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How well can we reflect? Examining the quality and content of novice designers' reflections on social identity

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ABSTRACT: Humans, with their various social identities, form an important part of engineering design. Therefore, designers must reflect on the implications of social identity when designing products. However, little research has examined the quality and content of student designers' reflections on the importance of social identity in design, and we aim to explore this research gap. The results of our study revealed higher frequencies of responses related to personal experiences and design/action among designers with minoritized social identities. Designers with minoritized identities also provided higher-quality reflections than those in the majority group. These results suggest that designers with different social identities may vary in their ability to critically reflect on the impact of social identity in design and call for the need for new reflective design tools and educational approaches.

KEYWORDS: social identity, reflection, design education, education, design learning

1. Introduction

Humans are essential to engineering design, from designers to stakeholders, and users. Humans are comprised of various dimensions of social identity (e.g., race, gender, and socioeconomic status), and these dimensions are influenced by personal experiences, self and external perceptions, and situational factors (Cikara et al., 2022; Ellemers et al., 2001). The social identity of the user could play an important role when considering human-centred design, and in some contexts, the implications of not accounting for users' social identity could be severe. A recent example was witnessed during the COVID-19 pandemic when pulse oximeters – designed primarily for users with lighter skin tones (Bickler et al., 2005; Feiner et al., 2007) – led to fatal misdiagnoses among Black patients (Tobin & Jubran, 2022). This example illustrates that designers must critically and carefully consider the impact of their users' social identity when designing products.

Similarly, designers' social identities could also influence the outcomes of the design process. For example, designers who identify as men have been observed to exhibit higher levels of ownership bias compared to those who identify as women (Toh et al., 2016). This behaviour could have problematic consequences in gender-biased fields such as engineering (Cohen & Deterding, 2009) as it could lead to feelings of exclusion among designers with marginalized identities. This effect was observed by Cole et al., (2023), who reported that women in design teams report a greater sense of psychological safety with other women in the team compared to men. Therefore, designers with different social identities may have different experiences, while carrying their own biases and behavioural tendencies. Moreover, as presented by Li & Hölttä-Otto, (2022), the identities of the user and the designer could interact to influence design outcomes in the context of human-centred design.

Reflection has been identified as an important skill for success among practitioners (Schön, 2017), and research has emphasized its importance to engineering design practice and education (Allen et al., 1997; Sepp et al., 2015; Turns et al., 2014). Furthermore, the iterative nature of engineering design presents a unique opportunity to embed reflection through the various design steps (Adams et al., 2003). That is,

since designers often retrace their steps to improve their solutions, these iterations could act as opportunities for designers to reflect on their decisions in the previous iteration and find areas to improve upon in the following iteration. Reflection-based interventions have also been used to introduce practices such as mindfulness in engineering design which could increase the quality of ideas generated (Nolte et al., 2022, 2023).

Reflection on social identity may help designers to be aware of and therefore, manage their cognitive biases. On the surface, this effect could be attributed to priming, wherein a certain concept or idea is implicitly brought to the forefront of one's cognitive process (Schacter & Buckner, 1998). Asking participants to reflect on their social identity could prime them to consider how social identity affects design outcomes more generally and, therefore, encourage them to consider their users' social identity (Brown & Prabhu, 2024). On a deeper level, reflective practice could motivate designers to think about the privileges and challenges that are associated with their social identity (Walgenbach & Reher, 2016). Such reflection could highlight any alignment or deviations of the designers' experiences from those of the user and, therefore, motivate the designer to make an additional effort to better understand the users' needs (Cikara et al., 2011). These biases could be particularly important in persona and human-centred engineering, where identity – both the users' and the designers' – is intertwined with the effectiveness of design solutions. Designers can bring a more inclusive and nuanced perspective to their work by understanding their social identity. Strategies such as these empower students to ask new and thought-provoking questions, leading to fresh insights and innovative solutions in their design work (Özçam, 2022).

