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ORIGINAL ARTICLE

Person or thing oriented: A comparative study of individual differences of first-year engineering students and practitioners

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Abstract

Background: Engineering practice is meant to advance the human condition, yet curricula do not appear to fully promote the human-centered philosophy of engineering in implementation. The educational system may inadvertently signal to students that engineering is a career choice better suited for those preferring to work with things rather than people. This framing of the profession prompts questions regarding student interests when compared to those of practicing engineers and how such interests become concrete through education and introduction into the profession.

Purpose/Hypothesis: We compare engineering students' and practitioners' interest in working with people or things in their environment. We examine gender differences for each sample.

Design/Methods: Multiple analysis of variance was used to examine the samples of practicing engineers ($n = 339$) and first-year engineering students ($n = 383$). A multiple-group confirmatory factor analysis provides evidence of measurement invariance and justifies the use of the person–thing orientation (PO–TO) scale structure for both samples.

Results: Detailed PO values reveal that students' PO scores ($n = 383$, $M = 3.313$) are more than one and a half points lower than practicing engineer counterparts examined ($n = 339$, $M = 4.836$). However, no significant difference between practicing engineers and students was found for TO. Further, statistically significant differences in PO and TO were found between male and female participants within both samples, students and practicing engineers.

Conclusions: Differences detected in PO and TO across the samples suggest possible environmental factors influencing student perspectives of the engineering profession. This condition may inadvertently discourage more diverse students from pursuing engineering.

KEYWORDS

career choice, engineering practice, first year, professional identity, workplace culture

1 | INTRODUCTION

A shift in the portrayal of engineering could be valuable when considering how to attract more women into the engineering profession (National Academy of Engineering, 2012). Despite efforts to reframe engineering in a more exciting and female-friendly way (Giddens et al., 2008), studies investigating female interest in science and medicine over engineering often cite a preference among females for occupations focused on helping others (Miller, Rosser, Benigno, & Zieseniss, 2000). There exists a distinct female preference for occupations that engage people rather than mechanical artifacts (Miller et al., 2000). Industrial engineering, of all engineering disciplines, is noted to disproportionally attract more females because of its perceived focus on humans and society (Brawner, Camacho, Lord, Long, & Ohland, 2012).

This work draws on two constructs, person-orientation (PO) and thing orientation (TO), to capture the divergent interests of students (Graziano, Habashi, Evangelou, & Ngambeki, 2012). PO concerns the preference for social engagement, while TO is the preference for working with objects. Limited work has comprehensively examined the difference in the two orientations in representative samples of engineering students and, a more elusive group to research, of practicing engineers. A review of the literature suggests there is a desire to improve the image of engineering as a socially engaged discipline that helps humanity, moving it toward a PO (National Academy of Engineering, 2008). The literature's assumption asserts that emphasizing the potential of engineering as a human-centered endeavor will result in higher initial and prolonged interest in engineering. Research investigating engineering as a profession has found few examples of specific engineering disciplines considered to be person-oriented (Diekman, Brown, Johnston, & Clark, 2010). The lack of social sensitivity may suggest engineering is a career choice better aligned to individuals with a TO rather than a PO.

2 | BACKGROUND

Broadening participation in engineering has long been a goal of engineering education (Lichtenstein, Chen, Smith, & Maldonado, 2015). This goal is highlighted by grant opportunities offered by funding agencies like the National Science Foundation and the presence of cocurricular support centers (Lee & Matusovich, 2016) for students from underrepresented groups. Although such programs are numerous, this work concerns a specific reframing of the engineering profession, one centered on meeting human needs. To situate the purpose of this article in the literature, we discuss the attempts engineering educators have made to expand the perception of engineering beyond being thing orientated. Then the disconnect in the approaches is presented along with frameworks to conceptualize why changing the perceptions of engineering is difficult to achieve.

