TE-2023-000349

Words That Resonate: Synthesizing Insights from Engineering Faculty Collaboration on Entrepreneurial Mindset

Agnieszka Kwapisz (https://orcid.org/0000-0002-1628-3186) and Brock J. LaMeres (https://orcid.org/0000-0001-9388-4092), *Senior Member, IEEE*

Abstract—Contribution: **This study synthesizes insights into the thematic focuses and linguistic attributes that resonate most in engineering faculty collaborations aimed at fostering entrepreneurial mindsets. It provides a roadmap for educators and institutions to effectively communicate and encourage entrepreneurial thinking in engineering.**

Background: **Amid the heightened emphasis on entrepreneurial thinking in engineering education, understanding the factors that resonate with faculty is pivotal for informing curriculum development, aligning with global trends, and optimizing the preparedness of engineering graduates.**

Research Questions: **1) What elements of the entrepreneurial mindset are most frequently emphasized by faculty in their shared educational content? 2) What aspects of the entrepreneurial mindset resonate most with academic faculty? 3) How do these relations differ in the electrical or computer engineering disciplines compared to other engineering fields?**

Methodology: **A comprehensive analysis of educational resources shared by faculty on the topic of entrepreneurial mindset was conducted. By leveraging text analytics, the study assessed engagement metrics such as views, shares, favorites, and downloads. The data were analyzed using Stata.**

Findings: **Faculty engagement strongly resonates with the three core components of the entrepreneurial mindset: Curiosity, Connections, and Creating Value, often emphasized in their shared educational content. Specifically, the "Creating Value" component emerged as the most significant across most engagement measures, with nuanced variations in the electrical and computer engineering disciplines.**

***Index Terms*—Communication effectiveness, discussion forums, engineering education, entrepreneurship, linguistics**

I. INTRODUCTION AND BACKGROUND

THE global economy's evolving dynamics highlight the pressing need for technological innovation, reshaping the multifaceted roles that today's engineers assume [1], [2], [3]. No longer restricted to mere technical problem-solving, contemporary engineers are infused with entrepreneurial skills [4], [5], [6]. This positions them to adeptly navigate market analysis, discern value propositions, and enact decisive moves amidst uncertainties [7]. Such adaptability allows them to strike a balance between technical feasibility, customer appeal, and business pragmatism [3], [8], [9]. As technological evolution hastens, engineers are increasingly poised to identify and harness business opportunities presented by these advancements [1], [3], [9], [10].

Entrepreneurship, historically equated with business inception, now encapsulates a broader, innovative design perspective. This transition underscores the imperative for engineers to cultivate an entrepreneurial mindset. Entrepreneurial mindset (EM) is defined as a set of attitudes, dispositions, habits, and behaviors that shape a unique approach to problem-solving, innovation, and value creation [11]. Such a mindset extends beyond simply starting businesses, encouraging engineers to drive innovation and provide value-centric solutions within existing organizational frameworks. Beyond sharpening technical skills and entrepreneurial insight, engineering curricula must encourage a lifelong love of learning, emphasize teamwork, and promote societal responsibility. Recognizing these evolving educational needs, numerous universities have initiated undergraduate engineering entrepreneurship programs [10], [12], [13], [14], [15]. Evaluations of these programs reveal positive outcomes, boosting academic performance, retention, and entrepreneurial intent [8], [14], [16]. They also enhance crucial professional abilities, such as leadership, problem-solving, and managing technical teams [17], [18], [19], [20], [21].

However, seamlessly weaving this comprehensive approach into engineering education presents its own set of challenges [12], [18], [22], [23]. First, traditionally focused on technical proficiency, there's often limited room to explore broader socio-economic and ethical facets of engineering [24]. Second, certain competitive dynamics within engineering institutions can hinder collaboration and innovative risk-taking, potentially limiting the development of a modern entrepreneurial mindset essential for 21st-century success [25]. Furthermore, while much attention has been given to the advantages students reap from entrepreneurial education, the distinct requirements and challenges faced by the faculty tasked with its implementation have often been sidelined. This oversight is pivotal, as the

Manuscript received October 16, 2023; revised April 5, 2024; accepted XXX. Date of publication XXX; date of current version XXX. This work was supported in part by the Kern Foundation Grant 2019-01466. *(Corresponding author: Agnieszka Kwapisz).*

Agnieszka Kwapisz is with the Jake Jabs College of Business & Entrepreneurship, Montana State University, Bozeman, MT 59717 USA (e-mail: akwapisz@montana.edu).

Brock J. LaMeres is with the Department of Electrical and Computer Engineering, Montana State University, Bozeman, MT 59717 USA (e-mail: lameres@montana.edu).

Digital Object Identifier

This article has been accepted for publication in IEEE Transactions on Education. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/TE.2024.3416866

effectiveness of entrepreneurial programs hinges primarily on faculty commitment and endorsement. Few researchers, including [26] and [27], have ventured into this space. Gibb [26] underscores prevalent biases that deter the integration of entrepreneurial themes into curricula. Teerijoki and Murdock [27] ascertain that dedicated training programs for educators can foster a more favorable outlook on entrepreneurial education. Both studies concur that many educators lack the necessary independence and resources to smoothly introduce entrepreneurial education models.

Given these constraints, engineering educators are actively seeking innovative curricular designs and pedagogies that prioritize a well-rounded skill set [2]. External support becomes crucial here. Organizations like Kern Entrepreneurial Engineering Network (KEEN) emerge as vital pillars, providing educators with tools like "information cards," workshops, and peer networks to foster EM in their courses. In particular, KEEN cards, designed as templates for various academic activities, provide a current overview of the procedures and strategies used to foster EM in engineering. They also highlight the latest research on the EM subject.

As the movement to incorporate EM into engineering education intensifies, a pivotal question emerges: What truly resonates with faculty dedicated to integrating EM principles? This study addresses this by evaluating the appeal of KEEN cards, particularly those emphasizing the KEEN's three elements of EM—Curiosity, Connections, and Creating Value ("3Cs") [11]. The analysis dissects how thematic undertones in the cards, entrepreneurial mindset assessment [5] [7], and linguistic attributes align with the preferences of the engineering faculty, with special attention to electrical and computer engineering fields. Through this research, there is an aspiration to bolster the design and content of KEEN cards, ensuring they resonate with the evolving pedagogical ambitions of faculty in entrepreneurial engineering education.

This synthesis serves as a guide for educators, curriculum designers, and supporting organizations to refine their content, ensuring it aligns with faculty interests. By identifying what resonates most, the goal is to amplify the effectiveness of resources in merging technical skills with entrepreneurial thinking, providing a pathway for more dynamic engineering education in the modern era. Specifically, this article addresses the following three research questions: 1) What elements of the entrepreneurial mindset are most frequently emphasized by faculty in their shared educational content? 2) What aspects of the entrepreneurial mindset resonate most with academic faculty? 3) How do these relations differ in the electrical or computer engineering disciplines?

Many engineering faculty surveys, notably a 2015 American Society for Engineering Education (ASEE) members' study, emphasize the consensus on integrating entrepreneurship into engineering curricula [28]. Recognizing the challenges in achieving this holistic integration, national initiatives such as the National Science Foundation's (NSF) Epicenter Pathways Initiative and the NSF I-Corps Program have come to the fore. Moreover, the Kern Entrepreneurial Engineering Network (KEEN) stands out by fostering collaboration and knowledge-sharing across institutions and faculty. KEEN provides educators with tools and a distinctive framework centered on the 3Cs [29]. KEEN includes more than 60 colleges and universities in the United States and is committed to establishing EM in all undergraduate engineering students. KEEN promotes a dynamic interchange of best practices and faculty development through national workshops, mentorship, and grants for collaborative projects. Its Engineering Unleashed community comprises over 6,000 academics. Faculty can join this community at no cost, accessing a rich platform for sharing resources and highlighting efforts to elevate engineering education.

There are several reasons why KEEN was chosen as a baseline for this synthesis of work performed in the EM in engineering. First, EM, despite its widespread discussion in engineering entrepreneurship, lacks a universally accepted definition, as indicated by numerous scholars [13], [14]. KEEN network, by defining the 3Cs of EM seeks to provide clarity and alignment to the profession. The network actively advocates this framework, positioning it as a benchmark for both setting goals and devising assessments.

Second, the KEEN's 3Cs framework has elicited considerable attention in academia. It forms the underpinning for an array of studies examining EM in engineering students. In their recent review of engineering entrepreneurship, [13] spotlighted KEEN as a central figure, observing that over 40% of the surveyed studies had either KEEN financing or were anchored in its 3Cs framework. The widespread endorsement and validation of this framework across multiple institutions vouch for its efficacy in mapping EM within engineering contexts.

