

Considering Aspirations and Impact: Using Storytelling to Encourage Engineering Students to Reframe their Experiences

Stephanie J. Lunn*, Cristi L. Bell-Huff†

The Wallace H. Coulter Department of Biomedical Engineering
Georgia Institute of Technology
Atlanta, GA 30332, USA

Email: *stephanie.lunn@bme.gatech.edu, †cristi.bell-huff@bme.gatech.edu

Abstract—This research full paper describes an eight-week, extra-curricular, multi-institutional program centered around sharing personal narratives. Over the course of the experience, we provided ($n = 24$) engineering students with scaffolding materials to develop their storytelling skills and opportunities for them to craft and present stories around specific prompts. The program culminated in a Story Slam where students orally delivered four-minute stories that communicated “who you are, what has shaped you, and the story you want to tell with your life’s work and why.” The Kern Entrepreneurial Engineering Network (KEEN) framework of the 3Cs (Curiosity, Connections, and Creating value) for the development of an entrepreneurial mindset guided the programmatic development and shaped our inquiry to explore: 1) how storytelling prompts can encourage students’ consideration of their goals and potential impact on society; and 2) beneficial approaches to story-driven learning. To better understand students’ motivations and thoughts about the program, we qualitatively examined their open-ended responses. We also applied a rubric to quantify aspects of KEEN’s 3Cs observed in videos of students’ stories shared during the final Story Slam. The results suggest that storytelling can promote communication, allow students to reframe their experiences, and help them to think about their professional aspirations. Students’ curiosity not only shaped their desire to participate in the program, but for many students, was also a major contributor in their pathways into engineering. The content and materials offered in the program provided foundations that students connected with, as evidenced by the information and mentions they brought into their own stories. Furthermore, the stories presented illustrate that students want to create value both personally and professionally. Students preferred to share their stories in smaller groups and also appreciated positive feedback and comments from their peers and the facilitators. Additionally, they described how listening to other students’ stories helped them to grow and raised their awareness of others’ lived experiences. These insights serve to inform educators about the value of storytelling and to identify opportunities to support students when employing story-driven learning.

Index Terms—Entrepreneurial mindset, storytelling, personal narratives

I. INTRODUCTION

Engineering programs in higher education increasingly seek to not just develop theoretical and technical foundations but also to foster professional skills (e.g., leadership, collaboration, and creative thinking) [1], [2]. While there may be many ways

of doing so, we sought to explore the potential of storytelling, a pedagogical tool that has been shown to enhance engagement and improve recall of information [3]. Scholars have noted it can also be beneficial for organizing and making meaning of experiences, building interpersonal relationships, and eliciting and understanding the needs of various stakeholders [3], [4].

To further elucidate the potential of constructing and sharing personal narratives, we developed an eight-week, extra-curricular, multi-institutional program for undergraduate engineering students. Over the course of the experience, we tried to equip students to tell their unique stories of growth, identity, and vision and to encourage them to consider their aspirations and the mark they wanted to leave on the world (their legacy). We developed the program together with faculty from institutions associated with the Kern Entrepreneurial Engineering Network (KEEN) Engineering Unleashed partnership.

The KEEN community includes schools that collaboratively endeavor to cultivate an Entrepreneurial Mindset (EM) in engineers [5]. An EM is considered beneficial for engineers’ long term success and can empower them to identify opportunities, encourage them to take action, and lead them to innovative solutions [6], [7]. It can also promote focusing on the value they intend to create “for themselves and others” [8].

KEEN created a framework that describes EM in terms of its educational outcomes, to inform the design of courses and content [8]. They suggest that these outcomes can be measured via action and activity to build upon students’ foundational knowledge. KEEN’s model (see Table I) considers three “building blocks” for the EM, referred to as the **3Cs**: Curiosity, Connections, and Creating Value.

We applied the 3Cs framework in the creation of the program and our story prompts, as well as in our evaluation of the experience. The program was called **Exploring LegaCs** (hereafter referred to as LegaCs) to encompass the notion of sharing the Life stories (L) of Engineers (e) Growing (g), Acting on (a), Curiosity, Connections, Creating value (the Cs). It culminated in an event called the Story Slam where students presented four-minute oral stories about “who you are, what has shaped you, and the story you want to tell with your life’s work and why.”

Component	Purpose	Educational Outcomes
<i>Curiosity</i>	In a world of accelerating change, today's solutions are often obsolete tomorrow. Since discoveries are made by the curious, we must empower our students to investigate a rapidly changing world with an insatiable curiosity.	DEMONSTRATE constant curiosity about our changing world EXPLORE a contrarian view of accepted solutions
<i>Connections</i>	Discoveries, however, are not enough. Information only yields insight when connected with other information. We must teach our students to habitually pursue knowledge and integrate it with their own discoveries to reveal innovative solutions.	INTEGRATE information from many sources to gain insight ASSESS and MANAGE risk
<i>Creating Value</i>	Innovative solutions are most meaningful when they create extraordinary value for others. Therefore, students must be champions of value creation. As educators, we must train students to persistently anticipate and meet the needs of a changing world.	IDENTIFY unexpected opportunities to create extraordinary value PERSIST through and learn from failure

TABLE I: KEEN's 3Cs student learning outcomes to support the development of the entrepreneurial mindset [8]

The purpose of this research was to explore how students perceive the impact of storytelling, as applied in LegaCs. The investigation was guided by the following research questions (RQs):

- **RQ1:** *How does storytelling help students consider their future aspirations and impact?*
- **RQ2:** *What approaches can educators take to provide students the greatest benefit from story-driven learning?*

We provide pertinent background literature in Section II. Section III describes the LegaCs program in greater detail, including its implementation and the methods employed to analyze its impact. Section IV explains the outcomes of this analysis and then we interpret the results in the context of our RQs in Section V. We detail the limitations of this work in Section VI and then conclude in Section VII with the implications of this work and how this can be adapted into other programs or coursework.