2.1 | Efforts toward person-oriented curricula

Considering that engineering is traditionally thought of as a thing-oriented profession, students with a PO may remove most of the engineering disciplines from consideration as a career long before they submit their college applications. Student recruitment then becomes the issue for advocates of underrepresented groups and scholars of diversity since, in an engineering program, overcoming traditional perceptions must occur before the first year. Perhaps more troubling is that engineering educators' description of engineering mimics students' typically thing-oriented perceptions of engineering. Faculty describe engineering as applied science and math, problem-solving, and making things (Pawley, 2009), all of which do not support the PO narrative.

Beyond academia, the view of the engineering profession often depends on public perceptions and shared experiences of practicing engineers. Engineering is generally described as concerned with the creation of artifacts, processes, and systems (National Academy of Engineering, 2005; Sheppard, Colby, Macatangay, & Sullivan, 2007). The public perception of engineering is one of the most attractive reasons why young people choose to pursue this profession. Students who choose engineering as a career are looking for the opportunity to improve and create designs in our material world (Bairaktarova, Pilotte, Evangelou, & Cox, 2013). Several specific engineering disciplines are solely concerned with the creation of tangible objects in one form or another, but more broadly, human interests and desires do factor into designs. Yet, most descriptions of engineering define the field generally by a central concern with the creation of things. Students tend not to see beyond the TO perception until they participate in professional work experiences such as co-ops, which are often transformative experiences for their development of an engineering identity

(Eliot, Turns, & Xu, 2008). However, such experiences often occur too late in the curriculum to influence career trajectories.

Higher education research reveals that students persist once they find where they belong (Cross & Vick, 2001; Morrow & Ackermann, 2012). Considering the evidence, providing a broad and accurate view of engineering in practice by highlighting practitioners' PO in intensive design roles seems critical. In particular, doing so may be important in attracting and retaining all students, including populations such as women with lower initial interest. Although first-year engineering programs have recently taken a more holistic approach to the formation of engineers, issues persist regarding how engineering is viewed. These perceptions may be driven in part by early engineering education in P-12, where many instructors rely heavily on hands-on learning engaging technology and materials to aid understanding of mechanics and spatial reasoning (Brophy, Klein, Portsmore, & Rogers, 2008).

In the classroom, some educators have attempted to create environments to facilitate the matriculation of a more diverse first-year population and to appeal to the interests of students with a PO. Faculty have leveraged educational models focusing more on the human experience than simply training students to create functional and innovative artifacts. Some of these educational models include Service-Based Learning and Immersive Experiences (Zoltowski, Oakes, & Cardella, 2012); Empathic Experience Design (EED) Method (Genco, Johnson, Hölttä-Otto, & Seepersad, 2011); Product Realization for Global Opportunities (Mehalik, Lovell, & Shuman, 2008); Engineering for Development and Product Innovation for the Bottom of the Pyramid (Prahalad, 2012); and Eco-Design Courses (Morris, Childs, & Hamilton, 2007). Related research reveals that the utilization of user interviews, focus groups, and immersive practice has had a beneficial impact in design engineering activities in industry (Vredenburg, Mao, Smith, & Carey, 2002). Visual thinking is also purported to be an effective means of engaging students in empathic design without using physical materials. It is feasible to use a supplemental assignment to infuse empathic design thinking into an existing course traditionally considered thing-oriented (Bairaktarova, Bernstein, Reid, & Ramani, 2016).

Trevelyan (2008) argues that engineering education must shift its current position from the periphery "to integrate studies of engineering practice in the curriculum to help overcome widely perceived weaknesses in engineering education" (p. 12). This curricular refocus toward authentic practice has become quite visible in the design field in recent years. This shift has led to the development of several methodologies: human-centered design, empathic design, design for affordability, and user-experience design to name a few. Designers feel a tremendous sense of responsibility today as they create for increasingly diverse users, cultures, and environments. Also, they frequently must address systematic and so-called wicked design challenges (Buchanan, 1992). Design-focused engineers look for alignment of project stakeholders and in recent years, concern themselves with their customers' feelings (Jordan, 2000; Yun, Han, Hong, & Kim, 2003). The increased concern for stakeholder emotions, wants and desires is a guiding premise of empathic design as "remarkable things can happen when empathy for others plays a key role in problem-solving" (Battarbee, Suri, & Howard, 2015, p. 1). Through the reframing of engineering in the classroom from a TO to a PO, the curriculum designers attempt to create a sense of belonging for a broader set of students outside of those already sending in their college applications to engineering colleges and programs.

