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Examining the Relationship Among Perceived Academic Climate, Belongingness, and Engineering Identity

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Abstract

An attempt to cultivate an inclusive learning environment in engineering is trending as a response to women's underrepresentation and a lower retention rate than men undergraduates. This study was situated in such an undergraduate engineering program where interventions were embedded in the course curriculum focusing on cultivating an inclusive engineering identity. Following a sociocultural perspective, the present study aimed to examine the relation of engineering identity with perceived academic climate, sense of belonging, and gender among two engineering cohorts (before covid and during covid context). A total of 482 first-year engineering undergraduates' survey responses were analyzed in this study using a moderated mediation model. The findings of this empirical study revealed that the sense of belonging mediated the effect of perceived diversity promotion of academic climate on engineering identity. These relationships were not found to be varied between males and females, nor before and during COVID 19 pandemic. This study shed light on the social, cognitive, and affective factors that impact engineering identity in an inclusive curriculum and informed future design of interventions.

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Sumaia Ali Raisa

Table of Contents

List of Tables

List of Figures

Introduction

In the last several decades, there has been growing attention to supporting women undergraduates in engineering as they tend to switch to non-engineering majors at a higher rate than men undergraduates (Litzler & Young, 2012, p. 337). Improving Undergraduate STEM Education (NSF-based IUSE project) through an inclusive curriculum is one attempt to increase retention and support women by strengthening students' identity or sense of fit in engineering (Atadero et al., 2018, p. 5). However, the process of the influence of IUSE interventions requires further study. To understand the pathways of influence, the current research investigated the relationship among engineering students' social, cognitive, and affective factors in a context having inclusive interventions. Among the social, cognitive, and affective factors that IUSE interventions focused on, this study examined three factors-engineering identity, organizational diversity promotion perceived by the students as an indicator of perceived academic climate, and sense of belonging. The COVID 19 pandemic was a situational factor that has been found to impact faculty and students learning experiences, medium of learning, and social interaction as there was an emergency transition to remote teaching and learning (Tecce DeCarlo et al., 2022). The present study sought to elucidate the relationships among the aforementioned social, cognitive, and affective variables. It was also examined whether the relationships among perceived academic climate, sense of belonging and engineering identity differed by gender and were there differences among groups who participated in the IUSE project before or during the COVID-19 pandemic.

Gender was an important factor in this study because women are underrepresented in engineering (Walton, et al., 2015). Despite persistent efforts to promote diversity, equity, and inclusion, with more women attending and graduating from college than men, women remain woefully underrepresented in engineering. Women are about half (52%) of the collegeeducated workforce, but the percentages of female students in the engineering classrooms and the profession are less than expected (National Science Board, 2020). Women comprised 22% of the bachelor's degrees conferred in engineering by the postsecondary institutions in the 2017-18 academic year (Hussar et al., 2020, p. 159), and only 16% of the engineering workforce (National Science Board, 2020). Moreover, female undergraduate students switch majors and leave engineering during the first two academic years at higher rates than their male counterparts (Litzler & Young, 2012). Women frequently attribute their lack of persistence in engineering programs and in the engineering workforce to a historically male-dominated climate in engineering (Walton, Logel, et al., 2015).

This study was situated in a larger study directly targeting the climate in engineering by addressing the issues head-on through classroom-based intervention activities. Within this work, engineering identity was at the core of the constructs of interest. I narrowed my interest down, especially to first-year engineering undergraduates, because the attrition rate of female engineering first-year undergraduates is alarming (Litzler & Young, 2012). This study was designed to examine the relationship among perceived academic climate, sense of belonging, and engineering identity of first-year engineering undergraduates and whether there were any differences based on gender and between groups who participated before and during the pandemic.

Theoretical Framework

I followed a synthesis of three theoretical frameworks to conceptualize students' engineering identity. These are social identity theory, multiple identity theory, and community of practice theory. The synthesized theoretical framework considers identity as the central component and shows the influence of cognitive, affective, social, and contextual factors. Figure 1 presents the framework and its components in bubbles that influence each other.

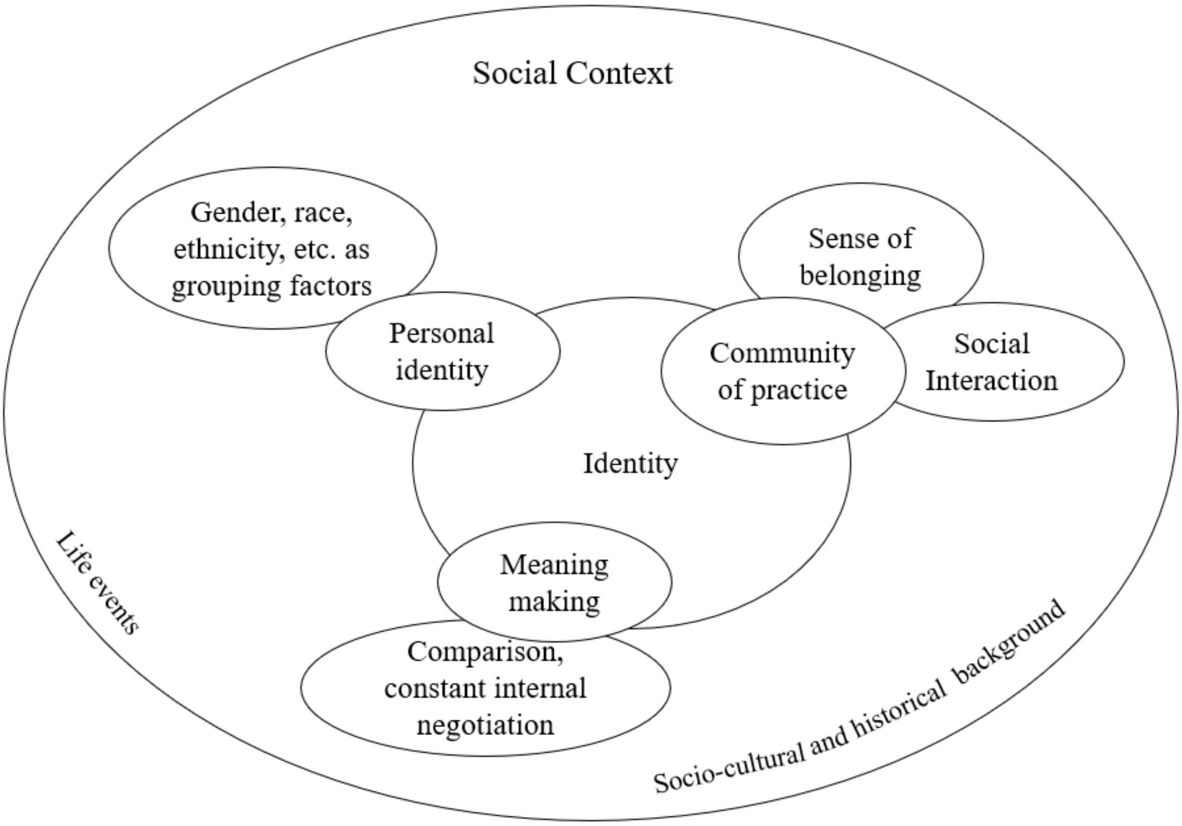

Figure 1: Components of the social learning theory, multiple identity theory and the community of practice

Social Identity Theory

The social identity theory entails that how one sees and defines themselves and others is shaped by their social world. It is a group-based identity theory where social groups and organizational components are the key determiners of identity development. The social identity theory connects two components of identity- social and personal. The personal component is individual characteristics, and the social factor is informed by group membership (ingroup vs. outgroup) based on personal traits. The perception of organizational factors develops the group membership. It underlies three mental processes: social categorization (by sorting similar characteristics, and can result in racism, sexism, etc.), social identification (modifying behavior, attitudes, and beliefs to match the group), and social comparison (compare ingroup with other groups to affirm identity) (Tajfel & Turner, 2004). Social categorization is the social structure that shapes self-concept by defining social order (historical distribution of power, prestige, and status).

