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I'm Not the Creative Type: Barriers to Student Creativity within Engineering Innovation Projects

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Abstract

Conceptual and technical creativity during design are critical skills for engineering graduates. Current research, however, suggests that students experience design fixation and do not place high value on creativity. In this study we explored engineering students' creativity and perceptions of their creative ability. Twenty seniors in nine different engineering majors participated in two think-aloud protocols, one to document their process for developing an innovative solution and one to generate innovative ideas to an open-ended design problem. Each of these phases was followed by a semi-structured interview. Students also completed a final semi-structured interview to describe their experiences on innovation projects and views of innovation. The data sources were audiovisual recordings, written work, and sketches and writing captured with smart pens. Our analysis resulted in three key findings. First, students often did not see themselves as creative. Second, they avoided creative solutions that were not immediately feasible. Third, they limited themselves to familiar tasks that aligned with their academic discipline. Interview responses indicated that these behaviors represented responses to constrained project and educational environments as well as technical and feasibility orientations developed in school. We conclude with recommendations for engineering design education practice.

Introduction

Creativity is recognized as an essential skill for many engineers, especially in the context of design and innovation projects[1-5]. While general creativity skills can be useful, research indicates that a special type of creativity is relevant for engineering work[1,6]. This view of engineering creativity indicates that solutions need not only be novel, but functional, practical, and feasible[6-8]. Thus engineers must be able to (1) identify *what* new products, processes, and systems will address critical societal and technical problems and (2) realize those *how* those solutions can be developed and implemented.

While researchers and instructors have long emphasized improving engineering students' creativity[2,3,9-13], results show that engineering students often do not develop these skills as undergraduates[14,15], nor do they value creativity as an aspect of their engineering design process[16]. In order to help engineering students nurture the ability and motivation to apply creative thought to their engineering innovation projects, more work is needed to understand how engineering students perceive, develop, and apply creativity. This study seeks to identify barriers to engineering creativity from a student perspective. In order to address this goal, this study explores the following research question:

What do students discuss as barriers to creativity in engineering innovation projects they have experienced?

Literature Review

Two bodies of literature are relevant for this work. First we discuss conceptions of creativity in engineering design. Then we discuss creativity in the engineering education context.

Creativity in Engineering Design and Innovation

Creativity is considered a key element in the engineering design process[4,5,17]. Not only must engineers identify new concepts, they must identify how to realize those concepts such that they are feasible, functional, and address stakeholder needs[5,6]. As Snider and colleagues[18] indicate, creativity occurs in the act of using new knowledge or old knowledge in a new way. Engineering creativity requires expanding, rather than restraining, the problem or solution space[17,18]. This can be accomplished through considering alternative solutions, new materials or processes, reorganizing one's conception of the problem, or finding novel ways to work within constraints[17-19]. In this way, creativity can be thought of as the opposite of routine design[18].

While a popular view of creativity may be linked to imagination or the ability to develop novel ideas, positioning creativity as expansion demonstrates its applicability beyond conceptual design. For example, engineering creativity can be linked to identifying a new water purification method, but it can also be linked to developing effective, inexpensive, and safe materials to use in that water purification system. Research shows that creativity is relevant even for engineers whose work is not focused on design but operational in nature[5]. In this paper, we define a barrier to engineering creativity as anything that inhibits students from identifying or developing solutions that have the potential to be feasible, novel, and functional/useful.

Creativity in Engineering Education

The finding that engineering students do not demonstrate creativity in engineering design has been attributed to the way they are educated[2,14]. Engineering professors often define engineering through technical skills such as the application of math and science, problem-solving, and making things [20]. Students themselves indicate that their instructors do not reward risk, emphasize efficiency rather than consideration of new and alternative solution paths, assign few open-ended projects, and exhibit a number of other behaviors that downgrade the importance of creativity in engineering[15]. These results indicate that often creativity is not only neglected but discouraged in engineering education.

The lack of emphasis on creativity in engineering education can affect students in a number of ways. First, without opportunities to apply or demonstrate creativity in an engineering context, students may not develop the ability to find creative solutions to engineering design problems. Cropley and Cropley[2] suggest, for example, that many engineering students experience a paradox between developing practical solutions and novel solutions, and often opt for practicality. While finding practical solutions can be a sufficient goal, difficult and complex problems often require new solutions and knowledge[21]. Perhaps more severe is the suggestion that technical training promotes design fixation among many engineering students[14]. Rather than failing to identify an opportunity to develop a novel solution into something feasible, these students see the design problem at a technical level only. They develop solutions similar to those that already exist and ignore people-oriented details that may lead to a better understanding of the problem and ideas for innovative solutions.