2.2 | Theoretical framework

Most would agree it is essential for engineering students to understand the interconnection of things *and* people. Little (1968) developed a theory on how people selectively orient to environments that are congruent with their interests. Just as human interests can be parsed into categories of people and things, one can parse the environment in a similar fashion. Therefore, we might expect people to choose learning and work environments congruent with their interests (Ginzberg, Ginsburg, Axelrad, & Herma, 1951) and affinity for the role (Kniveton, 2004). This decision-making strategy is particularly true in the United States, where personal interests are primary motives for career choice (Maltese & Tai, 2011).

Based on the work by Graziano et al. (2012), an individual's preference between people-oriented events and activities versus TO (PO–TO) can also be established. The two constructs are independent of each other as has been shown empirically (e.g., Woodcock et al., 2013). As the science, technology, engineering, and math (STEM) fields are perceived as thing-oriented, we might expect that people high in TO are attracted to STEM (Graziano et al., 2012; Graziano, Habashi, & Woodcock, 2011; Yang & Barth, 2015). For example, in a related study (Graziano et al., 2011), gender differences in the choice of a college major were highly correlated to the PO and TO dimensions. Additionally, these researchers found that PO may push people towards person-oriented careers and drive people away from TO careers, while TO was found to move people toward thing-oriented careers while being *unrelated to* the selection of person-oriented careers (Graziano et al., 2011). Finally, the study found that women and men high in TO expressed more interest in thing-oriented careers, an effect particularly pronounced for women (Graziano et al., 2012). Therefore, interests are an important determinant of career choice when considering the pursuit of a given career, particularly for women, when the choices are perceived to be at odds with gender role stereotypes.

Gender role stereotypes, traits associated with a "typical man" and a "typical woman," exist in most STEM fields (Guimond, Chatard, Martinot, Crisp, & Redersdorff, 2006) and exacerbate career preferences associated with PO and TO. Further, in traditionally masculine domains such as STEM, women typically underestimate their performance compared with men and may not persist despite a TO preference. Gender-biased self-evaluations mediated by social stereotypes can have detrimental effects on women's performance and persistence in these domains (Woodcock & Bairaktarova, 2015). Thus, women typically enter their undergraduate engineering training with lower evaluations of their ability to succeed than men; and this gap is sustained, and even widens, over the course of their undergraduate years (e.g., Besterfield-Sacre, Moreno, Shuman, & Atman, 2001; Felder, Felder, Mauney, Hamrin, & Dietz, 1995; Woodcock & Bairaktarova, 2015).

In this study, we utilize Graziano et al.'s (2011) PO–TO scale to examine how the person versus thing tendencies appear in engineering college students and practicing engineers. We aim to identify potential sources of differentiation for these preferences within and across the sample populations. Once an understanding of the PO–TO profiles of student and practicing engineers is achieved, then work can begin examining engineering educational practices, the impact of student profiles on disciplinary selection and retention, and long-term individual decision making regarding engineering career choices and persistence.

Accordingly, the objectives associated with this work are to (a) identify potential sources of differentiation around PO and TO associated with the engineering profession and (b) look across the sample populations to explore gender differences. As such, the following research questions were posed:

RQ1: *What are the differences between the PO–TO scores of first-year engineering students and practicing engineers?*

RQ2: *What are the differences in the PO–TO scores between genders in both sample populations?*

3 | METHODS

This study was conducted as two independent data collections in which each of two distinctly different sample populations, first-year engineering students and practicing engineers, were provided with person-thing related questions via the PO–TO scale survey (Graziano et al., 2011). In addition to the PO–TO questionnaire, participants from both samples self-reported demographic information (age and gender), which allowed for additional disaggregation. In the following sections, we outline the sources of data and method of analysis.

3.1 | Data collection

For the target subject populations, data were collected using an electronic survey instrument hosted by Qualtrics (Qualtrics Labs Inc., 2012) via a secured cloud server. The survey instrument administered to the students and the practicing engineers consisted of the Graziano et al. (2011) PO–TO scale items with Likert-type responses inquiring about participant interest in each prepared statement, ranging from "not at all [interested]" to "extremely [interested]." The responses were assigned a one- to five-point numeric value.

