



## First-Year Engineering Students' Interpretation of Curiosity in the Entrepreneurial Mindset Through Reflective Practice

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## Abstract

This study explores how first-year engineering students interpret Curiosity, one of the 3Cs of an Entrepreneurial Mindset, when they write about themselves as learners. In 2005, the Kern family established the Kern Entrepreneurial Engineering Network (KEEN), a network of 45 schools dedicated to instituting an entrepreneurial mindset (EM) in undergraduate engineering students. From this EM, three main concepts were developed for success: Curiosity, Connections, and Creating Value, otherwise known as the 3Cs. Previous research regarding EM and reflective practices in an undergraduate engineering curriculum has been performed, but rarely have researchers considered both simultaneously. Also, many studies have yet to research how students interpret an EM. This paper focuses on students' writings about Curiosity, as it was chosen most often by students as the C that related to their reflections on themselves as learners.

During the fall semester at a mid-size, suburban, public university, undergraduate engineering students were prompted on a biweekly basis to reflect on their college experiences and to choose one of the 3Cs to accompany their reflection. The first prompt of the semester asked students to reflect on their previous experiences with school and themselves as learners, and then select one of the 3Cs of an EM and write about why they chose that C. The responses to the secondary question about the 3Cs were anonymized and then grouped by the C that students chose (e.g., all of the reflections for which the student chose Curiosity were analyzed together). Of the 3Cs, students most often associated their reflections with Curiosity (58%), but Connections and Creating Value were also present (25% and 17%, respectively). Once separated, the responses related to Curiosity were analyzed using in vivo, deductive coding by a team of researchers in order to determine how students conceptualize Curiosity in relation to a reflection about themselves as learners. Nine themes were identified and applied, with *Motivation*, *Type of Learner*, and *Interest* being the most frequently applied codes. A Cohen's kappa of 0.627 indicates a moderate level of agreement between the researchers. The results from this paper provide insight into how students interpret Curiosity and can be used to develop materials about EM that might better resonate with first-year students. Future work will explore the remaining two "Cs": Connections and Creating Value.

## Introduction

This study involves integrating fortnightly reflective practice into a first-year engineering course while simultaneously beginning to instill an entrepreneurial mindset (EM) (as defined by the Kern Engineering Entrepreneurship Network (KEEN)) in the engineering students at a mid-size, Mid-Atlantic, public university. Of particular interest is understanding students' conception of Curiosity, one of the KEEN "3Cs" - Curiosity, Connections, and Creating Value.

## Reflection

It is a practice of human nature to reflect on experiences of the past and present. However, in the case of reflection, most people fail to recognize the use of these experiences to aid in the future.

True reflection “on experience can be framed 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)” [1]. It takes various elements and perspectives to achieve reflective thinking. Schon simplified reflection down to two categories known as “reflection-on-action” and “reflection-in-action”[2]. In “reflection-on-action,” the subject looks back after an experience and processes to see what can be learned from it, while “reflection-in-action” pertains to comprehending and adjusting during a present occurring experience. Schon considered reflection-in-action to be most vital to those in executive positions in order to ensure organization and professionalism in times of stress or uncertainty [2].

Reflection is a practice studied in large depth in medical and other high-level professions, and many courses today implement objectives to promote the practice of reflective thinking [1]. In recent years, reflective practice has been increasingly integrated into engineering curriculums. In 2014, twelve university campuses joined forces to establish The Consortium to Promote Reflection in Engineering Education (CPREE) in order “to address the need for a broader understanding and use of reflective techniques in engineering education” [3]. CPREE draws attention to how reflection is used in the engineering curriculum. These efforts have led to a great rise in reflective practices being used in engineering education and research regarding their efficiency and success. At the 2015 Annual Conference of the American Society of Engineering Education (ASEE), the founders of CPREE published a paper to identify the current status of reflective practices found in engineering education [4]. While it was determined that reflective practices were on an upward trend, scholars also determined many papers on reflection to be fairly surface level, and lack in recognizing reflective practices as a main focus.

### ***KEEN and the Entrepreneurial Mindset***

The Kern Family Foundation started the Kern Entrepreneurial Engineering Network (KEEN) in 2005 to bring together colleges of engineering that are interested in training students to have an EM. There are currently 45 schools in KEEN who are making curricular and other changes to bring EM to engineering graduates [5]. In KEEN’s parlance, an EM includes Curiosity, Connections, and Creating Value (the “3Cs”).

