The Role of Prosocial Goal Congruity on Student Motivation in Electrical Engineering

Brock J. LaMeres, *Senior Member, IEEE*, Maxwell S. Burns, Dustin B. Thoman, and Jessi L. Smith

Abstract*—*Contribution: **Prior studies on goal congruity show that students are more motivated to pursue careers that allow them to work with and help others and give back to their community (i.e., careers that afford prosocial value). This paper discovers this same pattern in electrical engineering (EE) and discovers that prosocial affordance beliefs are significantly associated with intensions to persist, while agency beliefs are not.**

Background: **Goal congruity theory finds that people are more motivated to pursue a career if it aligns with values they endorse. This theory can shed light on why some students do not persist in EE because of the stereotype that the profession does not allow working with and helping others.**

Research Questions: **This paper seeks to answer whether EE students perceive the profession as affording prosocial value, and to test associations between prosocial perceptions and motivation to persist in the field.**

Methodology: **The first study in this paper was conducted on students in an introductory EE course ($n = 79$) that measured affordance beliefs about the EE profession and tested associations with intensions to persist. The second study compared affordance beliefs and trait endorsements held by students in the introductory level course with those in an advanced EE courses ($n = 51$).**

Findings: **Mediation analysis revealed that the more novice students believe that EE allows them to fulfill prosocial goals, the greater their persistence intentions (95% CI: 0.01 to 0.34). This analysis also showed that agency beliefs were not strongly associated with persistence intensions.**

***Index Terms*—Expert-novice, goal congruity, motivation, persistence, social responsibility.**

I. Introduction

To MEET the grand challenges facing society, there is a need for more engineers, more diverse thinking in engineering, and a workforce that considers the global impact of engineering decisions. This engineering workforce must be able to think about problems from different vantage points, including those outside the technical domain [1]. The engineering workforce of tomorrow will need to work as part of highly interdisciplinary teams that include stakeholders from business, policy-making organizations, and regulatory bodies. Additionally, to implement solutions to the grand challenges, engineers will need to lead teams that, as well as meeting technical requirements, can garner the political and social will for these technical solutions to be enacted [2]. As the stewards of technology and its consequences, it also falls to the engineering workforce to develop solutions that are sustainable and serve all members of society regardless of social status or ethnicity [3].

In 2004 and 2005, the National Academy of Engineering (NAE) released seminal reports describing the characteristics needed by the *engineer of 2020* to meet the grand challenges facing society in the next century [4], [5]. An overarching theme of these reports was that the challenges engineers will face are on an unprecedented scale, and need to be approached in a new way. The report chronicled that while technological advances over the past century led to unprecedented prosperity for some portions of society and fueled exponential global population growth, they simultaneously created problems so complex they cannot be solved by a single engineering discipline. The NAE reports call for engineers who think about solving problems in a global context. They further highlighted that problems of this scale can only be solved by highly interdisciplinary teams. This call for interdisciplinary problem solving was unique in that it transcended traditional engineering disciplines, calling for knowledge from the social sciences, business, political science, and the humanities in order be successful. The report called for a renewed effort to strengthen the engineering workforce through recruitment of people with different backgrounds into the profession, especially those who weigh social responsibility as being equal to technical achievement.

As the year 2020 draws near, engineering has not witnessed a significant cultural shift to valuing professional skills (working with others, communications, ethical treatment of technology) at the same level as traditional technical skills. There is thus a renewed focus on studying the processes, both formal and informal, by which a person becomes an engineer [6]. This line of research could help increase both the size and the diversity of thought in the engineering workforce [7], [8], declared in numerous reports to be a global imperative [1], [2], [6]–[8]. The two studies in this paper seek to contribute to the body of knowledge on how preconceptions

Manuscript received December 8, 2017; revised August 2, 2018 and November 19, 2018; accepted January 20, 2019. Date of publication March 13, 2019; date of current version October 29, 2019. This work was supported in part by the National Science Foundation under Award 1544147.
(Corresponding author: Brock J. LaMeres.)

B. J. LaMeres is with the Department of Electrical and Computer Engineering, Montana State University, Bozeman, MT 59717 USA (e-mail: lameres@montana.edu).