Reflection is also an effective method to encourage designers to critically examine their design decisions and improve upon them in subsequent iterations. Reflective design could guide designers to analyse their values as a person, ensuring that they are mentally oriented towards the user to bridge the gap between designers and users. Consequently, social identity-based reflection could help designers be more mindful of the effects of social identity – both their own and their users – as they progress through the design process (Sengers et al., 2005). Such interventions could also encourage the reflexive practice of design, wherein designers are mindful of their positionality and account for the potential effects of their own social identity on their design decisions. However, limited research has investigated the utility of social identity-based reflection in human-centred design. As a first step towards addressing this research gap, we aim to examine the quality and content of student designers' reflections on the effects of their social identity. Toward this aim, we seek to answer the following research questions (RQs):

- RQ1: What topics do participants discuss in their reflection responses? Does the content of their reflection responses vary based on whether they belong to a majority or minority social group?
- RQ2: What is the quality of participants' reflection responses? Does the quality of participants' responses vary based on whether they belong to a majority or minority social group?

2. Experimental methods

To answer these RQs, we conducted an observational study comprising a reflection exercise and a design task. The experiment was approved by Lafayette College's Institutional Review Board and informed consent was obtained from the participants before the experiment was conducted. The details of the experiment are discussed next. It should be noted that the data used in this paper was part of a larger study (Brown & Prabhu, 2024).

2.1. Participants

Participants (N = 10) were recruited from a capstone design course in mechanical engineering at Lafayette College, a small liberal arts college in the northeastern USA. Participants were fourth-year undergraduate students in engineering. Nine participants identified as men, and one participant identified as women. Additionally, six participants self-identified as White, two as Hispanic, and one as White / Asian when asked for their ethnicity. Seven participants identified as White, one as Irish American, one as Hispanic, and one preferred not to answer when asked about their racial identity.

2.2. Procedure

First, participants were asked to complete a baseline survey. In this survey, we collected demographic information such as gender and ethnicity. The demographic questions were developed based on the

guidelines proposed by Hughes et al. (2022). Upon completing the survey, the participants were asked to complete a reflection exercise on social identity. They were asked to reflect on the following open-ended cues, to encourage reflection on different dimensions of their social identity:

1. What is your relationship with your gender identity and how do you think it impacts you as an engineer?
2. What are your thoughts about your racial, cultural, and ethnic backgrounds, and their impact on you as an engineer?
3. How do you feel that your socio-economic status has affected your life and how do you think this factor will shape you as an engineer moving forward?
4. What are some unique challenges you have faced because of aspects of your social identity, and their effects on you as an engineer?

These cues were formulated based on prior work and prompted participants to reflect upon how past experiences could impact their future actions (Csavina et al., 2017; Thomas et al., 2016). After completing the reflection exercise, participants were asked to complete a design task. The data from the design task was collected as part of a larger study, the results of which are presented in (Brown & Prabhu, 2024)

2.3. Metrics and coding scheme

The data was analysed using a mixed-methods approach using the metrics discussed next.

2.3.1. Coding scheme used to examine reflection responses

Participants' reflection responses were qualitatively coded using a deductive content analysis approach (Elo & Kyngäs, 2008). In this approach, the collected data is explored to identify recurring themes and contrasts theory-driven inductive content analysis. First, one of the two authors reviewed the complete dataset to identify the most common themes and created an initial codebook. Then both authors independently reviewed 25% of the dataset using the initial codebook with any disagreements resolved through discussions. This iterative process resulted in four main themes being identified as seen in Table 1: (1) experience-based, (2) perspective and awareness, (3) design and action, and (4) no effect. After coding the dataset, the frequency of each topic was calculated for each participant and these frequencies were used as the data to answer RQ1.