The first, and perhaps most relatable, concept of the EM is Curiosity. The ideas that form Curiosity are the very principal for the creation of scientific study. Research shows people “who are actively engaged with and are continuously exploring and adapting to their surroundings will become increasingly critical for individual and organizational success” [6]. It follows that any individual utilizing an EM should share this trait. Curiosity is differentiated into two main categories: perceptual and epistemic curiosity. Perceptual curiosity (PC) is defined by Berlyne as a type of “curiosity which leads to increased perception of stimuli”, whereas epistemic curiosity (EC) handles the curious “drive to know” [7]. The EM focuses on the latter of the two. Overall, Curiosity acts as an instigator to drive people towards new information and discovery, and is a valuable trait to garner, especially to engineers.

The other two Cs are Connections and Creating Value. These are not the focus of this paper, but are critical components of an EM. Keene and Zimmerman found that people tend to make three types of connections over the course of receiving information: they connect the text to personal

experience, other texts, or real-world scenarios [8]. The EM aims to encourage all three forms of connections, as they can become vital in real-world problem solving. Creating Value results from identifying and capitalizing on opportunities and both achieving and learning from failure. The creation of value is “relative, perceived by the user or customer, and... may be situational, seasonal, or temporal” [9]. The creation of value is in the eye of the beholder; the main focus is that value *is* created.

### ***Research Questions***

This study investigates how first-year students connect the 3Cs of an EM to their reflections and how students conceptualize Curiosity. The main questions this study aims to answer are:

- Which of the 3Cs do students link with reflections about themselves as learners?
- What attributes do students associate with the C Curiosity?
- How do student responses about Curiosity compare with the official KEEN definition of Curiosity?

The remaining sections of this paper explain the methods used to answer these questions and the results of the analyses conducted.

## **Methods**

### ***Data Collection***

Data was collected during the 2018 fall semester at Rowan University, a mid-size, suburban, research university. 369 undergraduate engineering students enrolled in a first-year fundamentals of engineering course received biweekly prompts that questioned the students regarding their experiences in their engineering education. The prompts always ended by asking students to briefly accredit their experiences to one of the aforementioned 3Cs. This class met in person twice a week, however these prompts were distributed through student emails on the Google Forms format, or through Rezzly, the course’s engineering homework platform. Twelve instructors taught fifteen sections of the course in which the prompts were assigned. The reflection prompts were only briefly discussed in class, however each week, professors would provide written responses to their students’ reflections. This made the assignment more personal, and also helped students to establish a positive relationship with their professor. The first reflection task asked students to:

Please write a reflection about your previous experiences with school, your perceptions of yourself as a learner, what you’ve enjoyed and struggled with, and any out of school factors that may be impacting your learning. Your write up will help me get to know you better to assist your learning. Thanks for your honesty!

Students were then asked to additionally provide a few sentences as to how their responses related to the 3Cs via the prompt:

Curiosity, Connections, Creating Value: At XYZ Engineering, we want you, our students, to embody the 3Cs of an Entrepreneurial Mindset because we believe having these characteristics will help you become great engineers. Based on what

you wrote in response to this week’s reflection, choose one of the 3Cs and write 2-4 sentences about how that C relates to your reflection.

Before writing their responses, students were also equipped with the graphic in Figure 1 to help them distinguish the differences between the various 3Cs. This organizer also could help to spark ideas in students before formulating their respective responses.



Figure 1: Entrepreneurial mindset graphic organizer. Designed by Michael Johnson, Kern Family Foundation.

This study focused only on the students’ responses to the second prompt, and did not consider students’ responses to the overall reflection prompt. All of the reflection data were anonymized and then analyzed. Only reflections for which a particular student responded to both the first and last reflection prompts of the semester were analyzed; this resulted in a total of 280 reflection responses being analyzed for this paper.

### ***Coding Process***

Code development was completed in the first cycle via in vivo coding of a subset of all of the responses that were about Curiosity (“training data”) [10]. One way key terms were analyzed was through word clouds (Figure 2). Word clouds proved helpful because words that occurred most appear biggest, which provided a visual for identifying themes. Second cycle coding was used to create pattern codes using the results of the first cycle [10]. After applying the codebook to the training data, researchers came together to discuss any inaccuracies in the codes or



navigate successfully. For these reasons, students may have found Curiosity to be the easiest C to relate to.