Another argument is that engineering students have the skills and mindsets to be creative, but do not utilize their creative skills in an engineering context. Kazerounian & Foley[15] found that students who indicated that their instructors did not support creativity in engineering valued creativity in a general sense[15]. In this case, students may separate their creative identities from their engineering identities. Atman and colleagues[16], for example, found that only 30% of engineering seniors valued creativity in the engineering design process, a statistically significant drop from first-year engineering students. Thus students who are creative in other areas of their lives may not find it prudent to apply creativity to their engineering work. While creativity differs between domains, general creativity skills are often found to be relevant in creative engineering design[17,22]. The further qualitative analysis in this study seeks to identify some of the reasons, whether skill or motivation based, engineering students may not demonstrate creativity.

Methods

This study is part of a larger project to investigate how engineering students view and approach innovation. In order to address this topic we performed a multiple case study[23]. Multiple case studies follow two phases of analysis: within-case and cross-case analysis [23]. Within-case analysis allows us to explore each case in depth. Cross-case analysis allows us to identify themes that represent a variety of cases. Further, by comparing group themes to individual cases, we can highlight the variation and depth of those themes[24]. These variations allow us to "understand how [cases] are qualified by local conditions (pg. 172)"[24].

In this particular study, we utilized the multiple case study method to identify barriers to creativity that persisted across the participant pool. Further, we explored how those barriers enacted in different academic and social contexts in order to identify elements of those contexts that can challenge creativity. It is important to note that while cross-case analyses may *suggest* generalizations across a larger group[24], the findings primarily represent the specific group who participated in this study. More work is needed to understand barriers in additional contexts. These findings can be considered a starting point to understanding robust barriers to creativity in engineering education.

Research Participants

Twenty engineering students at a large research university participated in the study. These students came from a variety of engineering disciplines and had a variety of project experience related to innovation. All students identified themselves as seniors. Table 1 provides a glimpse of the participants by gender, academic discipline, relevant project experience, and self-described project role. These data do not reflect the depth and complexity of each student or their academic environment. They are included to provide brief contextual information about the types of projects they have experienced and how they interacted with those projects. Project roles listed in quotes represent the student's own words. We use pseudonyms to protect student confidentiality.

Table 1. Participants

Name	Gender	Discipline	Typical Role on Projects	Project Experience
Alice	Female	Chemical Engineering	Technical Problem-Solver	Internship
Anne	Female	Civil Engineering	Team Leader/"Structures Person"	Global Engineering, First-Year Design, Internship
Bethany	Female	Chemical Engineering	Team Organizer	Internship
Brian	Male	Materials Engineering	Technical Problem-Solver	Senior Design, Internship
Cassie	Female	Biological Engineering	Collaborator/Team Organizer	Senior Design
Don	Male	Industrial Engineering	Project Organizer	EPICS, Personal Project, Internship
Ellen	Female	Agricultural Engineering	Entrepreneur	Global Engineering, EPICS, Personal Project
Jamie	Female	Chemical Engineering	Collaborator	Senior Design, Course Projects, Non-Engineering Internship
Julie	Female	Chemical Engineering	Team Player	High School Design Competition
Len	Male	Mechanical Engineering	Team Leader	Senior Design
Leslie	Female	Civil Engineering	Technical Problem-Solver	Internship
May	Female	Mechanical Engineering	Team Player	Sophomore Design
Michael	Male	Mechanical Engineering	Technical Problem-Solver	Internship
Ralph	Male	Engineering Management	Entrepreneur/Networker	Personal Projects, Interdisciplinary Design Course
Rebecca	Female	Chemical Engineering	Team Leader	Internship, Senior Design
Rhonda	Female	Chemical Engineering	Technical Problem-Solver	Internship, Personal Project
Rick	Male	Mechanical Engineering	Team Leader	Senior Design, High School Engineering Design Projects
Rusty	Male	Civil Engineering	Technical Problem-Solver	Global Engineering, Senior Design
Stan	Male	Chemical Engineering	Lab Specialist/Solo Worker	Laboratory Research, Senior Design
Zachery	Male	Aeronautical Engineering	"Operations Guy"	Internship, High School Competition

