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Exploring the Unconscious in Engineering Design Education: A Psychoanalytic Approach

Dr. Andrew L Gillen, Northeastern University

Andrew L. Gillen is an Assistant Teaching Professor at Northeastern University in the First Year Engineering Program and an affiliate faculty member to Civil and Environmental Engineering. He earned his Ph.D. in Engineering Education from Virginia Tech and B.S. in Civil Engineering from Northeastern University.

Mr. Daniel Fisher

Daniel Fisher is an Outpatient Therapist at Community Counseling of Bristol County. He earned his Master's in Clinical Mental Health Counseling from the Boston Graduate School of Psychoanalysis where he is currently pursuing his doctorate. He also earned his Bachelor's/Master's in Forensic Psychology from John Jay College (CUNY). His work experience spans multiple age groups and contexts, including time spent working in a correctional facility and youth residence programs.

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Abstract

This research paper details a collaboration between an engineering professor with a background in engineering education and a mental health counselor with a background in modern psychoanalysis and cognitive psychology. We discuss the implementation of a novel intervention for first-year engineering students around conscious and unconscious bias in engineering design. Beyond typical discussions of bias in engineering, we take the concept a step further to the root psychoanalytic mechanisms, taking a deep dive into concepts around the unconscious mind, and using these to structure our intervention activities. A qualitative study was conducted based on the results of a group activity where students articulated their thoughts within four psychologically derived categories around one of two design scenarios, aiming to build a better understanding of how student groups characterize their chosen engineering design scenarios within these categories. Lastly, we explore some conclusions and recommendations for practitioners looking to expand their engineering design curriculum by emphasizing the unconscious mind in direct and engaging ways.

Introduction and Background

Despite concerted efforts by engineering educators, bias among graduates persists. Whether we uncover a racially biased healthcare algorithm applied to 200 million annually (Obermeyer et al. 2019) or encounter gender-biased crash-test dummies (Linder and Svensson 2019), the need for training our future engineers is clear.

Most explorations of bias in the literature center around studying the inequities that exist for underrepresented groups in engineering based on demographics such as gender, race, disability, and intersectional identities (e.g., Fouad, Fitzpatrick, and Liu 2011; Garriott et al. 2023; Smith et al. 2023; Davis et al. 2023; Cech 2023). There is even some exploration of increasing engineering students' awareness of their unconscious bias through classroom modules (e.g., Lauber and Mertz, 2021). However, we argue that these discussions and others like them often exclude a key component that could help students build a better understanding of their hidden mind: emphasizing the underlying mental processes. It can be easy for students to dismiss bias in their work, and while some students readily grasp the idea of hidden or unconscious bias, for many others, the idea that there is a potential "unawareness" within us all is a hard pill to swallow. The first year of engineering programs is a particularly formative time and presents the opportunity to instill this understanding at an early stage.

This study goes beyond the buzzwords of bias in design. Based on material directly from psychoanalysis and cognitive psychology, we embarked on a cross-disciplinary teaching project. While there is historically limited empirical support for psychoanalytic approaches in engineering education, related and reframed constructs–such as "cognitive bias"–have been explored in design and engineering literature (e.g. Rakitta & Wernery, 2021; Mohanani et al., 2020). We sought to foster an understanding of the nature of this "unawareness" more into the conscious mind of our first-year engineering students by exploring a series of activities promoting a psychoanalytically informed view of one's self as a budding engineer. Given that the advancement being emphasized in this paper is the incorporation of psychoanalysis, we focused our literature review and discussion in this area.

What is the Unconscious?

The unconscious refers to the processes occurring in our minds outside our conscious awareness that shape and influence our conscious thoughts and actions (Freud, 1915). Practitioners of psychoanalysis operate under the informed belief that this unknown mind drives human behavior. To apply these concepts to our classroom, we synthesized 4 categories, partially based on cognitive psychology lectures from John Jay College, and operationalized them for the engineering design context. While not intended to be exhaustive, these categories, listed below, served as a framework for guiding both the intervention and analysis. Their primary aim was to encourage students to examine several ways in which unconscious processes influence and bias decision-making.