II. RELATED WORK

In this work, we consider the link between stories, personal narratives, reflection, and introspection. We also consider how stories, and specific prompts, may encourage students to shape their own self-concept in regards to aspects described by the 3Cs framework towards developing an EM. Accordingly, we describe each further below, along with how it relates to our research.

A. Stories, Personal Narratives, Reflection, and Introspection

Storytelling and/or the sharing of personal narratives are considered valuable tools to structure individual experiences, make associations, and for the transmission of culture [3]. In the context of education, they are seen as beneficial for their ability to promote understanding, encourage interest, foster inclusivity, and make content digestible [3], [9], [10]. However, researchers suggest it is insufficient to merely recount a story, and emphasize that delivery is pivotal to engagement [3], [10]. These scholars recommend proper application of communication mechanisms like enthusiasm, tone, pitch, and inflection to make stories more memorable and to incite an emotional investment from the audience.

For individuals creating a story around their own lived experiences, introspection can be particularly critical. Introspection is a form of self-reflection, where reflection is defined as "...an intentional and dialectical thinking process where an individual revisits features of an experience with which he/she is aware and uses one or more lenses in order to assign meaning(s) to the experience that can guide future action (and thus future experience)" [11, p. 1]. This deliberate process can be applied to pedagogy to help students attribute meaning to their own experiences and to integrate knowledge pertaining to ethics and/or global (or civic) awareness through listening to others. While it can be incorporated into courses in different ways, some potential methods for reflection and introspection include participating in active listening exercises (where an individual restates the message of the speaker), developing portfolios, or writing in journals, diaries, learning logs, or essays [12].

B. Entrepreneurial Mindset

Studies have highlighted the connection between entrepreneurship, innovation, and creativity [13]–[16]. They emphasized the need for engineering students to not just understand technology and ideate, but also for them to be able to consider the market and to communicate the value of their ideas. Doing so is enhanced by internalization of broader concepts such as entrepreneurial affect (e.g., coping with failure, empathy), consideration of stakeholders, and product development [15]. It also encompasses professional (e.g., teamwork, time management), technical (i.e., those related to engineering), and business (e.g., marketing, sales) skills.

As a result, entrepreneurship education for engineers typically is modeled after business schools. Several scholars have previously compared students from engineering and business, to better understand their approaches and intentions towards entrepreneurship [14], [16]. Berglund and Wennberg [14] illustrated that while both populations of students had high creative potential, they applied their creativity in unique ways. Engineering students (with training on entrepreneurship) often considered creativity in the context of problem solving. They approached problems more incrementally, finding potential avenues for improvement. Meanwhile, the business students

were more concerned with the conditions in the market, and conceptualized creativity in the context of the commercialization of their ideas. Later work by Gilmartin et al. [16] further emphasized the discipline-sensitive nature of “entrepreneurial intent” and described that gender may also play a role [16, p. 329]. For example, they described a positive relationship between women and being able to “switch gears” despite setbacks to achieving goals [16, p. 329].

Rather than focusing on building a business venture, the KEEN definition of EM centers on student outcomes that allow for opportunities, designs, and an impact [8] that “create personal, economic, and societal value through a lifetime of meaningful work” [17]. The desire to create scalable, sustainable, and human-centric solutions with a lasting impact has led to a growing interest for educators to consider deploying and exploring entrepreneurship. While some studies have worked to understand students’ perceptions, attitudes, and intentions towards entrepreneurship [13], [15], [16], [18], others have focused more on quantifying EM. Previously Kleine and Yoder (2011) described applying a rubric to operationalize and assess entrepreneurial mindset [19]. They used the KEEN’s learning-outcomes to develop criteria for assessing students’ performance and encouraged educators to consider its impact on various learning activities, courses, and programs.

As mentioned, we employed personal narratives to encourage students’ to develop skills and reframe their experiences in ways that may help them to see themselves as entrepreneurially minded. Prior literature has illustrated that self-perception of one’s own identity, the process of creating one’s self-concept through choices, can make an individual more likely to act in a certain way [20]. The link between storytelling and entrepreneurship has been described before, as necessary for setting expectations and valuable in the context of gaining the support of stakeholders in new ventures [21], [22]. Storytelling can aid in making the ‘unfamiliar familiar’ and assist in digesting concepts to make them more “understandable and thus legitimate” [23, p. 549]. While we were less focused on the business aspect of entrepreneurially minded thinking, we did seek to explore how storytelling and specific prompts could help students consider their broader life goals.

III. METHODS

A. LegaCs Program

The LegaCs program included 24 voluntary undergraduate engineering participants, 9 facilitators, 2 student assistants, and 2 story coaches from five different KEEN institutions. The participants met weekly, and were given synchronous activities, lessons, and prompts to help reflect and consider their lived experiences, goals and aspirations, and the impact on themselves and others (see Table II). Each session occurred virtually via Zoom and lasted for one hour.

The format initially included a welcome with the entire group where a facilitator offered an overview of the content for the week and/or materials related to an activity. Then, the group split into four smaller breakout rooms with six students and two facilitators each. Within these groups, students were

Focus	Week	Story Prompts
<i>Curiosity</i>	1	Stories from our childhoods. How have they shaped you?
	2	Stories of defining moments. How did you grow?
<i>Connections</i>	3	Tell me about yourself. Why did you become an engineer?
	4	Tell me about yourself. Who are you?
<i>Creating Value</i>	5	Imagining future paths. What if?
	6	Stories of impact. Who will be different because of you?
	7	The LegaC Story: What story do you want to tell?
<i>Celebration</i>	8	Exploring LegaCs Story Slam showcase event

TABLE II: LegaCs story prompts

given a few minutes to develop a story around the prompt of the week (to eliminate potential homework for students since this was an extra-curricular program), and then were asked to share. Later, the groups recombined to allow individuals the opportunity to voluntarily share their stories with everyone, and to provide programmatic updates and closing comments.