Table 1. The coding scheme used for coding the content of the reflection responses

Theme	Description	Example
Experience-based	Considers personal experiences, whether they be positive or negative	"I do not see as many students with my background in most of my classes. This breeds a feeling of imposter syndrome"
Perspective & Awareness	Considers matters such as reflecting a unique viewpoint, implicit bias awareness, and the acknowledgment of privilege	"Since I am white, I have felt that I have had the privilege of being more comfortable in class because I am always the majority race"
Design & Action	Reflects on how social identity has created engineering morals and impacted decision decisions	"In terms of problem framing for senior design, I could only come up with problems that affect me"
No Effect	This category includes non-reflection and the assertion of no influence	"I don't see an impact"

2.3.2. Scale used to evaluate the quality of participants' reflections

The quality of participants' reflections was evaluated using the four-point scale proposed by Kember et al., (2008). According to this scale, the lower level of reflection is labelled "non-reflection". At this level, participants did not attempt to reach an understanding or attempt to reflect. The second level is labelled as "understanding" in which participants present surface-level reflections without any critical analysis. The third level is labelled as "reflection" in which participants consider the question in relation to their personal life. Finally, the highest level of reflection is labelled as "critical reflection". At this level, participants deeply reflected and offered some form of critical analysis. Participants' responses to each of the four reflection cues were evaluated using this four-point scale at the question level and these

scores were used to examine RQ2. Examples of reflection responses corresponding to each level are presented in Table 2.

Table 2. The four-point scale used to evaluate participants' reflection responses and corresponding examples

Reflection Level	Description	Example
Non-Reflection	No attempt to reach an understanding	"I do not think it [gender] impacts me as an engineer"
Understanding	A surface-level response with little thought	"I don't see any impacts although I am sure that it somewhat affects my designs"
Reflection	Considering the question in relation to personal experiences	"Based on my ethnicity, I do not see as many students with my background in most of my classes. This breeds a feeling of isolation and imposter syndrome"
Critical Reflection	Reflection with a proposed solution or improvement or comment on something that should be improved	"As a male, I have been given plenty of opportunities . . . and I do not think it has impacted me much different than if I was a different gender. With that being said . . . the one thing that could still be fixed is the wage gap between women and men"

3. Data analysis and results

We analysed the data collected using mixed methods - i.e., a combination of qualitative and quantitative research methods. The details of our analyses and the corresponding results are discussed in this section.

3.1. RQ1: What topics do participants discuss in their reflection responses? Does the content of their reflection responses vary based on whether they belong to a majority or minority social group?

To answer our first RQ, we first qualitatively analysed participants' reflection responses at a phrase level using content analysis. Participant responses were assessed using a deductive content analysis approach using the coding scheme presented in Section 2.3.1. We conducted a one-way ANOVA to test whether some topics were discussed more frequently than others, and this result was not statistically significant ($p = 0.40$).

Next, we separated the participants into two groups based on their self-reported social identity: majority and minority. The 'majority' group comprised six participants, all of whom identified as White men whereas the 'minority' group comprised four participants, two of whom identified as racially or ethnically Hispanic, one as female, and one who identified as mixed-race (Asian and White). This distinction was determined based on prior identity-based distribution data in STEM (National Center for Science and Engineering Statistics, 2023). A two-way ANOVA was performed with frequency as the dependent variable, social identity group (i.e., majority or minority) as the first independent variable, and the topic as the second independent variable. The results of this ANOVA are presented in Table 3; we observe a significant interaction between the topic and group variables. We also noticed that the social identity group had a significant impact on the frequency. Therefore, we separated our results by topic and compared the frequencies for each topic between the two social identity groups. The results of this separation can be seen in Figure 1. We decided to use a larger threshold for significance ($p < 0.1$) due to the small sample size, making it difficult to ascertain significance owing to a lack of statistical power, therefore, prompting the use of follow-up qualitative analyses.

Table 3. Results of the two-way ANOVA testing the effects of topic and social identity group on the frequency of references

Independent Variable	SSE	F	p
Topic	10.28	1.29	0.29
Group	12.15	4.59	0.04
Topic * Group	27.68	3.49	0.02

We conducted a one-way ANOVA comparing the frequency of responses for the 'experience-based' topic between the majority and minority groups. This topic included aspects such as personal experiences, positive experiences, and negative experiences. The results indicated a significant effect of the social identity group on the frequency of this topic ($p < 0.06$, $F = 3.77$, and $SSE = 12.15$). Participants in the minority group discussed matters relating to this theme on an average of 4.25 times while the members of the majority group reflected on their personal experiences an average of 1.75 times. An example of a positive experience is LYON11 (majority group) stating in their reflection that "I think my socio-economic status has allowed me to succeed as an engineer". On the other hand, experiences such as "a feeling of isolation and imposter syndrome", felt by participant NATY05 (minority group), are examples of negative experiences. From this result, we infer that participants from minoritized identities may be more mindful of the effects of their social identity and be more adept at reflecting on their prior experiences in this context.