1. The Views of the People Around Us: How people may be influenced by their social environment and how it may be difficult to not conform to majority views.
2. Human Error and the Limits of Our Perception: The impact of "blind spots" in our perception due to limitations around what we are allowed or able to observe.
3. Internal Beliefs and Biases: This includes heuristics, quick assumptions our mind makes to improve efficiency (but not necessarily accuracy), as well as cognitive distortions, our irrational beliefs.
4. Distracting, Misleading, or Misinforming Factors: Irrelevant information, biased viewpoints, or inaccurate data that remove focus from the core issues or objectives can hinder effective problem-solving or decision-making processes.

The Views of the People Around Us (Category 1)

The famous Asch Experiment from the 1950s explores conformity and pro-social processes. People may be influenced by their social environment to conform with group thinking and group perceptions. It might be difficult for someone to share a different perspective in a room of people if there's a risk of being seen as going against the group. Breger and Ruiz conducted a similar experiment in 1966 and found that even giving participants an anticonformity appeal prior to the experiment did not reduce conformity. In fact, the experimental group provided with an appeal towards anticonformity trended more towards conformity–a finding the authors interpreted as a sign the appeal prompted anxiety and defensiveness in participants leading to more participants' conforming behavior (Breger and Ruiz, 1966).

Human Error and the Limits of Our Perception (Category 2)

As humans, we have blind spots in our perception, both internal and physical. For starters, it's hard to find something when we're focused on something else. In class, we showed a video of basketball players in which a gorilla walks through the frame and a curtain changes color. Viewers are focused on counting passes of a basketball and often miss these other changes. In engineering, if we’re focused on fixing a problem, we might not notice other problems we’re creating.

Our understanding is also limited to what we are allowed to and able to observe. In another video, we showcased this concept to students using a murder mystery scene in which many objects and people are swapped. Viewers often miss most if not all these changes until the video switches to a camera that shows a different perspective of the same scene that allows the audience to see the changes as they occur. This phenomenon can be seen playing out in the real world such as while watching recorded police encounters (Jones, Crozier, and Strange, 2019).

Internal Beliefs and Biases (Category 3)

Heuristics are shortcuts our mind creates to maximize the efficiency of our conscious cognitive processes. If our mind recognizes something, it will fill in the gaps with what it assumes should be there without checking if this is true to the current situation. For example, car accidents occur close to home when people are driving in a place their mind recognizes. Our minds see the familiar stimuli and then bypass perceptual observation in favor of routine–there isn’t usually a biker passing on our right at this intersection, so we begin to signal and make the turn without checking first to see if there is a biker there or not. Consider Figure 1. If you show someone this, they would likely see there is a red circle because they are able to complete the shape in their mind as they are perceiving it, despite there being gaps of information. Their mind recognizes something familiar: the shape of a circle and fills in the blanks to complete the familiar pattern.

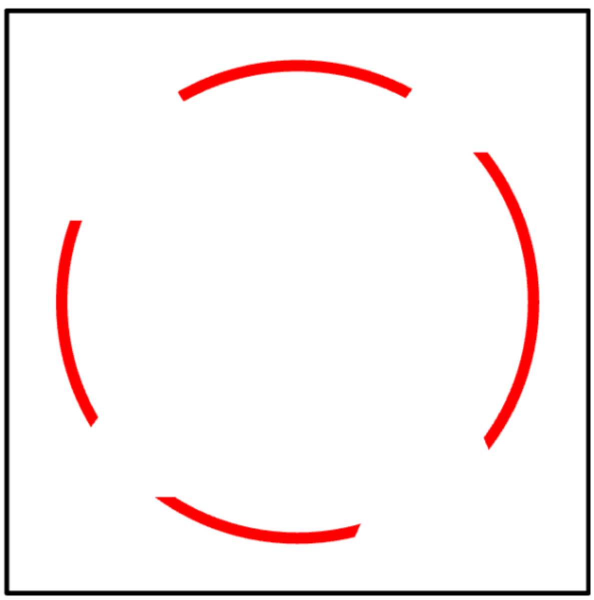

Figure 1. Red Circle Test

While heuristics can be wrong on occasion, they are generally useful as guidelines. Cognitive distortions are a little different. These represent consistent inaccuracies in our cognitive processes, disrupting our ability to reason, understand, and perceive the world as it truly is. For instance, someone with strong anxiety is likely to experience cognitive distortions that support the believability of their internal worries (Calvo and Eysenck, 1998).