Figure 1 shows that gender can be a social categorizing factor. Once individuals categorize themselves based on gender, they will compare themselves with the same gender and with groups of different genders. That comparison is informed by socio-historical and cultural positioning, or the evaluation of which gender has power and privilege in the society in a given context. These meaning-making processes inform individuals' behavior, attitudes, and beliefs and determine how they identify with the ingroup vs. the outgroup members. Being a member of one or multiple social categories determines how an individual will perceive themselves and others (Patrick & Borrego, 2016).

Multiple Identity Theory

While social identity theory focuses on the development of group identity as an interaction among the personal, social and contextual factors, the multiple identity theory posits a different view of identity. According to multiple identity theory, there are different types of identity that interact and are responsible for defining a certain kind of person (Gee, 2000). Tate and Linn (2005) studied the experiences of women of color engineering students through the multiple identity lens. They found students developed an academic identity, social identity, and intellectual identity, and the interactions between these three identities influenced the perception of their educational experiences. Figure 1 cannot fully capture the notion of multiple identity. It shows personal identity and social identity (based on gender, race, ethnicity etc.). There can be other identities, for example, academic identities. These different identities interact and shape one's experiences.

Both the social identity theory and multiple identity theory agree that identity development depends on the context and is dynamic. Borrowing from both the notions, this study viewed identity as a broad umbrella under which an individual's different identities interact and define them as a specific type of person within a context.

Community of Practice

The seminal work of Lave and Wenger on Community of Practice (CoP) is used in this study to understand the process of developing engineering identity. This theory combines the social learning theory and the idea of social constructivism and provides a collective identity theory (Lave & Wenger, 1991; Patrick & Borrego, 2016). The social learning theory and social constructivist approach focus on the social aspect of learning or learning from others and its situatedness within the context. Considering the historical and social context, the community of practice theory emphasizes the interrelationship of learning and identity. CoP explores learning in forms of apprenticeship in the sociocultural and historically grounded world. Wenger (1998) argued that learning happens in social interactions and is informed by the community of practice or a group of people who share a common goal. He also explained that the CoP requires the understanding of identity concerning the community or social group to which they belong. According to Wenger (1991), learning is becoming through and belonging to a community and is characterized as a component of identity.

Identity is viewed in the CoP as an ongoing developmental process that needs an internal negotiation of the historical past and the sense of what will happen in the future. This theory of community of practice by Lave and Wenger (1991) suggests an essential role of a sense of belonging in developing an academic identity (Lave, 1991). According to Lave (1991), developing an identity as a member of a community is motivated and shaped by the process of becoming a member of a community of practice.

The CoP has three components- understanding mutual engagement while participating in the community and individual contribution to the joint enterprise, and their contribution to creating a shared repertoire. The present study views the engineering classroom as a community of practice where teachers facilitate the interaction, and other institutional factors (e.g., diversity promotion, inclusivity, etc.) set the tone for participation in the community. Students create and shape their knowledge, understanding, and identity by interacting with each other within their learning environment.

The social identity theory, multiple identity theory, and the community of practice have shared views about identity. Identity is a dynamic process that underlies individual, social, cultural, historical, and contextual components and depends on social interaction. It is an ongoing process of becoming a specific type of person within a community. In this study, engineering identity is defined as a kind of professional identity that lies under the umbrella of social identity, indicating how competent engineering students view themselves and perceive how others see themselves in the engineering fields (Syed et al., 2018, pp. 10-11). This sense of fit in engineering is learning and engaging in engineering as a practice.

Perceived academic climate and engineering identity

The academic climate is a social component of a learning environment that represents learners' perspectives of institutional policy, procedures, and rules. It is comprised of the physical and social structure and the affective notion of the learning space. Based on the student-faculty interaction, and student-student interaction both before and after class, the perceived academic climate can be favorable and unfavorable. This perception of climate is responsible for guiding how students see themselves and others. (Barker et al., 2014; Settles et al., 2016). Students' perception of academic climate is constructed with the interaction of organizational factors, e.g., organizational fairness factor and diversity promotion, and personal factors- e.g., personal diversity value and comfort (Mor Barak et al., 1998). The personal factors are dependent on personal characteristics (like race, gender, ethnicity, previous experiences, etc.). So, the perception of academic climate, an influential factor in students' learning, can be different depending on the individual's background as well as institutional factors. The definition of academic climate perception underlies a social constructionism epistemology that assumes meaning is constructed by interacting with others within a social context (Crotty, 1998). This notion is also a focus of the community of practice theory.

The perception of academic climate contributes to students 'sense of fit' in an academic discipline. For example, in this study, engineering students' sense of fit in engineering was hypothesized to be informed by their perception of academic climate. Rincón and George-Jackson found that women's perception of an unsupportive academic climate is often tied to their lack of engineering identity (Fouad et al., 2017; Rincón & George-Jackson, 2016; Syed et al., 2018). Students who are underrepresented minorities in a discipline may have a lower sense of fit. The reason behind this relationship of sense of minority and academic identity is often tied to the power relations in a society which affects self-concept and self-esteem (Syed, Azmitia, & Cooper, 2011). That means a group of people with power, prestige, and status in a socio-historical context will have higher self-esteem and self-concept than the underrepresented group.

From the socio-cultural perspective of identity and learning, it can be said that an engineering student comes into the engineering college with an initial engineering identity, informed by socio-cultural historical context and previous lived experiences, that is further shaped by their perception of academic climate. In current literature, it is not evident how perceived climate is related to engineering identity among men and women in a context where the curriculum incorporates interventions to promote inclusive climate and enhance engineering identity.

Sense of belonging and engineering identity

Though the definitions of students' sense of belonging and engineering identity sometimes overlap and indeed have some similarities, there are some distinctions between the two constructs. Students' sense of belonging relates to their reflection on recent experiences and greater affective components in their majors, like- how comfortable they feel in an engineering classroom or college. It emerges from the self-reflection of the students' feelings when they compare themselves with their peers (Rohde et al., 2019). In contrast, engineering identity, borrowed from the concept of science identity, is their broader sense of fit in the engineering discipline, like- the extent student sees themselves as a prospective engineer (Estrada et al., 2011; Syed et al., 2018). According to Carlone and Johnson, the concept of science identity underlies three components 'performance' (social performance of relevant practice), 'recognition' (recognizing oneself and getting recognized by others), and 'competence' (knowledge and understanding of science content). A sense of belonging is crucial in developing science identity. It was found to mediate the relationship between students' faculty fixed mindset beliefs and math performance. Faculty fixed mindset belief is the belief of students that the faculty thinks intelligence is fixed, not malleable. From faculty's side, this belief often leads to quick judgment about students' ability (Canning et al., 2021).