The students completed the online survey outside of class as an additional activity. Participation was completely voluntary. The practicing engineers completed the online survey "at will" based on their availability and schedule. They were provided the online link via an initial outreach email invitation soliciting their participation.

3.2 | Participants

Participants from each population examined were recruited through convenience sampling. The first-year engineering student participants for this study were from a large Midwestern university in the United States and totaled 383. The sample was a subset of nearly 1,900 first-year engineering students and was selected because one of the researchers was an instructor. The sampled classrooms had a total of 404 students, resulting in a 95% response rate. Most of the 339 industry practicing engineering participants lived in the Midwest (Indiana/Illinois/Ohio/Michigan). These participants were solicited through outreach efforts that included emails to 42 industrial firms that commonly employ large numbers of engineers, to professional engineering associations, and through social networking sites. Participants in the sample were employed and working within the United States in a wide variety of firms across both product and service sectors, representing private, public ownership, and not-for-profit status. Study participants represented a variety of industry sectors that generally engaged in manufacturing operations. They included, but were not limited to, automotive, aerospace, consumer products, electronics, healthcare supplies and diagnostics, food processing, heavy industrial/agriculture equipment, and commercial/construction equipment. The participants also held a variety of roles and represented a broad range of professional employment tenure (Table 1). At least one participant completed the survey from each of the 42 firms; however, an exact response rate cannot be calculated due to uncertainty about the total number of engineers employed at the 42 firms at the time of the survey release.

Demographic summaries were calculated for each subject sample (Table 2). The total participating student sample ($n = 383$) was slightly larger (13%) than the practicing engineer sample ($n = 339$); yet, the gender identity of each sample was essentially equal at nearly 17% female and 83% male.

3.3 | Analysis

Prior to comparing PO and TO profiles of the student and practicing engineer samples, a multiple-group confirmatory factor analysis (CFA) was conducted on the PO–TO scale administered to the practicing engineers as no such evaluation of use for this target population had been validated to date. The Mahalanobis distance (Penny, 1996) was evaluated for each regression of the dependent variable to screen for exceptional multivariate outliers. The calculated Mahalanobis distance values for each dependent variable were below the critical value, indicating no substantial multivariate outliers. To determine the optimal number of scale factors for the practicing engineers' data for analysis, we set three criteria for selecting the final model. First, the model should fit the data well. Second, a model with one fewer factor should fit substantially worse. Finally, a model with one additional factor should not fit appreciably better. The comparative fit index (CFI), the Tucker–Lewis index (TLI), and the root mean square error of approximation (RMSEA)

TABLE 1 Industry sector, years of employment, and organization type for practicing engineer sample

Sample descriptors	% Sample
Industry sector	73%
Manufacturing	8%
Professional/scientific services	4%
Technical services	3%
Health care	4%
Communication/information	3%
Mining; construction; energy; distribution	2% each
Other	2%
Years of employment	
20 + years	34%
11–20 years	21%
6–10 years	14%
4–5 years	9%
0–3 years	22%
Organization type	
Publicly traded	80%
Private	18%
Non-profit	2%

TABLE 2 Demographics of sample populations

	FYE students		Practicing Engrs.	
	N	% Sample	*N*	% Sample
Gender				
Female	66	17.20%	59	17.40%
Male	317	82.80%	280	82.60%
Total	383	100%	339	100%
Ethnicity				
Asian	92	24%	24	7%
African American	8	2%	10	3%
Hispanic	8	2%	14	4%
Native American	1	0.30%	1	0.30%
White	234	61%	275	81%
Other/multiple	0	0%	5	1%
Did not provide	41	11%	10	3%
Total	383	100%	339	96%

Abbreviations: Engrs, practicing engineers; FYE, first-year engineering.

for each model are reported. Quantitative model scholars indicate that CFI and TLI values of 0.95 or greater reflect an adequate model fit (Hu & Bentler, 1999). RMSEA values of 0.05 or less indicate good fit, values ranging from 0.08 to 0.10 indicate mediocre fit, and values greater than 0.10 indicate poor fit (MacCallum, Browne, & Sugawara, 1996).