Distracting, Misleading, or Misinforming Factors (Category 4)

These factors can include irrelevant information, biased viewpoints, or inaccurate data, which can hinder effective problem-solving or decision-making processes. When people see something happen and then hear wrong information about it later, they might mix up the truth with the false details they heard; this is known in cognitive psychology as the misinformation effect. The effect of misinformation can be seen in action in the courtroom. A juror, someone who has sworn to demonstrate neutrality in their decision-making, may experience memory errors about the actual content presented at trial when introduced to misinformation in the deliberation process, even if they took notes during the trial (Thorley et al., 2020).

Intervention Description

The University and the First Year Engineering Program

This intervention took place at a University in the northeast United States. The institution is a private, not-for-profit university with an R1 Carnegie Classification for very high research activity. They are a competitive university known for their experiential learning, including their co-op program and emphasis on global experiences. As of 2022, the university has ~17,000 undergraduates, including ~2,700 in engineering. They have a high retention rate from the first year. In engineering in particular, all engineering students, regardless of major, are supported in their journey to the second year through the First Year Engineering Program (FYP) and their dedicated faculty. While there are multiple courses under the FYP umbrella, the flagship courses include two introductory/fundamental engineering courses. These are hands-on courses that also explore CAD software, computer programming, microelectronics, ethics, and design. The course goals are shared between the two courses and include the following overarching points developed by FYP faculty:

- Goal #1. Discover the iterative engineering design process through authentic, hands-on design projects.
- Goal #2. Integrate value-sensitive design, ethical principles, and professional responsibilities into engineering design.
- Goal #3. Develop problem-solving skills in algorithmic thinking through computer programming.
- Goal #4. Develop individual and team communication skills through written, oral, and visual modalities.
- Goal #5. Function effectively on a team to engage in collaborative and inclusive engineering practice.

Background on Practitioners

This intervention represents a collaboration between two practitioners: (1) an engineering professor with a background in engineering education and (2) a mental health counselor with a background in modern psychoanalysis and cognitive psychology. Because the professional expertise of these individuals is so central to the classroom intervention, it is important to briefly detail the background of the authors and their role in this intervention. Practitioner 1 is a teaching-focused faculty member dedicated to teaching first-year engineering, he has a doctorate in engineering education and structured the teaching and evaluation approach for this intervention. Practitioner 2 is a mental health professional who holds two Masters' in forensic psychology and clinical mental health counseling respectively. He has extensive experience engaging in psychoanalytic theory through his education at a graduate school of psychoanalysis. He provided most of the course content and guided the discussion and activities around the unconscious. In collaboration, the authors connected the psychoanalytic material with the engineering design process in a novel intervention that goes beyond traditional explorations of bias in engineering design.

Intervention Details

Our 65-minute intervention took place across four sections of the first introductory course in Fall 2023. The overall topic was described to students as "Becoming Aware of our Unawareness: Conscious and Unconscious Bias in Engineering." The goal was for students to come away with a budding awareness of the following: (a) The non-neutrality of technology and engineering and the societal impact of implicit and explicit biases, and (b) as engineers, what responsibilities do we have for being "aware of your unawareness?" (i.e., that there is an unconscious and it impacts our decision-making).

Part 1: The unconscious mind

We began the intervention by introducing ourselves to students. Then we detailed the conscious and unconscious mind as described in the conceptual background of this paper. Three online videos were shown with discussions in between to demonstrate the idea of the unconscious and help students apply it to themselves and their lives. These included, "The Monkey Business Illusion," "Test Your Awareness: Whodunnit?," and "The Asch Experiment." Collectively, these videos and the following class discussions covered concepts discussed in the Background section.

Part 2: The conscious mind

While all these videos were about probing the unconscious mind, we also wanted to make it clear to students that engineering and technology have also been used as overt tools for oppression, very much consciously. For this, we provided two examples, one in transportation and one in healthcare.

In the first example (Archer, 2020), we discussed how, in the US, the development of our interstate highway system has damaged communities of color. In decades past, in routing highways, many homes and important community focal points such as churches and schools were destroyed. New infrastructure was also used to create physical barriers and uphold the status quo of white supremacy. Highway engineers saw communities of color as a problem and their destruction as an engineering solution.

In the second example (Obermeyer et al., 2019), we discussed how a common healthcare system algorithm is racially biased against Black patients. Applied to 200 million people per year, this algorithm is used to flag patients for special care programs. The algorithm is racially biased because it under-identifies Black patients for these programs based on the use of healthcare costs as an indication of health, ignoring the fact that there is a racial disparity in healthcare spending.