While previous studies established the importance of a sense of belonging in learning and identity, the focus of this study was to understand the relationship of university sense of belonging to engineering identity. The University of sense of belonging was described here as students' feelings of belonging to the University. The engineering identity was perceived in this study as to how the students view themselves as fit in an engineering career and feel a part of the engineering community.

Perceived academic climate and university sense of belonging

Academic climate refers to the perception of the learning environment, and a sense of belonging is to what extent a student feels a part of their learning environment and academic community (Rohde et al., 2019). It is a sense of attachment and warmth with the institute, faculty, other students, and purpose in the academic environment (Syed et al., 2011). This definition is highly contextual. This study was concerned with the feeling of attachment to the engineering college, so the variable under study was the sense of belonging with the engineering college. Hurtado and Carter (1997) defined the sense of belonging as a cognitive evaluation of a person's position in a group that is informed by both cognitive and affective responses as a result of social interaction (p. 328). They also argued that academic climate directly affects students' sense of belonging. According to them, the perception of institutional climate for diversity can considerably impact social and academic lives. Discrimination and perception of prejudice are associated with a feeling of alienation and interpersonal tension (p. 330). Perception of diversity promotion is one of the crucial components of the perception of academic climate. In the following sections, the perception of campus climate and the perception of diversity promotion will be used interchangeably.

Gender as an intergroup factor

The current study viewed gender as an important intergroup factor. The theoretical frameworks suggested that an individual's background characteristics and academic climate could be responsible for differences in feelings of belonging to a group and the development of social identity. In an engineering classroom, students come from different backgrounds with an already established initial engineering identity that can be different for men and women, specifically, women tend to have lower engineering identity than men (Buontempo et al., 2017). It was found that students from minority groups may view the academic climate as more uncomfortable and feel a lower sense of belonging (Estrada et al., 2011; Hurtado et al., 2008; Hurtado & Carter, 1997). Women who are also underrepresented in the STEM field perceive their academic climate as more unwelcoming than their men peers which may affect a feeling of alienation (Jensen & Deemer, 2019). Previous studies suggested that students' self-perception, psychological sense of community, and science identity vary by gender and ethnicity (Hazari, Sadler & Sonnert, 2013, and Vincent-Ruz & Schunn, 2018).

Cohort (or modality) as an intergroup factor

Due to the COVID 19 pandemic, there is a shift in modes of interaction- face-to-face vs. face to screen in many educational institutes. A few studies focus on the impact of COVID on learning and identity showing how this altered context negatively impacted learning gain, engagement, social interaction, and wellness (Castro & George, 2021; Mesghina et al., 2021). As physical interaction was limited, and the modes of interaction were changed due to the pandemic, in this study, the aim was to know the general impact of the Pandemic situation on the relationship of perceived climate, belongingness, and engineering identity examined based on gender.

The sociocultural view of learning assumes that the discipline-based group identity develops in a social context where social interaction and collaboration are crucial. Social interaction and mutual engagement in a community is also key component of the community of practice theory. According to the CoP, identifying with a community of practice is a key component of learning (Lave & Wenger, 1991). The community members engage in joint activities and learn together. However, the community members need not meet daily. There can be face-to-face meetings or online meetings, and there can be formal or informal groups. Due to the COVID 19 pandemic, there is a change not only in the modes of social interaction but also in learners' emotional wellbeing (Dodd et al, 2021). Wester et. al (2021) investigated the impact of COVID 19 and the transition of the learning environment on students' behavioral engagement, cognitive engagement (e. g. sense of belonging and self-efficacy), and emotional engagement. They did not find any change in behavioral engagement but noticed decreased emotional engagement. The cognitive engagement did not change over the semester during COVID, while in other times, students' self-efficacy and sense of belonging increased over time. They argued that due to COVID 19, the transition to online learning had an overall negative impact on student engagement in science courses (Wester et al., 2021). It generally caused anxiety and stress, and also, the college showed more emotional support and empathy (e.g, relaxing due dates of assignments, being flexible in terms of class participation, etc). It can be hypothesized that there will be an influence of the Pandemic on the dynamics of engineering identity because students' group collaboration, social interaction, and emotion will vary in terms of changed modality, and contextual factors.

Current Study

The proposed research was situated in a unique context involving an inclusive engineering curriculum fostering engineering identity. I intended to examine the relationships among academic climate perception, sense of belonging, and engineering identity within the context. These relationships will also be investigated in different cohorts with varying degrees of social interaction (on-campus vs. online class).

To sum up, the primary research question of this study was the following:

- What were the relationships among perceived academic climate, sense of belonging, and engineering identity, and did these relationships vary by gender and different cohort (different due to modality)?

This research question has been narrowed down to two specific research questions. These are:

1. Did a sense of belonging mediate the relationship between perceived academic climate and engineering identity?

2. a) Did gender moderate the relationships among perceived academic climate, sense of belonging, and engineering identity?

2. b) Did cohort (modality) moderate the relationships among perceived academic climate, sense of belonging, and engineering identity?

The proposed model based on previous studies and the present study questions, is shown in figure 2.

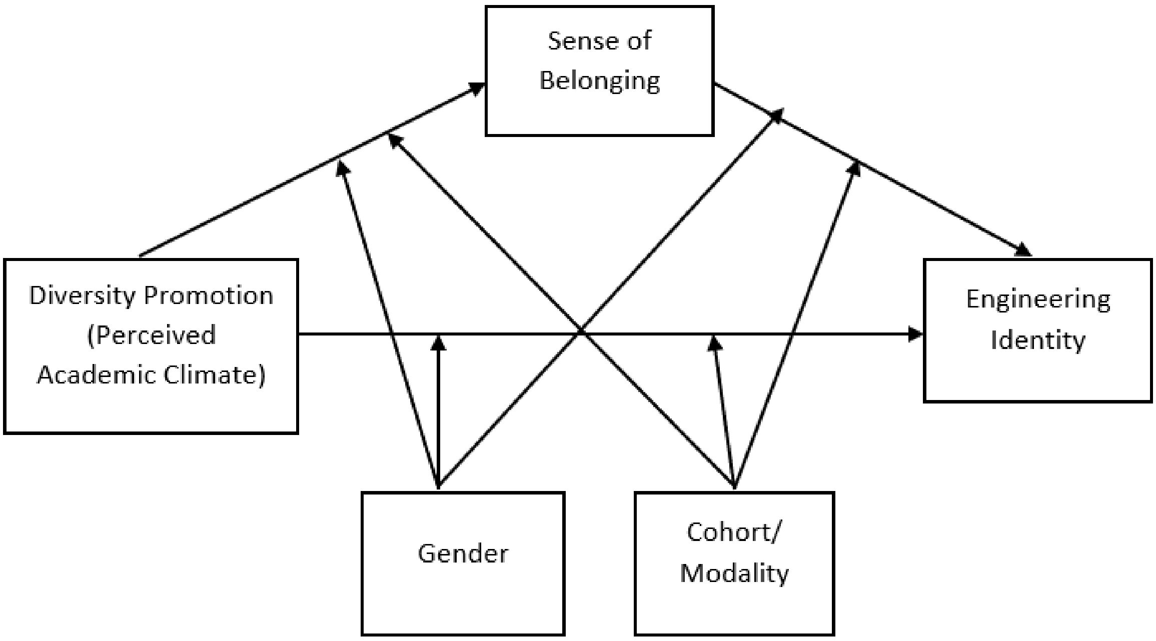

Figure 2: Hypothesized model showing the relationship of Perceived climate, sense of belonging engineering identity, gender and cohort