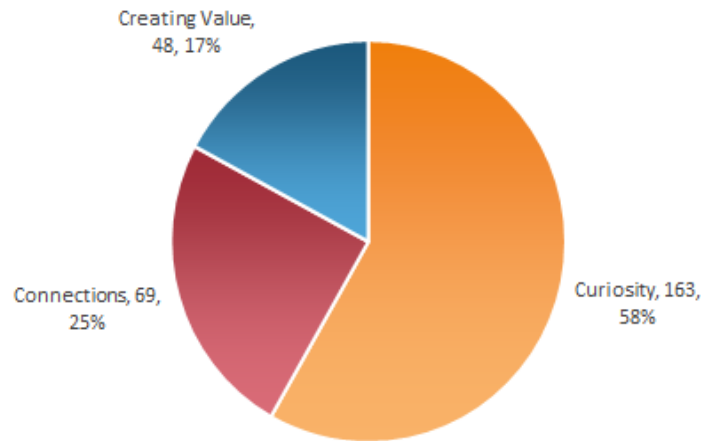


Figure 3: Frequency of student selection of each of the 3Cs (n = 280). Actual frequency and percentage frequency are included.

**Codes**

In Table 1, developed themes for Curiosity are listed, along with a definition of the theme’s intent and relationship with the idea of Curiosity. The table also features an example quote of each theme.

Table 1: Curiosity Theme Definitions

Theme	Description	Example Quote
Improvement	Discussion of improving self, others, or designs/products	“This curiosity helps us develop as students and guides us to find what will help us learn in the most efficient way possible.”
Motivation	Discussion of being motivated by Curiosity - to achieve, to innovate, to learn, to gain success	“My curiosity is the drive for all of my education.”
Interest	Interest drives Curiosity and vice versa	“Without curiosity, I wouldn't be interested, and not being interested in what I'm studying would have been detrimental to my success.”
Type of Learner	Curiosity is an inherent characteristic; discusses type of learner (visual/hands on)	“I stated that I am a hands-on learner, and this is at least partially attributed to my curiosity.”

Try New Things	Curiosity leads to new experiences, exploring opportunities, trying new things	“Trying different things made me realize what's better for me.”
Hands on	Take things apart, build things	“I also got involved with the robotics team and had always had a knack for using tools and building things.”
Things work	How/why things work	“By going into engineering, we must be curious about how things work.”
Negative	Curiosity as a distraction, lacking Curiosity in certain contexts	“I think my curiosity and constant wondering, causes my mind to wander a lot when I am in class.”
Future	Curious about the future	“I have been curious about what I'm going to learn in the classes that follow.”

### ***Inter-rater Reliability***

Table 2 shows the IRR between all of the codes for Curiosity. The training data had an IRR of 1.0, which equates to 100% agreement. This was due to the fact that this data was used for training and codes were discussed among researchers during the coding process. The remaining data for curiosity had a Cohen’s kappa of 0.627, reflecting a moderate level of agreement between researchers [11].

Table 2: Inter-rater Reliability of Coding Process

Data Type	Number of Responses	Inter-rater Reliability	
		Cohen’s Kappa	% Agreement
Training Data	102	1.00	100
Remaining Data	61	0.627	84.9

### ***Curiosity Theme Application***

Figure 4 depicts the code application frequency for all of the responses related to Curiosity. As is clear from the graph, *Motivation* was the most frequently applied code, suggesting that students see curiosity as a driver in their lives as learners. Students also tended to link curiosity to the *Type of Learner* they see themselves as-- that is, they see curiosity as inherent to themselves. *Interest* was the third-most applied code; students are curious about what they are interested in and vice versa. Although it was not frequently applied, the existence of the *Negative* theme is interesting; students who wrote about curiosity negatively were highlighting that their curiosity sometimes distracted them from the learning objectives at hand.



