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Intersections Between Entrepreneurial Minded Learning, Identity, and Motivation in Engineering*

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A growing trend in engineering education is to infuse entrepreneurial minded learning (EML) into design-based courses across the curriculum. This educational approach supports students in developing an entrepreneurial mindset by the time they graduate and enter the workforce where such a mindset will be vital for their success. We posit that the infusion of EML in the first year of engineering education sets students on a trajectory to develop an entrepreneurial mindset by graduation, along with enhancing their motivations to succeed in the field and developing their identity as engineers. To investigate the impacts of EML, motivation, and identity, we surveyed first- and fourth-/fifth-year engineering students across five different institutions representing variation in academic setting, approach to EML, and maturity of their EML program. Through our multi-method analysis, we did not find evidence of major differences across the five institutions as we anticipated. However, we found noteworthy differences in the impact of one particular program at one site compared to the other sites, including higher average scores for all EML student outcomes at this site. We also found differences between male and female students and students in different educational years. We observed a positive relationship between EML and motivation across all sites. Based on our analysis, we believe the practice of using EML in engineering education holds promise for supporting students' success as engineers in the field. However, additional research into the nuances of EML experiences is needed to identify what makes them successful as our work did not show as many unique findings across sites as were anticipated. We attribute the lack of patterns to the variability between and within site EML implementation.

Keywords: entrepreneurial minded learning; identity; motivation; engineering

1. Introduction

Engineering curriculum is ever evolving to incorporate additional aspects of design and project-based learning as well as creativity and entrepreneurship [1–5]. These changes are motivated by national calls for enhancements to engineering education (e.g., [6–11]). Educators, engineers themselves, and policymakers increasingly recognize that for engineering students to be competitive and meet the needs of an ever-changing world when they graduate, their education must evolve with it.

We believe that one change that will support engineering students' development into professionals who can meet the needs of the evolving work is including the entrepreneurial mindset within our engineering curriculum. A growing network of institutions known as the Kern Entrepreneurial Engineering Network (KEEN) have supported this view with professional development opportunities, networking, and funding [12]. KEEN brings together thousands of engineering faculty working to enhance undergraduate engineering education through entrepreneurial minded learning (EML). For the purposes of this study, EML is defined as applying an entrepreneurial mindset to learning in engineering coursework [13].

To ensure a solid foundation related to the entrepreneurial mindset, we posit that EML must begin in the first year of engineering education. Likewise, substantial evidence reflects the key role of first-year engineering in establishing motivation and identity (e.g., [14, 15]). Both first-year and capstone (typically taken in the fourth/fifth year) courses typically include a design project [16] which is an ideal setting to incorporate EML since many of the aspects of EML fit into the design process. Additionally, EML supports the complex roles of engineers in bringing to light the technical but also the social aspects of engineering work.

To investigate the importance of introducing EML in the first year, this research investigates the differences with respect to EML, motivation, and identity, across multiple institutions aiming to develop an entrepreneurial mindset in their students. Our work responds to a significant research gap, as we found little to no work that has coupled motivation and identity with EML impact in engineering during our literature search. We believe there is potential for interactions between these constructs, so we used both an EML lens and a combined motivation and identity lens in our analysis.

Since exploring these constructs in combination

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was new, we approached this work from an exploratory perspective. As such, the research question that guided this study was: *How do EML experiences affect engineering students' entrepreneurial mindset, motivation, and identity development in design-based courses across different institutions?* Specifically, we sought to answer the following sub-research questions (RQ):

- RQ1: To what extent do engineering students achieve EML learning outcomes as they work on design projects across different EML experiences?
- RQ2: How do EML experiences impact engineering students' identity development?
- RQ3: How do engineering students' motivations differ across EML experiences when working on design projects?
- RQ4: What is the relationship between engineering students' motivation and achievement of EML learning outcomes in design-based courses?

To answer these research questions, we distributed surveys to first-year and fourth-/fifth-year engineering students at five different institutions known to include EML experiences in their design courses. We initially examined differences across sites related to the entrepreneurial mindset, motivation, and identity as we hoped to gain a better understanding of EML's impact across the field when EML is infused into cornerstone and capstone design courses. Our initial analysis revealed no major differences or interaction between the constructs, so we continued to analyze our data for other noteworthy findings.

1.1 Background

EML promotes a specific mindset that engineering students can use to approach problem solving [17, 18]. Since the inception of the KEEN network in 2005, EML has been introduced in a variety of engineering educational contexts. Many institutions incorporated it into senior level capstone design courses (e.g., [19–21]). In these courses, students typically work on real-world projects and communicate directly with clients who may be industry partners or community members [16]. Regardless of the partnership, these experiences give students first-hand knowledge about EML, where the goal is to design a technology or solution to meet customer needs [21].

Institutions are also increasingly introducing EML into first-year engineering courses (e.g., [22–36]). In presenting these curriculum redesigns, scholars focused on the instructional change rather than assessing its impact (e.g., [22, 33, 35]). The quantitative assessments researchers have used tend to be student self-reported surveys focused on the KEEN framework (e.g., [24, 29, 31]), project-specific self-reported skills (e.g., [25, 32, 36]), or both the framework and skills (e.g., [30]). Others have used direct assessment of EML constructs via in-course rubrics (e.g., [28]) as well as directly examining student work for the elements of EML (e.g., [34]) and first-year student self-reflections on their learning (e.g., [23]).

1.2 Theoretical Framework

For this study, we used two theoretical frameworks to guide our work: the KEEN Framework [13] and the Longitudinal Model of Motivation and Identity (LMMI) [37]. The KEEN Framework allowed us to study EML while the LMMI allowed us to investigate motivation and identity. Given the exploratory nature of the study, we used the frameworks as separate lenses to view the findings but also sought to integrate them to elicit further insights.

The KEEN Framework includes the entrepreneurial mindset and engineering skillset [13]. The entrepreneurial mindset has three components known as the 3C's: *Curiosity*, *Connections*, and *Creating Value*. *Curiosity* is defined as a student's interest in the changing world and capacity to think critically about existing solutions to any product, problem, or system. *Connections* includes integrating various sources of knowledge to develop innovative solutions and evaluate risk. *Creating Value* requires students to consider others and their needs while recognizing unexpected opportunity and persisting through failure. The skillset includes opportunity, design, and impact. Each of these skillsets include six specific skills related to engineering ranging from identifying an opportunity to protecting one's intellectual property. The mindset plus the skillset combine to produce educational outcomes that include *Collaboration*, *Communication*, and *Character*. Our data gathering focused on the 3C's of the entrepreneurial mindset and the educational outcomes of this framework.

The LMMI [37] combines self-determination theory (SDT) [38] with possible-selves theory (PST) [39]. It is a conceptual model that is used to study individual development. PST serves as the base for an experience involving the SDT constructs of the basic psychological needs for Autonomy, Competence, and Relatedness. PST, which looks at both expected and feared possible selves, posits that students should set goals, think to the future, and envision themselves after an experience. The LMMI posits that when SDT needs are met during an experience, students have increased motivation and identity development.

At a high level, we posit that as students engage in EML, they are provided with the opportunity to develop their motivation to persist during engineering projects and further form their identity as engineers. To begin the exploration of this relationship, we measured items related to the entrepreneurial mindset, motivation, and identity separately and then compared the constructs during analysis to identify trends.

2. Methods

For this multi-method study, we used a survey administered to engineering students at five different institutions. The survey was distributed at the end of the Spring 2018 semester via Qualtrics and included both Likert-style scale and open-ended questions related to the KEEN Framework and the LMMI. The quantitative and qualitative analyses aimed to compare EML, motivation, and identity while looking for differences across demographic groups and institutions. To be able to measure and understand the impact of EML at each institution, we included students at different points in their engineering education in our sample. We selected first- and fourth-/fifth-year students because they commonly take design-based courses, which typically include EML elements.