Following these examples, we let students first discuss among themselves and then as a whole class the following two questions: How might these have been prevented? Can they be fixed? We also prompted them throughout the discussion to consider other examples of bias in computer programming and public infrastructure. Students identified things like racist facial recognition software and hostile architecture targeted toward unhoused individuals. The purpose was also to promote student understanding that often damage done is irreversible and that social solutions, rather than solely engineering solutions, may be necessary.

Part 3: Connecting to engineering design

We ended with a final activity connecting what they learned about the unconscious to engineering design. This activity also yielded artifacts that we used in this study which will be further detailed in the next section. We gave students two scenarios: (a) developing affordable modular housing for unhoused people, and (b) designing a new type of body-scanning machine (like an MRI). We first asked them to consider two overarching questions and discussed their thoughts. The questions were: How might unconscious bias affect the decision-making in projects or teams? and Could biases in engineering actually create more problems or hinder progress?

We then put them into groups in which they had already been working on their other class project. They were asked to pick either scenario A or scenario B based on their group's preferences. We then had them spread out around the room and on either chart paper or a whiteboard, they discussed how each of four given points might shape their engineering design process. These four points are based on the scholarship around the unconscious described in our Background. They include the following:

1. The views of the people around us.
2. Human error and the limits of our perception.
3. Internal beliefs and biases.
4. Distracting, misleading, or misinforming factors.

Part 4: Wrapping up the intervention

We concluded the intervention by reflecting as a class on major takeaways. For example, being more "aware of our unawareness" as engineers makes us better engineers. In this part, we also connected back to textbook topics on mitigating errors, biases, and assumptions in problem definition; promoting ethical behavior in engineering; and the engineering design process as a whole. With the few remaining minutes, we opened the class to questions for Practitioner 2 about the unconscious, psychoanalysis, and his professional experiences. Many students took us up on this offer and we ended the intervention with an engaging discussion that extended these topics even further.

Methods

How Psychoanalysis Connects to Engineering Design: A Systems View

Recall that the goals of our intervention were for students to come away with a budding awareness of (a) The non-neutrality of technology and engineering and the societal impact of implicit and explicit biases, and (b) as engineers, what responsibilities do we have for being "aware of your unawareness?" (i.e., that there is an unconscious and it impacts our decision-making). In Figure 2, we use a systemigram, a type of systems thinking diagram, to illustrate the intervention goals and how they led to the overall research question. In the figure, the goals are broken down into their component concepts, and text along arrows informs the connections between them. An enlarged version of Figure 2 can be found in the Appendix.