Third, KEEN facilitates academic collaboration on EM through its unique Engineering Unleashed cards online platform. These cards serve as templates for various academic tasks, offering an up-to-date overview of the methods and strategies used to teach and evaluate EM in engineering students. They include lesson plans, activities, and even entire courses on implementing EM within the classroom context. These resources can be downloaded, shared, or commented on. They also provide materials for outreach, community engagement, event planning, and research. Recognizing the inherent delays and selectivity of academic publishing, these cards offer a more immediate and encompassing view.

Finally, the KEEN cards platform provides metrics such as views, shares, favorites, and downloads, illuminating faculty engagement with topics related to the EM. These metrics present a valuable opportunity for the synthesis and integration of knowledge, allowing us to discern which aspects resonate most with engineering faculty. By analyzing this engagement, insights are gained into what faculty find compelling and instrumental as they work to integrate the EM into their curricula.

II. Methods

A. Data: KEEN Cards

Python's BeautifulSoup web scraping package extracted the

This article has been accepted for publication in IEEE Transactions on Education. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/TE.2024.3416866

content and data from all cards published on the KEEN platform [11]. At the time of data collection (April 2023), over 2000 cards existed, with some still in draft form and thus inaccessible. Statistics on the number of views, shares, favorites, and downloads for each published card were obtained. This effort culminated in obtaining a sample of 2166 cards, with all their statistics and textual content. The sample comprises a total of 1,255,342 words, with an average of 580 words per card. The data were analyzed using the Stata statistical software.

B. Synthesizing Faculty Interests: Metrics of Engagement

In the journey of integrating EM within engineering education, understanding faculty engagement becomes crucial. Identifying the materials or resources that captivate their interest provides essential feedback for enhancing educational methodologies and content. Views, shares, favorites, and downloads serve as pivotal markers of this engagement, making them a significant focal point for the synthesis. Each metric offers a distinct window into faculty perspectives, allowing for a layered understanding of their interaction with the resources. The decision to analyze engagement metrics offers a quantitative measure of faculty interest, providing a solid basis to answer what aspects of the entrepreneurial mindset most resonate with academic faculty.

The act of viewing a KEEN card serves as an introductory signal of interest [30], [31]. A view suggests that the content presented holds potential relevance or benefit to their teaching or research pursuits. This metric can also reflect a general curiosity, where faculty members explore topics or methods that spark their intrigue, even if it is a brief exploration.

Favorites, within the context of faculty engagement, can be perceived as a nuanced nod of acknowledgment. When faculty members designate a KEEN card as a favorite, it signifies an affirmation of the content's resonance or importance to their academic pursuits. The act of favoriting doesn't necessarily imply immediate application or widespread sharing; instead, it serves as a marker of intent to revisit or reflect upon the content later. It is an intermediate step of engagement, situated between the initial intrigue denoted by views and the deeper commitment signaled by downloads. Favoriting captures a space where faculty members recognize the value or potential of the content, earmarking it for future exploration, contemplation, or possible integration into their curriculum.

Sharing takes this engagement a step further. When faculty opt to share a KEEN card, it often reflects their resonance with the content. This act can be interpreted as an endorsement, indicating that they find alignment with the instructional methods, resources, or insights presented within the card. Moreover, sharing underscores the trust in the content's quality and relevance, suggesting that the faculty perceive it as valuable not just for themselves but for their peers as well. This behavior can also highlight the influential role of academic networks in shaping teaching methodologies and fostering connections among faculty.

On the deepest level of engagement, downloads signify a profound commitment. Choosing to download a card indicates an intent to delve deeper, be it for further study, direct application, or integration into their teaching repertoire. It signifies that faculty members recognize significant value in the content, seeing it as a tool or resource that can aid in their endeavors to instill EM within their students.

C. The Entrepreneurial Engineer: KEEN's 3Cs Model

The KEEN has sought to articulate a definition for an EM in the context of engineering education, underpinned by its three-pronged framework, commonly referred to as the 3Cs.

KEEN posits that "Curiosity" (the first "C") represents an unyielding interest in the surrounding environment, acting as the precursor to recognizing market voids and innovation potentials [32]. This element encourages students to perpetually question and contest prevalent norms, thus leading to novel ideation and the reevaluation of established solutions. Instilling curiosity has been seen as vital for engineers, catalyzing inquiry, discovery, and innovation. Striking the right balance can reveal crucial and unexpected insights, elevating engineering solutions to their highest potential [33], [34].

The second tenet, "Connections," highlights the importance of integrating varied information to gain insights [32]. KEEN's model accentuates the student's need to assimilate varied knowledge sources, comprehend and utilize networking benefits, and embrace divergent outlooks. Such a comprehensive viewpoint allows engineers to analyze complex systems, discern interconnections, and think creatively. The crux of connections lies in understanding engineering as an interwoven discipline, inextricably linked with economic, cultural, and technological landscapes. Techniques like systems thinking and biomimicry exemplify this approach, highlighting the importance of interconnected ideation in engineering [35], [36], [37], [38].

The third constituent, "Creating Value", emboldens students to unearth hidden opportunities to deliver unparalleled value while emphasizing resilience and learning from setbacks [38]. It extends beyond mere business creation. KEEN's depiction focuses on converting challenges into prospects. Value, in this sense, can be manifold - economic, societal, or personal. Engineers are envisioned as value creators, identifying stakeholder needs and deriving tangible benefits. By reorienting engineering practices with a value-first approach, the profession stands to render far-reaching impacts on multiple beneficiaries, from individual consumers to society at large.

In summary, KEEN's triad offers a clear conceptualization of the EM for engineering, encapsulating the broad spectra of curiosity-driven exploration, the amalgamation of diverse knowledge sets, and the relentless pursuit of creating meaningful value. This study chooses KEEN as a baseline for synthesizing work performed in EM in engineering because it offers a comprehensive yet distinct lens through which to view the convergence of entrepreneurship and engineering.

D. Linguistic

Modern technology makes it feasible to evaluate large

This article has been accepted for publication in IEEE Transactions on Education. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/TE.2024.3416866

volumes of text in an effective and efficient computer-based manner. This technology allows researchers to analyze text on a large scale, identifying patterns, trends, and insights that would be difficult to discover through manual analysis. Previous researchers analyzed social media feeds, news articles, academic journals, and many other sources of text to gain a deeper understanding of trends, opinions, and behaviors [39], [40]. Entrepreneurship researchers have recently turned to digital footprints to study entrepreneurial outcomes and behaviors, presenting a range of potential applications for linguistic analysis. Sentiment and linguistic analysis of tweets have been employed in various research contexts. For example, such analyses have been used to compare the entrepreneurial personalities of superstar entrepreneurs and managers [41] and to distinguish differences between entrepreneurs and the general population [42]. Further applications include examining the confidence levels of founders versus professional Chief Executive Officers [43] and investigating entrepreneurs' emotional changes following venture failure [44]. Others studied the influence of business angel investors' personalities on syndication behavior [45], and explored entrepreneurial personalities in political leadership [46].

The ability to analyze large amounts of text can provide valuable insights into how to foster and develop the 3Cs in students. By using text analysis tools, one can identify patterns in language and communication that are associated with these key entrepreneurial skills. By leveraging text analytics, it is possible to answer this paper's research questions. It allows for dissecting the content of KEEN cards for thematic undertones and linguistic patterns, which directly aligns to discern faculty preferences in EM elements.

For evaluating the text of the cards, the Linguistic Inquiry and Word Count 2022 (LIWC-22) program was used, which is often used in research exploring the relationship between word use and psychological characteristics [47]. LIWC-22 includes over 80 linguistic categories that have been scientifically connected to a variety of psychological processes such as status, dominance, social connections, and emotionality [47]. LIWC-22 has been validated in over 100 empirical studies, making it a popular instrument in psychology and linguistics research [47]. The program counts the frequency of words and word stems and generates normalized scores that represent the percentage of words in each category in relation to the length of the text. Such an approach has shown to be a great source of information for researching personality traits and identifying true personality elements with exceptional accuracy [47], [48], [49], [50]. The application of LIWC-22 in this study offers a powerful and scientifically sound method for analyzing language and text.