Throughout the program, we attempted to establish a supportive community where students felt comfortable sharing and to build an impactful experience. We provided coaching and peer feedback. We shared rules of engagement emphasizing options such as “Be here now,” “Equal Voice,” and “Forget Perfect,” strategies suggested by StoryReady¹ (a company centered around storytelling for professional development). We encouraged interactions and created a Discord channel for students to converse outside of the program. We also designed and gave out T-shirts, provided books on communication and storytelling, and even mailed out snacks for the sessions. Our approach was intended for students to leave the program knowing that their stories had been heard and celebrated, to hopefully get to know others within the engineering community, and to help them feel prepared to articulate their own growth, role in the discipline, and goals.

B. Data Collection and Analysis

A convergent parallel mixed methods design [24] was used to collect, analyze, and interpret quantitative and qualitative data about students’ experiences and the stories they shared in the final Story Slam. The study, materials, and consent form used were previously approved by the Institutional Review Board. We employed thematic analysis to qualitatively examine our participants’ open-ended reflections about the LegaCs experience. We also used a rubric to quantify which aspects of the 3Cs were present in videos of students’ stories shared during the final Story Slam. The rationale for doing so was to explore how well the 3Cs may appear in relation to a specific prompt about students’ pathways and the story they want to tell with their life’s work and why. While the skills developed

¹<http://storyready.com>

over the course of the program and the 3Cs could indirectly affect EM, we were not trying to imply a direct causality, just to consider how these outcomes may appear when employing storytelling around verbalizing aspirations and impact. We describe the separate qualitative and quantitative data collections and analyses further below, and provide the combined interpretation of both later in Section V (the discussion).

1) *Qualitative*: Qualitative data collection involved open-ended questions administered after the experience through Qualtrics to assess students' motivations for joining the program and to understand their perceptions of its effectiveness. The qualitative questions asked in the post-experience survey were crafted using language based off of the 3Cs model and Brookfield's Critical Incident Questionnaire (CIQ) [25]. Examples of items included are: "How did your curiosity inform your decision to participate in this experience?" and "At what moment in the experience did you feel most distanced from what was happening?" Students were not required to complete the survey, and $n = 13$ students completed the questions in total, and their open-ended responses were analyzed using qualitative content analysis [26].

We employed a hybrid approach of inductive and deductive coding, as others have described [27]. First, the two authors separately read through the students' open-ended responses and created an early version of the codebook. This entailed applying key concepts from the 3Cs to construct a priori codes [28] and then expanding upon these codes as applicable based on the students' responses. We also sorted the codes into broader categories. The researchers then met to discuss and negotiate on variations in the observed codes, their definitions, and the themes observed. Upon agreement, a final codebook was established and used to independently code the students' responses in Dedoose (version 9.0.18). The researchers obtained a pooled Cohen's Kappa of 0.82, considered an "Almost Perfect" agreement (per Landis and Koch [29]).

2) *Quantitative*: To evaluate students' storytelling and how the responses to the prompt in the Story Slam might appear in terms of the 3Cs, we used videos of the stories shared and applied the rubric shown in Table III. The two authors initially watched two videos concurrently, rated them, and then discussed their interpretation of the outcome and its rating. Although there was variation in the way that students articulated components of the 3Cs when responding to the given prompt, aspects of the framework were evident throughout their Story Slam stories. For the purposes of rating them using the rubric, we considered the following applications (as determined based on the initial subset of videos examined together):

- **Exemplary (Yes)**: Explicitly states concept with applicable examples
- **Accomplished (Yes, but...)**: Mentioned concept but not fleshed out nor did participant include any real example(s)
- **Developing (No, but...)**: Was not mentioned explicitly but may touch upon concept with examples
- **Beginning (No)**: Not mentioned at all and does not touch upon

The 3Cs appeared in different ways in the Story Slam stories. The dimensions for curiosity were fairly straightforward. Yet, in terms of connections, and integrating information from many sources, students' responses may not always be in the context of course content. It also encompassed information from different experiences or obtained through individuals in their life (e.g., teachers, parents, and peers). For assessing and managing risk, we conceptualized it as having an attitude that something has never been done before and being willing to try. Furthermore, we approached identifying unexpected opportunities (part of creating value) as students describing how they wanted to solve problems and how they wanted to make an impact. For persisting through and learning from failure (also from creating value), we saw it as a reflection on their learning and being willing to keep trying despite setbacks.

After the initial two videos, the authors separately reviewed the rest. We used a linear weighted Cohen's Kappa coefficient ($\hat{\kappa}_w$) to assess our inter-rater agreement, a measure for ordinal classification which penalizes larger disagreements in ratings [30]. Overall, we obtained a $\hat{\kappa}_w = 0.73$ for the overall rubric agreement, $\hat{\kappa}_w = 0.72$ for Curiosity, $\hat{\kappa}_w = 0.65$ for Connections, and $\hat{\kappa}_w = 0.82$ for Creating Value. According to Landis and Koch [29], scores $.61 \leq \hat{\kappa}_w \leq 0.80$ represent a "Substantial" agreement beyond chance and scores $\hat{\kappa}_w > 0.90$ represent an "Almost Perfect" agreement.