2.1 Recruitment

The five institutions were all members of KEEN [12]. Specifically, we targeted institutions known for incorporating EML into their first-year engineering programs and courses, as this was less common than incorporating EML into capstone courses at the time. The institutions represent a variety of student body sizes, institutions that were both new and long-standing members of KEEN, a variety of geographic locations, both public and private universities, and whether the school was residential (e.g., fewer than 25% of undergraduate students lived on campus at Site 2 (Nonresidential Private University) but more than 50% did at Site 3 (Residential Private University)). The characteristics of the sites, based on the Carnegie Classification [40], are shown in Table 1.

All five institutions had first-year engineering programs that incorporate design projects within the curriculum. However, the elements of EML included in each program differed, as well as how the programs introduced EML concepts [41]. At Site 1 (Medium Public University), students completed open-ended design projects which incorporated EML elements in both first-year and capstone courses. At Sites 2 (Nonresidential Private University) and 3 (Residential Private University), students were exposed to EML in all 4 years. Site 4 (Large Midwest Public University) was divided into two subpopulations (labeled 4a and 4b) for the results in this paper based on two approaches to EML implementation. Site 4a (Large Midwest Public University – Integrated Program) was a small ~36 student per year cohort model that paired engineering students with business students and incorporated EML elements into their engineering design all years, with emphasis in first-year and capstone courses. The majority of Site 4 students were in Site 4b (Large Midwest Public University – Standard Program), which did not explicitly include EML content in their first-year and capstone design courses. The final site, Site 5

Table 1. Site Characteristics

Site Number (Pseudonym)	Control	Student Body (Fall 2017)	Engineering B.S. Degrees Awarded (2017–2018)[1]	Geographic Region	Year Joined KEEN	Size and Setting	Use of EML
Site 1 (Medium Public University)	Public	6,209	961	West	2018	Four-year, medium, primarily residential	In first-year and capstone courses
Site 2 (Nonresidential Private University)	Private	3,069	182	Midwest	2005	Four-year, small, primarily nonresidential	Across all 4 years
Site 3 (Residential Private University)	Private	3,088	89	Midwest	2005	Four-year, small, highly residential	Across all 4 years
Site 4 (Large Midwest Public University)	Public	59,837	1,593	Midwest	2017	Four-year, large, primarily residential	4a: Across all 4 years 4b: No EML use
Site 5 (Large Northeast Public University)	Public	18,484	313	Northeast	2016	Four-year, large, primarily residential	In first-year and capstone courses

[1] https://nces.ed.gov/ipeds/use-the-data – 2018 Completions Dataset A.

(Large Northeast Public University), had first-year and capstone open-ended design projects within their undergraduate curriculum that included EML elements.

Following approved Institutional Review Board (IRB) protocols which limited participants to 18 years or older, first- and fourth-/fifth-year engineering student participants were recruited from each institution to take the survey. A faculty or staff member at each institution distributed the survey. The engineering degrees awarded per institution in the year 2017–2018 (see Table 1) provided a comparison of the engineering participant population compared to the university population based on information available through the Integrated Postsecondary Education Data System [42]. As an incentive, participants were entered into a drawing for a chance to win one of two $50 gift cards that were available for each institution.

Table 2 shows the overall number of respondents, gender distribution, and the breakdown of the first- and fourth-/fifth-year students at each site. As seen in the table, the distribution by site was proportional to the student body distribution in Table 1. Site 4 (Large Midwest Public University), the largest site, represented 57.5% of the overall respondents and Site 3 (Residential Private University), the smallest site, represented 3.3% of the respondents. Furthermore, 54.6% of respondents were male and 41.1% were female. First-year students represented 48.7% of the respondents and fourth-/fifth-year students represented 51.3% of the total respondents. Because each survey was distributed by site contacts and we do not have access to the distribution lists, an exact response rate could not be calculated for each site. However, the total respondents per site did map to the study body noted in Table 1, where the largest university had the most responses.

2.2 Data Collection

The survey was distributed via email that included a Qualtrics link and took approximately 20 minutes to complete. The survey questions contained both Likert-style scale questions to elicit quantitative trends for both the EML framework and the SDT component of the LMMI framework, and open-ended questions corresponding to the PST component of the LMMI framework. In addition to demographic questions, the survey protocol included the following three sets of questions:

- **Part 1: KEEN Student Outcomes** – Eighteen four-point Likert-style scale questions that focused on the KEEN Framework's 3C's of EML (curiosity, connections, and creating value), as well as the three educational outcomes of EML (collaboration, communication, and character) [13]. These items were an adapted subset from the expanded KEEN student outcomes with three scale items chosen for each of the 3C's and educational outcomes. See Table 14 in the Appendix for a mapping of the EML items to the six EML constructs.
- **Part 2: Possible Selves Theory** – Four open-ended questions were adapted from the PST Questionnaire [43] to be suitable for undergraduate students and to elicit views about graduation. These four questions were:
  1. In the text boxes below, write about what you expect you will be like and/or what you expect to be doing after you graduate. Please list up to 5 goals.
  2. In addition to expectations and expected goals, we all have images or pictures of what we do not want to be like, what we do not want to do, or what we want to avoid being. Think a minute about ways you would not like to be after you graduate – things you are concerned about or want to avoid being like. In the text boxes below, write those concerns or selves to-be-avoided (STBA) after graduation. Please list up to 5 concerns or selves to-be-avoided (STBA).

Table 2. Number of Respondents by Site, Gender, and Year

	Total		**By Gender**				**By Year**	
Site	**Total # Responses**	**% of Total**	**Male**	**Female**	**Prefer Not to Answer**	**No Response**	**1st Year**	**4th & 5th Year**
1	57	11.7%	50.9%	49.1%	0.0%	0.0%	64.9%	35.1%
2	56	11.5%	57.1%	37.5%	3.6%	1.8%	35.7%	64.3%
3	16	3.3%	62.5%	37.5%	0.0%	0.0%	37.5%	62.5%
4a	15	3.1%	73.3%	26.7%	0.0%	0.0%	73.3%	26.7%
4b	266	54.4%	50.0%	47.0%	1.9%	1.1%	39.1%	60.9%
5	79	16.2%	65.8%	21.5%	0.0%	12.7%	75.9%	24.1%
Total	596	100%	54.6%	41.1%	1.4%	2.9%	48.7%	51.3%

Key: Site 1: Medium Public University; Site 2: Nonresidential Private University; Site 3: Residential Private University; Site 4a: Large Midwest Public University – Integrated Program; Site 4b: Large Midwest Public University – Standard Program; Site 5: Large Northeast Public University.

3. On the previous page, you identified goals for after graduation (repopulated below). Mark NO if you are not currently working on that goal or doing something about that expectation, and mark YES if you are currently doing something to get to that expectation or goal. For each expected goal that you marked YES, also write what you are doing now to attain that goal with the goal in the corresponding larger text box.
4. On the previous page, you identified concerns or selves to-be-avoided after graduation (repopulated below). Mark NO if you are not currently working on avoiding that concern or self to-be-avoided, and mark YES if you are currently doing something so this will not happen after you graduate. For each concern or self to-be-avoided that you marked YES, also write what you are doing now to reduce the chances that this will describe you after you graduate with the concern or to-be avoided self in the corresponding larger text box.

- **Part 3: Self-Determination Theory Basic Psychological Need Satisfaction Scale** – Twenty-one seven-point Likert-style scale statements modified to focus on design projects from the SDT basic needs scale for Autonomy, Competence, and Relatedness [44].

These questions were chosen to focus on EML, motivation, and identity which would allow us to compare the constructs in our analysis. The survey was reviewed by experts in the EML learning space along with a motivation and identity expert to establish content and face validity.

2.3 Analysis

Each set of questions was analyzed individually, with the type of analysis depending on whether the questions were Likert-style or open-ended. The quantitative data analysis was performed in IBM$^{(R)}$ SPSS$^{(R)}$ Statistics for the KEEN Framework and the SDT questions. Qualitative data analysis was performed in Microsoft Excel for the PST questions. Additionally, correlation analyses were conducted to assess the impact of motivation on EML student outcomes.

It should be noted that throughout our analysis, we used Site 4b (Large Midwest Public University – Standard Program) as a baseline group, as indicated by the asterisk in the subsequent tables. Because Site 4b (Standard Program) is the only site in this study in which EML was not being implemented at the time of this research, the other sites are compared to Site 4b (Standard Program) in terms of the KEEN Student Outcomes. We use Site 4a (Integrated Program) as a subset group which is more similar to the other sites.