Utilizing the LIWC-22's feature for custom dictionaries, this study pinpointed occurrences of the 3Cs within KEEN cards. These specialized dictionaries were designed to detect explicit references to each theme (e.g. "Creating Value" dictionary included phrases like "value creation" and "create value"). Unlike standard LIWC-22 dictionaries, which evaluate broader linguistic or psychological constructs, these custom dictionaries aimed solely to identify whether cards explicitly mention these themes. Consequently, the dictionaries provided a straightforward binary measure, indicating with a "1" if a card explicitly mentions these terms, thus focusing on the topic, and a "0" if it does not.

Finally, given the particular interest in the differential impact of electrical and computer engineering disciplines on the effectiveness and appeal of entrepreneurial educational resources, a binary variable, "EEE", was introduced. This variable is set to "1" if a card mentions disciplines such as Electrical & Computer Engineering, Computer Science, Computer Engineering, or Electrical Engineering, and "0" otherwise [4], [21].

E. Controls

In the regression analysis, multiple factors that might influence the popularity of KEEN cards are controlled for. Among these factors, specific attention is given to "need" and "want" states. The reason behind controlling for these states lies in their demonstrated power to influence human behavior and preferences [51]. "Need" states, represented in language, align with compelling actions or behaviors essential for an individual's well-being and survival (e.g., have to, need, had to, must). These states can elicit a stronger sense of urgency or importance when encountered, potentially driving higher interaction with certain KEEN cards. On the other hand, "want" states denote desires or preferences, suggesting elective or aspirational content that may resonate differently with the audience (e.g., want, hope, wanted, wish).

Six tone-related variables were included: positive tone, certitude, "I" and "you" references, male references, and netspeak. A positive tone is an important factor because it influences how the audience perceives the message. A positive tone has been linked to increased likability and engagement with the content [52]. The LIWC-22 "positive tone" dictionaries include words related to positive emotions (e.g., happy, joy, good, well) and words related to those emotions (e.g., birthday, beautiful). Certitude, on the other hand, reflects a degree of bravado or boasting of certainty that often reveals insecurity or lack of verifiable information (e.g., really, actually, of course, real). It can affect how the audience perceives the credibility of the message. The use of "I" vs. "you" references is another tone-related variable that can affect how the audience perceives the message. The use of second-person references (e.g., you, your, yourself) can be perceived as more inclusive and engaging, while the use of first-person singular references (e.g., I, me, mine) can be perceived as more self-centered and less engaging. Previous research [53] discovered that incorporating second-person pronouns in social media posts leads to a higher level of engagement in comparison to using first-person pronouns. Additionally, in studying the engagement of different audiences with KEEN cards, it is important to consider the potential impact of gender-specific language [1]. As a field that has been traditionally dominated by males, the use of male references in engineering communications has been prevalent [1]. However, the use of male references may not be

This article has been accepted for publication in IEEE Transactions on Education. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/TE.2024.3416866

well-received by female audiences, potentially due to a sense of exclusion or disconnection that may arise from the use of male-specific language. Therefore, the analysis controls for the use of male references in the cards (e.g., he, his, him, man). Lastly, netspeak is a form of informal language that includes emoticons, acronyms, and abbreviations (e.g., :), u, lol, hahaha). Its use can signal a more casual tone and may affect how the audience perceives the credibility and professionalism of the message.

Three additional control variables were also included in the analysis. The first one is the length of the KEEN card, which is measured in terms of word count. This variable is important to consider as longer cards may contain more information, which could potentially impact engagement with the content. The second control variable is whether the card was reviewed. KEEN allows users to submit their cards for optional peer review, which can provide additional feedback and potentially improve the quality of the content. Finally, the year a card was last updated has been included as a crucial control variable to account for unexplained factors in card templates and the availability of certain features on the platform. According to direct communication with KEEN, the functionalities of "Favorite" and "Share" cards have been available since the platform's inception. Additionally, although users could always download individual pieces of content (which is measured by downloads), the option to "Download All" for folders was introduced in 2022, alongside the initiation of card reviews. Additionally, the template provided by Engineering Unleashed underwent significant changes over the years, potentially influencing not only the content within a card but also its engagement metrics.

F. Estimation Method

Negative binomial regression was utilized to estimate the number of views, favorites, shares, and downloads ("nbreg" command is Stata). Negative binomial regression is well-suited for discrete variables with non-negative integer values, as it can account for over-dispersion commonly observed in count data. When the variance exceeds the mean, the negative binomial distribution is particularly appropriate for modeling count data with over-dispersion. Count data often exhibit more variation than expected based on a Poisson distribution, which assumes equal mean and variance. By utilizing negative binomial regression, it is possible to account for the extra variation and generate more accurate predictions. As the references to the 3Cs were slightly correlated to each other and affected the estimation results when entered together, separate regressions were conducted for each construct.

III. RESULTS

A. 3Cs in KEEN Cards: A Descriptive Overview

Faculty posting KEEN cards on this platform are likely among the most invested and engaged in the integration of EM into engineering education. By choosing to share these cards, they not only demonstrate their commitment but also offer a valuable repository of their experiences, insights, and effective practices. This act of sharing underscores their dedication to both the cultivation of EM in their students and the broader advancement of the educational community. Through their contributions, these faculty members illuminate what has proven successful and resonant in their endeavors to incorporate EM principles. The examination of the KEEN card content about the 3C framework reveals a slight hierarchy in the emphasis on these core components as presented in Table I. For each variable, this table presents its mean or proportion, minimum value (min), and maximum value (max) obtained using the "sum" and "tabstat" commands in Stata. The concept of "Connections" leads the way (Figure 1), appearing in 39% of the cards, emphasizing the importance of interlinking various fields, experiences, and notions in innovative engineering solutions. This is followed by "Curiosity", featured in 33% of the cards, which suggests a strong interest in fostering an inquisitive mindset among students. "Creating Value" is highlighted in 31% of the cards, showcasing the significance of leveraging opportunities to create a meaningful impact. These statistics provide a glimpse into the priorities and focal areas of faculty engaged in nurturing EM.

Further segmentation of the data highlights the differences between KEEN cards produced by electrical or computer engineering disciplines (EEE). To assess these differences, a "t-test" (ttest in Stata) was conducted to compare the means of two numerical data groups, and a "z-test" (prtest in Stata) was used for comparing proportions. Descriptive statistics reveal that almost 17% of the KEEN cards come from these domains. Notably, cards from these disciplines demonstrate a pronounced inclination towards KEEN's 3C framework. An examination of 6,247 members of Engineering Unleashed revealed that approximately 20% had some affiliation with EEE, indicating that the 17% of KEEN cards coming from these domains proportionally reflect the membership distribution. Specifically, about 47% of these cards touched upon "Connections", a proportion significantly higher than the 38% observed in cards from other disciplines (p-value < 0.01). The same trend was noted for "Curiosity" with 40% for EEE disciplines compared to 32% for others (p-value < 0.01). "Creating Value" saw a marginal difference between the two groups, with EEE disciplines at 35% and other disciplines at 31%, though this was not statistically significant at the conventional thresholds (p-value $= 0.065$).

On average, a KEEN card garnered 133 views, was downloaded 30 times, marked as a favorite 2.5 times, and notably, only shared 0.3 times (only 6% of cards were shared among users). Furthermore, a substantial 32% of cards delved into the topic of EM assessment, reflecting its importance in the discourse. No significant correlations were found among the independent variables, indicating that multicollinearity was not a concern in the regression analyses.

This initial analysis addresses both the first research question—Which elements of the EM are most frequently emphasized by faculty in their shared educational content? —and offers partial insights into the third question regarding differences in emphasis for EEE disciplines.

B. Faculty Engagement Driven by 3Cs: Regression Results

For the second research question, three separate regressions were conducted for each engagement type (views, favorites, downloads, and shares), using curiosity, connections, and creating value as independent variables due to the inherent collinearity among the 3Cs. The summarized results are presented in Table II, with full results for views and downloads available in the Appendix.

Firstly, the analysis pointed towards a unanimous inclination: all 3Cs were positively and significantly associated with views (i.e., curiosity: β=.164, $p<0.01$; connections β=.097, $p<0.05$; creating value: β=.245, $p<0.01$). This level of engagement signifies an introductory signal of interest from faculty members. It is akin to an academic's initial acknowledgment of a resource's potential. Such interactions may not just reflect a direct application to their teaching or research but might also symbolize an innate curiosity about embedding EM within their students. However, as the analysis delves deeper into the engagement metrics, a nuanced picture emerges. "Creating Value", one of the pillars of the EM, stood out as a consistent catalyst for continued interaction. This element was positively and significantly associated with both favorites (β=.197, $p<0.01$) and downloads (β=.740, $p<0.01$). In the entrepreneurial landscape, creating value is all about identifying opportunities and capitalizing on them for tangible benefits [54], [55]. KEEN cards focusing on this theme provide faculty with tools and insights to teach students how to spot and seize these opportunities for economic, societal, or personal benefit. It is then logical that such invaluable content would prompt faculty to earmark it as a favorite or download it for more in-depth exploration and integration into their curriculum.