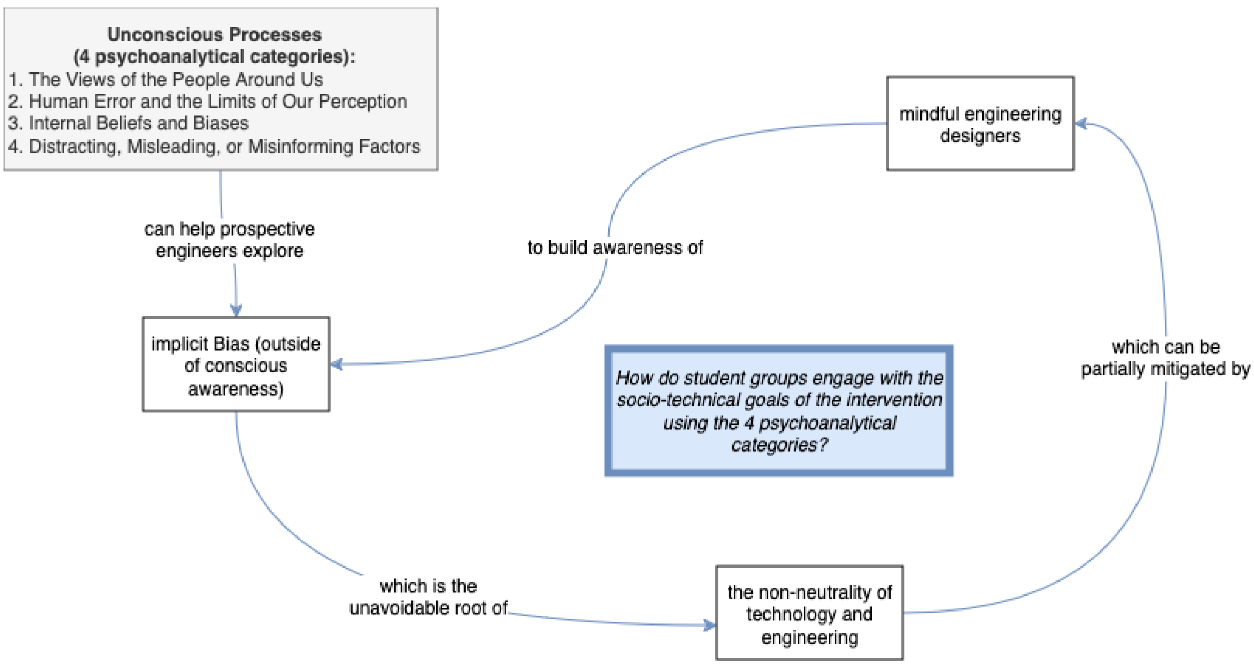

Figure 2. Systemigram

Tracing the logic of Figure 2, activities around unconscious processes can help prospective engineers explore bias outside of conscious awareness, which is the unavoidable root of the non-neutrality of technology and engineering, which can be partially mitigated by educating more mindful engineering designers who have awareness of unconscious processes.

Rooted in this loop, the guiding question for this study then becomes: *Around their chosen scenario, how do student groups engage with the socio-technical goals of the intervention using the 4 psychoanalytical categories?* We strongly believe in the mantra that good instruction and good assessment are one and the same (Shepard, 2000), and this question also draws directly from the artifacts students produced in the final activity.

Data Collection

In order to maintain the flow of the classroom lesson, demographic data was not collected for this intervention. Instead, we presented the overall data for the College of Engineering in Fall 2023 on the main campus, shortly before this intervention took place. Every student who enters the University for an engineering major goes through the first-year engineering program in which this intervention took place, and we argue that these numbers are roughly representative of the sample of students found in our classrooms in this study. This data uses the Integrated Postsecondary Education Data System (IPEDS) definitions for race and ethnicity ("Definitions for New Race and Ethnicity Categories" 2024). Rounded percentages were used and some gender and race categories were grouped together to avoid displaying categories that only had single individuals and may be identifiable. Responses left blank were also excluded, which is why the percentages do not add to 100%. These statistics are to provide a general sense of demographics for our programming and do not represent an official report of the numbers from the University.

Table 1. Overall demographic data for the College of Engineering

Demographic	**Percentage**
Male	52%
Female	45%
Nonbinary, Multiple selections, and/or Prefer not to say	2%
American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, and Multiple selections	35%
White	60%

The data for this study consists of classroom artifacts. Specifically, photographs submitted by students of the chart paper or whiteboard work they did during the final activity. Recall that this activity asked them to select one of two scenarios (modular housing for unhoused people or a new type of body scanner) and come up with ideas around the four areas we defined: The views of the people around us; Human error and the limits of our perception; Internal beliefs and biases; and Distracting, misleading, or misinforming factors. In total, approximately 120 students participated in groups of 3-4 students across 4 sections of the same first-year engineering course. Thirty-two images of their group work were analyzed for this paper.

Data Analysis

To analyze the open-ended data in the 32 chart paper/whiteboard images, we used qualitative classroom assessment techniques outlined by Barkley and Major (2016) supplemented by approaches described by Miles, Huberman, and Saldaña (2020). Through multi-cycle coding, we searched for patterns that emerged within the 4 psychoanalytical categories by scenario. Rather than taking a purely inductive approach, we sought patterns in the data within the categories used in the activity, while leaving ourselves open to new interpretations and discoveries.

In order to better make comparisons between different group's work, we coded for category 1, scenario A; category 1, scenario B; category 2, scenario A; category 2, scenario B, and so on in that pattern. In this process, we developed a mix of both descriptive and in-vivo codes (Miles, Huberman, and Saldaña, 2020). After completing a given section (e.g., category 3, scenario B), we summarized the codes into major patterns.