Next, using three multiple analysis of variance (MANOVA), an iterative examination of the independent variables (student vs. practicing engineers; male vs. female groups) was conducted to identify if statistically significant mean differences existed between groups in relation to the four hypotheses listed in Table 5.

4 | RESULTS

The results from the CFA are reported first, followed by the MANOVAs. The CFA provided support for the structure of the short-form of the PO–TO instrument and guided the design of the MANOVAs.

4.1 | Confirmatory factor analysis

To check for measurement invariance, a multi-group CFA was conducted on the 13-item scale with students and practicing engineers. The model provided good fit, $\chi^2(132) = 516.449$, $p < .0001$, CFI = 0.947, TLI = 0.935, RMSEA = 0.092 (90% CI interval = 0.084–0.100), SRMR = 0.083. All factor loadings were significant (all p values $<.001$). Configural invariance held based on the overall model fit. Next, the factor loadings were constrained to be equal. Metric invariance, that is, factor loadings did not change across administrations, was sound. The assessment of metric invariance was based on the changes in the model's CFI and RMSEA from the baseline configural model being equal to 0.008 and 0.003, respectively, below the threshold recommended by Cheung and Rensvold (2002). Finally, the intercepts of the items were constrained to be equal. Scalar invariance, meaning item intercepts are equal and the groups can be compared, was also defensible with a further change of 0.001 in the RMSEA and 0.014 in the CFI, slightly above the threshold. In summary, the baseline configural model experienced a total change of 0.017 in the CFI and 0.009 in the RMSEA after all constraints had been applied. The overall multi-group CFA results are given in Table 3.

The PO and TO individual variables were created using specific scale element responses obtained from each sample. For each participant, a mean was calculated across eight items for the PO score and again for five items for the TO score. Table 4 shows the average PO and TO values by group and gender.

We can immediately note that the PO values (Table 4) reveal that students' PO scores ($n = 383$, $M = 3.313$) are 1.523 points lower than their practicing engineer counterparts ($n = 339$, $M = 4.836$). This difference is captured in the

TABLE 3 Multi-group confirmatory factor analysis results

	Pattern coefficient estimates		Standard errors		*z*-value	
Item	**FYE**	**Engrs**	**FYE**	**Engrs**	**FYE**	**Engrs**
Listen in on a conversation between two people in a crowd.	0.441	0.300	0.028	0.035	15.78	8.549
Strike up a conversation with a homeless person on a street.	0.547	0.552	0.029	0.033	18.927	16.548
Listen with caring interest to an old person who sits next to you on a bus.	0.704	0.734	0.280	0.033	25.173	22.186
Notice the habits and quirks of people around you.	0.607	0.452	0.029	0.033	21.113	13.741
Make the first attempt to meet a new neighbor.	0.631	0.535	0.027	0.032	23.168	16.726
Attend a speech given by a person you admire without knowing the topic of the speech.	0.486	0.547	0.030	0.033	16.352	16.381
Attempt to comfort a total stranger who has had a disaster happen.	0.722	0.788	0.028	0.035	25.699	22.371
Gain a reputation for giving good advice for personal problems.	0.696	0.470	0.028	0.035	24.625	13.411
Redesign and install a stereo sound system yourself.	0.755	0.639	0.030	0.029	24.797	22.269
Take apart and try to reassemble a desktop computer.	0.430	0.740	0.031	0.029	23.684	25.910
Stop to watch a machine working on the street.	0.504	0.716	0.032	0.03	15.552	23.942
Remove the back of a mechanical toy to see how it works.	0.741	0.809	0.032	0.029	23.197	28.038
Try to fix your own watch, toaster, and so forth.	0.705	0.783	0.030	0.028	23.482	27.742

Abbreviations: Engrs, practicing engineers; FYE, first-year engineering students.