KEEN cards mentioning the EEE disciplines (Table II) exhibited a distinct pattern in user engagement. Cards mentioning these fields were significantly more frequently shared compared to cards from other fields (β =.934 to .990, $p<0.01$). The specificity or niche quality of the content might make faculty more inclined to share them, potentially believing that their peers or colleagues would find unique value in these cards. However, these cards were less likely to be downloaded for direct integration into their curriculums (β=-.406 to -.531, $p<0.01$). For example, the EEE coefficient for the regression with Downloads as the dependent variable and Curiosity as the independent variable (β=-.494***) means that there is a roughly 39% decrease (1-exp(-.494)) in the expected number of downloads for EEE-related cards compared to cards from other disciplines. Users might view this content as more complex or not as valuable in its applicability.

When a KEEN card mentions the EEE disciplines also addresses the EM aspect of "Creating Value", it seems to have a diminishing effect on downloads as indicated by the only significant interaction effect between this variable (EEE) and 3Cs (β = -1.148, $p<0.01$, Table II). This negative interaction might suggest that when faculty from other engineering disciplines encounter content that combines the intricacies of EEE fields with the broad entrepreneurial tenet of "Creating Value", they may find it challenging to directly integrate or relate to their existing curricula or teaching approach. The EEE fields might have a unique approach or perspective on "Creating Value" that diverges from broader, more generalizable engineering teachings. When combined, the specific interpretations of "Creating Value" within the EEE context could be perceived as too niche, resulting in fewer downloads. These findings address the second and third research questions: "What aspects of the entrepreneurial mindset resonate most with academic faculty?" and "How do these relations differ in the electrical or computer engineering disciplines compared to other engineering fields?".

C. Beyond the Core Analysis: The Interplay of Language, Tone, and Topic

Cards focusing on the topic of assessing EM are more frequently marked as favorites (β=.107 to .122, $p<0.05$; full estimation results available upon request). This indicates a strong interest among users for content that provides insights into evaluating EM. However, a contrasting trend emerges when it comes to sharing. Such assessment-related cards are less likely to be disseminated among peers (β=-.536 to -.555, $p<0.10$). This could suggest that while users find personal value in this content, they might perceive it as specialized or niche, making them hesitant to share it broadly. However, this effect was only significant at the relaxed 0.10 level of significance.

Cards related to "Needs" and "Wants" show distinct patterns in user engagement. Cards discussing "Needs" (e.g., "have to", "must") consistently register fewer views (β=-.101 to -.111, $p<0.01$; Table AI) and are less often favored (β=-.181 to -.193, $p<0.01$) implying that topics centered on immediate necessities might not resonate as strongly or might be too commonplace to merit special attention. On the other hand, cards centered on "Wants" (e.g., "hope", "wish") are often marked as favorites (β=.279 to .286, $p<0.1$; Table AI). They are also notably shared more often (β=2.877 to 2.998, $p<0.01$), pointing to a broader appeal and relevance. This trend suggests that content focusing on aspirations and desires might evoke a stronger emotional connection, prompting users to engage more deeply and share the content with their networks.

Cards characterized by a positive tone consistently garnered more attention across the board, reflected in their higher likelihood of being viewed (β=.045 to .052, $p<0.01$), favorited (β=.096 to .101, $p<0.01$), downloaded (β=.175 to .192, $p<0.01$), and shared (β=.173 to .207, $p<0.1$-0.05). This underlines the preference users have for content that emits an optimistic or affirmative aura. Delving into more linguistic traits, the use of second-person references, such as "you" and "your", tends to resonate more with users across all metrics (views: β=.096 to .099, $p<0.01$, favorites: β=.145 to .146, $p<0.01$, downloads: β=.396 to .426, $p<0.01$, shares β=.389 to .412, $p<0.05$). This can be attributed to the inclusive and engaging nature of such terms, creating content that directly addresses the audience [56]. In contrast, frequent usage of

This article has been accepted for publication in IEEE Transactions on Education. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/TE.2024.3416866

first-person singular references, like "I" and "me", attract fewer views (β=-.091 to -.110, $p<0.01$) and downloads (β=-.437 to -.466, $p<0.01$). This is potentially because audiences perceive them as more self-centered and less engaging. Moreover, the world of engineering has a historical trend of male dominance [57]. However, such male-centric focus might not sit well with female audiences, likely due to feelings of exclusion [58]. This is evident in the lower number of views (β=-.225 to -.243, $p<0.01$), favorites (β=-.116 to -.177, $p<0.1$), and downloads (β=-.780 to -.876, $p<0.01$) for cards containing male references. Lastly, certitude, or the expression of surety, negatively relates to views (β=-.145 to -.149, $p<0.05$) and shares (β=-1.047 to -1.087, $p<0.1$), suggesting that users do not appreciate such confident language which often reveals insecurity or lack of verifiable information.

Additionally, as expected, reviewed cards garnered more attention across all metrics (views: β=1.148 to 1.498, $p<0.01$, favorites: β=1.867 to 1.874, $p<0.01$, downloads: β=4.213 to 4.308, $p<0.01$, shares β=1.977 to 2.086, $p<0.01$) as cards published or updated in more recent years.

IV. DISCUSSION AND IMPLICATIONS

A. Insights and Interpretations

In the contemporary landscape of engineering education, the integration of entrepreneurial principles stands out as a crucial intersection [1], [2], [3], [4], [5], [22]. While the benefits of such an educational strategy for students are generally lauded [4], [7], [8], [14], [16], [17], [18], [19], [20], the unique difficulties and requirements encountered by the faculty, who are charged with putting it into practice, typically go unmentioned. Such an oversight is especially significant, given that the success of these programs is intrinsically tied to faculty engagement and dedication [26], [27]. A comprehensive understanding of the goals of entrepreneurial education may enhance its integration into curricula, suggesting its importance for faculty in navigating these initiatives. Within the broader discourse on entrepreneurial education in engineering, this study presents a comprehensive synthesis. It delves into the preferences and inclinations of engineering faculty, identifying the specific entrepreneurial aspects that hold their interest. While emphasizing the importance of our synthesis, it's recognized that in the context of the global economy's rapid changes and the evolving roles of engineers, resources that effectively integrate technical skills with entrepreneurial thinking are increasingly valued [59]. The examination of KEEN cards, a platform for facilitating faculty collaboration to nurture students' EM, yields insights that contribute meaningfully to discussions on educational strategies. The focus was to comprehend and clarify the preferences of the engineering faculty concerning the integration of entrepreneurial principles within the curriculum. In particular, this paper answers the following three research questions: (1) What elements of the entrepreneurial mindset are most frequently emphasized by faculty in their shared educational content? (2) What aspects of the entrepreneurial mindset resonate most with academic faculty? (3) How do these relations differ in the electrical or computer engineering disciplines?

Concerning our first research question, this study's exploration into the EngineeringUnleashed.com platform underscores the integral role of the 3Cs framework as a foundational aspect of the platform's design, encouraging faculty to align their contributions with these themes. Delving deeper into the nuances of these discussions, it becomes evident that "Connections" consistently emerge as the most frequently presented element. This trend is even more pronounced in dialogues that intersect with the EEE disciplines. Such a pattern underscores the perceived importance of interlinking various domains. The emphasis on "Connections" highlights the faculty's recognition of the need for integrative thinking, an ability to bridge diverse concepts, and crafting holistic solutions in engineering education. Litzinger et al. [60] also stress the importance of structuring engineering education around key concepts and principles of the field to facilitate students' abilities to access and transfer knowledge to new and novel situations. Van den Beemt et al. [61] and Caratozzolo et al. [62] call for a new type of interdisciplinary engineering education that brings together expertise from different disciplines.

A notable observation from the current study is the frequent discourse on the assessment of EM. This indicates that beyond the adoption of EM principles, faculty are actively engaged in evaluating its implementation and effectiveness, emphasizing the comprehensive approach to entrepreneurial integration in engineering curricula. Olds et al. [63] point out that the advancement of engineering education in many ways depends on assessment and that high-quality assessments can provide educators with the information they can use to move the field forward. Therefore, it is understandable that the topic of EM assessment occupies a significant focus among faculty aiming to advance this contemporary trend in engineering education.