3) *Validity, Reliability, and Positionality*: Validity is a concept that refers to whether the findings actually measure what they are supposed to measure [31]. In particular, construct validity evaluates how well a tool represents the intended concept. To establish this type of validity, and to understand how a specific prompt may contribute to students' consideration of their aspirations and impact, we explored the Story Slam stories for the presence of the 3Cs. While these components may be indirectly linked to skills from storytelling, we created the program employing established learning outcomes from KEEN and applied the 3Cs framework in the design of Exploring LegaCs prompts. The 3Cs concepts also guided the questions to encourage reflection in the post-experience survey, and shaped the analysis and interpretation of the study. Reliability refers to consistency and how repeatable measurements are. For both the quantitative and qualitative evaluations the two authors independently reviewed the material and we used inter-rater reliability to determine the internal consistency.

Given that individual perspectives can impact qualitative judgements and observations, we want to acknowledge our role in the process. The first and second authors were involved in the development and facilitation of LegaCs. We did deliberately create the program with the 3Cs in mind. We included scaffolding and story prompts in the program towards the end goal of helping students think about their legacy. We also were responsible for the data collection and analysis. Accordingly, our familiarity with the subjects and experience brought inside knowledge of reactions and participation which could have influenced the interpretation.

3Cs Framework Component	Educational Outcomes	Exemplary (Yes)	Accomplished (Yes, but...)	Developing (No, but...)	Beginning (No)	Comments/Evidence
Curiosity	Demonstrate constant curiosity about our changing world					
	Explore contrarian view of accepted solutions					
Connections	Integrate information from many sources to gain insight					
	Assess and manage risk					
Creating Value	Identify unexpected opportunities to create value					
	Persist through and learn from failure					

TABLE III: 3Cs rubric applied to the Exploring LegaCs Story Slam stories

IV. RESULTS

A. Qualitative Findings

The themes that emerged from the qualitative analysis of the students' open-ended responses, along with the codes that contributed to them, and representative quotes of each are presented in Table IV. As indicated, there was a total of eight codes which contributed to three broader themes: *Understanding Self*, *Understanding Others*, and *Programmatic Merit*. These themes are described further below.

- **Understanding Self:** The theme referred to the introspective aspect of students' responses. Students detailed how LegaCs evoked their own reflection and how it afforded them the opportunity to take inventory of their own positions, beliefs, and experiences. They made meaningful connections between their past experiences, considering how they may have shaped their own values and choices, through the prompts and activities. Understanding self also spoke to the students' curiosity about the program, what it might entail, and what their participation could (or did) help them to discover about themselves and others.
- **Understanding Others:** Students formed associations with others through LegaCs and storytelling. By listening to the stories of others in the group, they described gaining perspective on others' lived experiences and the struggles they may have faced. They spoke to how they felt in reaction to things shared, and recounted how hearing these stories enhanced their empathy and raised their own awareness.
- **Programmatic Merit:** LegaCs was viewed favorably from the perspectives of the participants. They spoke to how it informed their own personal growth and enhanced their professional skills. Furthermore, they touched upon how the environment and others involved in the program bolstered their confidence and helped them to open up on subjects they might have otherwise been reluctant to share. They also articulated how LegaCs encouraged them to think about their own trajectories and goals.

B. Quantitative Findings

As described, we applied the rubric shown in Table III to students' videos to assess their Story Slam stories for evidence of the 3Cs. For those ratings where both authors concurred on the score, we present the breakdown of the rubrics for each construct as proportions of each quality level (the rating, e.g., "Beginning (No)") as a percent of the total aligned evaluations in Figure 1. As illustrated, "Creating Value" had the largest percentage of scores where students

demonstrated an "Exemplary" level of mastery. However, all three components of the 3Cs were observed in the students' Story Slam stories.

V. DISCUSSION

A. RQ1: How does storytelling help students consider their future aspirations and impact?

Analyses of participants' stories shared at the Story Slam and thematic analysis of their open-ended responses demonstrated how creating, telling, and listening to personal narratives could help students consider their future aspirations and impact. Many times, the ways they described their self-conceptualization in the program and in their profession aligned with aspects of the 3Cs. While the open-ended responses provided more holistic insight into the students' perceptions of the program and storytelling, the stories themselves helped to interpret students' responses to the Story Slam prompt in terms of the 3Cs components. Some participants structured their story around a transformative incident, and others detailed the many contributing threads that wove together to shape their trajectory and drive their passion for their specific engineering discipline.

Students' curiosity not only shaped their desire to participate in the program, but for many students, was also a major contributor in their pathways into engineering. They described wanting to know more about their own past, families, and culture, and how learning about such areas expanded their interests, plans, and approaches. Their stories spoke to thinking outside the box, trying different things, and wanting to explore new methods and approaches. Such types of thinking encompass the principles of "epistemic curiosity," where an individual seeks to mitigate uncertainty and acquire understanding or knowledge [32]. Furthermore, the open-ended responses expressed how much they learned about others and their lived experiences, broadening their perspectives. This idea relates to "empathic curiosity," a form of curiosity that arises from a desire to know more about how others may think or feel [32]. Students' stories, as evaluated with the rubric, frequently illustrated some level of seeking to find answers and examining contrarian views. The majority of students exhibited this aspect of curiosity (78% based on aligned ratings) by touching on some form of problem solving either with examples or as a direct principle. Such inquisitiveness aligns with "perpetual curiosity," the urgency to remedy a particular issue [32].