M. S. Burns is with the Department of Psychology, Montana State University, Bozeman, MT 59717 USA (e-mail: maxwell.burns@montana.edu).

D. B. Thoman is with the Department of Psychology, San Diego State University, San Diego, CA 92182 USA (e-mail: dthoman@mail.sdsu.edu).

J. L. Smith is with the Department of Psychology, University of Colorado at Colorado Springs, Colorado Springs, CO 80918 USA (e-mail: jsmith20@uccs.edu).
Digital Object Identifier 10.1109/TE.2019.2897265

about the electrical engineering (EE) profession may hinder certain students from choosing it as a career path.

A. Prior Work on Engineering Attrition

Engineering attrition within higher education is a significant concern to those involved in the professional formation of engineers. First-year engineering students achieved academic success in high school and took the next key step in their formation by choosing engineering as their major. However, data from the U.S. Department of Education show that 41% of students who initially choose engineering either change to non-engineering majors, or ultimately do not obtain a degree [9]. Examining first-year persistence intentions (i.e., the percentage of students who intend to return to an engineering program their sophomore year) can shed light on why some students don't matriculate to graduation. Prior studies have found that persistence rates vary dramatically with institution type and student demographics. In elite universities with strict acceptance standards (i.e., <25% accepted), persistence rates can be as high as 100%, whereas in universities with open admissions it can be as low as 37% [10], [11]. Women and underrepresented minority (URM) students show even more variability in persistence rates. The majority of studies, however, cite the "culture" of the profession as the most common reason for students leaving engineering [12]–[14].

Student persistence in engineering has been studied for over a half century [14]. Prior studies have revealed six broad factors that contribute to attrition in engineering: (1) classroom and academic climate; (2) grades and conceptual understanding; (3) self-efficacy and self-confidence; (4) high school preparation; (5) interest and career goals; and (6) race and gender. Each of these factors are interrelated. There are theoretical frameworks that exist within each factor and others that account for multiple factors simultaneously [14].

The work in this paper contributes to factor (5), interest and career goals. Research in this area requires considering the interplay between multiple factors as it attempts to explain how interests in a field develop over a student's lifetime and what processes influence a student's decisions to take action toward achieving (or not achieving) a career in that field. One widely used framework in this area is Social Cognitive Career Theory (SCCT) [15]. SCCT posits that motivation to pursue a career is based on three interrelated aspects: how career interests develop; how educational and career choices are made; and how career success is obtained. SCCT is based on three linked variables: self-efficacy; outcome expectations; and personal goals. Social Role Theory (SRT) is another key framework within factor (5), as it investigates how societal stereotypes influence personal goals [17]. SRT helps explain differences in personal goals and expectations as a function of social norms and stereotypes. The studies in this paper are framed within the personal goals component of SCCT and SRT using a framework known as *Goal Congruity Theory*. Goal Congruity Theory work shows that students' career choices are less about personal values (although they are important) and more about the perception of the profession as prosocial (versus agentic). The studies in this paper, focused specifically on the electrical engineering profession, contribute to the field by creating knowledge of how a student's understanding about the prosocial nature of the profession predict motivation to persist, as well as the relationship, if any, with a student's own personal prosocial trait values.

B. Theoretical Framework

Motivation is a critical component in the formation of engineers. As well as propelling learning, it also describes the willingness of a student to persist through the process of becoming an engineer. Goal Congruity Theory states that people are more likely to pursue a career that affords values they endorse [18]–[21]. On one side of this theory are values that the student personally endorses. On the other side are work-goal affordances that the student believes the profession offers (i.e., stereotypes about the profession). Goal congruity research has further found that there are generally two categories of values: agency (self-oriented, such as wealth or prestige) and prosocial (other-oriented, such as working with and helping others, or benefitting society) [21], [22]. While it is possible to view a profession as affording *both* agency and prosocial value, work on goal congruity finds that most people desire professions that allow them to work with and help others. Additionally, women, first-generation college students and URMs are especially attracted to professions that afford high levels of prosocial value [19]–[24]. This is partly because the social roles of these students tend to be those of caregivers, so they endorse prosocial traits as part of their identity [21], [25], [26]. As a result, prosocial goal congruity has the ability motivate *all* students, but could be especially important to those currently underrepresented in the engineering workforce [27]. This point is discussed further in Section IV.