Methods

Study Context

The present study was a subset of a larger study aimed at cultivating inclusive identity among engineering students. I used the existing survey data of that study and examined it from the social identity lens for my research. The inclusive curriculum of the larger study incorporated some interventions. Among the interventions, the students of this study participated in five interventions. These are- Implicit Bias Assignment, Dean's Talk and Reflection Activity, Theatre Sketch Activity, Teamwork Activity, and Iceberg Activity. The description of each intervention is described as follows.

The purpose of the *implicit bias assignment* was to make the students aware of the concept and understand and be mindful of their own implicit biases. This activity included watching a video introducing the implicit bias concept, taking a self-assessment Implicit Association Test (IAT), and watching a second video on the impacts of implicit bias. The students were required to write an essay based on some prompts, such as the difference between explicit and implicit bias, discuss the IAT test results, and significant takeaways on the impact of implicit bias on teamwork (Rambo-Hernandez et al., 2019).

The *dean's talk and reflection activity* invited the students at the beginning of the semester, where the dean of the college of engineering was the guest speaker. The dean talked about egalitarian norms and the importance of inclusivity, diversity, and functioning as an engineer in a global workforce. The students were allowed to ask questions during the session (Rambo-Hernandez et al., 2019).

The *theatre sketch activity* started with an icebreaker to remove the students from their comfort zones. The students watched a sketch performed by three students (two males and one female). In the sketch, the three students were working on a team project. The team did not function well because of the behavior of one of the men towards the woman. There was an empty fourth chair throughout the sketch. The sketch was performed again, and the students were allowed to stop the play and intervene as the fourth member of the team at any time. After the intervention, trained facilitators held a Q/A session and discussed the sketch, such as how the intervention worked. After attending it, the students were asked to write and submit a reflection essay on the theatre sketch activity (Paguyo et al., 2015; Rambo-Hernandez et al., 2019).

In the *teamwork activity*, the students were required to watch a video on psychological safety in teams. Then the students were asked to complete a reflection questions based on some prompts, such as- “(1) Describe a setting where you would be willing to admit mistakes when working with a team, (2) What can you do to help establish a team dynamic where mistakes are welcomed and recognized as part of the design process?, and (3) How important is psychological safely in engineering teams and why?” (Rambo-Hernandez et al., 2019).

The *iceberg activity* focused on how society promotes conscious or subconscious assumptions and preconceptions about people and how those assumptions are often erroneous. In this activity, the students are given a worksheet to fill in out of class. The students were required to think about a character from the campus read “Hidden Figures”, and provide adjectives describing that person. The students were also asked to write what adjectives or identities people might assign to them if they met them for the first time and what people would say after getting to know them. The students had an in-class discussion afterward on significant takeaways from this activity and how it will impact their approach to working with others (Rambo-Hernandez et al., 2019).

Participants

This study took place at a large R1 research university in the mid-Atlantic region. I followed a purposive convenient sampling technique for this study. This study comprised the data of a total of 482 first-year engineering undergraduates (27.4% women, 72.6% men) with an average age of 18.19 years (*SD* = 0.88). These students took engineering 191 and engineering 101 courses, and so they have had similar sets of inclusive interventions. The interventions focused on building awareness about implicit bias, fostering teamwork, and promoting diversity and inclusion. It comprised of assignments, reflection essays, and attending out-of-class experiences.

Cohort 1 included the data of 270 first-year engineering undergraduates (23.33% women, 76.67% men). Cohort 1 took the classes on campus and consented to use their survey responses for the research in the fall 2019 semester. Of note, students were given an open-ended option for gender. After coding the open-ended responses, this study selected students who responded as either men or women.

Cohort 2 represents students who consented to use their survey responses in fall 2020. A total of 212 first-year engineering undergraduates (32.55% women, 67.45% men) served as the second cohort. In fall 2020, all the classes and intervention activities were conducted online.

Measures

In the larger NSF project, the surveys included demographic items and measures of different psychological constructs. I used the scales of perceived academic climate (perception of institutional diversity promotion), engineering identity, and sense of belonging. All response options were Likert type ranging from 1 (strongly disagree) to 7 (strongly agree).

Students' perception of diversity promotion (DP), which is also an indicator of perceived academic climate, was borrowed from the Campbell-Whatley scale of perception of diversity and campus climate (Campbell-Whatley, et al., 2012). The original scale had five items. After doing a confirmatory factor analysis (shown in Table 4) and evaluating the items, one item was dropped from this scale (Table 1). After dropping that item, the model fit indices were improved. This study used four items from the perception of diversity promotion factor. Sample items include, “I think my campus climate is positive in terms of issues concerning diversity.”, “I think there are numerous efforts to increase diversity on campus.”. Higher scores on the scale indicate a positive perception of diversity promotion, hence a higher level of the academic climate. This measure had acceptable internal consistency (ω = 0.85).

The **sense of belonging (SOB)** of the students was measured using a 6-item scale, adapted from the work of Slaten (Slaten et al., 2018) and Goodenow (Goodenow, 1993). The original scale had 11 items (Table 2) and showed inadequate model fit after evaluating the CFA. Based on the CFA results (Table 4) and the items themselves, six items showed to have a good model fit for a one-factor model. The sense of belonging scale contained items such as, “I feel a sense of belonging to [this university’s Engineering] College.”, “I can be myself and feel welcome in [this university’s Engineering] College.”. Higher scores on this scale indicated a higher sense of belonging. The sense of belonging measure had a good internal consistency (ω = 0.94).

Engineering identity (EID) was measured using four items such as “I have come to think of myself as ‘an engineer’ “Being an engineer is an important reflection of who I am.”, developed from Chemers’ science identity survey (Chemers et al., 2011; Estrada et al., 2011). The survey borrowed four items from Estrada’s modified version of Chemer’s science identity scale. The original scale had five response options 1 (strongly disagree) to 5 (strongly agree). The present study followed a 7-point response option due to consistency with other measures. Higher scores were associated with a stronger engineering identity. After performing a CFA, one item was dropped, and three items were used for the analysis (Table 3). The engineering identity scale had good internal consistency (ω = .88).