We conducted a similar analysis for our second topic, i.e., 'perspective and awareness'. This topic includes themes such as reflecting on things that have given the designer a new viewpoint on things, or, more commonly, an acknowledgement of privilege. We see a significant difference in the frequencies of the second topic between the majority and minority groups ($p < 0.06$, $F = 3.77$, $SSE = 22.8$). Participants in the majority group reflected on the themes related to this topic an average of two times throughout the reflection, with most of those being an acknowledgment of privilege. On the other hand, participants in the minority group reflected on this topic an average of 4.66 times with participant SAYN02 stating "it also shapes the way I budget costs for materials I need for projects I may work on in the future . . . ". This reflection shows a different priority than those typically seen by the majority group wherein minority group members tend to evoke an aspect of their social identity to describe a unique perspective, in this case, budgeting, into a design team.

Our third topic was labelled as 'design and action' and consisted of items that represented themes ranging from the development of engineering morals to the context in which design decisions are made. In this topic, we see no significant differences in frequencies between the two groups ($p = 0.37$, $F = 0.89$, and $SSE = 2.02$). In this instance, both groups reflected nearly the same amount on how different aspects of their social identity impacted their design outcomes. An interesting observation was that some participants discussed the difficulty of designing for someone different from themselves, such as majority group member ANRK07 saying "In terms of problem framing . . . I could only come up with problems that reflect me". Interestingly, the only participants who did reflect on how their social identity impacts their design outcome were members of the minority group, with LEON09 reflecting that "culturally I have been exposed to a lot of different cultures and my designs reflect this".

The final topic was labelled 'no effect' and participants' phrases coded under this topic did not show reflection on their social identity. An example of a non-reflection is participant NENG11 discussing "this has no impact on me". We see a significant difference in the frequencies of this topic between the majority and minority groups ($p < 0.09$, $F = 3.49$, SSE = 9.6). This topic shows that majority group members said more often that social identity has no effect on decision/engineering experiences compared to minority groups. Looking deeper, if we were to remove the one minority participant who identified as "White, Asian", or 'mixed', the differences are statistically significant ($p < 0.001$, SSE = 8.4). This result leads us to believe that more work should be done to understand how a designer's mixed background social identity, particularly between minority and majority groups, impacts them as a designer. The implications of these results regarding differences in the content of participants' reflections are discussed further in Section 4.

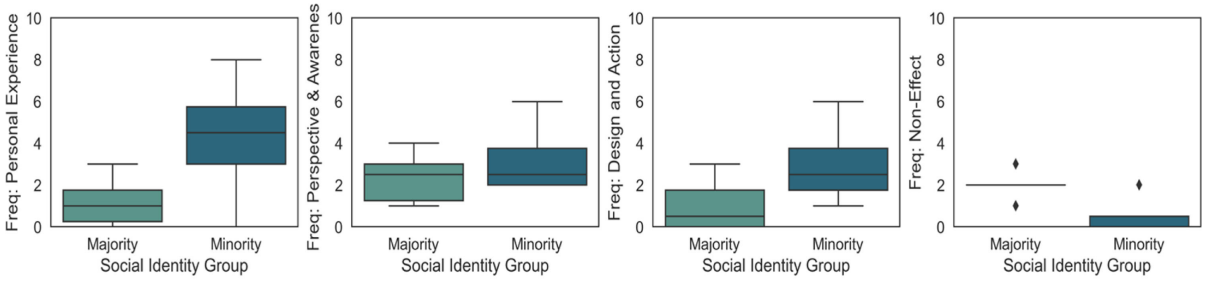

Figure 1. Comparing frequencies of the various topics based on the social identity group

3.2. RQ2: What is the quality of participants' reflection responses? Does the quality of participants' responses vary based on whether they belong to a majority or minority social group?