Data Collection Protocols

All data collection occurred during a two-hour interview protocol conducted by one of two researchers. The protocol began with a brief open-ended interview to build rapport and identify background information about the participant. The introductory interview was followed by two tasks: a process mapping task during which participants were prompted to sketch/write and describe their innovation process, and an open-ended idea generation task during which they were asked to identify creative and innovative solutions to improve gum health and hygiene. During these phases, students produced (1) a process map of an innovation project and (2) notes, sketches, and conceptual designs of potential solutions to improve gum health. Both tasks were followed by brief interviews during which students discusses their approach and deliverables. Finally, the participants completed semi-structured interviews about their experiences and perspectives on innovation projects. Participants also completed a brief online demographic survey.

Data Sources

Data sources for this study included: audiovisual and smart pen recordings from each phase of the protocol, notes and sketches from the process mapping and idea generation tasks, and transcripts of all audiovisual data. Data from each portion of the protocol highlight unique elements of students' views, approaches, and perceived barriers to creativity in the context of engineering innovation projects. The *process mapping task* provides insights into cognitive elements of their understanding of innovation. The *interview* portions highlight attitudes and views about innovation and creativity. These data also describe how experiences and environmental elements may have contributed to the students' views and attitudes. Data from the *idea generation task* demonstrate how students utilize creativity in an open-ended engineering design task. Interview data proved to be the most helpful in this study, but process mapping and idea generation data also contributed. Triangulation of all data allowed stronger interpretation of views of creativity at the individual level.

Data Analysis

Data analysis occurred in two phases: within-case and cross-case analysis[23].

Within-Case Analysis. During within-case analysis we considered each participant individually and developed team case reports around the central topic of how the participant viewed innovation. First, two to three researchers independently performed inductive analysis[25] to indentify patterns and themes for each participant around the central topic. Researchers were instructed to consider and report initial findings from each data type independently before considering all portions together. This method allowed researchers to identify findings unique to each element, and thus to identify variations within each individual case along with elements that were more consistent. Once individual researchers completed each case report, the team compiled joint case reports within which similarities between individual case reports were included and disagreements were discussed and reconciled. Discussions during these meetings also lead to new discoveries and emergent themes. One of the most prominent themes was the creative barriers discussed in this proceeding.

Cross-Case Analysis. Cross-case analysis allowed us to identify themes that cut across a variety of cases[24]. In order to facilitate such comparison, we constructed a *case-level display*[24]. A case level display was a table that described how each participant viewed, approached, or experienced the aspects of innovation that emerged from our analysis. These aspects included everything from descriptors of innovative solutions to preferred tasks to their goals for innovation. We compiled this table collaboratively and iteratively. First, we met to discuss potential categories. Then we independently identified how (and whether) each participant fit into each category. Finally we compiled the case-level display. We then used this table to identify the barriers to engineering creativity. These barriers included those described by the students as well as those interpreted by the researchers.

Results and Discussion

This section presents and discusses key barriers to engineering creativity experienced by the twenty seniors we interviewed. Despite the students having participated in projects they believed to have innovative and creative outcomes, they often did not see themselves as creative or able to contribute much creative thought to engineering projects. Students identified barriers to their creativity at multiple levels, including individual skills, environmental factors, and broader engineering discourses. The three barriers we observed are described below, along with preliminary discussion of reasons they may have occurred. *You Just Solve the Problem* discusses students' orientation towards technical problem-solving, which reflects a broader engineering discourse. *I'm Not the Creative Type* discusses students' perceived lack of the skills, knowledge, and motivation necessary to demonstrate creativity during an engineering project. *Constraints (Do Not Always) Inspire Creativity* discusses environmental factors such as time pressures and project specifications that students saw as constraining their creativity.

You Just Solve the Problem

As engineers, the students were most interested in solving technical problems. Michael designed clamp system for a car chassis. Bethany developed a new chemical purge process. Rusty worked on multiple community water filtration systems. Each of these projects was innovative according to the students who worked on them, but innovation was not their intended goal. The students simply wanted to develop something that solved a problem. Thus, they tended to frame problems based on technical requirements and solved to meet those needs rather than create something novel. As Zachery, a senior in aeronautical engineering, stated, "While I'm working on something I'm not thinking, 'Well, this has to be innovative.'"