Answering our second research question ("What aspects of the entrepreneurial mindset resonate most with academic faculty?"), a nuanced understanding of faculty preferences unfolds. While all three components of the 3C framework garner attention as indicated by the "views", there is a marked distinction when considering the more committed action of "downloading". Downloading serves as a barometer for content that faculty find particularly applicable or useful for their curricula. In this context, "Creating Value" emerges as particularly resonant, suggesting that faculty members perceive this element as more actionable and integral to instilling EM in their students. Furthermore, when considering which topics are earmarked as "favorites", again, "Creating Value" stands out. This indicates a special emphasis on the significance of teaching students not just to innovate, but to ensure that their innovations have a tangible, positive impact. This matches previous literature that community engagement has recently become a focus in engineering education [64]. Paterson et al. [65] and others [21], [66] also note an increasing number of learning through service programs being developed in engineering. Muñoz et al. [67] stress the social impact and sustainable development in engineering education.

This article has been accepted for publication in IEEE Transactions on Education. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/TE.2024.3416866

It is interesting to note that while “Connections” (which is about integrating diverse knowledge sets to foster interdisciplinary insights) are frequently presented in KEEN cards, “Creating Value” (which is focused on identifying opportunities to deliver tangible benefits to society) is ultimately seen by faculty as the most actionable and impactful component of EM. This reflects a nuanced prioritization among educators, highlighting a crucial balance between theoretical discussion and practical application in engineering education.

Finally, addressing the last research question (“How do these relations differ in the electrical or computer engineering disciplines compared to other engineering fields?”), within the compendium of discussions, cards pertaining to EEE fields occupy about 17% of the total. Interestingly, while these cards were more frequently shared among the community interested in fostering EM, they were less often downloaded for direct use. This pattern suggests a dual-faceted perception. On one hand, the heightened shares indicate that EEE topics are perceived as intriguing and worthy of broader dissemination. Sharing, in this context, might be driven by the belief that peers and colleagues would benefit from being made aware of these discussions, even if they do not directly pertain to their immediate curricular needs. On the other hand, the diminished download rate suggests that while these topics are deemed valuable for awareness, they might be perceived as either too complex, too specialized, or not worth direct integration into curricula. It may also indicate a potential need for more accessible or directly applicable resources in EEE disciplines.

B. Implications

This study’s findings offer several significant contributions to the realm of engineering education and its intersection with entrepreneurial principles.

The pronounced engagement of educators with the “Creating Value” aspect of the EM, as evidenced by significant relations with rates of downloads, views, and favorites, signals a clear prioritization within the engineering education community. This trend implies that faculty members recognize the importance of integrating real-world, impact-driven projects into their curricula. It underscores an educational focus on preparing students not just to be innovators, but to be change-makers who can identify opportunities and translate them into tangible societal and economic benefits. The implication for teaching practices is a shift towards experiential learning models that emphasize the practical application of skills in creating value [64], [65], [66], [67]. For entrepreneurship education research, this highlights the need to further investigate effective methodologies for cultivating a value-creation mindset and the impact of such education on both student outcomes and broader societal contributions. This shift represents a nuanced understanding among educators of their role in fostering a generation of engineers equipped not only with technical skills but also with the vision to drive positive change.

Another essential implication is the need for the development and dissemination of resources focused on “Creating Value.” Creating such materials not only aligns with faculty interests but also supports the practical application of EM principles in engineering education, fostering a curriculum that emphasizes real-world impact and innovation. This ensures that educators have the tools necessary to prepare students effectively for their future roles as innovators and entrepreneurs. However, “Creating Value” was addressed at a lower rate in existing KEEN cards compared to other components of EM. This suggests a need for further development of materials focused on “Creating Value” addressing this disparity and better aligning with faculty interests. One way to teach students “Creating Value” to society is through service learning. Paterson et al. [65] point out that some faculty hesitate to engage in learning through service due to concerns of unfamiliarity with potential community partners and time constraints. Others enter it with enthusiasm but lack the knowledge to develop mutually beneficial partnerships and programs. Natarajarathinam et al. [64] list logistics constraints, cultural barriers, and disconnect as major challenges to the success of engineering community engagement programs. Developing resources addressing such topics is desirable.

Interestingly, different implications emerge for the EEE fields. The topics of “Connection” and “Curiosity” are discussed more in the cards from these fields and engagement is significantly lower when the card addresses “Creating Value”. But the EEE cards are also less likely to be downloaded. This may suggest a need for a strategic shift in these fields towards developing resources that not only highlight “Creating Value” within the EEE context but are also designed for higher direct applicability and relevance, thereby potentially increasing both their download rates and educational impact.

Finally, linguistic insights, especially those highlighting gender references, should serve as a clear call for making educational content more inclusive, catering to a diverse cohort of learners. The inclusivity push isn’t merely about gender representation but ensuring that all students, irrespective of their backgrounds, find relevance and resonance in the educational material [1], [19], [57], [58]. Also, educators are encouraged to employ a positive tone in their delivery. At the same time, they should be cognizant of the potential negative effects of using overly confident or self-focused language, which might detract from the core message and intent of fostering EM.

Moreover, the nuances unearthed in this research could chart the course for future scholarly endeavors, delving deeper into themes or linguistic attributes that resonate most within entrepreneurial education.

V. Limitations And Future Research

Despite the study’s useful insights, certain limitations should be considered when interpreting the findings. Firstly, the study was conducted solely using the KEEN network community, and it is unclear whether the findings can be generalized to the whole field of entrepreneurship engineering education. Future research, possibly using surveys, could investigate whether the

This article has been accepted for publication in IEEE Transactions on Education. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/TE.2024.3416866

same elements hold similar importance across broader academic settings in engineering education. Secondly, while this study concentrated on written communications, examining the influence of oral communication in educational contexts could offer complementary insights into faculty strategies for discussing EM themes. Therefore, further research could examine the impact of oral language, such as classroom discussions or lectures, on fostering EM. Third, the study utilized a cross-sectional dataset, limiting the ability to infer causality between the variables. Future research could employ longitudinal or experimental designs to establish causal relationships between the constructs. Lastly, the study only investigated the impact of individual linguistic elements, but it is possible that a combination of multiple linguistic elements could have a greater impact on the development of EM. Additionally, exploring the language used by successful entrepreneurs in their communications could provide further insights into effective linguistic strategies. Therefore, future research could expand upon the findings by examining the language used by students and successful entrepreneurs to gain a more comprehensive understanding of the role of language in entrepreneurship education.

In summary, the findings of this study shed light on the communication preferences of academic faculty regarding EM within the engineering discipline, highlighting a fertile ground for further investigation. Future research should address the limitations of this study and investigate the potential of combining different linguistic elements to maximize their impact on the development of EM.

VI. Conclusion

As engineering programs begin to embrace entrepreneurship education, it is crucial to understand the needs of the academic faculty tasked with implementing these changes. However, little research has been done on how faculty members can use their language to effectively inspire creativity, connections, and value creation. This study aims to elucidate the preferences and communication strategies of academic faculty regarding EM within engineering education, focusing on the resonance of specific linguistic and thematic elements. This study's findings can be used to create engaging teaching materials and activities centered around the 3Cs while incorporating linguistic elements such as a positive tone, female references, and a second-person point of view. Armed with these insights, engineering educators can cultivate EM in their students, ultimately contributing to the development of successful entrepreneurs or intrapreneurs.

References

[1] P. Shekhar, "Engineering Entrepreneurship Program Participation: Differences Across Men and Women," *IEEE Transactions on Education*, vol. 66, no. 2, pp. 188–196, Apr. 2023, doi: 10.1109/TE.2022.3208524.

[2] A. Huang-Saad, C. Bodnar, and A. Carberry, "Examining Current Practice in Engineering Entrepreneurship Education," *Entrepreneurship Education and Pedagogy*, vol. 3, no. 1. SAGE Publications Inc., pp. 4–13, Jan. 01, 2020. doi: 10.1177/2515127419890828.

[3] G. Barbosa, D. A. Silva, H. G. Costa, M. Duarte, and D. E. Barros, "Entrepreneurship in Engineering Education: A Literature Review."

[4] D. Cordero, S. Astudillo, and D. Cisneros, "Attributes and Entrepreneurial Intention in University Students of Electrical Engineering and Computing Sciences," *IEEE Transactions on Education*, vol. 66, no. 4, pp. 386–392, Aug. 2023, doi: 10.1109/TE.2023.3253839.

[5] A. Y. Huang-Saad, C. S. Morton, and J. C. Libarkin, "Entrepreneurship Assessment in Higher Education: A Research Review for Engineering Education Researchers," *Journal of Engineering Education*, vol. 107, no. 2, pp. 263–290, Apr. 2018, doi: 10.1002/jee.20197.