To answer our RQ2, the quality of participants' reflections was assessed using a four-point scale (see Section 2.3.2.), and each response was scored using the criteria seen in Table 2. The data is visualized in a series of graphs (see Figure 2). From a high-level perspective, we can see that very few participants scored a four, with most participants scoring a two. Therefore, we examined differences in reflection quality scores for each reflection cue based on the participants' social identity group, as discussed next. These results are summarized in Figure 3 and discussed next.

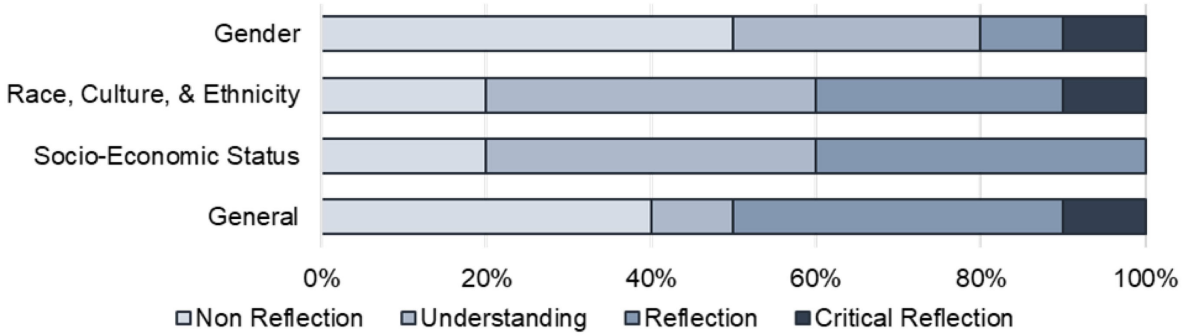

Figure 2. The overall distribution of reflection quality scores based on the reflection questions

For the first reflection cue, relating to gender identity, we see that an overwhelming majority of the participants scored either a one or a two, meaning that they engaged in little to no reflection. An example of this is participant LERE03's response: "I find this has almost no impact on [me] as an engineer". All these participants were in the majority (i.e., White men) group. However, the sole female participant scored higher, receiving a three, indicating that they had reflected on a deeper level. A quote for this participant was: "Therefore, being a woman has had some positive impact that I've seen. I've also been fortunate enough to be at a college with a higher percentage of women". The only participant to receive a four on the reflection, representing a critical level of reflection, was the only participant who criticized the idea of gender having any impact on engineering. In response to the first question, participant LYON11 stated "I do not think [my gender identity] has impacted me more than if I was a different gender. With that being said, women have been welcomed into the STEM field, as well as other non-binary genders, but the one thing that could be fixed is the wage gap between women and men . . . it does not matter what gender you are". Despite this criticism, they still showed signs of deep reflection including personal experiences and critical analysis.

The second reflection cue asked participants to reflect on the effects of their racial, cultural, and ethnic backgrounds on their performance as engineers. From the results, we can observe three things. First, the two participants who self-identified as Hispanic both scored higher on reflection quality than the rest of the majority group. An example of higher-level reflection from these participants includes a response from LEON09 (minority group member) saying "I think culturally I have been exposed to a lot of different cultures and my designs reflect this". In addition, the sole female participant showed a critical level of reflection, discussing themes such as "as an engineer, this has impacted me in my design solutions to include as many diverse stakeholders as possible". In contrast, participants from the majority group, such as NENG11 said "I think that my background has not impacted me as an engineer". This result suggests that participants in the minority group are more easily able to reflect deeply on how their unique racial, cultural, or ethnic backgrounds affect them as engineers while members of the majority group do not acknowledge them.