Quality Measures

We took several steps to promote quality in developing our findings. Using a qualitative approach, we relied on techniques to promote trustworthiness as described by Guba and Lincoln (1982). Threats to credibility were mitigated by informally checking results with students. This was done through the process of design reviews throughout the rest of the term. The instructor looked for evidence of the types of thinking demonstrated in the results through these reviews. For transferability, we sought to detail the activities and background of this intervention so that readers could make a judgment about how these findings may apply to their context. Dependability is supported in this study by virtue of design in which we collected data across sections and compared results in summarizing to develop major patterns. Lastly, for confirmability, the authors explore their own positionality relative to this study and consider how backgrounds, experiences, and biases may have impacted the analysis. This sort of reflexive practice is a hallmark of quality interpretive research and was firmly in our minds when conducting this study.

Findings

Recall our guiding question: *Around their chosen scenario, how do student groups engage with the socio-technical goals of the intervention using the 4 psychoanalytical categories?* The results of our analysis are presented here and discussed in terms of relevant literature. Approximately 60% chose scenario A and approximately 40% chose scenario B. It is interesting to note that more student groups chose scenario A about housing than scenario B about medical scanning. Please note that these categories are not discrete. They overlap, and the results below support this idea. We provide specific examples or quotes for the more notable patterns that emerged.

Category 1: The Views of the People Around Us

Category 1 has to do with how people may be influenced by their social environment and how it may be difficult to not conform to majority views.

Table 2. Findings from Category 1, Scenario A

Finding	**Group Responses**
• The voices of unhoused people are not a common perspective in our social environment.	5 groups
• Community backlash ("not-in-my-backyard" attitude). • Choosing less desirable or more hidden locations due to stigma. • *Example: "Treating people as the problem due to the stigma of unhoused people" (Group #3).*	9 groups
• People's life experiences dictate how they perceive what is affordable or necessary for unhoused people.	3 groups
• Some responses excluded (unclear or unrelated to the prompt).	2 groups

Table 3. Findings from Category 1, Scenario B

Finding	**Group Responses**
• Normative values around demographics such as body types, gender, age, ability status, or medical needs. • *Example: "differences in backgrounds, body size inclusivity, disability, previous experiences" (Group #26).*	11 groups
• Designing professionals only focusing from a narrow lens such as a particular medical specialty.	2 groups
• One outlying group mentioned thinking about profit before design. This group also mentioned normative value conflicts around sizing and inclusive design *(Group #25)*.	1 group (overlapping)
• Some responses excluded (unclear or unrelated to the prompt).	2 groups

Category 2: Human Error and the Limits of Our Perception

Category 2 emphasizes the impact of “blind spots” in our perception due to limitations around what we are allowed or able to observe.

Table 4. Findings from Category 2, Scenario A

Finding	Group Responses
• Engineers’ unawareness about unhoused people’s needs based on their background, having never been unhoused, and general disconnection from the unhoused community. • *Examples: differing “views of affordable” (Group #30) and what is an acceptable “location” (Group #20).*	11 groups
• Able-minded engineers may not see potential disability/access issues.	3 groups
• Narrow engineering-minded focus. • *Examples: Engineers not seeing a good way to “measure a need for housing” (Group #27), errors when CADing/dimensioning (Group #5), and focusing on housing over other solutions (Group #31).*	3 groups.
• Some responses excluded (unclear or unrelated to the prompt).	2 groups

Table 5. Findings from Category 2, Scenario B

Finding	Group Responses
• Similar to Scenario A, most responses were about unawareness engineers may have about disabilities, body types, medical knowledge, personal experiences, etc. • *Example: "If there's an issue you're unaware of, you won't be looking for ways to fix it" (Group #11).*	8 groups
• One outlier said that we can’t make a machine to meet everyone’s needs, giving up on the concept of exploring our unawareness altogether *(Group #14).*	1 group
• Another outlier was user-focused rather than engineer-focused. They talked about blind spots of the patients and misconceptions about machine safety *(Group #9).*	1 group
• Some responses excluded (unclear or unrelated to the prompt).	3 groups

Category 3: Internal Beliefs and Biases

Category 3 is about our internal beliefs and biases including quick assumptions our mind makes to improve efficiency (but not necessarily accuracy) as well as cognitive distortions (irrational beliefs).

Table 6. Findings from Category 3, Scenario A.

Finding	Group Responses
• Assumptions or distortions about unhoused people (how they got that way and what they need). • *Examples: Treating unhoused people as a monolith (all the same) and "they did it to themselves" (Group #22)*	11 groups
• Two responses overlapped with category 1 (based on background and social perception). • Two responses overlapped with category 2 (not all unhoused people are visible and limits of engineers' imaginations/experiences).	4 groups
• Some responses excluded (unclear or unrelated to the prompt).	4 groups

Table 7. Findings from Category 3, Scenario B.