Gender. It was a self-reported open-ended survey item. Later, I coded their responses and kept only the responses of male (coded as 0) and female (coded as 1) participants.

Cohort. This variable is created based on the semester when the data were collected. Cohort 1 indicated students from fall 2019 who had classes and interventions in-person (coded as 0). Cohort 2 comprised students from fall 2020 when the COVID pandemic pushed the classes and interventions online (coded as 1).

I presented the survey items in Table1, Table 2, and Table 3.

Design

This study followed a cross-sectional survey research design using a quantitative approach. I used the survey data collected for a larger NSF-funded project at an engineering undergraduate level.

Procedures

This work was part of a larger multi-year NSF-funded grant incorporating experimental interventions to build an inclusive curriculum. Prior to data collection, the larger IUSE project sought ethics approval from the University Institutional Review Board (IRB). Surveys were administered at the beginning and end of each semester as part of that project. In this study, responses from the survey administered at the end of the semester were used. The surveys included scales to measure perceived academic climate, university sense of belonging in engineering classes, engineering identity, and demographic questions such as gender and ethnicity. The surveys were a part of their coursework. The students were required to take the survey to receive points. However, they had the choice to consent to use their responses for the research. The students should be 18 years or older to consent to the research. For this study, the survey responses authorized to use are extracted.

Data analysis

At first, I cleaned the data and deleted the missing cases. I ran confirmatory factor analyses to test the internal structures of the scales using MLM estimation in Mplus (Muthén & Muthén, 2017). The factor scores were saved for later analysis. A measurement invariance test for the diversity promotion scale or the predictor variable was conducted to examine whether respondents from the two cohorts interpreted the same measure in a similar way (Byrne, B. M., 2012). After that, a moderated mediation using two dichotomous moderators (gender and cohort) was performed using Hayes process macro, model 76 in SPSS version 28 (Hayes, 2018). The factor scores of the composite scales were used in the moderated mediation instead of the sum of scale scores. Estimated factor scores are advantageous to use over sum scores because they are more exact and robust than the sum of scores (McNeish & Wolf, 2020).

Results

Preliminary Analyses

Confirmatory Factor Analysis

Perception of diversity promotion: I evaluated a one-factor structure in which each of the four diversity promotion items is modeled to load onto one latent factor using MLM estimation. The model chi-square statistic was $\chi^2(2)=0.98$ and was not statistically significant ($p > .05$). I preliminarily concluded that the model demonstrates fit. The approximate fit indices were also analyzed. Values of RMSEA- 0.01, 0.05, and 0.08 indicate excellent, good, and mediocre fit, respectively. The value of RMSEA here was 0.00, which shows an excellent fit. Another model fit index is the Comparative Fit Index (CFI). Higher value (≥ 0.95 = good fit) indicates better fit. In this analysis, the value of CFI and TLI was 1.00, a indicating perfect fit for the one-factor solution. The Standardized Root Mean Square Residual (SRMR) was also <0.08, which indicates a good fit. I checked the standardized factor loadings. No factor loadings were below the threshold (<.50), indicating an overall strong model (Table 5).

Sense of belonging: A confirmatory factor analysis (CFA) was performed to evaluate a one-factor solution where six items were modeled. The model chi-square was $\chi^2(9)=59.34$ and was statistically significant ($p < .05$). It indicated an inadequate model fit. The approximate fit indices were analyzed. The value of RMSEA here was 0.11, which showed a poor model fit. In this analysis, the CFI value was 0.97, indicating a good fit for the one-factor solution. The Standardized Root Mean Square Residual (SRMR) was also <0.08, which is the indicator of good fit. I examined the standardized factor loadings. No factor loadings were <.65, indicating an overall moderate model (Table 5).

Engineering identity: The engineering identity scale had three items. The model was just-identified, and the chi-square was 0. However, an examination of the standardized factor loadings revealed all the items were above 0.80 (Table 5).

Invariance based on gender

A measurement invariance test by gender was run to assess whether the perceived diversity promotion items measured the same construct for males (n = 350) and females (n = 132) (shown in table 6). Invariance testing is a sequential process of testing the equivalence of model parameters across groups under increasingly restrictive constrictions. To evaluate configural invariance, a CFA model was estimated for both genders simultaneously, with all parameters freely estimated. Successive models were then estimated in which factor loadings (metric invariance), and intercepts (scalar invariance) were examined. The same model indices were used as in the CFA.

The analysis showed that I had achieved configural invariance, χ^2 (4) = 1.54, p = .82, RMSEA = 0.00 (90% CI: .00, .06), CFI = 1.00, TLI = 1.00, and SRMR = .01. Though the upper value of the 90% CI of RMSEA exceeds 0.08 the overall value is excellent. Chi square contribution for male and female was also calculated. Male had χ^2 (2) = 0.81, p = 0.67, and female showed χ^2 (2) = 0.73, p = 0.70, indicating good model fit. Model fit information for the metric model also showed model invariance, χ^2 (7) = 2.05, p = 0.96, RMSEA = 0.00 (90% CI: .00, .00), CFI = 1.00, TLI = 1.00, and SRMR = .01. I also achieved a scalar invariance, χ^2 (10) = 7.69, p = 0.66, RMSEA = 0.00 (90% CI: .00, .06), CFI = 1.00, TLI = 1.00, and SRMR = .03. The invariance test results suggested that the factor structure was good across groups and comparisons of variances and covariances were permitted. I decided to proceed with further analysis by gender.

Invariance based on cohort

I conducted a test of measurement invariance across the two cohorts to assess whether the perceived diversity promotion items measured the same construct for cohort 1 (n = 270) and cohort 2 (n = 212) (presented in table 7).

The analysis showed that I had achieved configural invariance, χ^2 (4) = 3.48, p = 0.48, RMSEA = 0.00 (90% CI: .00, .09), CFI = 1.00, TLI = 1.00, and SRMR = .01. Though the upper value of the 90% CI of RMSEA exceeds 0.08 the overall value is excellent. Chi square contribution for each cohort was also calculated. Cohort 1 had χ^2 (2) = 2.35, p = 0.31, and cohort 2 showed χ^2 (2) = 1.12, p = 0.57, indicating good model fit. Model fit information for the metric model also showed model invariance, χ^2 (7) = 5.87, $p > 0.05$, RMSEA = 0.00 (90% CI: .00, .07), CFI = 1.00, TLI = 1.00, and SRMR = .03. However, I did not achieve a scalar invariance, χ^2 (10) = 21.72, $p < 0.05$, RMSEA = 0.07 (90% CI: .03, .11), CFI = .98, TLI = .98, and SRMR = .05. As I had configural and metric invariance, this suggested that the factor structure was good across groups and comparisons of variances and covariances were permitted. I decided to proceed with further analysis.

Correlation

Pearson product-moment correlation revealed a moderate positive relationship between perceived diversity promotion and students' sense of belonging (r = .37, p <.001) and a small positive association with engineering identity (r = .28, p <.001). The sense of belonging variable was found to have a large positive correlation with engineering identity (r = .71, p <.001). A point biserial correlation was conducted to determine the relationship between each of the study variables and gender. The gender variable was coded as 1 for females and 0 for males. It was found that gender was negatively correlated with engineering identity (r = -.15, p <.001). The correlation between gender and engineering identity showed that female (coded as 1) undergraduates had significantly lower engineering identity on average than male engineering undergraduates. The correlation matrix is shown in table 8.