First, the data was prepared for the analysis, starting with merging the survey results from each site into one dataset while keeping the site identifier. Next, the EML student outcomes responses were averaged to obtain scores for each of the six constructs (see the Appendix for the mapping of the items to the constructs) and certain SDT responses were reverse coded for alignment. The PST items were quantitized [45] for inclusion in the dataset following the coding instructions developed by Oyserman [46]. This included evaluating the responses (up to five per respondent) for each of the expected and feared possible selves, yielding up to ten responses per respondent. Each response was indicated with a value corresponding to the category to which it was referring: 1 for achievement, 2 for interpersonal relationships, 3 for personality traits, 4 for physical/health-related, 5 for material/lifestyles, and 6 for negative (for expected possible selves) or non-normative/risky behaviors (for feared possible selves). Only one category per response was selected.

Once the data was prepared, Cronbach's Alpha and Kolmogorov-Smirnov normality tests were performed for the EML student outcomes and SDT constructs to ensure their reliability and determine whether the data was normally distributed. The Cronbach's Alpha reliability statistics for the EML student outcomes and SDT (in Table 3) indicate that the constructs were reliable. Furthermore, the data for both constructs were normally distributed and, therefore, did not require non-parametric statistics.

To analyze the EML student outcomes by construct (to answer RQ1), mean scores were obtained for each of the six constructs overall and by site, breaking it down further by first-year and fourth-/fifth-year students and gender. T-tests with a 95% confidence interval were performed to compare the mean scores for the schools and determine if there were differences in genders and between first- and fourth-/fifth-year students. To analyze the PST

Table 3. Cronbach's Alpha for EML and SDT Constructs

Construct	Item	Cronbach's Alpha
EML Student Outcomes	Curiosity	0.723
	Connections	0.733
	Creating Value	0.732
	Communication	0.760
	Collaboration	0.750
	Character	0.776
SDT	Autonomy	0.695
	Competence	0.705
	Relatedness	0.842

construct (to answer RQ2), frequencies were calculated to compare the expected and feared possible selves by category for each site and for first- and fourth-/fifth-year students. For the SDT responses (to answer RQ3), mean scores for the *Autonomy*, *Competence*, and *Relatedness* constructs were calculated by site, gender, and first- and fourth-/fifth-year students. T-tests with a 95% confidence interval were also performed to compare the differences between sites as well as by gender and first- and fourth-/fifth-year students. Lastly, a correlation analysis was performed between the two quantitative, Likert-style constructs, SDT and EML Student Outcomes, to provide more detail on the relationship between EML and motivation (to answer RQ4). Once all analyses for each of the sets of questions were completed, the quantitative and qualitative results were reviewed holistically to understand the impact of EML on engineering students' motivation and identity.

3. Results

The results of this work include an exploratory investigation into EML, motivation, and identity across the various institutions. In this section, we provide a detailed analysis of the various tests that were performed on the data. The results are organized by our four sub-research questions.

3.1 KEEN EML Student Outcomes (RQ1)

Table 4 shows the mean scores by site for the KEEN EML student outcomes and whether the sites were statistically different from Site 4b (Large Midwest Public University – Standard Program), as indicated by the bold font. Site 4a (Large Midwest Public University – Integrated Program) had higher scores for all constructs when compared to Site 4b (Standard Program), with *Connections* being a statistically significant higher mean score. Conversely, when comparing Site 2 (Nonresidential Private University) to Site 4b (Standard Program), Site 2 had lower scores for all constructs, with statistically significant lower mean scores for both *Creating Value* and *Communication*. There were no significant differences in any of the EML student outcomes when comparing Site 1 (Medium Public University), Site 3 (Residential Private University), and Site 5 (Large Northeast Public University) to Site 4b (Standard Program).

When comparing the EML student outcomes by gender, as shown in Table 5, *Character* was the only EML construct to have significantly different means, with females having higher mean scores than males for Site 4b (Standard Program) and Site 5 (Large Northeast Public University). Otherwise, there was no pattern between sites or across EML constructs, and scores varied as to whether males or females had higher scores.

The results for comparing EML student outcomes by year in school are shown in Table 6. Except for Site 1 (Medium Public University) in which there were no significant differences, the student outcomes that had significant differences between first- and fourth-/fifth-year students varied, with no visible pattern across sites. Fourth-/fifth-year students had significantly higher mean scores for *Connections* at Sites 4b (Standard Program) and 5 (Large Northeast Public University), for *Communication* at Sites 2 (Nonresidential Private University) and 5 (Large Northeast Public University), and for *Character* at Site 3 (Residential Private University). Conversely, first-year students had significantly higher mean scores than fourth-/fifth-year students for *Creating Value* at Site 4a (Integrated Program). Furthermore, *Curiosity* and *Collaboration* did not have any significant differences between years in school at any of the sites.

3.2 Possible Selves Theory (RQ2)

The analysis of the PST questions focused on the six categories for which the students' responses corresponded: (1) Achievement, (2) Interpersonal Relationships, (3) Personality Traits, (4) Physical/Health-Related, (5) Material/Lifestyles, and (6) Negative (for expected possible selves) or Non-Normative/Risky Behaviors (for feared possible

Table 4. Comparison of Mean Scores to Site 4b Baseline

KEEN EML Student Outcome	Site 4b*	Site 1	Site 2	Site 3	Site 4a	Site 5
Curiosity	3.22	3.31	3.11	3.18	3.36	3.15
Connections	3.20	3.27	3.09	3.26	**3.55**	3.23
Creating Value	3.06	3.23	**2.89**	3.14	3.35	3.01
Communication	3.22	3.24	**3.02**	3.43	3.43	3.15
Collaboration	3.21	3.25	3.19	3.33	3.47	3.23
Character	3.25	3.32	3.12	3.36	3.47	3.33

Bold numbers represent statistically significant differences, $p < 0.05$.
Key: Site 1: Medium Public University; Site 2: Nonresidential Private University; Site 3: Residential Private University; Site 4a: Large Midwest Public University – Integrated Program; Site 4b: Large Midwest Public University – Standard Program; Site 5: Large Northeast Public University.

Table 5. KEEN EML Student Outcomes Mean Scores by Site and Gender

Construct	Gender	Site 1	Site 2	Site 3	Site 4a	Site 4b	Site 5
Curiosity	M	3.35	3.09	3.15	3.38	3.23	3.12
	F	3.27	3.16	3.25	3.33	3.22	3.35
Connections	M	3.32	3.05	3.30	3.53	3.19	3.24
	F	3.21	3.17	3.17	3.60	3.20	3.42
Creating Value	M	3.17	2.84	3.13	3.28	3.05	2.97
	F	3.08	2.93	3.17	3.53	3.09	3.18
Communication	M	3.24	2.95	3.37	3.44	3.19	3.12
	F	3.24	3.11	3.58	3.40	3.29	3.37
Collaboration	M	3.17	3.14	3.27	3.44	3.17	3.22
	F	3.35	3.24	3.50	3.53	3.28	3.33
Character	M	3.22	3.02	3.30	3.50	**3.18**	**3.32**
	F	3.44	3.21	3.50	3.40	**3.36**	**3.65**

Note: M = Male; F = Female.
Bold numbers represent statistically significant differences, $p < 0.05$.
Key: Site 1: Medium Public University; Site 2: Nonresidential Private University; Site 3: Residential Private University; Site 4a: Large Midwest Public University – Integrated Program; Site 4b: Large Midwest Public University – Standard Program; Site 5: Large Northeast Public University.