C. Work-Goal Affordances of Engineering

The engineering profession is often misperceived as not affording prosocial value. Instead, engineering carries the stereotype of individuals working in isolation with a singular focus on technological achievement [28], [29]. Certainly parts of an engineering job involve working alone, but engineering problems in the 21^{st} century are almost exclusively solved by teams working together to create solutions that benefit others. Thus the perception that engineering does not afford prosocial value (i.e., working with and helping others) is inaccurate.

This stereotype is of concern because goal congruity research shows that the majority of people pursue careers that afford prosocial value, so this inaccurate perception of the engineering workforce makes it unappealing to certain students [30]. This is of further concern because it deters people with the characteristics of wishing to help others and benefit society from working in engineering, in direct contrast to the call from the NAE to strengthen the workforce through broadening participation and thinking about engineering decisions in a global context.

Engineering does carry the stereotype of affording agentic values in that it can provide a career that brings wealth and prestige [29]. Perceptions of prosocial and agentic goal affordance of engineering are not mutually exclusive, in that students can believe the profession provides both. However, prosocial goal affordance is key to goal congruity theory as it is common to most students [30]. One of the aims of the studies in this paper is to test whether prosocial or agentic goal affordances of the electrical engineering profession are more associated with intentions to persist.

Compounding the impact of misconceptions about the prosocial goal affordance of engineering is diminished prosocial trait endorsement over time. In 2014, sociologist Erin Cech discovered a "culture of disengagement" in engineering [31]. In this five-year, longitudinal study of over 300 students from all engineering majors at four universities nation-wide, students rated their professional/ethical responsibility as engineers, their concern for understanding the consequences of technology, their degree of social consciousness, and their concern for understanding how people use machines. Ratings were collected twice during their college career, and once 18 months following graduation. The results of this study revealed that engineers, both as students and working in industry, showed a decrease for public welfare across the time points. This report highlighted that engineering students over time showed diminished concerns about public welfare. Cech's prior findings are thus specific to public welfare concerns and included all types of engineering. The authors build on her findings to understand whether there exists differences in prosocial expectations about EE, and if there are differences in prosocial trait endorsement between first-year and senior-year EE students. There is a void in the literature on studies that measure and analyze prosocial expectations and traits in specific majors. As each type of engineering has its own "culture," this paper adds to the literature by providing insight into EE students specifically, using both Cech's measures and validated measures from the goal-congruity literature.

D. The Potential to "Add Value"

Another rationale for the studies in this paper is that the value side of motivation has great potential to strengthen the prosocial goal congruity surrounding the engineering profession. Subjective task value can be further broken down into attainment (importance for identity), intrinsic (enjoyment or interest), cost (effort), and utility (relevance). Utility value (UV) has a unique contribution to the formation of engineers, being the most extrinsic of all the values students encounter as they pursue tasks to achieve a "goal" (as opposed to for their own sake). UV's extrinsic nature makes it ideally suited for external interventions. Prior work has shown that it is easier to help students make connections between tasks and their own personal goals, than convincing a student that the task is interesting or important for their identity [26]. Prior UV interventions in science fields have been proven to have a lasting impact, even when implemented within the short timeframe of college [32], [33]. Thus, if the proposed hypotheses are true, there is potential to design future interventions in this area to increase student prosocial beliefs about the engineering profession, which could have important motivational benefits. This research also seeks to measure student attitudes on the prosocial-relevance of electrical engineering, to provide guidance for future UV interventions. These types of UV interventions could have a potentially large return on investment, because they only require a relatively simple redesign of assignment descriptions, rather than a course redesign or a cultural shift within engineering faculty. It should be noted that the studies in this paper are not focused on measuring subjective task value, but are motivated by the potential of future UV interventions.