Sense of belonging

Initial evaluation of the model revealed that the more students perceived their campus climate promoted diversity, the more they felt belonged to their college (*X* to *M*), $b=0.48$, $t=6.65$, $p<.001$. The interaction by gender (*W*) was not significant, $b= -0.24$, $t= -1.78$, $p=.08$, suggesting that the effect of perceived diversity promotion on the sense of belonging did not differ by student gender. The interaction by cohort or modality (*Z*) was also not significant, $b=0.08$, $t=0.73$, $p=.46$, suggesting that the effect of perceived diversity promotion on the sense of belonging did not differ by cohort.

Engineering Identity

Students' sense of belonging score was found to be a significant predictor of engineering identity (*M* to *Y*), $b=0.79$, $t=14.62$, $p<.001$. The interaction by gender (*W*) was not statistically significant, $b= 0.10$, $t= 1.05$, $p=.29$, suggesting that the effect of a sense of belonging on engineering identity did not differ by student gender. The interaction by cohort or modality (*Z*) was also not significant, $b=0.03$, $t=0.30$, $p=.77$, suggesting that the effect of a sense of belonging on students' engineering identity did not differ by cohort. The direct effect of perceived diversity promotion (*X*) on engineering identity (*Y*) was also not significant, $b=0.04$, $t=0.53$, $p=.60$. There were no significant interactions by gender (*W*), $b= -0.24$, $t= -1.78$, $p=.08$, and cohort (*Z*), $b=0.48$, $t=6.65$, $p<.001$. These results suggested that the effect of perceived diversity promotion and sense of belonging on engineering identity did not differ by student gender and cohort.

Mediation

I examined any indirect effect of students' perceived diversity promotion scores on their engineering identity through their sense of belonging. The significance of the indirect effect was tested through the calculation of a bootstrap confidence interval using 5,000 bootstrap samples. Combined with perceived diversity promotion, a sense of belonging accounted for approximately 53% of the variance in engineering identity (R^2=0.53), indicating a large effect.

As there was no interaction between the moderating variables and the study variables, the conditional indirect effects were not reported here. The indirect effect of perceived diversity promotion on engineering identity via sense of belonging was statistically significant *b* = 0.39, Boot *SE* = 0.06, 95% *CI* [0.28, 0.51]. The direct effect of perceived climate on engineering identity (*X* to *Y*) was not statistically significant, *b*= 0.04, Boot *SE* = 0.08 95% *CI* [-0.13, 0.21].

Discussion

I examined three social-cognitive and affective constructs to understand undergraduate engineering students' experience in an inclusive curriculum intervention. These are perceived diversity promotion in an academic climate, university sense of belonging, and engineering identity. It was also investigated whether these relationships differed based on gender and modality change (in person vs. online due to COVID 19). Previous studies on engineering identity framed the learning environment and campus climate as influential factors in determining engineering identity. The social identity theory and community of practice theory placed a sense of belonging as an important affective factor in influencing engineering identity. The synthesized theoretical framework of this study indicated that the sense of belonging might mediate the relationship between perceived diversity promotion and engineering identity.

In the present study, there was evidence of the sense of belonging mediating the effect of perceived diversity promotion on engineering identity. The higher students' perception that their campus climate promoted diversity, the more they felt they belonged to their college, which fostered their engineering identity. This finding was supported by the theoretical framework of this study (Gee, 2000; Lave & Wenger, 1991; Patrick & Borrego, 2016). The affective construct sense of belonging was found to be very influential in developing identity. Based on this finding, it is recommended that an intervention should be focused on fostering a sense of belonging. To increase a sense of belonging, the students should have meaningful interaction with their peers, teachers, and others in their learning environment so that they think they are a part of that community and feel a sense of belonging with their group. One limitation of this study is the small sample size. In-depth analysis with a large sample and having qualitative data could give more information about those relationships among perceived climate, sense of belonging, and engineering identity among female engineering students.

Moderation by gender: The mediation of the sense of belonging between the relationship of perceived diversity promotion and engineering identity was not moderated by gender. In a previous study, the perception of faculty fixed mindset created a context of stereotype threat that lowered the sense of belonging, which in turn undermined women undergraduates' performance (e.g., grade) but not the performance of men undergraduates' (Canning, 2021). The present study context is different from previous studies as inclusive interventions were embedded in the curriculum. The interventions might be able to promote the perception that the campus climate supported diversity which might have reduced the gender gap in developing a sense of belonging and engineering identity. The purpose of the interventions in the study context was to make the students aware of the diversity, equity, and inclusion issues and to show them the importance of being better team members. The student's participation in these activities might have increased their sense of belonging. An in-depth study following a qualitative approach might give more insight into that. However, this study had some limitations in claiming that the interventions reduced the gender gap. First, the sample size was small. Larger sample size could increase the power of the test. Second, the study did not have any control or comparison group to compare and draw a conclusion about the interventions. Third, the moderated mediation was conducted using cross-sectional data. Though there are studies that used mediation on cross-sectional data, this approach is more appropriate in experimental studies or longitudinal studies when there is temporal precedence of the predictors and the mediator variable. The mediation underlies causal processes that take place over time. Using cross-sectional data for mediation analysis may produce a biased estimate of the indirect effect. A strong mediator in cross-sectional data may produce an indirect effect of zero in longitudinal data (Maxwell et al., 2011). A previous study, where gender moderated the relationship among faculty fixed mindset belief, perceived stereotype, sense of belonging, and performance, followed an experimental design, and the variables were manipulated in a controlled setting (Canning, 2021). Future studies on engineering identity can follow a more robust design (e.g., experimental design or mixed-method study) to determine causality among the variables.

Moderation by cohort: This study was comprised of two cohorts who participated before and during COVID 19 pandemic. These two cohorts of this study differed beyond the modality (in-person vs. online) of class because the pandemic was found to impact our lives in many ways. For example, it negatively impacted well-being and a sense of belonging (Dodd et al., 2021; Wester et al., 2021). Though there were not enough studies on the impact of the COVID 19 pandemic on engineering students' sense of belonging, it was expected that sense of belonging would be lower among students from cohort 2.

The moderation of cohort was not found to predict engineering identity from perceived diversity promotion via the sense of belonging. The previous studies were conducted on students in medicine, health science, biology, and chemistry (Dodd et al., 2021; Wester et al., 2021). These students' experiences and habits of mind might be different from the engineering students. For example, students from biology majors might have experienced major shifts in engagement and learning from laboratory work to online simulation projects. In comparison, engineering students might not have observed major shifts in online projects and assignments. My argument is the pandemic shifted our learning experiences to some extent, but the impact is different based on the students majors. Maybe the pandemic did not impact the sense of belonging and engineering-related identity as much as it caused other majors (e.g., biology, chemistry, etc.). Students' habits of mind and task type might be crucial in this case. While designing an intervention, these contextual issues should be kept in mind.