We observed connections in disparate ways, but ultimately they aided in students' personal comprehension (in alignment with the theme *Understanding Self*). This is not unusual,

Theme	Code	Definition	Representative Quotes
<i>Understanding Self</i>	Curiosity	Students' inquisitiveness about the program and their desire to learn more about themselves	"I was very curious to meet new people, hear their stories, and explore my own creativity."
			"I was curious about storytelling, especially as an engineer. I have always loved to write, but rarely about myself. Learning how to tell my story in a concise and compelling way is a valuable skill and I'm glad this program caught my attention!"
	Making Connections	Integrating information and experiences to gain insight	"My story surprised me - it was something that had been there all along but that I had never truly fleshed out and I learned so much about myself from putting together the pieces!"
			"It helped me by helping me realize all the things that I have done that make an impact on my life as well as the lives around me."
	Reflection	Recognizing one's own thoughts, feelings, and beliefs and altering their thinking or perspectives, to influence action(s) in the future	"I am transitioning, transforming, and evolving as a person, and this program helped me articulate who I am, who is influencing me, and what value I want to create with my life. If I don't stop to think about these crucial questions, it is easy to get caught up in the motions and not take a step back. I hope to continue this kind of storytelling over and over again as my dreams evolve. This program also reminded me that everybody around me has value. Every human being has dreams and visions, and sometimes I need to be reminded of this, so as to really treat people with the dignity they deserve." "Taking the time to formulate my legacy story and having people enjoy hearing about it really helped me understand that I don't have to have it all figured out yet while still making an impact."
<i>Understanding Others</i>	Gaining Perspective	Acknowledging others' lived experiences or situations and its impact on them	"The perspectives I heard broadened my sense of the overall human experience, which made me more empathetic." "Hearing other people's stories and walks in life really opened my eyes to how people across the country have lived their life."
	Sharing Feelings	Taking on the emotions of another based on something that they expressed	"Feeling emotion for other's circumstances" "Being able to understand or feel what someone else is feeling"
	Bonding	Attachments formed with others, whether those part of the program or externally	"I think I made some connections with other students, especially in sharing our stories and giving feedback."
			"Yes I definitely feel close to those in my small group since those were the people I really got to engage with."
<i>Programmatic Merit</i>	Creating Value	How the individual described their future goals or how they want to contribute to society	"By reflecting on the ways others have and how I have already, I have a better understanding of the effective and meaningful ways to create value." "This program helped me think about what I want to do in life, but also why I want to do it and how which was really helpful for visualizing my goals for the future."
	Professional Development	How the experience cultivated skills such as writing and/or speaking and empowered students	"I hoped to learn how to tell an effective story and filter through the events of my life."
			"I'm most surprised that I actually have gained confidence in telling my stories. I did not think a 8 week program would actually be able to improve my self-confidence."

TABLE IV: Thematic analysis of students' open-ended responses

as others have also spoken about how storytelling can help individuals to learn about themselves [33]. Students connected with the content and materials offered in the program, as evidenced by the open-ended comments. In addition, they made connections to the information shared in references brought into their own stories, such as our "what if" prompt presented in a prior lesson. As mentioned already, the Story Slam prompt elicited responses which articulated connections between the individuals and experiences in their life. Scholars have described similar linkages forming in the context of other disciplines (i.e., psychology), where the authors described that narratives can be valuable for students to "bridge past, present, and future experiences" [3, p. 251].

Making connections was especially critical to gaining perspective (part of the theme of *Understanding Others*) and consideration of social and societal needs, as addressed by some goals from the KEEN's 3Cs framework. Narratives have been shown to help process information more efficiently, particularly when they have social relevance [34]. Likewise, students in LegaCs linked their own hardships and those faced by others as an impetus for their desire to make a difference

and/or to consider global needs. Such remarks align with the work of others who have encouraged using digital storytelling to promote engagement with course content while also creating narratives to enhance students' critical thinking, raise diversity issues, and foster cultural competency [35].

The responses and stories presented illustrated students desire to create value personally and professionally. As exemplified by the theme of *Programmatic Merit*, LegaCs encouraged the students to express their goals and this often was linked to the potential contributions to society. In the stories shared during the Story Slam, students also described risks they took, and when they faced setbacks, how they learned from them and/or persevered. Others have detailed how structuring stories around overcoming obstacles, and undergoing a transformation, rather than just focusing on successes can "humanize us" and encourage others to "empathize with us" [36, p. 7]. Similarly, our participants found inspiration from their struggles and mentioned using them as learning experiences when crafting their stories. In their open-ended responses about the program, they commented how surprised they were that others were willing to open up about such personal

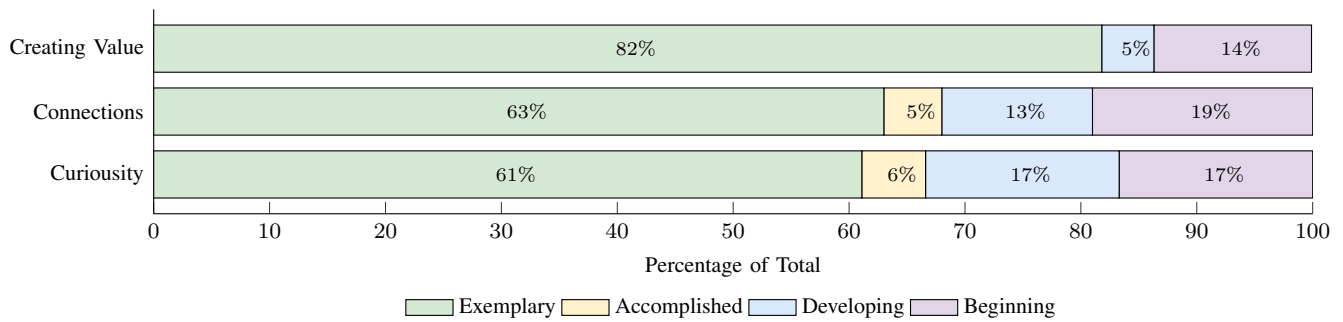


Fig. 1: Percent of total ratings for each component of EM

struggles, but that they felt it strengthened the ties formed within the LegaCs community.