Table 6. KEEN EML Student Outcomes Mean Scores by Site and Year in School

Construct	Year	Site 1	Site 2	Site 3	Site 4a	Site 4b	Site 5
Curiosity	1st year	3.26	3.00	2.90	3.35	3.11	3.11
	4th/5th year	3.35	3.21	3.33	3.33	3.27	3.29
Connections	1st year	3.28	3.00	3.20	3.64	**3.08**	**3.15**
	4th/5th year	3.25	3.18	3.30	3.50	**3.28**	**3.54**
Creating Value	1st year	3.15	2.88	2.80	**3.48**	3.05	3.03
	4th/5th year	3.06	2.99	3.33	**2.67**	3.11	3.02
Communication	1st year	3.18	**2.84**	3.07	3.39	3.16	**3.06**
	4th/5th year	3.31	**3.18**	3.63	3.33	3.28	**3.52**
Collaboration	1st year	3.21	3.18	3.20	3.52	3.25	3.23
	4th/5th year	3.38	3.22	3.41	3.50	3.20	3.29
Character	1st year	3.38	3.10	**2.93**	3.48	3.24	3.29
	4th/5th year	3.21	3.13	**3.59**	3.67	3.24	3.50

Bold numbers represent statistically significant differences, $p < 0.05$.
Key: Site 1: Medium Public University; Site 2: Nonresidential Private University; Site 3: Residential Private University; Site 4a: Large Midwest Public University – Integrated Program; Site 4b: Large Midwest Public University – Standard Program; Site 5: Large Northeast Public University.

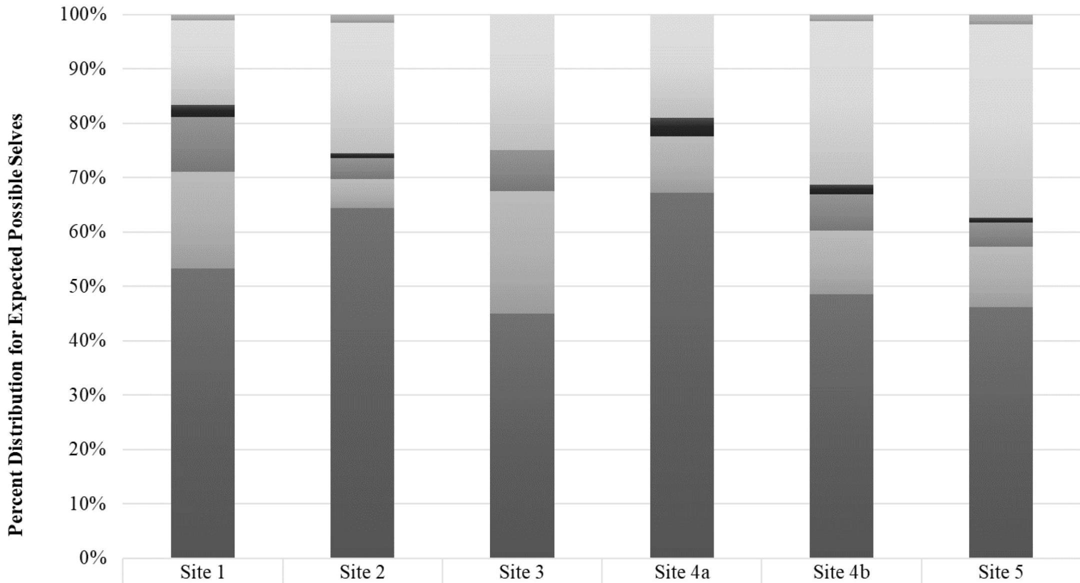
selves). The definition of each category (from Oyserman [46]) and examples of student responses for each of these categories are provided in Table 7.

Overall, the *Achievement* and *Material/Lifestyle* categories had the highest frequency for both the expected and feared possible selves, with 80% and 63% of the responses relating to these categories, respectively, while the *Physical/Health-Related* and N*egative or Non-Normative/Risky Behaviors* categories had the lowest frequency, accounting for 3% and 7% of the responses, respectively. The percent frequencies were also compared across sites, as depicted in Figs. 1 and 2.

For Expected Possible Selves, the category with the highest frequency of responses for all sites was *Achievement*, with Site 4a (Integrated Program) having the highest frequency at 67%. The next most frequent response category was *Material/Lifestyle* while the two lowest frequencies were *Physical/Health-Related* and *Negative/Non-Normative Behaviors*, with some sites having no responses in these categories. For Feared Possible Selves, *Achievement* and *Material/Lifestyle* again were the most frequent responses, with Site 1 (Medium Public University) having a higher frequency for *Material/Lifestyle* than any other site. Responses in the *Personality Traits* category were more frequent for Feared Possible Selves than Expected Possible Selves, although still not very frequent. Similar to Expected Possible Selves, the *Physical/Health-Related* and *Non-Normative/Risky Behaviors* categories received the least number of responses for Feared Possible Selves across all sites, with Site 5 (Large Northeast Public University) having a higher frequency for non-normative/risky beha-

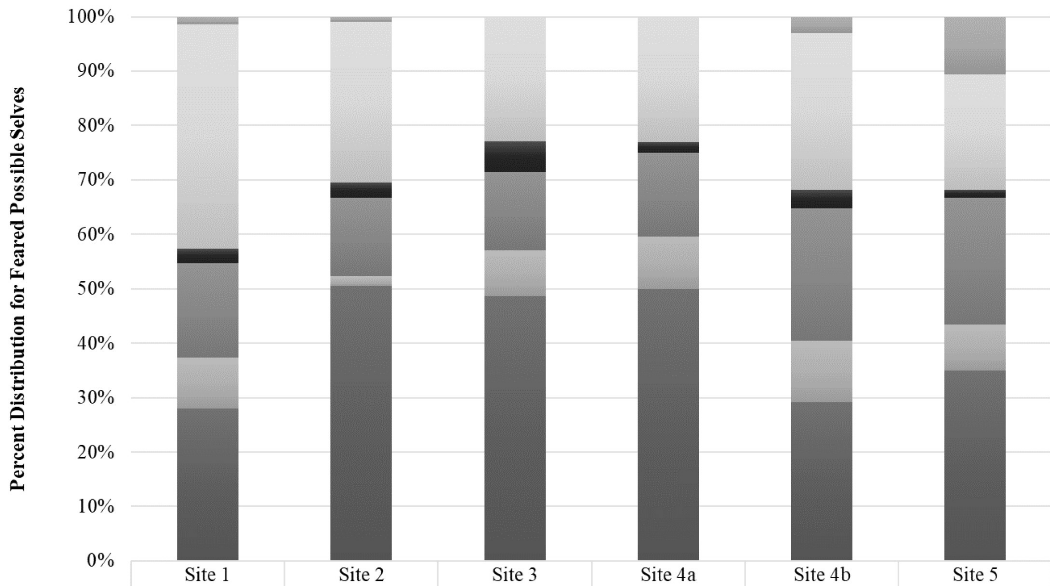
Table 7. Definition and Examples of PST Categories

Category	Definition	Example Responses of *Expected* Possible Selves	Example Responses of *Feared* Possible Selves
1. Achievement	Relates to school and school interactions with teachers, achievement-related activities	• "Continuing on with higher education" • "Happy in my career and moving up in my company"	• "Hopefully not working in a cubicle setting" • "A work-a-holic: I don't want work to be my life." • "Unemployed"
2. Interpersonal Relationships	Involves family, friends, relationships, and social interactions except with teachers	• "Have a family" • "Respected in the workplace" • "Find a social group that I can build friendships"	• "Lonely" • "I don't want to lose contact with my friends and family" • "Not networking"
3. Personality Traits	Relates to personality characteristics, self-descriptions of traits	• "Get better at leadership" • "Perform/be known as a moral, value driven leader" • "Self-motivated"	• "Lazy and lethargic and unsure of what to do and where I am going." • "Not treating people as equal" • "Avoid being disappointed in myself"
4. Physical/ Health-Related	Relates to physical health, weight, height	• "Stay fit and healthy" • "Lose 15 pounds" • "I hope to run a marathon"	• "Overworking at the expense of my mental/physical health" • "No health insurance"
5. Material/Lifestyle	Relates to material possessions and living situation, including moving	• "Get money" • "Travel" • "Purchase a nice house" • "Pay off my student loans"	• "Concerned about finances" • "Being homeless" • "Live with my parents" • "Depend on others too much for help"
6. Negative or Non-Normative/ Risky Behaviors	Includes all negatively worded responses or negative and illegal behaviors such as smoking, drinking, involved in fights, gangs, etc.	• "I'm 30 so I'm not going to change much" • "Careless"	• "No drugs" • "Depressed" • "Becoming a gambler" • "Get arrested"



	Site 1	Site 2	Site 3	Site 4a	Site 4b	Site 5
Negative	1%	2%	0%	0%	1%	2%
Material/Lifestyle	16%	24%	25%	19%	30%	36%
Physical/Health-Related	2%	1%	0%	3%	2%	1%
Personality Traits	10%	4%	8%	0%	7%	4%
Interpersonal Relationships	18%	5%	23%	10%	12%	11%
Achievement	53%	64%	45%	67%	49%	46%

Fig. 1. Distribution of Expected Possible Selves by Site.