The third reflection cue asked participants to think about their socioeconomic status and how it has impacted them as engineers. We can see that there was very little difference between the scores of the two social identity groups, with almost all the participants either acknowledging that they had an advantage because of their socio-economic status (which received a score of two) or sharing personal experiences about how their status has impacted them (which received a score of three). For example, participant LERE03 (majority group and scored a two) mentioned "I think it [socio-economic status] has given me an edge" while participants who received a three shared a personal story, such as SAYN02 in the minority group reflecting about how hard it was to afford the price of books and how that has impacted

their studies. However, the two participants who scored a one are both in the majority group. These results suggest that there was a small difference between minority and majority groups regarding the quality of reflection when considering socio-economic status, however, the highest scores in this category were all members of the minority group.

The fourth reflection cue was open-ended and prompted the participants to reflect broadly on any unique effects of their social identity on their experience as engineers. Once again, the participants' scores were evenly distributed from a three and below, with the only female-identifying participant scoring a four. Members of the minority group scored an average of three whereas members of the majority group scored an average of 1.66. Participants reflected on a variety of factors, to varying degrees of efficacy. Participants such as LERE03 said "I have dyslexia so often I take longer to do stuff", which received a three. Others, such as IAWA04 (of the majority group) stated that they are "not really in a position to face . . . challenges". These results suggest that participants, particularly those in the majority group, struggled to reflect in a meaningful manner when provided with an open-ended reflection cue.

Another interesting finding is that the average reflection quality scores across the four reflection cues were higher among participants belonging to the minority social identity group and this difference was statistically significant (F = 5.48, p = 0.05, SSE = 2.60). Specifically, participants belonging to the majority group, on average, scored 1.70 on reflection quality whereas those belonging to the minority group scored 2.75 on average. This result suggests that members of the minority group tend to have higher quality reflection performance than members of the majority group. The implications of these results are discussed further, next.

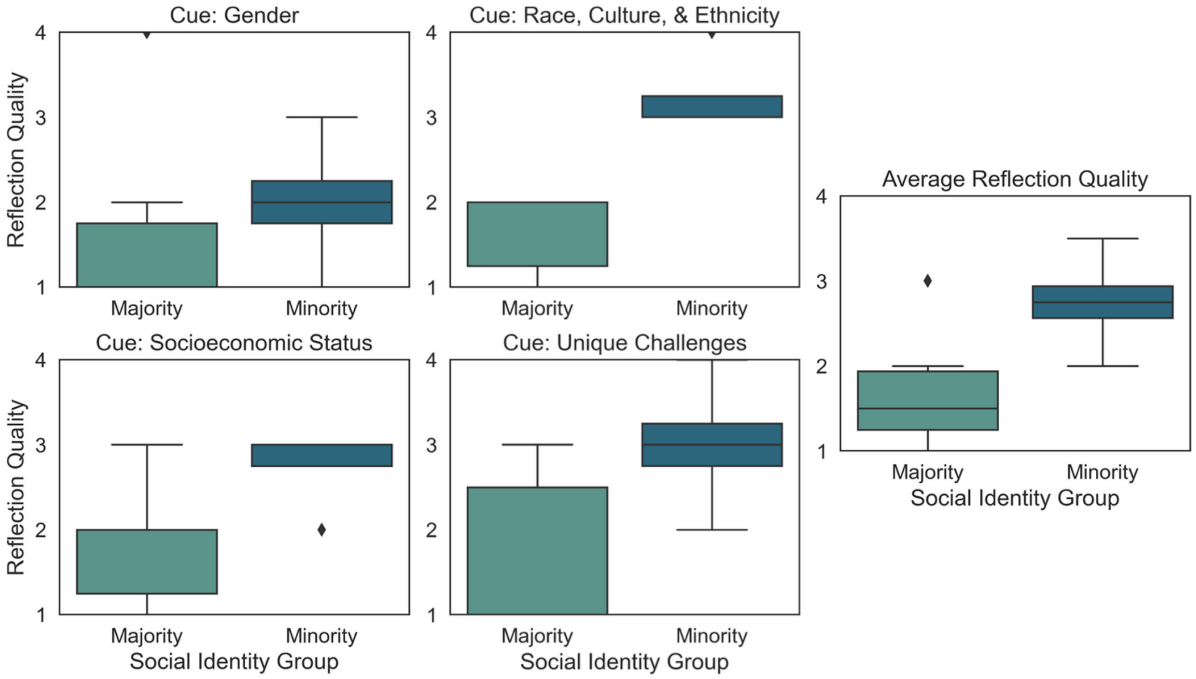

Figure 3. Reflection quality scores based on social identity groups for the four reflection cues