TABLE 4 Person-orientation and thing-orientation mean values by group and gender

Population		***N***	**TO Mean**	**TO *SD***	**PO Mean**	**PO *SD***
Total sample male		597	3.561	0.787	3.986	0.958
Total sample female		125	2.955	0.838	4.229	0.873
	Total	722	3.456	0.828	4.028	0.948
Practicing male		280	3.521	0.828	4.816	0.377
Practicing female		59	2.932	0.823	4.930	0.415
	Total	339	3.418	0.854	4.836	0.386
FYE student male		317	3.597	0.749	3.252	0.676
FYE student female		66	2.976	0.675	3.602	0.675
	Total	383	3.490	0.804	3.313	0.688

Abbreviations: FYE, first-year engineering; PO, person orientation; TO, thing orientation.

MANOVAs in the next section. The relationship across PO and TO was investigated using the Pearson product–moment correlation coefficient. Pre-investigative analyses were performed to ensure no violation of normality, linearity, and homoscedasticity assumptions before conducting the primary analysis. The two variables (PO and TO) are weakly correlated ($r = .170$, $n = 383$, $p < .01$) for the student sample, as expected.

4.2 | Multiple analysis of variance

Three MANOVAs between the sample groups, students and practicing engineers, and within sample groups by gender as outlined in the research hypotheses (Table 5) were conducted to explore the relationship with the PO–TO scores. A statistically significant difference was detected between students and practicing engineers in PO scores [$F(1,721) = 1{,}300.785$, $p < .0001$]. There was no statistical difference in TO scores between students and practicing engineers. However, a statistically significant difference was found between the genders on both PO scores [$F(1,721) = 6.860$, $p = .009$] and more strongly in TO scores [$F(1,721) = 59.872$, $p < .0001$]. The practicing engineer

TABLE 5 Results for the research hypothesis at the α = .05 significance level

Hypothesis	Result	Decision
Differences do not exist in PO scores between FYE students and practicing engineers	(N = 722) [F(1,721) = 1,300.785, $p < .0001$]	Reject
Differences do not exist in TO scores between FYE students and practicing engineers	(N = 722) [F(1,721) = 1.343, p = .247]	Fail to reject
Differences do not exist in PO scores between genders	(N = 722) [F(1,721) = 6.860, p = .009]	Reject
Differences do not exist in TO scores between genders	(N = 722) [F(1,721) = 59.872, $p < .0001$]	Reject

Abbreviations: FYE, first-year engineering; PO, person orientation; TO, thing orientation.

sample had a statistically significant higher mean PO score than the first-year engineering student sample. Table 5 presents a summary of the findings for the statistical significance testing of each of the four research hypotheses.

5 | DISCUSSION

The results of the study analyses highlight two key findings: (a) differences exist in PO between first-year engineering students and practicing engineering professionals and (b) differences exist in PO and TO by gender within the samples. Next, we offer viable implications for each finding as a meaningful addition of consequence to the current body of engineering education research.

5.1 | Differences between students and professionals

First, the results reveal that students' PO scores (n = 383, M = 3.313) are more than one and a half points lower than their practicing engineer counterparts (n = 339, M = 4.836). Because the study instrument measures only personal interest, we cannot claim to know how the lower PO scores of students influence their perception of engineering. Yet, for whatever reason, practicing engineers' PO scores, which represent different points in engineering development from students, are meaningfully different. If explored further, this finding potentially adds to the current literature by providing an increased understanding of students' awareness of the human-centered nature of engineering (Pawley, 2009). As noted previously, precollege students elect to become engineers, in part because of their perceived alignment of personal values with the profession as they understand it (Matusovich, Streveler, & Miller, 2010; Pilotte & Bairaktarova, 2013). To the extent the profession of engineering projects a TO identity through its educational tenor, public images, and associated stories about what it means to engineer, it would follow that students who self-identify with that image would direct themselves toward engineering.