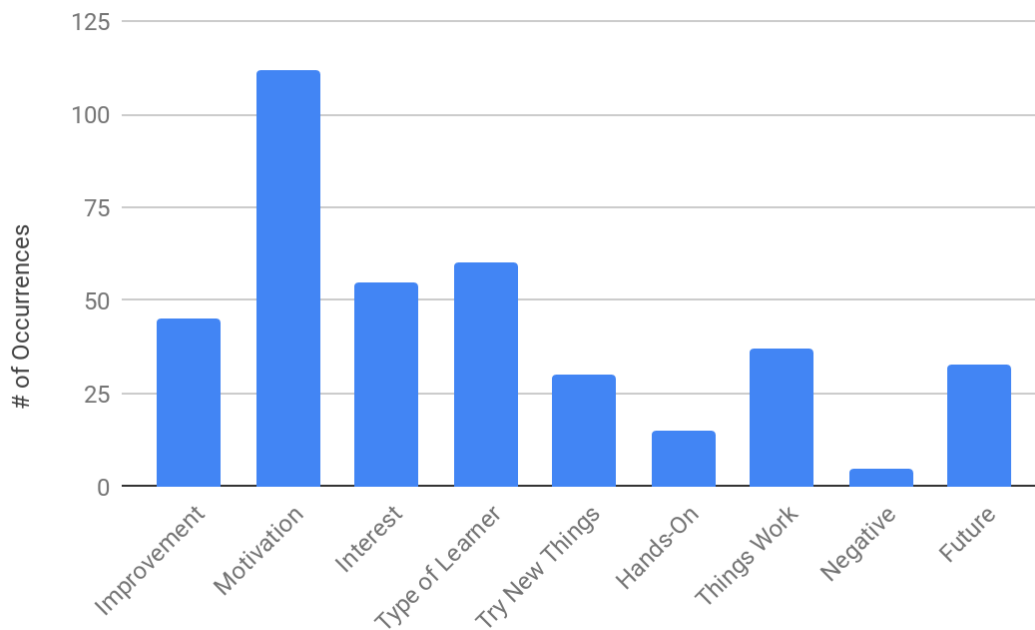


Figure 4: Presence of Themes Coded for Curiosity (n = 163). Each student response could have more than one code applied.

When discussing Curiosity, KEEN states “students will demonstrate constant curiosity about our changing world and explore a contrarian view of accepted solutions” [13]. Ideas of Curiosity regarding the changing world are easily seen in themes such as *Future*, *Things Work*, and *Improvement*. One student response remarked “wondering what could be improved, and imagining the possibilities with future technology is amazing and drives all brilliant inventions”. Student responses also show a correlation with exploring contrarian views in themes like *Try New Things*, *Hands-On*, and *Interest*. A student response that reflected these ideas conveyed “just knowing that there's so much in the world that's undiscovered is what interests me in [engineering]”. It can be inferred that Curiosity aids students in exploring their surroundings, and inspiring them to learn about and help the world around them.

### ***Implications***

These results have several implications for how instructors and curriculum designers can capitalize on students’ affinity for curiosity. First, recognizing that students are motivated and interested when they are curious provides impetus to design projects and lessons to start with questions or require students to ask questions about the topic through the Question Formulation Technique [14]. In addition, our results showed that students often link Curiosity with the type of learner they are, with doing hands on work, and trying new things. These relationships also provide opportunities for project design. In the program at Rowan University we make a concerted effort to engage these pieces of students’ curiosity through the projects in our first-year engineering course. For example, we have a project during which students design and produce toys using principles from Universal Design [15] and a project where students design and conduct experiments on a consumer product [16],[17]. Each of these projects requires students to be curious about some aspect of the project, but also motivates their curiosity by being hands on and something new.

## **Conclusions**

KEEN's model of the EM is a vital tool that undergraduate engineering students should be taught. The 3Cs, Curiosity, Connections, and Creating Value, are KEEN's main goal with a purpose "to equip engineers with a technical skill set and an entrepreneurial mindset" [13]. Reflection also proves to be a positive practice in engineering education. A study regarding the trends between reflection and engineering education found that "understanding the trends of reflection across literature can help us to further analyze its prevalence and utilization in the engineering education community" [4]. By instituting these ideals into modern undergraduate teaching methods, it is KEEN's idea that with an EM and reflective learning practices, students will be better prepared and, as a result, the world will be better equipped with innovators for the future.

This study examined how students linked the 3Cs of an EM with a reflection about themselves as learners and also explored how students' perceptions of Curiosity compared to the definition provided by KEEN. It was found that students responded most with the concept of Curiosity and responded least to Creating Value. Of those students who selected Curiosity, many wrote reflections that linked directly with KEEN's conceptualization of that C.

### ***Further Research***

Future research will consider the other two Cs of the 3Cs using similar analyses. Additionally, there were also seven other reflection prompts that students responded to throughout the semester. The final reflection prompt featured the same prompt as this study, so moving forward, further research could compare the difference one semester can make in the EM of an undergraduate engineering student, as well as how students change their perceptions of the 3Cs. Another possibility could be leading a deeper study on which EM concepts students most identify with and how educators can strengthen students' perceptions of the 3Cs that are not as well received. Researchers also could, in the future, consider the relationship between students' selected 3C and the "life experiences" discussed in the original reflection prompt. These efforts could lead to major improvements in undergraduate engineering curriculums, as well as empower undergraduate engineering students to recognize the importance of reflection and utilizing an EM.

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