Finding	Group Responses
• The most prominent response involved assumptions about what body type to design for.	6 groups
• In general, preferencing design choices based on particular groups or yourself.	4 groups
• One outlier was user-focused like the example in Category 3B. They mentioned user misconceptions about radiation/safety *(Group #14)*.	1 group
• Another outlier mentioned ignoring potential harm to other parts of the body not being scanned *(Group #18)*. This also overlaps with Category 2.	1 group
• One response excluded (unclear or unrelated to the prompt).	1 group

Category 4: Distracting, Misleading, or Misinforming Factors

Category 4 is about distracting, misleading, or misinforming factors within the engineering design process. In this category, we noticed more thorough responses for scenario B than A, suggesting that this may be a better example to use in class.

Table 8. Findings for Category 4, Scenario A

Finding	**Group Responses**
• Problems with research/poor needs assessment. • *Example: "ability to differentiate credible sources" (Group #3).*	5 groups
• Misunderstandings of unhoused people (e.g., stigmas against unhoused people and low-income stereotyping). This also overlaps with category 2.	6 groups
• Engineering miscalculations/poor decision-making. • *Example: Predicting wrong what is affordable (Group #6).*	3 groups
• Too narrow focus (can't see forest for trees). • *Examples: How will they apply for housing (Group #5) and this is not a long term solution (Group #23).*	3 groups
• Two responses excluded (illegible handwriting).	2 groups

Table 9. Findings for Category 4, Scenario B

Finding	**Group Responses**
• User-focused responses rather than engineer-focused. • *Example: "machines that diagnose illness cause cancer" (Group #13).*	3 groups, including 1 overlap group
• Problems with design research (bad sources and biased data). • *Example: The biased healthcare algorithm given as examples in class (Group #11).*	3 groups
• Designers too hung up on past designs. • *Example: Too focused on the way an MRI runs (Group #25)*	2 groups
• Over/under considerations of cost; focusing on profit.	3 groups, including 1 overlap group
• One outlier included concept that opposing viewpoints could cause misinformation, for example, between doctors and engineers *(Group #4).*	1 group
• Overlapping significantly with category 3. • *Examples: Overweight=unhealthy (Group #17). Design based on creator's body type (Group #18).*	2 groups
• One response excluded (mainly reiterates the prompt).	1 group

Assumptions and Exclusions

In some very limited cases (noted above), the text was not legible or the meaning was unclear. Similarly, some responses were unrelated or not substantive. For example, one group wrote for category 1, scenario A, “solve homelessness with affordable housing,” which is effectively a reiteration of the scenario description. In these few occurrences, they were excluded from the formal analysis but still considered in developing our overall interpretations and recommendations. Also, students often used short phrases or bullet points. In these situations, reasonable assumptions were made about the students’ intentions based on the class and activity context.

Discussion

Tasked with identifying examples of each type of unconscious bias outlined in the class lecture, students collaborated within their assigned groups to explore various instances within their selected real-world scenarios. These instances ranged from subtle slips to more overt forms of discrimination that could potentially arise within the group dynamics of engineering teams. Furthermore, analysis of the presented data revealed patterns indicating the presence of unconscious bias within the classroom groups themselves. This is supported by a systematic literature review of problem-based-learning literature in engineering education in which the authors found that students on teams had different “ways of thinking, working habits, and paradigms of their subjects, which shaped their beliefs and world views and led to gaps in their understanding of others’ perspectives” (Chen, Kolmos, and Du, 2021, p. 102).

The ideas put forth by student groups provide insight into their understanding of how unconscious bias might affect their future roles as engineers. Through their collaborative efforts, students uncovered findings related to both commonly and less commonly identified forms of unconscious bias. Upon completion of the task, virtually all groups documented at least one example for each of the four categories of unconscious bias relevant to their chosen engineering team project scenario. However, the effort to neatly organize biases into these discrete categories appeared to both facilitate students' consideration of various manifestations of unconscious bias and hinder comprehension due to confusion about distinguishing between these types of biases, which do not always neatly fit into predefined categories. Finding new ways to support learning in this area is critical for the future of engineering. Researchers investigating engineers’ complex problem-solving approaches found that contextual aspects in particular (e.g., environmental, sociocultural) were often overlooked in the discussion (Dugan et al., 2024).