	Site 1	Site 2	Site 3	Site 4a	Site 4b	Site 5
Non-Normative/Risky Behavior	1%	1%	0%	0%	3%	11%
Material/Lifestyle	41%	30%	23%	23%	29%	21%
Physical/Health-Related	3%	3%	6%	2%	4%	2%
Personality Traits	17%	14%	14%	15%	24%	23%
Interpersonal Relationships	9%	2%	9%	10%	11%	8%
Achievement	28%	50%	49%	50%	29%	35%

Fig. 2. Distribution of Feared Possible Selves by Site.
Fig. Key: Site 1: Medium Public University; Site 2: Nonresidential Private University; Site 3: Residential Private University; Site 4a: Large Midwest Public University – Integrated Program; Site 4b: Large Midwest Public University – Standard Program; Site 5: Large Northeast Public University.

viors than all other sites (11% compared to a range of 0–3%).

The distribution of frequency by categories was further compared by gender and year in school. For gender, males and females had similar distributions for both Expected Possible Selves and Feared Possible Selves, as seen in Table 8. The largest difference between genders was for the *Non-Normative/Risky Behaviors* category for Feared Possible Selves; males had more fears in this category than females. Furthermore, both males and females had more *Achievement*-related Expected Possible Selves but more *Personality Traits*-related Feared Possible Selves.

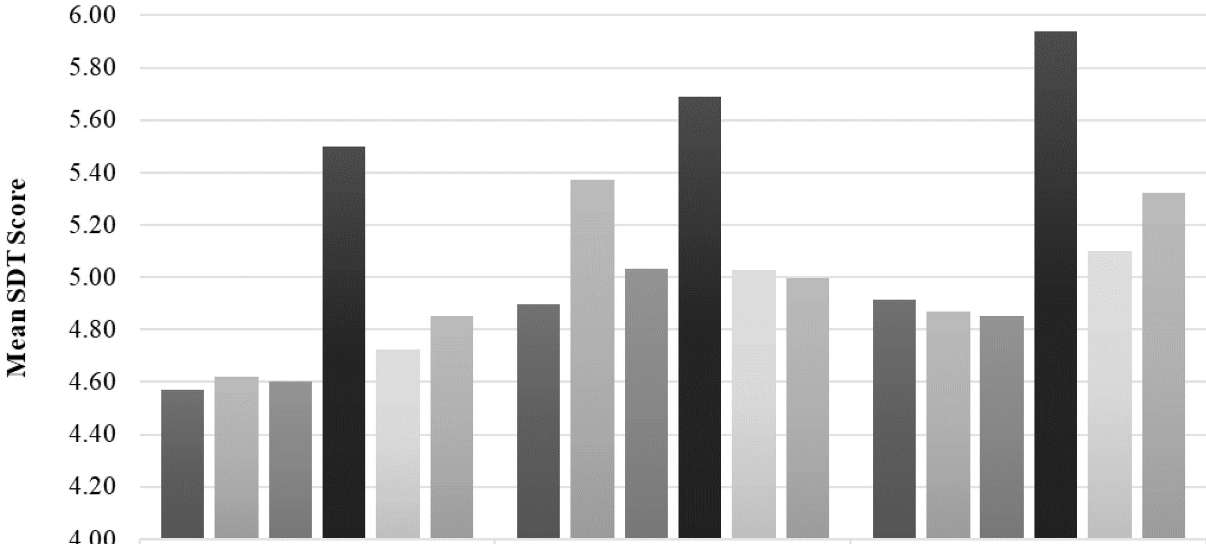
When comparing the distributions by first-year students and fourth-/fifth-year students (shown in Table 9), the Expected Possible Selves had different distributions. First-year students had more expectations in the *Interpersonal Relationships* category, accounting for 14% versus only 9% for fourth-/fifth-year students. Conversely, the fourth-/fifth-year students had more expectations in the *Achievement* category, accounting for 55% versus 49% for first-year students. All other categories for Expected Possible Selves had similar distributions between the years in school. When analyzing the distributions for Feared Possible Selves, it is seen that the distributions between the years was similar. Additionally, a similar pattern to the gender distributions was seen, such that both first- and fourth-/fifth-year students had more expectations for *Achievement* but more fears for *Personality Traits*.

Table 8. Distribution of Possible Selves by Gender

	Expected Possible Selves		**Feared Possible Selves**	
Category	**M**	**F**	**M**	**F**
Achievement	52%	52%	35%	33%
Interpersonal Relationships	11%	12%	8%	11%
Personality Traits	4%	7%	22%	21%
Physical/Health-Related	1%	2%	3%	4%
Material/Lifestyle	29%	26%	25%	31%
Negative/Non-normative	2%	0%	6%	1%

Table 9. Distribution of Possible Selves by Year in School

	Expected Possible Selves		Feared Possible Selves	
Category	**1st Year**	**4th/5th Year**	**1st Year**	**4th/5th Year**
Achievement	49%	55%	35%	35%
Interpersonal Relationships	14%	9%	9%	10%
Personality Traits	5%	6%	20%	24%
Physical/Health-Related	1%	2%	3%	3%
Material/Lifestyle	30%	27%	29%	26%
Negative/Non-Normative	2%	1%	3%	2%



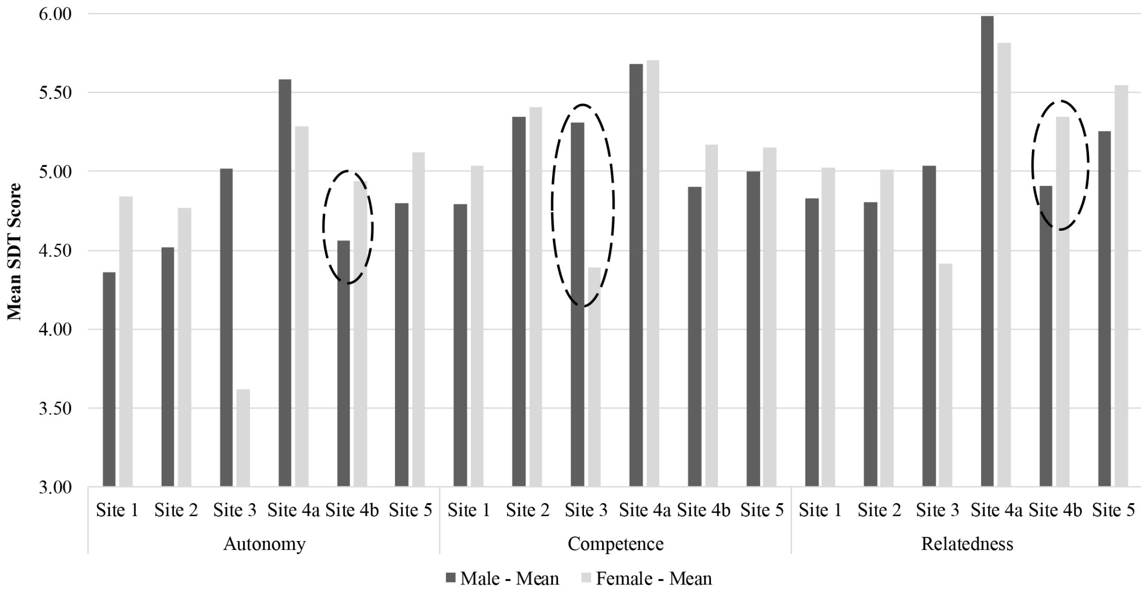
	Autonomy	Competence	Relatedness
Site 1	4.57	4.90	4.91
Site 2	4.62	5.37	4.87
Site 3	4.60	5.03	4.85
Site 4a	5.50	5.69	5.94
Site 4b	4.72	5.03	5.10
Site 5	4.85	4.99	5.32

Fig. 3. Mean SDT Scores by Construct and Site.
Fig. Key: Site 1: Medium Public University; Site 2: Nonresidential Private University; Site 3: Residential Private University; Site 4a: Large Midwest Public University – Integrated Program; Site 4b: Large Midwest Public University – Standard Program; Site 5: Large Northeast Public University

3.3 Self-Determination Theory (RQ3)

The results of the SDT analysis focused on comparing the mean scores for the *Autonomy, Competence*, and *Relatedness* constructs by site. Overall, Site 4a (Large Midwest Public University – Integrated Program) had statistically significant higher mean scores for all constructs than all other sites. The mean SDT scores by construct and site are shown in Fig. 3.

