum—which occupies the bulk of a students' time—does little to produce engineers *and*. Rather, it is the tangential clubs and minor programs that develop students' passions beyond engineering.

Thus, we see the support for the existence of the pillars of disengagement. In both surveys, students and faculty recognize depoliticization in their engineering culture – students recognize that their social and political passions are not incorporated into "real" engineering courses and faculty recognize that values of ethics and empathy take a back seat to traditional engineering values like handling high work loads and professional and financial success.

Students also recognize and some push against technical/social dualism. Responses to the SPS revealed that students perceive their core, technical, engineering courses to be much more important to competence as an engineer than their marginalized liberal arts courses. Currently, students and

faculty believe the most value is placed on hard work, handling high work loads, professional success, contribution to industry and high salaries—all traits that go hand in hand with what is perceived as the technical side of engineering. However, survey data also show that students and faculty agree that our campus should promote values like empathy, ethics and integrity. These issues may, perhaps, be framed as non-technical values, explaining why they are perceived as currently less important, i.e., bracketed as social and external to engineering. But, students and faculty want these values to be central to engineering. In fact, 62% of students and 69% of faculty agree empathy should be a core value, 85% and 87% agree ethics should be key, and 85% and 94% integrity, respectively. The question becomes, how can we overcome the forces of depoliticization and technical/social dualism in order to create a community that holds the values we believe it should? Cech suggests that if engineering programs can “overcome forces of isomorphism” – the push to all follow the same, set structure – and “challenge the ideological pillars of disengagement,” they can create a “new brand of engineer” that values the interplay between public welfare and technology [3].

VI. CONCLUSION

These results call for more research to investigate cross-institutional patterns and to understand whether change is merited in the treatment of student passions in technical engineering courses. Essentially, the message from respondents to the SPS could be summed up in this manner: Rather than checking passions at the door, invite them in. Whenever relevant, connect passions for volunteering, the outdoors, and social justice, to technical engineering content. Most importantly, show students how the content fits into the values they want the program to hold. Engaging student passions in the classroom can transform engineering education, increase engagement and begin to dismantle depoliticization and technical/social dualism.

Since the passion survey had a response rate of 2.7%, this is a limitation of this study. However, the findings of this survey are compelling qualitatively, calling for further investigation into the intersection of student passions and technical curriculum approaches and its impact on engagement and retention. Future studies should investigate multiple institutional contexts via surveys and perhaps interviews on student passions and the role students and faculty think those passions should play inside the engineering curriculum. Those studies should also investigate learning gains with and without passions engagement in technical courses.

Altogether, student passions are not to be ignored. Engineering students have passions that are inherently linked to engineering, yet in this study, students clearly indicated that those passions are not engaged in the engineering classroom. Thus, emphasizing passions serves as a leadership opportunity for faculty. This is not a call for professors to jettison relevant technical content nor is it a call to focus on integrating each and every individual passion (that is impossible). However,

professors can make connections between content and common passions when appropriate. For example, a fluids class could mention the Dakota Access Pipeline to engage students passionate about social justice and the outdoors and emphasize the importance of learning the technical content. Students look to educators to learn how engineering makes a difference in real-world applications and why it matters. Making relevant connections between content and passions can help bolster student learning, especially when using ill-defined problems and critical thinking exercises [13], and inspire students to engage with and better their world.

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APPENDIX A

Campus Values Survey

(Options listed for multiple choice questions)

1. What is your position at Mines?
Academic faculty, administrative faculty, undergraduate student, graduate student, staff
2. If you are a student or faculty, what academic department or major are you in?
Chemical and Biochemical Engineering, Chemistry & Geochemistry, Metallurgical & Materials Engineering,

Physics, Applied Mathematics & Statistics, Civil & Environmental Engineering, Electrical Engineering & Computer Science, Mechanical Engineering, Economics & Business, Geology & Geological Engineering, Geophysics, Liberal Arts & International Studies, Mining Engineering, Petroleum Engineering, Other/not applicable/undeclared

3. To what extent DO the following currently define the core values of the Mines community? Note that this asks you about existing values; a subsequent question will ask for your thoughts on what “should” define our values.

Rank: To a great extent, somewhat, hardly or not at all

Financial success, high salaries; hard work, handling high work loads; challenge, addressing difficult or complex issues or problems; compassion, kindness, understanding; balance, in work and life; integrity, honesty, trustworthiness; humility, modesty; empathy, understanding others; open-mindedness, free exchange of ideas, openness to new ideas or contrary opinions; diversity, of opinions, backgrounds, perspectives; environmental stewardship, sustainability; professional success, contribution to industry; collaboration, working in teams; intellectual curiosity, engagement; selflessness, putting needs of others above self; health and safety, personal safety of others; ethics, doing the right thing; compliance, following rules and regulations; creativity, innovation; helping students succeed

4. To what extent SHOULD the following currently define the core values of the Mines community? These may be things that do appear to define our values, or things that may not appear to do so.

(Same options and ranking system as Question 3)

5. In your own words, what should be the most important core values of the Mines community?

6. Thinking about faculty, teachers, or others who have taught you at Mines or elsewhere, what actions, attitudes, or approaches stand out as having supported your learning and growth? Please specify whether you are talking about Mines or elsewhere.

7. Thinking about faculty, teachers, or others who have taught you at Mines or elsewhere, what actions, attitudes, or approaches did NOT support your learning and growth? Please specify whether you are talking about Mines or elsewhere.

8. What actions (big or small) can members of our community (faculty, students, staff) do to create a more supportive, caring,

or less stressful, climate? Please feel free to be as specific as you like. Sometimes, real, tangible suggestions can be more helpful than broad statements.

APPENDIX B

Student Passion Survey

This survey is designed to better understand CSM students changing interests to enrich Mines undergraduate education.

Please answer the questions below

Required Questions:

1. Please list your major

2. Please list your minor

3. Year at Mines

First-Year, Second-Year, Third-Year, Fourth-Year, Fifth-Year, Graduate, Other

4. Please list the three organizations/activities that you are most involved with on campus

5. What do you hope to do after Mines?

Graduate school, humanitarian work, industry, start my own business, teaching, undecided, other

Optional Questions:

1. Beyond engineering/science, what are you passionate about?

2. Have you been able to develop your passions while you’ve been at Mines? What has Mines done to foster your passions?

3. Do you think the time you’ve spent fostering those passions will make you a better engineer/scientist? If so, how? If not, why?