Quantitatively, we observed creating value also was the 3Cs facet most often perceived as exemplary. We posit this may have been influenced, at least in part, by the Story Slam prompt. Resiliency and overcoming obstacles were a major thread in the videos as well. While we cannot infer a causal relationship from our assessment, conducting interviews with the students involved in the program could offer additional insight going forward. We also hypothesize there may be linkages between persistence despite barriers and disciplinary identity, as sociotechnical competencies of problem solving and accountability (or personal responsibility) can contribute to engineers' trajectories [37]. Again, this is an area we suggest exploring further in future work.

B. RQ2: What approaches can educators take to provide students the greatest benefit from story-driven learning?

Based on students' responses, they perceived the LegaCs program as a positive experience. As described by the theme of *Understanding Self*, they sated and grew their own curiosity, made connections, and reflected on themselves to incite action and shape future goals. This finding further supports literature that extracurricular activity participation can expand students' knowledge, creativity, and motivation and further their entrepreneurial skills [38].

They found merit in crafting their own stories and sharing them with others. They also described how listening to other students' stories helped them to grow, made them feel, and raised their awareness of others' lived experiences (as the theme of *Understanding Others* described). As scores on the quantitative rubric illustrated, they also integrated information from multiple sources, when developing their own narrative.

In addition, the students' feedback suggested that the structure of LegaCs was conducive to establishing an environment that encouraged sharing and bolstered their confidence. As encompassed by the theme of *Programmatic Merit*, multiple features allowed them to consider creating value and enhanced their professional development. From the results' analyses, we propose the following strategies for others looking to create similar experiences or to integrate storytelling into the curriculum:

1) *Offering more private breakout rooms with facilitators to guide discussions in smaller groups:* Several students noted they felt more distanced during the experience when in the larger group. Students preferred to present their stories in the breakout rooms and mentioned they helped them to feel more engaged. This is not uncommon as synchronous discussions in small groups through Zoom have been shown by other researchers to improve students' satisfaction and social presence [39]. The students cited feeling more open in their interactions with their group over the course of the program which we attribute, at least partially, to the relationships developed. Shared experiences have been suggested to aid in cultivating links with peers and to aid in overcoming isolation in engineering [40].

2) *Providing coaching and directed feedback on stories shared:* Beyond the feedback given throughout the program, we also offered additional office hours for students to ask questions, obtain recommendations, or receive coaching about their Story Slam stories. These practice sessions were described as both beneficial and affirming in the open-ended responses. Students also communicated that they appreciated the feedback and comments from their peers and the facilitators throughout LegaCs. However, they specified it was most meaningful when they felt heard based on what they had said and not just for the sake of being complimented.

External recognition can be important for encouragement. It can impact others' perceptions of an individual, and affirmation has also been linked to the development of students' disciplinary identity in STEM fields [41]–[43]. As such, we urge others to offer directed feedback and consider the framing of what is stated to prevent silencing or harshly delivered criticism that could adversely impact students' motivation to speak further.

3) *Giving resources on storytelling, scaffolding, and prompts to evoke introspection:* Respondents indicated that scaffolding storytelling with lessons about how to construct a story, thorough explanations, and providing prompts were beneficial. We recommend teaching students how to structure stories and what kinds of elements can make for a compelling story. To maximize the emotional trajectory, it has been suggested to apply Gustav Freytag's structure that mimics the rising and falling shape of a pyramid, including the: Beginning, Rising problem, Climax, Cooldown, and Resolution [36],

[44]. In our lessons, we encouraged students to consider the areas described below (content created by StoryReady) when crafting a story:

- **Transformation.** To tell a meaningful story, something has to happen. Narratives need people who are changed by the events of the story.
- **Land the plane.** The more specific a story, the more universal it is. So, focus your story on a specific day, a specific moment.
- **Last first.** Start the process by writing the final sentence of the story. If the goal is a big transformation, knowing your final sentence allows you to craft an opening that allows for big change.
- **Make it sticky.** Details are what make stories come alive. A few compelling details make a story engaging, specific and real. So, help the listener “see” your story (like they are watching a movie).
- **See it, see it, feel it.** Deliver an emotional experience by telling your listener what you are feeling in response to what’s happening in the story. If you feel it, we will too.

The notion of transformation we suggested aligns well with Freytag’s structure, allowing for a story to build, reach its culmination, and then settle back to its conclusion in terms of an evolution. Such a layout can also help individuals realize how their own instances of dealing with challenges have impacted them, leading to possible reframing of experiences in alignment with aspects of the 3Cs, such as identifying opportunities to create value.

4) *Creating a welcoming and open environment:* Establishing a space where students could speak without feeling judged was regarded as important. Students mentioned they may have felt more vulnerable initially, but that the supportive group made it easier to open up. Within the small groups, each person was able to share their stories each week and the students stated feeling included.

C. Summary

The results suggest that storytelling is an effective means of promoting introspection, cultivating communication, and can be used to help students articulate their experiences. We encourage educators to consider incorporating the principles of the 3Cs and storytelling to contribute towards a wider critical pedagogical praxis and students’ disciplinary and personal development. There could be multiple ways of including the writing and sharing of personal narratives, and not just as part of an external program as we described.

Stories could be integrated into in-class activities and lessons, or they could be part of course assignments (e.g., homework, projects, or portfolios). Beyond the classroom, faculty could consider creating storytelling workshops or events. Stories could be used to start meetings, to encourage rapport-building and to prompt reflection. They could be used to tell the story of the product or customers (although this represents a story about another and not a personal narrative as we have described). Alternatively, they could also be added into

projects with community partners to encourage students to share engineering projects with others.