II. Method

A. Research Questions

This research seeks to answer the questions: (1) What are student perceptions about the work-goal affordances of the electrical engineering profession? (2) What is the level of prosocial trait endorsement among EE students? (3) Are there associations between the work-goal affordances of electrical engineering (both prosocial and agency) and novice students' intentions to persist in EE ? (4) Do the results of questions (1) and (2) differ at the novice and advanced levels?

B. Procedures

An online survey was designed and administered to students enrolled in entry- and advanced-level required EE courses at a medium-sized land grant institution in the northern Rockies region. The survey consisted of 186 questions and took approximately 10-15 minutes to complete. Students in the entry-level course took the survey in the fall semester of their first year, which is when these students would typically be taking Calculus 1, Physics 1, and other general education courses. The entry-level course gave an overview of electrical engineering, and had hands-on laboratory and programming experiences. Students in the advanced-level course took the survey in the spring semester, usually the last semester prior to graduation, when they would typically be taking only professional elective courses. The course covered the professional responsibilities of electrical engineering and ethical considerations of the impact of technology.

For this type of study student attitudes about a program they are part of can be unintentionally biased by a desire to please their instructor or research director [33]. A cover story was therefore used to hide the true motivation for the survey, to reduce social desirability and assure more natural and unbiased responses. The cover story, that the survey was intended to collect feedback on internal learning environment preferences for use in future classroom and laboratory designs, was reinforced by the actual ongoing construction and remodeling projects students walked by each day. Since deception was used, approval was received in advance from the university's institutional review board (IRB).

The surveys were administered five weeks into the semester, after the drop deadline but before the first exam in each class. To reduce suspicion, seven filler questions on learning environments were intermixed with the items about student attitudes. The filler questions were designed to support the cover story while logically transitioning the survey into questions about student attitudes. A research assistant, not associated with engineering, announced the survey to the class and gave a link that was posted to the course website. Participation in the survey was voluntary, and participants were given a $10 amazon.com gift card for completing the survey. Participation in the survey did not impact the students' grades and the instructor of each class did not know who took the survey. The students entered demographic information about themselves as part of the survey. Three attention check questions were included in the survey. Four of the instrument items were reverse coded, which served as an additional attention check. Students not passing the attention checks or responding to a reverse coded item that did not stay consistent with the other items in the instrument set were excluded from the final dataset either completely, or for that block. The data was then coded and analyzed using T-tests and multilevel regression modeling to explore associations between variables.

C. Instrument Selection

The survey used pre-existing instruments previously tested for validity and reliability in other studies. To measure agentic and prosocial value affordances of the electrical engineering profession, instruments were used from prior studies on personal field stereotypes (35 items) [34], [35], society field stereotypes (27 items) [36], and role congruency (three items) [37]. To measure value endorsements, the studies used Cech's disengagement instruments (15 items) [31] and included a well-known trait empathy measure (eight items) [38]. Instruments were also included on intentions to persist (seven items) [39] and intrinsic motivation experienced in the class (13 items) [40]. Each item used a five-point Likert scale with the exception of empathy, which used a six-point Likert scale. Internal consistency of the measures was calculated to verify the reliability of the combined instruments used in these studies. The Cronbach's α's for each measure are reported in Table I. There is no estimate of internal consistency of the empathy measure as it is a single instrument. Every α was found to be either good ($0.9 \leq \alpha \leq 0.9$) or acceptable ($0.7 \leq \alpha \leq 0.8$) for the instruments used.

D. Participants

The survey was offered to students in an introductory-level EE course with an enrollment of 117. A total of 85 students in the class took the survey. Of those participating, six were excluded for failing attention checks, giving a maximum n = 79 for each topic block of the survey. The average age of the participants was 18.97 years (SD = 2.02). The majors in the introductory-level class were 60% electrical engineering, 28% computer engineering, and the rest were a combination of computer science, mechanical engineering, and technology education majors. For the introductory class participants, 76% reported their gender as male and 15% reported their gender as female. The only race within the novice class reportable (without the potential for identifying individual students) was white, at 73%, and 5.9% were international students.