According to the students, the technical focus did not necessarily preclude them from developing innovative solutions. If the initial problem statement thoroughly considered stakeholder needs or was particularly challenging, creativity would often be required to create a sufficient solution. Elements of their technical problem-solving, however, often limited their ability to demonstrate such creativity. Students' almost unanimously mentioned feasibility as a design requirement, many listing it at the forefront of their considerations. Students wanted to make sure a solution would function, could be implemented, and was not cost prohibitive before they pursued it further. In many cases concern for feasibility precluded students from identifying or developing novel solutions that could also be functional. For students like Jamie, potentially creative solutions were disregarded in favor of more routine solutions. For students like Rusty, the focus on feasibility limited the ability to even consider novel solutions.

> *And then, in the end, I just started to look at what would the cost of this be. After putting this down on paper, looking at all those other logistics, to make sure that it's feasible. (Jamie, Chemical Engineering)*
>
> *So once I had this concept of what will work, my next thought shifts to how you can make that work. (Rusty, Civil Engineering)*

In addition to the focus on feasibility, students also emphasized the knowledge, techniques, and approaches specific to their home discipline. According to Anne, a problem is "broken down by specialty" and approached by individuals or subgroups with relevant expertise. Students thus favored familiar problems or applied familiar methods to both routine and open-ended problems. While this technique can improve efficiency and likely leads to a greater ability to develop a solution that at least "works," it often limits students' abilities to consider new approaches and perspectives. Thus many students disregarded potentially creative avenues that were outside their technical "comfort zones." In some cases, such as Anne's, working in an educationally diverse team helped overcome this barrier, but other students struggled if this was not the case.

> *I always thought: what's the building gotta be made out of? ... There was another member… in construction engineering, and he was always focused on, " how are we going to build it?" So each team member just brought a different style of thinking… Even if before the meeting you felt like, "I've done everything that I can," you go in and somebody else would bring up some other aspect or idea that you haven't thought about or thought to consider. (Anne, Civil Engineering)*

Further, students felt less inclined to go beyond technical problem solving if they did not feel connected to the problem. Students like Ralph, Ellen, Rusty, Zachery, and Rebecca appreciated a challenging project and were more motivated to pursue alternative solution paths. Other students indicated they were more likely to develop a creative solution to projects related to their areas of interest. Stan was particularly engaged in a cell categorization process. Brian was interested in improving the thermal properties of electronic materials. Other students, such as Cassie and May, felt it was difficult to develop a novel solution if they could not see the design problem as an actual problem.

> *I wasn't as empathetic towards the situation…Unless I can see a real need for it, I'm usually fine with the way things are now…But if it's a solution to a problem that's important I'll be encouraged to continue. (Cassie, Biological Engineering)*

I'm Not the Creative Type

Along with their focus on technical problem-solving, engineering students often did not see themselves as creative, at least in the context of an engineering project. Michael, for example, discussed using unexpected beats as a drummer. Leslie, Rebecca, Bethany, and Cassie all enjoyed crocheting interesting designs. Brian utilized creative strategies and formations in soccer. Yet students did not discuss a connection between creativity in their personal lives and engineering creativity. Instead, they tended to disassociate creative work from engineering work. Engineering work, as indicated in the above section, strives for technical efficiency and functionality and is part of their professional identity. Creative work is for non-engineers.

> *I'm an engineer, not an industrial designer. That's why I became an engineer. I'm more adept at understanding mechanics of things than being able to make something extremely concerned with aesthetics. (Rusty, Civil Engineering)*

Other students mentioned participating in some creative work, such as collaborative idea generation, but did not emphasize it as part of their primary task on the project. Instead it was something that occurred at the beginning of the project, from which technical problem-solving followed. Moreover, it was distributed across a team, so that no one individual was responsible. As Anne described:

> *We were able to bounce ideas off of each other and it wasn't just me sitting down and thinking, brainstorming things on a piece of paper It was us talking out ideas and, um, figuring out problems together. (Anne, Civil Engineering)*

Though many of the students avoided overtly creative tasks, thus limiting their opportunity to demonstrate creativity, students did describe a type of "technical creativity" that was often required to develop innovative engineering solutions. This creativity is based on a deep content knowledge and intelligence.