This study contributed to the literature on the relationship among three important constructs in engineering education. I considered the context of an inclusive curriculum and showed the importance of a sense of belonging in developing an engineering identity. A sense of belonging is a salient factor that enhances in-group feelings that confirm group membership and help develop a stronger identity with the group (Tajfel & Turner, 2004). While planning and designing an intervention for empowering women in engineering classrooms, it should be considered whether the intervention can foster a sense of belonging in a way that students feel they are a part of the engineering community. Strengthening group dynamics can help minimize stereotyped climate effects. So, interventions should be designed around increasing students' belongingness in an engineering group and fostering a climate that promotes diversity. Increasing participation and meaningful interaction among engineering students can be helpful.

Another limitation should be considered to contextualize the findings. I excluded a small number of non-binary respondents and retained only those self-selecting either male or female gender. I acknowledge that gender is a socially constructed non-binary phenomenon. Further analysis of the non-binary responses with techniques appropriate for a small sample is recommended.

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Table 1: Item-level descriptive statistics and applicable subscale for perceived diversity promotion of climate scale

Item code	**Item Stem (7-point Likert-type response)**	Cohort 1-Fall 2019 (*n* = 270)		Cohort 2-Fall 2020 (*n* = 212)	
		Mean	*SD*	Mean	*SD*
CDPR1	I think my campus climate is positive in terms of issues concerning diversity	5.93	1.21	6.20	1.00
CDPR2	I think the campus climate encourages diversity	6.00	1.16	6.08	1.11
CDPR3	I think there are numerous efforts to increase diversity on campus	5.87	1.24	6.11	1.04
CDPR4	I would describe the Statler College as having a diverse student population	5.62	1.49	5.48	1.39
CDPR5	[deleted] I think the Statler College is considerate of a diverse student population	5.97	1.17	6.03	1.05

Table 2: Item-level descriptive statistics for sense of belonging scale

Item code	**Item Stem (7-point Likert-type response)**	Cohort 1-Fall 2019 (*n* = 270)		Cohort 2-Fall 2020 (*n* = 212)	
		Mean	*SD*	Mean	*SD*
USOB1	I am enthusiastic about attending WVU's Statler College	5.81	1.25	5.99	1.20
USOB3	I feel a sense of belonging to WVU's Statler College	5.61	1.31	5.85	1.23
USOB4r	[deleted] I feel alienated in WVU's Statler College [recoded]	5.53	1.62	5.56	1.67
USOB5	I see myself as part of the community in WVU's Statler College	5.35	1.41	5.60	1.29
USOB6	WVU Statler College is one of the best schools for me	5.46	1.53	5.64	1.35
USOB7	I identify strongly with being a student in WVU Statler College	5.58	1.47	5.71	1.33
USOB8	[deleted] I am a typical student in the WVU Statler College	5.19	1.43	4.80	1.68
USOB9	[deleted] There are many other people like me in WVU's Statler College	5.20	1.39	5.14	1.31
USOB10	I can be myself and feel welcome in WVU's Statler College	5.70	1.25	5.89	0.99
USOB11	[deleted] I feel like I fit in WVU's Statler College	5.63	1.29	5.72	1.19
USOB12r	[deleted] I feel like I have to hide parts of who I am to fit in WVU's Statler College [recoded]	5.31	1.61	5.38	1.58

Table 3: Item-level descriptive statistics for engineering identity

Item code	**Item Stem (7-point Likert-type response)**	Cohort 1- Fall 2019 (*n* = 270)		Cohort 2- Fall 2020 (*n* = 212)	
		Mean	*SD*	Mean	*SD*
ID1	[deleted] In general, being an engineer is an important part of my self-image	5.19	1.58	5.08	1.50
ID5	Being an engineer is an important reflection of who I am	5.20	1.55	5.15	1.51
ID7	I have come to think of myself as "an engineer"	5.16	1.56	5.18	1.48
ID9	I feel like I belong in the field of engineering	5.60	1.34	5.63	1.24

Note: The items (in Table 1, Table 2, and Table 3) in red are removed after confirmatory factor analyses

Table 4: Model fit statistics and the standardized factor loadings for the one factor CFA models of the original scales (*N*= 482)

Variables	**Model χ^2**	***Df***	***p***	**RMSEA (90% *CI*) (≤0.08 = acceptable)**	**CFI (≥ 0.95 = good fit)**	**TLI (≥ 0.95 = good fit)**	**SRMR (<0.08 = acceptable)**	**Factor loadings**		**90% *CI***
Perceived diversity promotion	56.77	5	<.01	.15 (.11, .18)	0.94	0.87	.04	CDPR1	.78	(.71, .85)
								CDPR2	.86	(.82, .90)
								CDPR3	.82	(.76, .88)
								CDPR4	.67	(.61, .73)
								CDPR5	.83	(.79, .87)
Sense of belonging	59.34	9	<.01	.11 (.08, .14)	.97	.94	.02	USOB1	.86	(.83, .90)
								USOB3	.92	(.90, .94)
								USOB4r	.25	(.16, .34)
								USOB5	.87	(.85, .90)

								USOB6	.84	(.81, .87)
								USOB7	.86	(.83, .88)
								USOB8	.35	(.27, .44)
								USOB9	.41	(.33, .49)
								USOB10	.70	(.64, .76)
								USOB11	.82	(.78, .85)
								USOB12r	.29	(.21, .38)
Engineering identity	31.98	2	<.01	.18 (.13, .23)	.97	.91	.04	ID1	.93	(.90, .95)
								ID5	.96	(.94, .97)
								ID7	.79	(.75, .83)
								ID9	.72	(.65, .78)

Note: The items in red are deleted based on the evaluation of the modification indices and the item itself following an iterative process.

Table 5: Model fit statistics and the standardized factor loadings for the one factor CFA models of the final scales (N = 482)

Variables	Model χ^2	*Df*	*p*	RMSEA (90% *CI*) (≤0.08 = acceptable)	CFI (≥ 0.95 = good fit)	TLI (≥ 0.95 = good fit)	SRMR (<0.08 = acceptable)	Factor loadings		90% *CI*
Perceived diversity promotion	.98	2	.61	.00 (.00, .07)	1.00	1.00	.01	Item 1	.77	(.69, .85)
								Item 2	.92	(.88, .96)
								Item 3	.82	(.75, .89)
								Item 4	.59	(.52, .66)
Sense of belonging	59.34	9	<.01	.11 (.08, .14)	.97	.94	.02	Item 1	.88	(.84, .91)
								Item 2	.93	(.91, .94)
								Item 3	.87	(.84, .89)
								Item 4	.84	(.81, .88)
								Item 5	.86	(.84, .89)
								Item 6	.65	(.57, .73)
Engineering identity	-	-	-	-	-	-	-	Item 1	.85	(.81, .90)
								Item 2	.88	(.84, .91)
								Item 3	.80	(.74, .86)

Table 6: Model fit statistics for tests of measurement invariance across gender (*N* = 482)