VI. LIMITATIONS

There are several limitations to this work which should be discussed. Not all the students elected to complete the open-ended responses upon completion of the program. Accordingly, the responses obtained include only those willing to participate. In addition, baseline levels of the 3Cs to characterize an EM were not collected, and the data explored represents the 3Cs elements evident at a cross-section in time, in response to a specific prompt. The 3Cs components observed in their Story Slam stories may be reflective of students’ natural inclinations, or influences external to the program, rather than the suggested topic. Our goal was not to imply a causation of the 3Cs or EM but to suggest that storytelling could allow students to reframe their experiences, consider their aspirations and impact, and encourage them to see themselves as entrepreneurially minded. Going forward, it would be valuable to conduct additional assessments of the 3Cs or students’ EM at the start and end of the program to gain additional insight. The program could also be followed up with qualitative interviews to learn more about the intentions and preferences of the participants.

VII. CONCLUSIONS

In summation, we described an extra-curricular program for engineering students focused on storytelling. The prompts given in the experience encouraged students to consider the legacy they wanted to leave with their life’s work to make contributions to their field and to society. We evaluated the students’ interpretation of the value of the program, storytelling, and the Story Slam prompt in Exploring LegaCs using quantitative and qualitative methods.

Our analyses indicated the program did help students to reframe their experiences and consider their future aspirations and impact. We made recommendations on takeaways for others to consider applying. Although this was merely the first iteration of the Exploring LegaCs program, we want to continue to grow and expand the experience. We also hope that our description of the program and the benefits of sharing personal narratives may serve as a roadmap for others looking to integrate story-driven learning as they seek to prepare future engineering leaders and innovators.

ACKNOWLEDGEMENTS

This material is based upon work supported by the National Science Foundation (Award # 2025080). Any findings, conclusions, and recommendations expressed in this work do not necessarily reflect the views of the National Science Foundation. We would also like to thank the Kern Family Foundation for additional funding through a KEEN Rising Star Award awarded to the second author. Moreover, we want to express our gratitude to the entire Exploring LegaCs team for their contributions to the program.