> *You have to be pretty intelligent to innovate [at a large scale]. Because innovating scientifically is trickier. You have to have a certain set of skills. You need to have some kind of scientific or special training to innovate like that. (Rhonda, Chemical Engineering)*

Many students noted that they had not reached a sufficient level of expertise to demonstrate such creativity. In this situation, students like Michael and Brian found it useful to consult more knowledgeable engineers at work or in school. Without such opportunities for feedback, and lack of confidence in their technical knowledge, students were often worried about the quality of their solutions. According to students like Stan and Zachery, you're likely to develop a routine solution or something that already exists.

> *If you don't have a sound technical background, you're not going to know what's going on to come up with a novel or innovative solution. (Zachery, Aeronautical Engineering)*

Along with the lack of confidence in technical knowledge, students remained averse to taking risks with their projects. They remained skeptical of any innovative idea not tied to an extant solution. They were not confident in their own knowledge related to these solutions or ability to develop them into feasible options. They thus chose to safer, more traditional options and accepted that these outcomes would not greatly improve the current problem. Jamie, for example, described her team questioning a potentially novel solution because nothing like it existed.

> *Looking at what has been done, and saying, "okay, I think we have a good idea, but if it hasn't been used before, and there must be something we're overlooking. So maybe it's not a good idea… There might be a problem with what we're doing we can't see yet… all these industries, maybe they used to used it and they don't use it anymore. Why is that? In a way that made us also question our ideas a bit more."(Jamie, Chemical Engineering)*

Constraints (Do Not Always) Inspire Creativity

The popular adage that "constraints inspire creativity" did not always resonate with the students. Instead, many found that certain constraints hindered their ability to develop creative solutions. Many students discussed limitations of the project environment. These constraints included insufficient equipment, unwilling teammates, and lack of time. For example, students frequently discussed how time pressures forced them to focus only on a single design option rather than multiple alternatives.

> *You really need to be inspired to come up with something new. It's just hard to be creative given two months to come up with something. (Zachery, Aeronautical Engineering)*

Students also described problem constraints as impeding creativity. These constraints were often tied to work in a specific engineering discipline (most frequently civil and chemical engineering). Civil engineering students, for example, indicated that municipal codes, existing infrastructure, and available resources only allowed a limited number of possible solutions. Due to the perceived limit of potential design alternatives, students did not feel able to develop a solution that was sufficiently novel and pursued routine solutions. As Leslie described, "There aren't that many crazy solutions that you can think of with a roadway." Professional engineers experience similar constraints, but have found ways to leverage those constraints into creative solutions[19,26].

Finally, students felt constrained by lack of necessary information. Students like Jamie, Rusty, and Cassie found it difficult to identify useful information related to solutions they believed to be creative. A similar information scarcity is recognized in the innovation literature[21]. In such cases, students often opted against the less documented solutions rather than delaying their decisions until more information could be compiled or developed. In addition to lack of technical information, students also felt constrained by lack of user information. Students expressed difficulty identifying useful solutions for poorly detailed or unknown user groups. This was especially prevalent in conceptual design situations, such as the idea generation task in this study.

Variations

The three previous sections demonstrate three key barriers to creativity students experienced during their innovation projects. These included an emphasis on technical problem solving, a perceived lack of creativity, and inhibiting constraints. In other words, students perceived barriers to creativity at the personal, professional, and environmental level. These sections also showed some of the variation in these barriers experienced by individual students. An effect of a multiple case study is that these variations can be illuminated and local factors can be identified as contributing to these variations. Three key variations we identified include: project role, individual motivation, and project environment. These variations demonstrate that individual and contextual differences can modify how students connect with the major barriers to engineering creativity.

As noted by Table 1, participants came to their projects oriented towards different team roles. Two prominent roles were the technical problem-solver and the team leader. Students also came to their projects with unique motivations. Anne and Cassie wanted to help people. Ellen and Ralph were interested in developing new products and technology that aligned with personal interests. Don and Brian strived for personal success. Leslie and Zachery wanted to contribute strong engineering work.

These individual differences were evident in a number of variations on the key themes. Cassie, in her desire to help people and commitment to her senior design team, persisted through lack of information and poor initial functionality to develop a functional and novel solution to a key need area. Jamie, responding to similar situation, opted for a more conventional solution that had sufficient, but limited, functionality. Anne noted a situation in which she and her team only pursued one solution due to time constraints. Rusty often pursued a single solution due not to time constraints but because he was not interested in considering alternatives.