Likewise, students who *do not* identify with the prevalent images associated with engineering as a profession would self-select out of engineering without ever having fully experienced what the profession might have to offer them, as suggested by Little's theory (1968) and Ginzberg et al. (1951). The issue of engineering identity, self-identity, and, at a larger scale, culture has been used in other scholarly works to partially explain why women fail to be attracted to or are not retained in the engineering profession (Faulkner, 2007; Pilotte, 2013; Pilotte, Ngambeki, Branch, & Evangelou, 2012). The identity of a profession is thought to be formed through its espoused values as well as the rituals, the practices, and the proclaimed heroes of the given culture (Hofstede, Hofstede, & Minkov, 2010). Based on Hofstede and colleague's elements of professional culture, perhaps the education-based understanding of engineering practice that students are being taught is somehow disconnected or incongruent with the "real world" version of the engineering culture of practicing engineers.

Likewise, if explored further, the significantly higher PO scores of practicing engineers could add to the literature as a contrasting viewpoint between what students find interesting in engineering versus the lived experience of engineering practice (Bairaktarova et al., 2013; Pilotte et al., 2012). The higher PO orientation of practicing engineers may be a different version and function of a treatment effect. For example, once in the world of work, a person retaining lower PO may be met with slower professional success, fewer career growth opportunities, and reduced options for work assignments. The change may occur since the world of work is a collaborative endeavor requiring some level of human orientation and empathy (Pons, 2016; Rogers & Ellis, 1994; Walther, Miller & Sochacka., 2017). If the previous assertions are true, finding ways to make students aware of the realities of engineering practice is a non-trivial endeavor and essential for their professional formation.

The proposed reframing of the curriculum toward a PO will require more than an increase in student work experiences (treatment). A curricular reframing may also require a closer examination of how truly authentic the engineering culture presents itself through the practices, values, and heroes presented to students in educational settings; through the faculty; and in the nature, content, and dynamics of their coursework. The findings suggest there is still a great amount of work to be done in engineering education and with the profession, examining aspects critical to career selection and developing an understanding of engineering workplace treatments that influence a shift from TO to PO.

5.2 | Difference in gender

This study also offers findings demonstrating that females have a higher PO orientation than males, in both the student and practicing engineer samples (see Tables 3 and 4). Some may suggest that this second finding aligns with scholarly works proposing that women are innately person-oriented (Lippa, 2014). Prior engineering education research exploring the intersection of gender and professions might suggest that the orientations of the gender groups are further evidence of the effect of cultural norms and biases. (McIlwee & Robinson, 1992; Ngambeki et al., 2012). As authors of this study, we place no judgment on whether the result is biologically or socially constructed. Rather, we present the data as simply another metric of the “as is” condition of both students and practicing engineers.

Multiple studies report that women who leave engineering tend to migrate to non-engineering majors or professions (Min, Zhang, Long, Anderson, & Ohland, 2011; Seymour & Hewitt, 1997). In the often-cited book, *Changing the Conversation* (National Academy of Engineering, 2008), an urgent need to remarket the image of engineering is reported, with an aim to not only attract but also retain more students representing gender diversity. The premise for the rebranding is based on research suggesting that women are particularly more likely attracted to messages and images related to social engagement and helping others (National Academy of Engineering, 2008). As noted by literature referenced earlier in the paper, if students believe or come to believe that engineering is primarily a masculine and technology-focused profession, first-year engineering students with high PO orientation (in particular females) may identify less with the perceived professional culture before developing an opportunity to realize how person-oriented the engineering profession is or can be.

A range of research suggests student values, enjoyment for the field, and skill development are all challenged negatively in the first-year of engineering (Besterfield-Sacre et al., 2001; Marra, Rodgers, Shen, & Bogue, 2009; Pierrakos, Beam, Constantz, Johri, & Anderson, 2009). Where values and enjoyment are examined, perhaps such values and activities associated with being person-oriented are yet to be clearly isolated and fully understood in such studies. Insight may be found in research conducted by Leonardi, Jackson, and Diwan (2009), who describe how first-year engineering students practice engineering based on counterproductive perceptions of stereotypes associated with the profession, which then are normalized. These expectations include performing individualistic, isolated work low in collaboration. Such occupational rationalizations may work against those with high PO in the engineering classroom over time, ultimately leading to attrition associated with climate, culture, or interest/career goals (Geisinger & Raman, 2013).