Furthermore, when comparing the mean scores between first-year and fourth-/fifth-year students, there were no statistically significant differences in scores for any construct at any site. When comparing the scores by gender at each site, there were three statistically significant differences. At Site 3 (Residential Private University), males had a statistically significant higher mean score for *Competence* than females. At Site 4b (Large Midwest Public University – Standard Program), females had statistically higher mean scores for *Autonomy* and *Relatedness* than males. All other differences between genders at each site were not statistically significant. However, in most cases, females had higher mean scores than males for the constructs. The mean scores by gender are shown in Fig. 4, with the significant differences circled. It should be noted there was a large visible difference between male and female scores for *Autonomy* at Site 3 (Residential Private University) in Fig. 4, but further investigation indicated this item was not significant due



Male - Mean	4.36	4.52	5.02	5.59	4.56	4.80	4.79	5.34	5.31	5.68	4.90	5.00	4.83	4.80	5.04	5.99	4.91	5.26
Female - Mean	4.84	4.77	3.62	5.29	4.94	5.12	5.03	5.40	4.39	5.71	5.17	5.15	5.03	5.01	4.42	5.81	5.34	5.55
Male - St. Dev.	0.99	1.24	1.07	0.47	0.77	0.58	0.96	0.90	0.96	1.09	0.88	0.86	1.05	1.18	0.80	0.82	0.84	0.84
Female - St. Dev.	0.67	1.00	0.33	0.53	0.75	0.98	0.81	0.89	0.10	0.57	0.84	1.08	1.11	0.75	0.58	1.22	0.89	1.00
p-value	0.20	0.56	0.06	0.32	**0.01**	0.28	0.53	0.85	**0.04**	0.97	0.09	0.60	0.67	0.58	0.27	0.76	**0.01**	0.30

Fig. 4. Mean SDT Scores by Gender.
Fig. Key: Site 1: Medium Public University; Site 2: Nonresidential Private University; Site 3: Residential Private University; Site 4a: Large Midwest Public University – Integrated Program; Site 4b: Large Midwest Public University – Standard Program; Site 5: Large Northeast Public University.

to the small sample size at the site and large standard deviation for male scores (male mean: 5.02, male standard deviation: 1.07; female mean: 3.62, female standard deviation: 0.33; p-value: 0.06).

3.4 Construct Relationship (RQ4)

A correlation analysis performed between the two Likert-style scale constructs, SDT and KEEN EML student outcomes, resulted in all correlations being positive and significant. While none had a strong correlation, many had a moderate correlation in the 0.4–0.5 range (as indicated with bold text in Table 10). Overall, EML had significant correlations with all constructs of SDT: *Collaboration* and *Character* were moderately correlated to all three SDT constructs while *Connections* and *Communication* were only weakly correlated to all three. *Curiosity* was only moderately correlated to *Competence* while *Creating Value* was moderately correlated to both *Autonomy* and *Relatedness*.

Table 10. Correlation Between EML Student Outcomes and SDT Constructs

Construct	Autonomy	Competence	Relatedness
Curiosity	0.399**	**0.414****	0.307**
Connections	0.397**	0.396**	0.347**
Creating Value	**0.410****	0.363**	**0.410****
Communication	0.358**	0.399**	0.320**
Collaboration	**0.457****	**0.453****	**0.483****
Character	**0.432****	**0.400****	**0.418****

** Correlation is significant at the 0.01 level (2-tailed).

The correlation by year in school and gender showed similar patterns of significant moderately positive correlation coefficients between the EML student outcomes and the SDT constructs. For the comparison by year in school (shown in Table 11), first-year students had more moderate significant positive correlations for *Autonomy* while fourth-/fifth-year students had more moderate significant correlations for *Competence*, showing the impact of EML constructs on *Autonomy* for first-year students and on *Competence* for fourth-fifth-year students. Specifically, first-year students had significantly moderate correlations for all SDT constructs for *Collaboration* while fourth-/fifth-year students had significant moderate correlations for all SDT constructs for *Character*.

Comparing the correlations by gender (as seen in Table 12) showed that males had more significant moderate correlations for *Competence* for all EML constructs except *Communication*, while females had more significantly moderate correlations for *Relatedness* than males. Furthermore, males and females both had significant moderate correlations between *Collaboration* and all SDT constructs. *Curiosity* and *Communication* had the lowest

Table 11. Correlation between EML Student Outcomes and SDT Constructs by Year in School

Construct	Autonomy 1st Year	Autonomy 4th/5th Year	Competence 1st Year	Competence 4th/5th Year	Relatedness 1st Year	Relatedness 4th/5th Year
Curiosity	**0.429****	**0.421****	0.341**	**0.501****	0.266**	0.310**
Connections	**0.421****	0.391**	**0.400****	0.370**	0.320**	0.295**
Creating Value	**0.417****	0.392**	0.360**	**0.415****	0.353**	0.383**
Communication	0.363**	0.311**	0.382**	**0.407****	0.234**	0.314**
Collaboration	**0.482****	**0.431****	**0.461****	**0.478****	**0.482****	0.395**
Character	**0.429****	**0.482****	0.392**	**0.438****	0.362**	**0.442****

**Correlation is significant at the 0.01 level (2-tailed).

Table 12. Correlation between EML Student Outcomes and SDT Constructs by Gender

Construct	Autonomy		Competence		Relatedness	
	M	F	M	F	M	F
Curiosity	0.379**	0.395**	**0.467****	0.366**	0.308**	0.269**
Connections	**0.410****	0.369**	**0.403****	0.386**	0.349**	0.339**
Creating Value	0.366**	**0.447****	**0.411****	0.341**	0.403**	**0.400****
Communication	0.371**	0.300**	0.390**	**0.402****	0.334**	0.260**
Collaboration	**0.464****	**0.413****	**0.479****	**0.413****	**0.491****	**0.446****
Character	**0.411****	**0.433****	**0.407****	0.378**	0.379**	**0.474****

** Correlation is significant at the 0.01 level (2-tailed).

number of significant correlations, being significant for males and females, respectively, for only the SDT construct *Competence*.