Variations were also evident in project environments. Students connected more with projects in which they interacted with authentic stakeholders and users or developed working design solutions or prototypes. During these projects, opportunities to “see” the design in the authentic environments promoted persistence and inspired new ideas. Further, opportunities for feedback promoted testing and revision, and thus offered greater leeway for alternatives initially viewed as infeasible. Variations were also evident based on the design problem. Leslie, who worked in road design, did not feel the need to be creative to perform effectively because her design problems offered only two or three reasonable solutions. Students working on complex problems, however, saw innovation as essential and stressed the need for creativity.

Conclusions

One attribute that differentiates engineering innovation from other areas of innovation is the critical role of technical knowledge[27]. Other aspects such as conceptual creativity, willingness to take risks, and explore new territories are also essential for engineers to solve complex and novel problems[28-30]. Innovative engineers, thus, must balance between creative abilities and technical knowledge. Prior studies indicate that students often struggle with the creative side of innovation, both in terms of identifying creative solutions[2,14] and valuing the role creativity plays in engineering design[16]. This study adds to these findings by suggesting that many engineering students associate with the identity of the technical problem-solver. These students limit the solutions they can consider by avoiding solutions they do not immediately identify as feasible, adhering to the approaches and knowledge of their home discipline, and avoiding creative tasks. This result is not surprising considering that engineering faculty also define themselves as people who apply math and science to solve problems[20].

Interestingly, though, students' emphasis on technical problem-solving and feasible solutions seems to stem in part from a lack of confidence in their own technical abilities. Students may be unwilling to pursue or even identify potentially innovative solutions because they do not believe they will be able to develop such alternatives into working designs. Project constraints, time pressures, and unfamiliar topic areas seem to exacerbate this attitude. Students did indicate more comfort when able to receive feedback from experts, or when they were able to work in high-functioning teams. Thus, opportunities for effective teamwork and appropriate scaffolding may help students develop confidence to pursue creative solutions. Such strategies, however, may be ineffective for students who explicitly disassociate themselves from an engineering identity with creative attributes. While not all engineers will necessarily become innovators, even technical design can benefit from effective application of engineering creativity[18]. Facilitating comfort in taking risks and encouraging students to push beyond obvious solutions would be a means towards this end.

Implications for Teaching and Learning

The broader themes of this study suggest three considerations for engineering education practice. First, creating cross-disciplinary team environments may help students work outside their disciplinary comfort zones and engage with a variety of perspectives. Students in this study found such experiences effective for both creativity and their own learning, but occasionally struggled to transcend their disciplinary roles. Previous research demonstrates that cross-disciplinary teams may be particularly effective when students are allowed a high degree of autonomy during project work[31].

Second, this study in conjunction with other research indicates that students do not necessarily see engineering as a creative profession[15]. Nor do they recognize their own creativity as applicable to engineering projects. Encouraging students to pursue potentially creative solutions despite potential "failure" can support creative confidence and promote an engineering identity beyond technical problem-solving. One easy solution is to review project evaluation criteria and ensure creativity is valued in all applicable aspects of a design project. For example, are students to encouraged to identify and *consider* a variety of design alternatives? Are they encouraged to explore non-routine ways of realizing those alternatives?

Third, students responded to project authenticity both in terms of access to stakeholders and creation of realistic prototypes or deliverables. Such authenticity led to increased motivation to pursue non-routine solutions and also required students to consider alternative perspectives.

Prototyping or simulation tools can help make projects more authentic but can be costly. For example, Cassie, Julie, and Jamie indicated their projects did not have access to machinery and instrumentation necessary to "scale up" their preliminary designs. In the absence of key technological resources, project deliverables could include simple prototypes made from everyday objects to demonstrate key project features. Further, instructors might consider setting projects in local communities or providing realistic portraits of stakeholders.

As a final note: the variations in the major themes of this study suggest that every student and every learning context is unique. Instructors should carefully consider the findings of this and other studies in light of their own classroom contexts. The above recommendations may be helpful to many, but may also require modification or reconsideration. Further, it is important to note that every student will interact with themes of engineering creativity differently. Responsiveness to individual student perspectives and needs may also be a key element in supporting engineering creativity of future graduates.

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