4. Discussions and implications of results

Our aim in this study is to examine the quality and content of student designers' reflections on the effects of their social identity. Toward this aim, we conducted an observational study with novice student designers, and two key findings were observed from the results:

1. **Higher frequencies of responses related to personal experiences and design/action were observed among members of the minority group (RQ1).**

This finding could be attributed to the inherent reflection that comes with being a member of a minority group. Previous research has found that students can lack the motivation to deeply engage in a reflection exercise, which can be observed in the majority group (Wilson, 2013). This difference can be seen more clearly as members of the two groups tend to have vastly different experiences during design projects (Smith & Trede, 2013). This finding suggests that designers with different social identities may require

differently formulated prompts when implementing reflective interventions in design practice and education. These prompts must be carefully designed to encourage designers, especially those who occupy majority identities, to recognize the effects of social identity on their decisions as engineers and designers. The formulation of these prompts may be particularly challenging as designers who occupy majority identities may have prior experiences that starkly contrast those with minority identities, making it difficult to anchor their experiences within the reflective context.

2. **Participants in the minority group provided higher-quality reflections compared to those in the majority group (RQ2).**

It is interesting to note, that even the one participant who self-identified as a White woman provided higher quality reflections when concerning other aspects of social identity, such as racial, cultural, and ethnic backgrounds, compared to members of the majority group. This result further reinforces our previous inference calling for the need to carefully formulate the prompts used in reflective interventions as these prompts could not only impact the content but also the quality of reflections. Furthermore, these prompts should be formulated such that designers - especially those who occupy majority identities - are empowered to provide meaningful and high-quality reflections. Such efforts will enable designers to be aware of the effects of social identity on their decisions as engineers and designers and enable the design of inclusive engineering solutions that account for users of diverse social identities and needs.

5. Conclusions, limitations, and directions for future work

Our aim in this study was to examine the quality and content of student designers' reflections on the effects of their social identity. Toward this aim, we conducted an observational study with fourth-year engineering students comprising a reflective intervention and a problem-framing design task. Upon a qualitative analysis of the reflection responses, we see that participants who occupy minoritized identities (e.g., women in STEM) provided detailed and higher-quality reflection responses. Our results suggest that the designers' social identity may impact their engagement with reflective interventions and the effects of these interventions on their design decisions. These results call for a further investigation into the formulation of reflective interventions in design practice and education, especially those that are carefully tailored for designers with different social identities. Furthermore, our results highlight the need for educational and reflective interventions that encourage designers who occupy majority social identities to reflect on the effects of social identity on design outcomes, as their experiences may starkly contrast those of designers who occupy minoritized identities.

Despite these key insights from our study, we had a small and relatively homogenous sample. While a homogeneous sample provides internal validity (Reynolds et al., 2003), it is important to replicate these results on a larger and more diverse sample. Similarly, the participants were sampled from a small liberal arts college in the northeastern US. Engineering students from this institution may have greater exposure to topics in social sciences and humanities compared to engineering students from larger institutions (Chopp et al., 2014; Rhoten et al., 2006). This exposure could bias the outcomes of the study, for example, through self-selection bias. Therefore, future research must extend our findings to student designers from different institution types and across different levels of experience. Moreover, our analyses only accounted for two demographic variables: gender and race. However, participants' experiences and, therefore, their reflection responses, could be influenced by other demographic variables such as socio-economic status. Moreover, these dimensions of social identity could have complex, cumulative effects that are not captured through a categorical approach (Cikara et al., 2022). Therefore, future research must aim to replicate our findings, either using a large-scale study with an extended sample or using a qualitative approach to obtain a nuanced understanding of designers with intersectional identities.

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