However, different patterns emerged when analyzing the correlations by site (shown in Table 13). There was a mix of strong significant positive correlations in the 0.6–0.8 range (in bold italics), mostly at Site 4a (Large Midwest Public University – Integrated Program), in addition to the moderate significant positive correlations in the 0.4–0.5 range (in bold), mostly at Site 2 (Nonresidential Private University). Specifically, Site 4a (Integrated Program) had strong positive correlations for all three SDT constructs for the EML student outcomes *Curiosity*, *Collaboration*, and *Character*. Site 2 (Nonresidential Private University) had moderate correlations for all three SDT constructs for the EML student outcomes *Creating Value*, *Collaboration*, and *Character*. Furthermore, Sites 4b (Standard Program) and 5 (Large Northeast Public

Table 13. Correlation between EML Student Outcomes and SDT Constructs by Site

Site	Construct	Curiosity	Connections	Creating Value	Communication	Collaboration	Character
Site 1	Autonomy	0.384	0.166	0.255	0.087	**0.501***	0.034
	Competence	0.272	0.319	**0.509***	0.222	**0.541****	0.096
	Relatedness	0.388	0.221	0.350	0.257	**0.562****	0.147
Site 2	Autonomy	**0.445***	0.341	**0.460****	0.366*	**0.507****	**0.511****
	Competence	**0.594****	**0.521****	**0.439***	**0.484****	**0.528****	**0.570****
	Relatedness	0.372*	0.274	**0.548****	**0.453***	**0.517****	**0.433***
Site 3	Autonomy	0.480	0.272	0.350	0.101	0.128	0.086
	Competence	0.172	0.338	0.245	0.079	0.272	0.313
	Relatedness	0.540	***0.781****	**0.642***	0.435	0.495	0.365
Site 4a	Autonomy	***0.742****	0.443	0.401	**0.576***	***0.671****	***0.713****
	Competence	***0.640****	0.391	**0.593***	0.470	***0.687****	***0.611****
	Relatedness	***0.632****	0.532	**0.546***	0.466	***0.783****	***0.787****
Site 4b	Autonomy	0.398**	**0.422****	**0.447****	0.367**	**0.434****	**0.490****
	Competence	**0.406****	0.365**	0.342**	**0.432****	**0.404****	**0.456****
	Relatedness	0.304**	0.335**	0.392**	0.276**	**0.457****	**0.477****
Site 5	Autonomy	0.369**	**0.457****	0.377**	**0.544****	**0.491****	**0.460****
	Competence	**0.428****	**0.472****	0.364**	**0.463****	**0.461****	0.359**
	Relatedness	0.162	0.284*	0.334**	0.317*	0.383**	0.262*

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

University) had mostly moderately positive correlations, indicating a moderate connection between EML and SDT at these sites. Conversely, Site 3 (Residential Private University) had the least number of significant correlations; however, those that were significant had strong correlations (i.e., between the SDT construct *Relatedness* and both *Connections* and *Creating Value*). Additionally, *Collaboration* had significant moderate or strong correlations for all SDT constructs for all sites except for Site 3 (Residential Private University), for which the correlations were weaker and not significant.

4. Discussion

Based on our exploratory analysis there were no clear trends that consistently differentiated the sites or the demographic groups of students when examining the entrepreneurial mindset, motivation, or identity. We attribute this lack of distinct, consistent patterns to the variety of ways EML is incorporated into first- and fourth-/fifth-year engineering curricula, meaning there is too much variety within and across sites to produce clear results. This inherently makes EML and the connections we were interested in difficult to assess. Additionally, while the focus of this analysis was on the first and fourth/fifth years, integrating entrepreneurial mindset content throughout the curriculum and specifically to second- and third-year technical courses has become more common (e.g., [47, 48]). This presence of additional EML content in the second and third years further complicates the data at Site 4a (Large Midwest Public University – Integrated Program), which is a four-year continuous integrated program with intentional EML experiences in all four years. Similar complications are seen at Sites 2 (Nonresidential Private University) and 3 (Residential Private University) which also expose students to EML elements in all four years. While groups such as KEEN have tried to share resources and streamline implementation, there is still great variability within sites which leads to minimal trends across sites and challenges with assessment in general.

While there is no clear overall trend that directly related to each site or connected the constructs of interest as we had anticipated, three key domains of findings provide significant insight for implementation of EML. First, Sites 4a (Integrated Program) and 2 (Nonresidential Private University) showed distinctions from the other sites. Second, patterns by gender were significant. Third, first-year and fourth-/fifth-year students showed significant differences related to PST.

4.1 Differences by Site

As discussed above, Site 4a (Large Midwest Public University – Integrated Program) is a unique integrated business and engineering program. To start, the average scores for all six EML student outcomes were higher at Site 4a than any other site. When comparing to Site 4b (Large Midwest Public University – Standard Program) directly, the difference in average scores for *Connections* was significant. Site 2 (Nonresidential Private University), which exposes students to EML across all four years, had the opposite pattern: all six EML student outcomes scores were lower than any other site, with *Creating Value* and *Communication* differences being significant when compared to Site 4b (Standard Program). Site 3 (Residential Private University), which also integrates EML across all four years, did not have any significant differences to Site 4b (Standard Program), and its EML mean scores were comparable to Sites 1 (Medium Public University) and 5 (Large Northeast Public University). This demonstrates the differences in how EML is being introduced at each site and the variability within a site.

When assessing patterns across sites for PST, all sites had a similar distribution for both the expected and feared possible selves categories, even though implementation of EML across sites varied. While the impact of EML on participants' identities could not be discerned, interesting patterns regarding engineering students' identities still emerged. The similar pattern across sites shows that students have the most expectations and fears around *Achievement* and *Material/Lifestyle*, and the least expectations and fears related to the *Physical/Health-Related* and *Negative/Non-Normative Behaviors* categories. This suggests that students are more concerned with the external-facing and tangible aspects of their future identities, such as whether they have a job or money after graduation, rather than internal-facing or personal aspects, such as whether they will stay physically and mentally healthy. This finding demonstrates that multiple factors within and outside the engineering curriculum and learning environment interact with one another to impact engineering students' identity development.

In terms of the relationship between SDT and EML, Site 4a (Integrated Program) had stronger significant positive correlations between the three SDT motivation constructs and EML student outcomes than any other site. Specifically, mean scores for the EML student outcomes *Curiosity*, *Collaboration*, and *Character* were high at Site 4a (Integrated Program) and strongly correlated with all three SDT motivation constructs. *Creating Value* was also higher at this site and strongly correlated to two of the SDT motivation constructs, *Competence* and *Relatedness*. At Site 4a (Integrated Program), first-year engineering students are partnered with business students to complete a product design process focused on user needs and value creation. This cohort of students then has additional EML programming throughout years 2 and 3, which culminates in a customer-driven product design capstone course during year 4. Similarly, at Site 2 (Nonresidential Private University) where EML is also taught in all four years, there were significant correlations to all three SDT constructs for *Collaboration*, *Character*, and *Creating Value* and to two of the three SDT constructs for *Curiosity* (*Autonomy* and *Competence*) and *Communication (Competence* and *Relatedness)*. Meanwhile, Site 3 (Residential Private University) did not have many significant correlations. However, the two that were significant were strong: between SDT's construct *Relatedness* and *Connections* (0.781) and *Creating Value* (0.642). Our findings suggest that these elements strongly promote the entrepreneurial mindset.

Site 4a (Integrated Program) and Site 2 (Nonresidential Private University) saw similarities in their relationship to the EML construct *Character*. *Character* had significantly strong correlations with all three SDT constructs at both Sites 4a (Integrated Program) and 2 (Nonresidential Private University). This suggests that the higher SDT mean scores at these sites, particularly for *Competence*, led to improved EML outcomes in sites where EML was explicitly taught across all four years, particularly for *Character*, defined as demonstrating the ability to set and achieve goals, accepting responsibility for your actions, and recognizing the impacts of ethical practices.

Conversely, Site 4a (Integrated Program), Site 2 (Nonresidential Private University), and Site 3 (Residential Private University) saw differences in their relationship with the *Creating Value* EML construct. Site 4a (Integrated Program) students had weaker correlations between the SDT constructs and *Creating Value*, along with *Connections* and *Communication*, whereas Sites 2 saw some moderate positive correlations, with the correlations between *Creating Value* and all three SDT constructs being significant. Site 3 had a strong correlation between *Creating Value* and *Relatedness*. While the capstone course at Site 4a (Integrated Program) did include a discussion of stakeholder and customer needs, fourth-/fifth-year students may not have seen this piece as unique or as important as they did during their first year and therefore may not have had as great an impact as it did in their first year.

The higher mean scores for all SDT constructs among students at Site 4a (Integrated Program) could be due to the recruitment process of this unique program. We posit that when the students choose to apply and are selected for the program, they are told about the elite nature and selectivity of the program. Therefore, it is not surprising that participants from Site 4a (Integrated Program) would score highly when asked to reflect on their *Autonomy* and *Competence*. A similar phenomenon occurs in engineering broadly. Students are often told they are smart (i.e., have a high level of competence) in primary and secondary education, and therefore, they choose to study engineering because they believe being an engineer requires intelligence [49]. We believe this type of messaging and impact could translate to the engineering program presented at Site 4a (Integrated Program) as well. This program is considered selective and elite and thus we are likely to see higher self-reported *Competence* scores. Additionally, the cohort aspect to the program would be likely to positively impact the *Relatedness* construct since students enter the program and continue to connect throughout their undergraduate degrees. This level of connection was less formal and structured at the other sites where students were not part of a cohort model.