[6] L. B. Bosman and M. Phillips, "Integrating the Entrepreneurial Mindset into the Engineering Classroom," *IEEE Transactions on Education*, vol. 65, no. 2, pp. 150–155, May 2022, doi: 10.1109/TE.2021.3101360.

[7] E. Pardede and J. Lyons, "Redesigning the assessment of an entrepreneurship course in an information technology degree program: Embedding assessment for learning practices," *IEEE Transactions on Education*, vol. 55, no. 4, pp. 566–572, 2012, doi: 10.1109/TE.2012.2199757.

[8] E. Kim and G. J. Strimel, "The Influence of Entrepreneurial Mindsets on Student Design Problem Framing," *IEEE Transactions on Education*, vol. 63, no. 2, pp. 126–135, May 2020, doi: 10.1109/TE.2019.2918253.

[9] S. Yi and N. Duval-Couetil, "What Drives Engineering Students To Be Entrepreneurs? Evidence of Validity for an Entrepreneurial Motivation Scale," *Journal of Engineering Education*, vol. 107, no. 2, pp. 291–317, Apr. 2018, doi: 10.1002/jee.20199.

[10] T. Turner and P. Gianiodis, "Entrepreneurship Unleashed: Understanding Entrepreneurial Education outside of the Business School," *Journal of Small Business Management*, vol. 56, no. 1, pp. 131–149, Jan. 2018, doi: 10.1111/jsbm.12365.

[11] Engineering Unleashed, "Entrepreneurial Mindset: Equipping engineering students to excel," https://engineeringunleashed.com/mindset.

[12] S. K. Gilmartin, A. Shartrand, H. L. Chen, C. Estrada, and S. Sheppard, "Investigating entrepreneurship program models in undergraduate engineering education," *Int J Eng Educ*, vol. 32, no. 5, pp. 2048–2065, 2016.

[13] S. E. Zappe, S. L. Cutler, and L. Gase, "A Systematic Review of the Impacts of Entrepreneurial Support Programs in Science, Technology, Engineering, and Math Fields," *Entrepreneurship Education and Pedagogy*, vol. 6, no. 1, pp. 3–31, Jan. 2023, doi: 10.1177/25151274211040422.

[14] P. Shekhar, A. Huang Saad, and J. Libarkin, "Understanding student participation in entrepreneurship education programs: A critical review," *International Journal of Engineering Education*, vol. 34, no. 3, pp. 1060–1072, 2018.

[15] A. Kwapisz, W. J. Schell, K. Aytes, and S. Bryant, "Entrepreneurial Action and Intention: The Role of Entrepreneurial Mindset, Emotional Intelligence, and Grit," *Entrepreneurship Education and Pedagogy*, vol. 5, no. 3, pp. 375–405, Jul. 2022, doi: 10.1177/2515127421992521.

[16] N. Duval-Couetil, A. Shartrand, V. Amherst, M. A. And, and T. Reed, "The Role of Entrepreneurship Program Models and Experiential Activities on Engineering Student Outcomes." [Online]. Available: www.venturewell.org,

[17] C. S. E. Woodcock, P. Shekhar, and A. Huang-Saad, "Examining Project Based Entrepreneurship and Engineering Design Course Professional Skills Outcomes*."

[18] M. W. Ohland, S. A. Frillman, G. Zhang, C. E. Brawner, and T. K. Miller, "The effect of an entrepreneurship program on GPA and retention," *Journal of Engineering Education*, vol. 93, no. 4. Wiley-Blackwell Publishing Ltd, pp. 293–301, 2004. doi: 10.1002/j.2168-9830.2004.tb00818.x.

[19] M. W. Ohland *et al.*, "Race, gender, and measures of success in engineering education," *Journal of Engineering Education*, vol. 100, no. 2, pp. 225–252, 2011, doi: 10.1002/j.2168-9830.2011.tb00012.x.

[20] L. Bosman and S. Fernhaber, "Applying authentic learning through cultivation of the entrepreneurial mindset in the engineering classroom," *Educ Sci (Basel)*, vol. 9, no. 1, Mar. 2019, doi: 10.3390/educsci9010007.

[21] B. J. Lameres, M. S. Burns, D. B. Thoman, and J. L. Smith, "The Role of Prosocial Goal Congruity on Student Motivation in

Electrical Engineering," *IEEE Transactions on Education*, vol. 62, no. 4, pp. 256–263, Nov. 2019, doi: 10.1109/TE.2019.2897265.

[22] M. Täks, P. Tynjälä, M. Toding, H. Kukemelk, and U. Venesaar, "Engineering students' experiences in studying entrepreneurship," *Journal of Engineering Education*, vol. 103, no. 4, pp. 573–598, Oct. 2014, doi: 10.1002/jee.20056.

[23] M. I. Mendelson, "Entrepreneurship in a graduate engineering program," in *Journal of Engineering Education*, Wiley-Blackwell Publishing Ltd, 2001, pp. 601–607. doi: 10.1002/j.2168-9830.2001.tb00646.x.

[24] T. Standish-Kuon and M. P. Rice, "Introducing engineering and science students to entrepreneur ship: Models and influential factors at six American universities," *Journal of Engineering Education*, vol. 91, no. 1, pp. 33–39, 2002, doi: 10.1002/j.2168-9830.2002.tb00670.x.

[25] J. Blake Hylton, D. Mikesell, J. D. Yoder, and H. LeBlanc, "Working to Instill the Entrepreneurial Mindset Across the Curriculum," *Entrepreneurship Education and Pedagogy*, vol. 3, no. 1, pp. 86–106, Jan. 2020, doi: 10.1177/2515127419870266.

[26] A. Gibb, "Concepts into practice: Meeting the challenge of development of entrepreneurship educators around an innovative paradigm: The case of the International Entrepreneurship Educators' Programme (IEEP)," *International Journal of Entrepreneurial Behaviour and Research*, vol. 17, no. 2, pp. 146–165, Mar. 2011, doi: 10.1108/13552551111114914.

[27] H. Teerijoki and K. A. Murdock, "Assessing the role of the teacher in introducing entrepreneurial education in engineering and science courses," *International Journal of Management Education*, vol. 12, no. 3, pp. 479–489, Nov. 2014, doi: 10.1016/j.ijme.2014.05.005.

[28] A. R. Peterfreund, E. Costache, H. L. Chen, S. K. Gilmartin, and S. Sheppard, "Infusing innovation and entrepreneurship into engineering education: Looking for change as seen by ASEE Members, 2012 to 2015," in *ASEE Annual Conference and Exposition, Conference Proceedings*, American Society for Engineering Education, Jun. 2016. doi: 10.18260/p.25691.

[29] A. Dinh, "What's in a mindset? Exploring the entrepreneurial mindset," 2022.

[30] H. Shahbaznezhad, R. Dolan, and M. Rashidirad, "The Role of Social Media Content Format and Platform in Users' Engagement Behavior," *Journal of Interactive Marketing*, vol. 53, pp. 47–65, Feb. 2021, doi: 10.1016/j.intmar.2020.05.001.

[31] P. Bryła, S. Chatterjee, and B. Ciabiada-Bryła, "The Impact of Social Media Marketing on Consumer Engagement in Sustainable Consumption: A Systematic Literature Review," *International Journal of Environmental Research and Public Health*, vol. 19, no. 24. MDPI, Dec. 01, 2022. doi: 10.3390/ijerph192416637.

[32] J. S. London, J. M. Bekki, S. R. Brunhaver, A. R. Carberry, and A. F. Mckenna, "Advances in Engineering Education A Framework for Entrepreneurial Mindsets and Behaviors in Undergraduate Engineering Students: Operationalizing the Kern Family Foundation's '3Cs,'" 2018. [Online]. Available: http://engineeringunleashed.

[33] M. P. Lynch and A. C. Corbett, "Entrepreneurial mindset shift and the role of cycles of learning," *Journal of Small Business Management*, vol. 61, no. 1, pp. 80–101, 2023, doi: 10.1080/00472778.2021.1924381.

[34] B. D. McLarty, J. S. Hornsby, and E. W. Liguori, "Advancing entrepreneurial mindset: What do we know and where do we go?," *Journal of Small Business Management*, vol. 61, no. 1. Taylor and Francis Ltd., pp. 1–11, 2023. doi: 10.1080/00472778.2022.2140809.

[35] P. Godfrey, R. Deakin Crick, and S. Huang, "Systems Thinking, Systems Design and Learning Power in Engineering Education*."