Model	χ^2	***df***	***p***	**RMSEA (90% CI) (≤0.08 = acceptable)**	**CFI (≥ 0.95 = good fit)**	**TLI (≥ 0.95 = good fit)**	**SRMR (<0.08 = acceptable)**	**Models Compared**	χ^2	***df***	***p***
Configural Invariance	1.54	4	.82	.00 (.00, .06)	1.00	1.00	.01	-	-	-	-
Metric Invariance	2.05	7	.96	.00 (.00, .00)	1.00	1.00	.01	Metric against Configural	.47	3	.93
Scalar Invariance	7.69	10	.66	.00 (.00, .06)	1.00	1.00	.03	Scalar against Metric	7.17	3	.07

Table 7: Model fit statistics for tests of measurement invariance across cohort (*N* = 482)

Model	χ^2	***df***	***p***	**RMSEA (90% CI) (≤0.08 = acceptable)**	**CFI (≥ 0.95 = good fit)**	**TLI (≥ 0.95 = good fit)**	**SRMR (<0.08 = acceptable)**	**Models Compared**	χ^2	***df***	***p***
Configural Invariance	3.90	4	.42	.00 (.00, .10)	1.00	1.00	.01	-	-	-	-
Metric Invariance	6.97	7	.43	.00 (.00, .08)	1.00	1.00	.06	Metric against Configural	3.04	3	.39
Scalar Invariance	25.50	10	<.01	.08 (.04, .12)	.94	.93	.07	Scalar against Metric	**23.96**	3	<.01

Table 8: Pearson correlation for study variables (*N* = 482)

Variables	Diversity promotion	Sense of belonging	Engineering identity
Sense of belonging	.37**		
Engineering identity	.28**	.71**	
Gender	-.01	-.05	-.15**
Cohort	.07	.09	.01

**Correlation is significant at the .01 level

Table 9. Summary of Process analyses of proposed moderated mediation model

Effects	**Unstandardized coefficients (*b*)**	**Boot SE**	**Boot LLCI**	**Boot ULCI**
Perceived Diversity Promotion => Sense of Belonging	.48*	.10	.28	.66
Sense of Belonging => Engineering Identity	.79*	.08	.61	.94
Perceived Diversity Promotion * Gender => Sense of Belonging	-.24	.13	-.49	.02
Perceived Diversity Promotion * Cohort => Sense of Belonging	.08	.09	-.15	.33
Perceived Diversity Promotion * Gender => Engineering Identity	.11	.14	-.16	.38
Perceived Diversity Promotion * Cohort => Engineering Identity	-.06	.12	-.29	.19
Sense of Belonging * Gender => Engineering Identity	.10	.12	-.15	.32
Sense of Belonging * Cohort => Engineering Identity	.03	.13	-.23	.29
Direct Effect Perceived Diversity Promotion => Engineering Identity (Without Sense of Belonging)	.04	.08	-.13	.21
[a]Indirect Effect Perceived Diversity Promotion on Engineering Identity via Sense of Belonging	.39*	.06	.28	.51

[a]Process model 76 in SPSS showed the conditional indirect effect i.e., the effect of perceived diversity promotion on engineering identity via sense of belonging for each level of the moderators (cohort and gender). As the moderating effect is not significant, the overall indirect effect is requested using process model 4 and reported here.

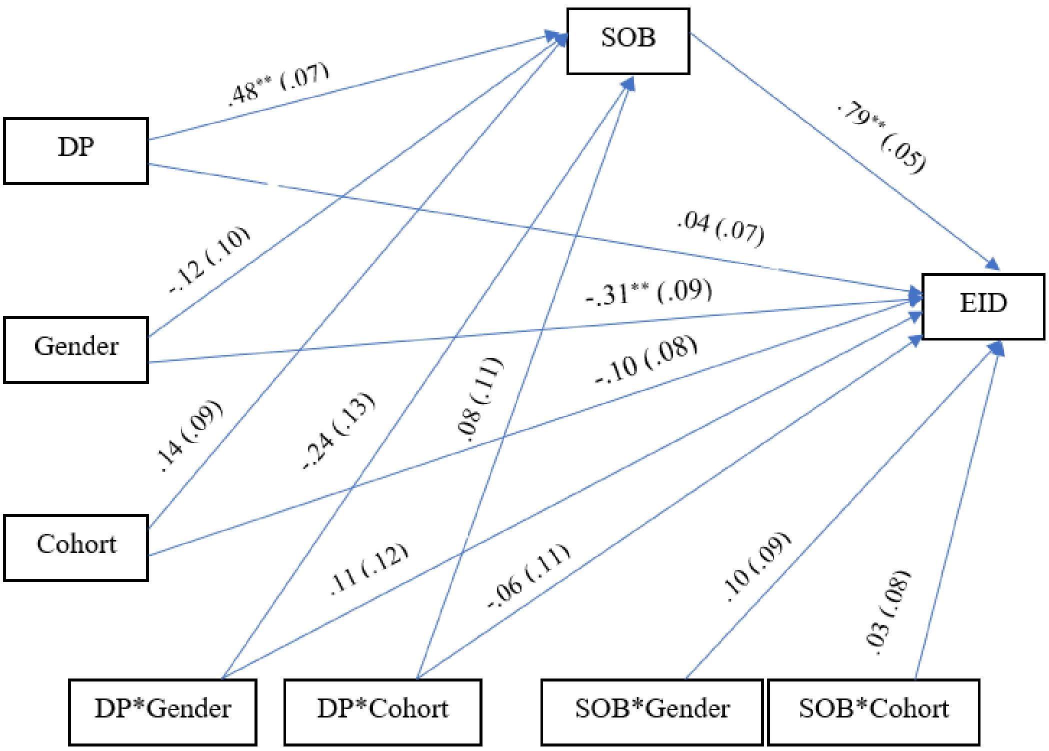

Figure 3: Moderated mediation model showing the unstandardized coefficients (*b*) and corresponding standard error (*SE*) of each path. **Correlation is significant at the .01 level

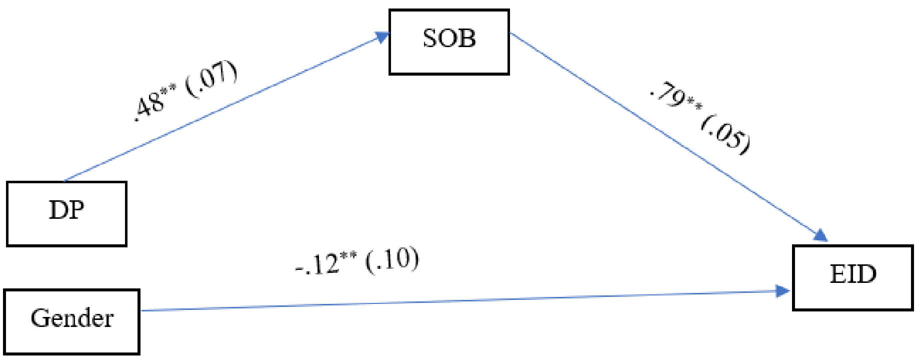

Figure 4: Final model showing the significant paths with their unstandardized coefficients and standard error