4.2 Differences by Gender

When comparing the EML student outcomes by gender, females had higher scores than males at all sites for *Collaboration* and all sites except Site 4a for *Character*. Across all other EML constructs, females had higher scores than their male counterparts for at least half the sites. Within the remaining subset, male and female scores were found to be about the same. However, the only statistically significant differences between males and females were at Sites 4b (Standard Program) and 5 (Large Northeast Public University) for *Character* with females having higher mean scores than males. These findings align with past research studying differences in female and male experiences and performance in engineering. For example, women in engineering have higher 6-year graduation rates than men [50], and women are more likely than men to describe the potential social impact of engineering work, rather than the financial benefits, as a motivation [51]. While women are significantly underrepresented in engineering [52], we hypothesize that these higher scores represent their unique experiences.

Related to PST, our data showed no gender differences, except in the higher prevalence of *Negative/Non-Normative* responses in the male population and a slight increase in *Personality Traits* in the female population. This aligns with PST work over the past four decades. Gomez-Mejia

[53] hypothesized that as work experiences in the same occupations were increasing in the 1980s, gender differences in value patterns should disappear. Likewise, Beutell and Brenner [54] found that among 202 advanced undergraduate business students, the importance of work outcomes was the same across genders, with the top being "Work that provides a feeling of accomplishment." The researchers suggested this reflected the emergence of an androgynous work value pattern. Our data collected in 2018 using PST, particularly our data for the *Achievement* and *Material/Lifestyle* categories, suggest this pattern has continued, that it is evident among engineering students, and can be detected with different instruments than those Beutell and Brenner or Gomez-Mejia used.

Other gender-based differences surfaced during our investigation into SDT. Overall, males had more significant and stronger correlations to the EML constructs for *Competence* than females and about the same correlations for *Autonomy* and *Relatedness*. The EML construct *Collaboration* was significantly strong for both males and females for all three SDT constructs. Specifically, at Site 3 (Residential Private University), males had a statistically significant higher mean score for *Competence* than females. At Site 4b (Large Midwest Public University – Standard Program), females had statistically higher mean scores for *Autonomy* and *Relatedness* than males. Given our limited information about the sites' programs outside of EML in the first or fourth/fifth year, we cannot discern these differences but considered what role other programs such as living/learning communities and mentors play related to students' view on these constructs, especially those related to working with others (e.g., *Collaboration* or *Relatedness).* From past research, we know these types of programs are impactful for student engagement among women (e.g., [55]).

4.3 Differences by Year

Evidence of development can be seen between the first- and fourth-/fifth-year student PST data. The fourth-/fifth-year students had a higher percentage of expected *Achievement* responses, which relates to academic success and obtaining a job. This finding aligns with literature related to the transition from adolescence to adulthood, or emerging adulthood, which occurs during the academic career and profoundly impacts the development of identity. The time spent in an academic environment rather than in the workforce, which was what was expected prior to the emphasis put on pursuing a degree, results in a period of delayed identity development [56]. Much identity exploration occurs in these formative years and depends, in part, on their dedication to a specific path [57, 58]. Forming a coherent sense of self across these transitions is predictive of future developmental outcomes such as achievement, interpersonal relationships, and altruistic pursuits [59], and improved decision making and problem solving [60]. This is further supported by the positive change in SDT motivation constructs for fourth-/fifth-year students, specifically related to the EML student outcome of *Character.* Our findings are indications that the fourth-/fifth-year students have successfully emerged through this transition to adulthood with a positive outcome.

4.4 Limitations

The limitations of this work include the difference in sample sizes across sites, instructor differences, and survey limitations. Related to sample size, the institutions who participated in this study varied greatly in their size, from 3,000 to 60,000 students in their undergraduate population across all majors. As such, the participant groups in this research also varied. While this difference was expected and intentionally incorporated so we could capture a range of experiences, it does limit our ability to directly compare the settings statistically, as small variations in the smaller samples had larger effects.

Additionally, instructor differences across the sites should be acknowledged. While each school was affiliated with KEEN, the level of awareness, training, and pedagogical techniques used to support EML by the individual faculty who taught first-year and capstone courses were vast. These differences could have an impact on the student results. In particular, the instructor who taught at Site 4a (Large Midwest Public University – Integrated Program) is deeply connected with EML and KEEN, which may have an impact beyond the design of the program.

Finally, there are limitations within the survey itself. Since this was an initial exploratory study of the sites, there are additional enhancements that could be made in the future to improve the survey. For example, the version used had double-barreled questions which allowed the survey to map to the KEEN framework. While this was important for streamlining across the sites, which all use the framework in some form, it induced a limitation to the study in that some of the items asked were multi-faceted.

4.5 Future Work

The three domains of findings in this study merit further investigation to understand the broader impact of EML in engineering education. Related to Site 4a (Large Midwest Public University – Integrated Program) and female students, we noticed higher scores related to each of the constructs and are interested in the factors that affect those items so they can be rolled out more broadly. We are interested in qualitatively investigating Site 4a (Integrated Program) to understand the unique cohort that is being developed in that program and how it evolves over a student's undergraduate career. While further analysis of Site 4a (Integrated Program) is not possible at this time given our limited data, we wonder if further investigation into this unique site would provide specific insights that could be included in other programs to strengthen the students' entrepreneurial mindset. Such insights might also strengthen our ability to develop effective assessments that capture the detailed growth of students related to the entrepreneurial mindset. Similarly, related to female students, we are interested in further comparing their experiences to their male colleagues to identify differences and build support programs. Longitudinal interviews with these female engineering students would provide unique insights to better understand these findings and their development over time within the programs, including an investigation into how constructs change between the first and fourth/fifth year. Finally in both domains, we would be interested in collecting additional data to further explore the correlations we observed. Given our dataset, we are limited in the conclusions we can draw, but the correlations that were found can be a starting point for additional investigation and data collection. We believe a deeper understanding of these domains will aid us in improving the implementation of EML in engineering broadly.

5. Conclusions

Engineering is adding more EML experiences to the curriculum across distinct types of institutions. These experiences help foster an entrepreneurial mindset among students, which aids in preparing them for the real-world problems they will face as practicing engineers. Through our work, we examined EML's impact on the entrepreneurial mindset along with motivation and identity. While our analysis did not yield major differences across our sites or connections between EML, motivation, and identity, there was a positive relationship between EML and motivation, showing the potential impact of EML experiences on students' motivation to succeed in the engineering field. We also observed a unique difference between one of our sites and the others as well as noteworthy differences between male and female engineering students and first- and fourth-/fifth-year students across the different constructs. Additional research is needed to fully understand these differences, but we believe incorporating EML into engineering education will have a positive impact as we prepare our students for the workforce.

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Appendix

Table 14. Mapping of the 18 KEEN Framework Items to the 6 EML Constructs

EML Construct	KEEN Student Outcome
Curiosity	Ask questions.
	Recognize and explore knowledge gaps in the design.
	Gather data to support and refute ideas.
Connections	Identify and evaluate sources of information.
	Connect content from multiple courses to solve a problem.
	Consider a problem from multiple viewpoints.
Creating Value	Identify the needs and motivations of various stakeholders.
	Create solutions that meet customer needs.
	Describe how a design could be scaled and/or sustained.
Communication	Articulate the idea to diverse audiences.
	Present technical information effectively (graphs, tables, equations).
	Identify and organize information in a format suited to the audience.
Collaboration	Recognize my own strengths, skills, and weaknesses, as well as those of others.
	Identify and work with individuals with complementary skill sets, expertise, etc.
	Network and see the value of others.
Character	Demonstrate an ability to set, evaluate, and achieve personal and professional goals.
	Recognize potential impacts while making informed ethical and professional decisions.
	Accept responsibility for my own actions, and credit the actions of others.

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