As they explored the potential manifestations of unconscious bias in group decision-making within real-world scenarios, the student groups inadvertently became a forum where such biases could influence decision-making processes. When tasked with selecting a real-world situation for analysis, the groups displayed a tendency to favor Scenario A over Scenario B, hinting at a possible unconscious bias within the classroom towards the former option. This inclination might have been shaped by the lecture's emphasis on examples of unconscious bias exacerbating social inequality. Specifically, students may have been more inclined to select a real-world example explicitly mentioning a vulnerable population, such as "unhoused" populations, due to its stronger association with social inequality compared to the alternative option. It is important to note, however, that unconscious bias does not have to be about inequality. Unawareness in designers could encompass a diverse range of areas. For example, unawareness of what citizens value in a public space project (Duivenvoorden et al., 2021), unexamined feelings on sustainability in building energy systems (Rakitta & Wernery, 2021), or relying too much on previously completed work to guide a building project (Biskjaer et al., 2021). The common idiom, “I don’t know what I don’t know” is applicable here, which is why we argue the benefits of examining the unconscious as a concept in class.

Thinking further, students may have already begun considering examples applicable to the first option presented before hearing the second option and thus been more likely to continue with Scenario A. In psychology, this unconscious preference for information presented first is known as the primacy effect. DiGirolamo and Hintzman (1997) found that when participants were shown a list containing two similar versions of the same stimulus, they tended to remember the version presented first more often than the later version.

Additionally, if the first students in a group vocalized a preference for scenario A, then group conformity biases may have prevented members from asserting a desire to explore the other option. This effect would be analogous to the conformity effect studied in the aforementioned Asch Experiment. Prior work in engineering design education that applied specially created design tools to help engineering students expand and reshape their ideas (e.g., Leahy et al., 2019), could serve as an example of a similar approach to address these psychological effects.

The findings highlight the importance of addressing unconscious bias in engineering education and practice. By recognizing and understanding these biases, educators and industry professionals can take proactive measures to mitigate their influence on group interactions and decision-making processes.

Moreover, the identification of unconscious bias within classroom groups serves as a valuable learning opportunity for students. By reflecting on their own experiences and acknowledging the presence of bias, students can develop critical thinking skills and a heightened awareness of how biases may manifest in their future professional endeavors. This aligns with findings derived from a review of interdisciplinary engineering education in which socio-cultural sensitivity on design teams was a highlight in the literature (Van Den Beemt et al. 2020). Beyond the design project itself, within team dynamics, a direct intervention with engineering students around bias and discrimination suggested engaging with these concepts could be effective in changing behavior (Isaac et al., 2023). More self-awareness is essential for cultivating an inclusive and socially responsible engineering workforce capable of addressing complex challenges with creativity and integrity.

Conclusions and Recommendations

In conclusion, the collaborative examination of unconscious bias within student groups has illuminated its pervasive presence in engineering contexts and highlighted the importance of addressing these biases in educational and professional settings. By acknowledging and fostering awareness of the four categories of unconscious bias, educators and industry leaders can work towards creating more equitable and effective team environments in engineering practice, ultimately supporting innovation and inclusivity within the field.

While this study provides valuable insights into the manifestation of unconscious bias within engineering teams, it represents only a starting point. There is a need to explore how unconscious bias influences innovation and decision-making processes within engineering teams, which is supported by the lack of context-based thinking noted in the design literature (Dugan et al., 2024). Future research in this area could shed light on the extent to which biased attitudes and perceptions hinder creativity, problem-solving, and the adoption of diverse perspectives in engineering design projects and the classroom. Additionally, educational interventions tailored to addressing unconscious bias in engineering education represent another promising area for future research. Integrating discussions of bias and diversity into engineering curricula, promoting intergroup dialogue and perspective-taking exercises, and providing faculty training on teaching practices that raise students' awareness of their own unconscious biases are all potential avenues for intervention.

Ethics Approval

This research was approved through the exemption process of our university's Institutional Review Board.

Disclosures

The authors have no conflicts of interest to disclose. The views expressed here are that of the authors and do not necessarily represent those of their affiliated organizations.

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Appendix: Enlarged version of Figure 2. Systemigram