[36] M. Nehdi and R. Rehan, "Raising the Bar for Civil Engineering Education: Systems Thinking Approach", doi: 10.1061/ASCE1052-39282007133:2116.

[37] I. H. Yeter, V. S. Q. Tan, and H. Le Ferrand, "Conceptualization of Biomimicry in Engineering Context among Undergraduate and High School Students: An International Interdisciplinary Exploration," *Biomimetics*, vol. 8, no. 1, Mar. 2023, doi: 10.3390/biomimetics8010125.

[38] M. Boga-Akyol and S. Timur-Ogut, "Exploring Biomimicry in the Students' Design Process," *Des Technol Educ*, vol. 21, no. 1, pp. 21–31, 2016.

[39] A. Koutsoumpis, J. K. Oostrom, D. Holtrop, W. van Breda, S. Ghassemi, and R. E. de Vries, "The Kernel of Truth in Text-Based Personality Assessment: A Meta-Analysis of the Relations Between the Big Five and the Linguistic Inquiry and Word Count (LIWC)," *Psychol Bull*, vol. 148, no. 11–12, pp. 843–868, 2022.

[40] S. S. Hall, R. M. McGill, S. Puttick, and J. Maltby, "Resilience, science, technology, engineering, and mathematics (STEM), and anger: A linguistic inquiry into the psychological processes associated with resilience in secondary school STEM learning," *British Journal of Educational Psychology*, vol. 92, no. 3, pp. 1215–1238, Sep. 2022, doi: 10.1111/bjep.12496.

[41] M. Obschonka, C. Fisch, and R. Boyd, "Using digital footprints in entrepreneurship research: A Twitter-based personality analysis of superstar entrepreneurs and managers," *Journal of Business Venturing Insights*, vol. 8, pp. 13–23, Nov. 2017, doi: 10.1016/j.jbvi.2017.05.005.

[42] A. Tata, D. L. Martinez, D. Garcia, A. Oesch, and S. Brusoni, "The psycholinguistics of entrepreneurship," *Journal of Business Venturing Insights*, vol. 7, pp. 38–44, Jun. 2017, doi: 10.1016/j.jbvi.2017.02.001.

[43] J. M. Lee, B. H. Hwang, and H. Chen, "Are founder CEOs more overconfident than professional CEOs? Evidence from S&P 1500 companies," *Strategic Management Journal*, vol. 38, no. 3, pp. 751–769, Mar. 2017, doi: 10.1002/smj.2519.

[44] C. Fisch and J. H. Block, "How does entrepreneurial failure change an entrepreneur's digital identity? Evidence from Twitter data," *J Bus Ventur*, vol. 36, no. 1, Jan. 2021, doi: 10.1016/j.jbusvent.2020.106015.

[45] J. Block, C. Fisch, M. Obschonka, and P. Sandner, "A personality perspective on business angel syndication.," *J Bank Financ*, vol. 100, pp. 306–327, 2019.

[46] M. Obschonka and C. Fisch, "Entrepreneurial personalities in political leadership," *Small Business Economics*, vol. 50, no. 4, pp. 851–869, Apr. 2018, doi: 10.1007/s11187-017-9901-7.

[47] J. W. Pennebaker, R. L. Boyd, K. Jordan, and K. Blackburn, " The development and psychometric properties of LIWC2015," 2015.

[48] Y. R. Tausczik and J. W. Pennebaker, "The psychological meaning of words: LIWC and computerized text analysis methods," *Journal of Language and Social Psychology*, vol. 29, no. 1. pp. 24–54, Mar. 2010. doi: 10.1177/0261927X09351676.

[49] J. Golbeck, C. Robles, M. Edmondson, and K. Turner, "Predicting Personality from Twitter," *2011 IEEE International Conference on Privacy, Security, Risk, and Trust, and IEEE International Conference on Social Computing*, pp. 149–156, 2011.

[50] S. A. Golder and M. W. Macy, "Diurnal and seasonal mood vary with work, sleep, and daylength across diverse cultures," *Science (1979)*, vol. 333, no. 6051, pp. 1878–1881, 2011.

[51] M. Schaller, D. T. Kenrick, R. Neel, and S. L. Neuberg, "Evolution and human motivation: A fundamental motives framework," *Soc Personal Psychol Compass*, vol. 11, no. 6, Jun. 2017, doi: 10.1111/spc3.12319.

[52] N. N. Bazarova and Y. H. Choi, "Self-disclosure in social media: Extending the functional approach to disclosure motivations and characteristics on social network sites," *Journal of Communication*, vol. 64, no. 4, pp. 635–657, 2014, doi: 10.1111/jcom.12106.

[53] L. I. Labrecque, K. Swani, and A. T. Stephen, "The impact of pronoun choices on consumer engagement actions: Exploring top global brands' social media communications," *Psychol Mark*, vol. 37, no. 6, pp. 796–814, Jun. 2020, doi: 10.1002/mar.21341.

[54] M. A. Hitt, R. D. Ireland, D. G. Sirmon, and C. A. Trahms, "Strategic Entrepreneurship: Creating Value for Individuals, Organizations, and Society," *SSRN Electronic Journal*, May 2012, doi: 10.2139/ssrn.1994491.

[55] R. D. Ireland, M. A. Hitt, S. M. Camp, and D. L. Sexton, "Integrating entrepreneurship and strategic management actions to create firm wealth.," *Academy of Management Perspectives*, vol. 15, no. 1, pp. 49–63, 2001.

[56] L. Rodman, "You-Attitude: A Linguistic Perspective You-attitude is a pedagogically convenient cover term that subsumes considerable complexity, both with respect to the text effects it may include and the text charac-teristics that create these effects. Some of the insights on politeness, tact, and def-erence found in the work of."

[57] T. E. S. Charlesworth and M. R. Banaji, "Gender in Science, Technology, Engineering, and Mathematics: Issues, Causes, Solutions," *Journal of Neuroscience*, vol. 39, no. 37. Society for Neuroscience, pp. 7228–7243, 2019. doi: 10.1523/JNEUROSCI.0475-18.2019.

This article has been accepted for publication in IEEE Transactions on Education. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/TE.2024.3416866

[58] S. Cheryan, S. A. Ziegler, A. K. Montoya, and L. Jiang, "Why are some STEM fields more gender balanced than others?," *Psychol Bull*, vol. 143, no. 1, pp. 1–35, Jan. 2017, doi: 10.1037/bul0000052.

[59] B. Hynes, Y. Costin, and I. Richardson, "Educating for STEM: Developing Entrepreneurial Thinking in STEM (Entre-STEM).," in *Enhancing Entrepreneurial Mindsets Through STEM Education.*, vol. 15, S. Kaya-Capocci and E. Peters-Burton, Eds., 2023, pp. 165–194.

[60] T. A. Litzinger *et al.*, "Engineering education and the development of expertise," *Journal of Engineering Education*, vol. 100, no. 1, pp. 123–150, 2011, doi: 10.1002/j.2168-9830.2011.tb00006.x.

[61] A. Van den Beemt *et al.*, "Interdisciplinary engineering education: A review of vision, teaching, and support," *Journal of Engineering Education*, vol. 109, no. 3. John Wiley and Sons Inc, pp. 508–555, Jul. 01, 2020. doi: 10.1002/jee.20347.

[62] P. Caratozzolo *et al.*, "Developing Skills for Industry 4.0: Challenges and Opportunities in Engineering Education," in *Proceedings - Frontiers in Education Conference, FIE*, Institute of Electrical and Electronics Engineers Inc., 2022. doi: 10.1109/FIE56618.2022.9962444.

[63] B. M. Olds, B. M. Moskal, and R. L. Miller, "Assessment in engineering education: Evolution, approaches and future collaborations," in *Journal of Engineering Education*, Wiley-Blackwell Publishing Ltd, 2005, pp. 13–25. doi: 10.1002/j.2168-9830.2005.tb00826.x.

[64] M. Natarajarathinam, S. Qiu, and W. Lu, "Community engagement in engineering education: A systematic literature review," *Journal of Engineering Education*, vol. 110, no. 4. John Wiley and Sons Inc, pp. 1049–1077, Oct. 01, 2021. doi: 10.1002/jee.20424.

[65] K. G. Paterson, A. R. Bielefeldt, C. W. Swan, G. Rulifson, D. Kazmer, and O. Pierrakos, "Designing Value into Engineering Learning Through Service Activities Using a Blueprint Model," *International Journal for Service Learning in Engineering Special Edition*, pp. 64–83, 2013.