The description of engineering culture as person-oriented is rarely empirically demonstrated but is corroborated in this study through the first finding, as the practicing engineering sample has a statistically higher threshold of PO over the first-year engineering student sample examined. Yet, more work in this area is needed to better understand how this finding associated with the profession of engineering may elude first-year students.

6 | LIMITATIONS AND FUTURE WORK

While robust and controlled in its methods, this is a correlational study. Therefore, no causation can be established. Further, as with all research, this study has limitations. First, while both groups examined in this study were large, they relied on convenience samples and are heavily represented by a Midwestern demographic. It could be that factors associated with participants from the center region of the United States offer some unknown explanatory power for these results. Second, while we used the only available measure created specifically for empirical research on the two variables (PO–TO), we could not avoid the issue of participants self-reporting. Design of future research using the measure could include asking each participant to name two people who knew them well and send these “knowledgeable informants” the same scale to rate the student/practicing engineer from their perspectives.

Future studies aligned with this work have an opportunity to investigate institutional efforts focused on recalibrating student expectations around the high PO nature associated with the practice of engineering. Further research would benefit from increasing insight into how fundamental coursework within engineering education can be altered to speak to and value high PO orientations in engineering students or engineering student prospects.

This study also found that practicing engineers are significantly higher in PO than first-year engineering students. One plausible alternative explanation that we did not explore or discuss in this paper is that practitioners are older and more expert in their profession than college students. Are the results demonstrating an age/maturity effect or an expert/novice effect? Another plausible alternative explanation is that there is a generation/cohort effect. Perhaps, the previous generations of engineers (now practicing engineers) may have been trained through different programs and models of the profession and its expectations (i.e., variances in practices and/or values). We may be observing some form of training difference or perhaps a generation-related change associated with the image of the profession. Perhaps, it is that PO gave the engineering practitioners a selective advantage in the profession that high TO/low PO did not offer them during their early career transition?

In addition, we note that the practicing engineering sample is heavily overrepresented by the manufacturing sector. The manufacturing sector itself cannot provide a full and accurate portrayal of all engineering professionals. It could be the case that manufacturing naturally attracts those with higher PO scores than other industry sectors, leading to the results reported here. Future research could investigate the presence of high PO seen in these results by examining a larger and broader sample of engineering professionals beyond manufacturing.

Finally, regarding the role gender plays in individual differences, we replicated the gender PO–TO difference reported in prior research, but this time a different sample is represented—practicing engineers. Questions remain here as well. Why would women as a group be higher in PO than men as a group? Are women innately more person-oriented? We can raise the questions, but we lack specific data to address them. That said, we can make inferences. As these results represent a collection of individual differences, we are keenly aware that not all women are high in PO, nor are all men low.

Furthermore, because PO has been proven to be virtually orthogonal with TO, we may have unique configurations of individuals in the data (i.e., high PO/low TO, low PO/low TO, etc.). In the case of engineering, we may be observing niche picking (Scarr & McCartney, 1983) in that women higher in TO are attracted to engineering, just as the men who are higher in TO. For women, does the higher PO come along as a “bonus”? The answer to that question is also unknown. In sum, while many beneficial and insightful results are revealed in this study, many deep questions persist offering exciting future dimensions for empirical investigation.

7 | CONCLUSIONS

The purpose of this study was to explore if differences exist in PO or TO between first-year engineering students and more experienced practicing engineers. The second aim of this work was to build evidence of the extent to which we might examine the role of gender influence upon those orientations. This study provides unique empirical evidence that these two distinct populations of students and engineering professionals are differently oriented on the PO–TO scale. Further, the data reaggregated by gender provides additional insights into the differences across the samples examined. Specifically, this study provides data demonstrating higher PO in engineering professionals than in first-year engineering students and higher PO in women than men across both groups sampled.

While this study begins to shed light on old questions in the domain of engineering education research, many questions remain, and new questions are exposed. Future opportunities for meaningful research revolve around if and how knowledge of these PO and TO should inform student recruitment into engineering as well as program and curriculum design. Further, engineering education researchers are called to strongly consider expanding exploration into the culture of engineering practice to help highlight and align apparent disconnects in student expectation, classroom pedagogy, and practical engineering experience.

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