REFERENCES

- [1] L. Bosman and S. Fernhaber, "Applying Authentic Learning through Cultivation of the Entrepreneurial Mindset in the Engineering Classroom," *Education Sciences*, vol. 9, no. 1, p. 7, 2018.
- [2] P. Caratozzolo, A. Alvarez-Delgado, and S. Hosseini, "Perspectives on the use of serious-storytelling for creative thinking awareness in engineering," in *2020 IEEE Frontiers in Education Conference (FIE)*. IEEE, 2020, pp. 1–9.
- [3] R. E. Landrum, K. Brakke, and M. A. McCarthy, "The Pedagogical Power of Storytelling," *Scholarship of Teaching and Learning in Psychology*, vol. 5, no. 3, pp. 247–253, 2019.
- [4] N. Boulila, A. Hoffmann, and A. Herrmann, "Using storytelling to record requirements: Elements for an effective requirements elicitation approach," in *2011 Fourth International Workshop on Multimedia and Enjoyable Requirements Engineering (MERE'11)*. IEEE, 2011, pp. 9–16.
- [5] T. J. Kriewall, "Instilling the Entrepreneurial Engineering Mindset in College Undergraduates: A Panel Presentation," in *VentureWell. Proceedings of Open, the Annual Conference*. National Collegiate Inventors & Innovators Alliance, 2010, p. 1.
- [6] D. Rae and D. E. Melton, "Developing an Entrepreneurial Mindset in US Engineering Education: An International View of the KEEN Project," *The Journal of Engineering Entrepreneurship*, vol. 7, no. 3, 2017.
- [7] J. M. Bekki, M. Huerta, J. S. London, D. Melton, M. Vigeant, and J. M. Williams, "Opinion: Why EM? The Potential Benefits of Instilling an Entrepreneurial Mindset," *Advances in Engineering Education*, vol. 7, no. 1, p. n1, 2018.
- [8] KEEN Engineering Unleashed, "The Framework for Entrepreneurially Minded Learning," 2022. [Online]. Available: <https://engineeringunleashed.com/framework>
- [9] M. A. Danowitz and F. Tuitt, "Enacting Inclusivity through Engaged Pedagogy: A Higher Education Perspective," *Equity & Excellence in Education*, vol. 44, no. 1, pp. 40–56, 2011.
- [10] L. Phillips, "Storytelling as Pedagogy," *Literacy Learning: The Middle Years*, vol. 21, no. 2, 2013.
- [11] J. A. Turns, B. Sattler, K. Yasuhara, J. L. Borgford-Parnell, and C. J. Atman, "Integrating Reflection into Engineering Education," in *ASEE Annual Conference & Exposition*, 2014, pp. 1–16.
- [12] R. Habash, *Professional Practice in Engineering and Computing: Preparing for Future Careers*. CRC Press, 2019.
- [13] N. Duval-Couetil, T. Reed-Rhoads, and S. Haghighi, "Engineering Students and Entrepreneurship Education: Involvement, Attitudes and Outcomes," *International Journal of Engineering Education*, vol. 28, no. 2, pp. 425–435, 2012.
- [14] H. Berglund and K. Wennberg, "Creativity among entrepreneurship students: comparing engineering and business education," *International Journal of Continuing Engineering Education and Life Long Learning*, vol. 16, no. 5, pp. 366–379, 2006.
- [15] C. A. Bodnar and C. Hixson, "Capturing Students' Perception of Entrepreneurial Mindset: Tools for What and Why," *Advances in Engineering Education*, vol. 7, no. 1, pp. 1–11, 2018.
- [16] S. K. Gilmartin, M. E. Thompson, E. Morton, Q. Jin, H. L. Chen, A. Colby, and S. D. Sheppard, "Entrepreneurial intent of engineering and business undergraduate students," *Journal of Engineering Education*, vol. 108, no. 3, pp. 316–336, 2019.
- [17] KEEN Engineering Unleashed, "KEEN: The Kern Entrepreneurial Engineering Network," 2022. [Online]. Available: <https://engineeringunleashed.com/what-is-keen>
- [18] C. S. Morton, A. Huang-Saad, and J. Libarkin, "Entrepreneurship Education for Women in Engineering: A Systematic Review of Entrepreneurship Assessment Literature with a Focus on Gender," in *ASEE Annual Conference & Exposition*, 2016.
- [19] R. E. Kleine and J.-D. Yoder, "Operationalizing and Assessing the Entrepreneurial Mindset: A Rubric Based Approach," *The Journal of Engineering Entrepreneurship*, vol. 2, no. 2, pp. 57–86, 2011.
- [20] S. J. Schwartz, A. Meca, and M. Petrova, "Who Am I and Why Does It Matter? Linking Personal Identity and Self-Concept Clarity," in *Self-Concept Clarity*. Springer, 2017, pp. 145–164.
- [21] R. Garud, H. A. Schildt, and T. K. Lant, "Entrepreneurial Storytelling, Future Expectations, and the Paradox of Legitimacy," *Organization Science*, vol. 25, no. 5, pp. 1479–1492, 2014.
- [22] D. Chapple, N. Pollock, and L. D'Adderio, "From Pitching to Briefing: Extending entrepreneurial storytelling to new audiences," *Organization Studies*, vol. 43, no. 5, pp. 773–795, 2021.
- [23] M. Lounsbury and M. A. Glynn, "Cultural Entrepreneurship: Stories, Legitimacy, and the Acquisition of Resources," *Strategic management journal*, vol. 22, no. 6–7, pp. 545–564, 2001.
- [24] J. W. Creswell and J. D. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications, 2017.
- [25] S. D. Brookfield, *Becoming a Critically Reflective Teacher*. John Wiley & Sons, 2017.
- [26] J. F. DeFranco and P. A. Laplante, "A content analysis process for qualitative software engineering research," *Innovations in Systems and Software Engineering*, vol. 13, no. 2, pp. 129–141, 2017.
- [27] M. Ong, N. Jaumot-Pascual, and L. T. Ko, "Research literature on women of color in undergraduate engineering education: A systematic thematic synthesis," *Journal of Engineering Education*, vol. 109, no. 3, pp. 581–615, 2020.
- [28] H.-F. Hsieh and S. E. Shannon, "Three Approaches to Qualitative Content Analysis," *Qualitative Health Research*, vol. 15, no. 9, pp. 1277–1288, 2005.
- [29] J. R. Landis and G. G. Koch, "The Measurement of Observer Agreement for Categorical Data," *Biometrics*, pp. 159–174, 1977.
- [30] J. Sim and C. C. Wright, "The Kappa Statistic in Reliability Studies: Use, Interpretation, and Sample Size Requirements," *Physical Therapy*, vol. 85, no. 3, pp. 257–268, 2005.
- [31] E. A. Drost, "Validity and Reliability in Social Science Research," *Education Research and Perspectives*, vol. 38, no. 1, pp. 105–123, 2011.
- [32] D. Pusca and D. O. Northwood, "Curiosity, creativity and engineering education," *Global Journal of Engineering Education*, vol. 20, no. 3, pp. 152–158, 2018.
- [33] M. Gunawardena and B. Brown, "Fostering Values Through Authentic Storytelling," *Australian Journal of Teacher Education*, vol. 46, no. 6, pp. 36–53, 2021.
- [34] J. S. Downs, "Prescriptive scientific narratives for communicating usable science," *Proceedings of the National Academy of Sciences*, vol. 111, no. Supplement 4, pp. 13 627–13 633, 2014.
- [35] N. S. Grant and B. L. Bolin, "Digital Storytelling: A Method for Engaging Students and Increasing Cultural Competency," *Journal of Effective Teaching*, vol. 16, no. 3, pp. 44–61, 2016.
- [36] C. Cormick, "Who doesn't love a good story? — What neuroscience tells about how we respond to narratives," *Journal of Science Communication*, vol. 18, no. 5, pp. 1–10, 2019.
- [37] J. L. Huff, "Psychological Journeys of Engineering Identity from School to the Workplace: How Students Become Engineers among other Forms of Self," Ph.D. dissertation, Purdue University, 2014.
- [38] A. Jackson, S. Resnick, R. Hansson, K. Burgess, and C. A. Bodnar, "Exploration of the Experiences That Shape Engineering Students' Entrepreneurial Mindset Development," *Entrepreneurship Education and Pedagogy*, pp. 1–27, 2021.
- [39] M. I. Wijaya, S. Suzanna, D. Utomo, and K. Adnizio, "Analysing The Impact of Social Presence on Student Satisfaction Through Small Group Discussion in A Synchronous Online Learning," in *2021 International Conference on Software Engineering & Computer Systems and 4th International Conference on Computational Science and Information Management (ICSECS-ICOCSIM)*. IEEE, 2021, pp. 136–142.
- [40] S. Gulati, "Building a Sense of Community Online: Rapport Building Activities for a Remote Learning Environment," *Biomedical Engineering Education*, pp. 1–6, 2022.
- [41] A. Godwin, G. Potvin, Z. Hazari, and R. Lock, "Understanding Engineering Identity through Structural Equation Modeling," in *2013 IEEE Frontiers in Education Conference (FIE)*. IEEE, 2013, pp. 50–56.
- [42] R. Hughes, J. Schellinger, and K. Roberts, "The role of recognition in disciplinary identity for girls," *Journal of Research in Science Teaching*, vol. 58, no. 3, pp. 420–455, 2021.
- [43] L. Avraamidou, "Identities in/out of physics and the politics of recognition," *Journal of Research in Science Teaching*, vol. 59, no. 1, pp. 58–94, 2022.
- [44] A. J. Reagan, L. Mitchell, D. Kiley, C. M. Danforth, and P. S. Dodds, "The emotional arcs of stories are dominated by six basic shapes," *EPJ Data Science*, vol. 5, no. 1, pp. 1–12, 2016.