[66] A. R. Bielefeldt and M. Lima, "Service-Learning and Civic Engagement as the Basis for Engineering Design Education." [Online]. Available: www.intechopen.com

[67] L. A. Munoz, A. J. Gandara, and J. J. Ayala, "Implementing Social Impact and Sustainable Development in Robotics and Digital Systems Education: A Tec21 Model Approach," in *2023 IEEE IFEES World Engineering Education Forum and Global Engineering Deans Council: Convergence for a Better World: A Call to Action, WEEF-GEDC 2023 - Proceedings*, Institute of Electrical and Electronics Engineers Inc., 2023. doi: 10.1109/WEEF-GEDC59520.2023.10344150.

TABLE I

DESCRIPTIVE STATISTICS

AND T-TEST FOR MEANS AND Z-TEST FOR DIFFERENCES IN PROPORTIONS BETWEEN ELECTRICAL AND COMPUTER ENGINEERING (EEE) AND OTHER FIELDS (NOT EEE)

(*** P<.01, ** P<.05, * P<.1)

	All Cards (n=2166)				EEE (n=362)	Not EEE (n= 1,804)	t/z-test p-value
Variable	Mean/ Prop	Std. Dev.	Min	Max	Mean/ Prop	Mean/ Prop	
EEE	.167	.373	0	1			
Views	132.91	299.747	1	6442	156.182	128.241	0.053*
Downloads	30.069	273.448	0	5078	44.392	27.195	0.138
Favorites	2.494	4.596	0	77	2.591	2.475	0.330
Shares	.296	3.895	0	90	.669	.222	0.023**
If Curiosity	.330	.470	0	1	.401	.316	0.001***
If Connections	.393	.489	0	1	.467	.379	0.001***
If Creating Value	.314	.464	0	1	.348	.308	0.065*
If Assessment	.319	.466	0	1	.359	.312	0.038**
need	.577	.59	0	5.42	.575	.578	0.470
want	.087	.189	0	2.08	.080	.089	0.198
Positive Tone	2.397	1.501	0	13.2	1.993	2.478	0.000***
First-person singular pronouns	.258	.573	0	7.85	.333	.243	0.003***
Second-person pronouns	.501	.896	0	8.73	.370	.528	0.001***
Male references	.052	.275	0	4.33	.060	.050	0.273
Certitude	.199	.314	0	2.72	.199	.200	0.483
Netspeak	.092	.225	0	2.83	.089	.092	0.402
Reviewed	.056	.231	0	1	.088	.050	0.002***
Year	2020.183	1.554	2017	2023	2020.41	2020.14	0.0012***
Word Count	579.567	401.495	30	4460	740.691	547.235	0.000***

TABLE II

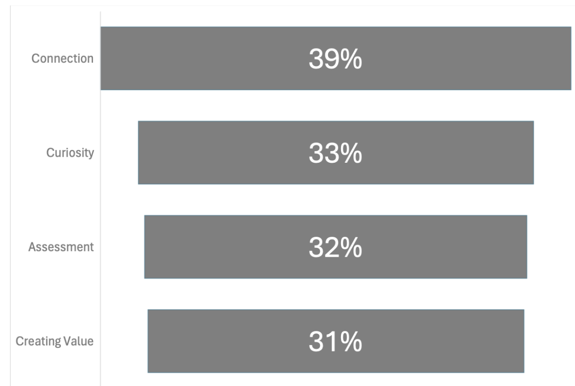
SUMMARY OF MAIN REGRESSION RESULTS

(*** P<.01, ** P<.05, * P<.1)

Variable	Coeff	SE	Coeff	SE	Coeff	SE
Dependent Variable: KEEN Card Views						
Curiosity	.164***	.040				
Connections			.097**	.040		
Creating Value					.245***	.042
EEE	.076	.05	.078	.051	.087*	.05
Dependent Variable: KEEN Card Favorites						
Curiosity	.016	.057				
Connections			.022	.056		
Creating Value					.197***	.058
EEE	.033	.071	.033	.071	.035	.071
Dependent Variable: KEEN Card Downloads						
Curiosity	.188	.148				
Connections			.192	.142		
Creating Value					.740***	.166
EEE	-.494***	.189	-.531***	.189	-.406**	.187
EEE x Creating Value					-1.148***	.375
Dependent Variable: KEEN Card Shares						
Curiosity	-.481	.301				
Connections			-.154	.289		
Creating Value					-.499	.313
EEE	.990***	.338	.934***	.338	.936***	.333

FIGURE I

PERCENTAGE OF KENN CARDS RELATED TO EM TOPICS



APPENDIX

TABLE AI

NEGATIVE BINOMIAL REGRESSION RESULTS WITH KEEN CARD VIEWS AS THE DEPENDENT VARIABLE (N=2166): FULL RESULTS (*** P<.01, ** P<.05, * P<.1)

Variable	Coeff	SE	Coeff	SE	Coeff	SE
Curiosity	.164***	.040				
Connections			.097**	.040		
Creating Value					.245***	.042
EEE	.076	.05	.078	.051	.087*	.05
Assessment	.066	.041	.066	.041	.056	.041
Need	-.104***	.031	-.101***	.031	-.111***	.031
Want	.046	.104	.039	.104	.035	.103
Positive Tone	.052***	.013	.051***	.013	.045***	.013
First-person singular pronouns	-.11***	.033	-.110***	.033	-.091***	.033
Second-person pronouns	.099***	.022	.097***	.022	.096***	.022
Male references	-.228***	.063	-.225***	.063	-.243***	.063
Certitude	-.149**	.06	-.145**	.060	-.149**	.06
Netspeak	.096	.081	.086	.081	.122	.081
Reviewed	1.481***	.087	1.492***	.088	1.498***	.087
Word Count	.000***	.000	.000***	.000	0.000***	.000
2018	-.285	-.28	.211	.782	-.262	.209
2019	-.28	-.27	.211	.776	-.263	.209
2020	-.159	-.151	.210	.783	-.151	.209
2021	.221	.232	.211	.791	.223	.21
2022	.142	.153	.212	.785	.152	.21
2023	.479**	.484	.221**	.807	.508**	.219
Constant	4.312***	4.313	.211***	.768	4.31***	.209
Ln(alpha)	-.362	-.358	.028	.042	-.369	.028
Pseudo r-squared	0.042		0.042		0.043	
Chi-square	1084		1073		1103	
Prob > chi2	0.000		0.000		0.000	
Akaike crit. (AIC)	24486		24496		24467	
Bayesian crit. (BIC)	24605		24616		24586	

This article has been accepted for publication in IEEE Transactions on Education. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/TE.2024.3416866

TABLE AII
NEGATIVE BINOMIAL REGRESSION RESULTS WITH KEEN CARD DOWNLOADS AS THE DEPENDENT VARIABLE (N=2166): FULL RESULTS (*** P<.01, ** P<.05, * P<.1)

Variable	Coeff	SE	Coeff	SE	Coeff	SE
Curiosity	.188	.148				
Connections			.192	.142		
Creating Value					.740***	.166
EEE	-.494***	.189	-.531***	.189	-.406**	.187
Assessment	.233	.158	.235	.158	.248	.153
Need	-.093	.135	-.089	.135	-.163	.132
Want	.756	.615	.805	.619	.885	.610
Positive Tone	.192***	.049	.191***	.049	.175***	.047
First-person singular pronouns	-.466***	.111	-.459***	.111	-.437***	.110
Second-person pronouns	.396***	.090	.401***	.091	.426***	.089
Male references	-.874***	.289	-.876***	.289	-.780***	.282
Certitude	.247	.258	.345	.263	.125	.258
Netspeak	-.110	.341	-.124	.340	-.007	.341
Reviewed	4.213***	.326	4.213***	.326	4.308***	.321
Word Count	.000	.000	.000	.000	0.000	.000
2018	-.092	.780	-.137	.782	-.065	.771
2019	.052	.775	.039	.776	.067	.765
2020	.447	.782	.395	.783	.413	.773
2021	2.424***	.789	2.365***	.791	2.042***	.784
2022	1.482*	.783	1.421*	.785	1.472*	.773
2023	2.156***	.806	2.104***	.807	2.181***	.798
Constant	-.143	.768	-.136	.768	-.168	.758
Ln(alpha)	2.104	.042	2.104	.042	2.088	.042
Pseudo r-squared	0.082		0.082		0.084	
Chi-square	711		711		730	
Prob > chi2	0.000		0.000		0.000	
Akaike crit. (AIC)	7973		7973		7954	
Bayesian crit. (BIC)	8092		8092		8074	