TABLE I
DESCRIPTIVE STATISTICS AND T-TEST VALUES FOR STUDY 1 VARIABLES

Variable	Class	n	M (SD)	Reliability (Cronbach's α)[x]	One Sample T-Test[+]
EE Agency Affordance	Novice	77	3.78 (.72)	0.84	9.63*
EE Prosocial Affordance	Novice	77	4.01 (.64)	0.87	13.96*
Ethical Responsibilities	Novice	79	4.20 (.93)	-	11.34*
Empathic Concern	Novice	76	3.85 (0.78)	0.71	3.90*
Experience of Interest in EE	Novice	77	3.98 (.63)	0.81	13.79*
Persistence Intentions in EE	Novice	77	4.46 (.58)	0.72	22.19*

Note 1: EE = Electrical Engineering.
Note 2: [+] Tested value was the midpoint of the scale. Greater numbers indicate stronger endorsement.
Note 3: All items are on a 1 to 5 scale (midpoint = 3) with the exception of empathetic concern, which was on a 1 to 6 scale (midpoint = 3.5).
Note 4: [x] an $\alpha > 0.7$ is considered an acceptable level of reliability. Ethical responsibilities has no alpha because it is a single item.

The survey was also offered to students in a senior-level EE course with an enrollment of 66. A total of 53 students in this class took the survey. Of those participating, two were excluded for failing attention checks, giving a maximum n = 51 for each topic block of the survey. The average age of the participants was 23.18 years (SD = 3.15). The majors in the senior-level class were 64% electrical engineering and 26% computer engineering. For these participants, 75% reported their gender as male and 15% as female. The only reportable race was white, at 74%, and 3.8% were international students.

E. Analyses Overview

For study 1 (determining if there were associations between affordance beliefs about EE and intensions to persist), the first step of the analysis was to test for the strength of the rating against the midpoint of the Likert scale, and, if that was significant, the direction of the rating. To do this, a one-sample t-test was conducting using a Bonferroni corrected probably of $p < .01$ to indicate statistical significance. The second step of the analysis was to test the relationship among the variables using a specified path analysis with maximum likelihood estimation and indirect effects using bootstrapped standard errors [42]. This technique allows a simultaneous test of the effects of affordance beliefs about electrical engineering through the specified sequence of motivational variables using mediation analysis in multiple regression.

For study 2 (determining whether there were differences in affordance beliefs and trait endorsements between novice and advanced students), the first step was again to test for the strength of the rating against the midpoint of the Likert scale, and if that was significant, the direction of the rating. To do this, a one-sample t-test was conducting using a Bonferroni corrected probably of $p < .01$ to indicate statistical significance. The second step was to test for the degree and direction of differences between the novice and advanced students using an independent sample t-test also using a Bonferroni corrected probably of $p < .01$ to indicate statistical significance. Where

TABLE II
DESCRIPTIVE STATISTICS AND T-TEST VALUES FOR STUDY 2 VARIABLES

Variable	Class	n	M (SD)	Between Group T-Test	Cohen's d Senior vs. First-Year	Reliability (Cronbach's α)^x	One Sample T-Test$^+$
EE Agency Affordance	Advanced Novice	51 77	3.88 (.84) 3.78 (.72)	0.68	0.13	0.84	7.52* 9.63*
EE Prosocial Affordance	Advanced Novice	51 77	3.52 (.81) 4.01 (.64)	3.84*	-0.67	0.87	4.56* 13.96*
Ethical Responsibilities	Advanced Novice	49 79	3.98 (.74) 4.20 (.93)	1.38	-0.26	-	9.27* 11.34*
Empathic Concern	Advanced Novice	51 76	2.49 (1.13) 3.85 (0.78)	8.04*	-1.40	0.71	-6.41* 3.90*
Experience of Interest in EE	Advanced Novice	51 77	3.19 (.45) 3.98 (.63)	7.76*	-1.44	0.81	3.12* 13.79*
Persistence Intentions in EE	- Novice	- 77	- 4.46 (.58)	-	-	0.72	- 22.19*

Note 1: EE = Electrical Engineering.
Note 2: $^+$ Tested value was the midpoint of the scale. Greater numbers indicate stronger endorsement.
Note 3: All items are on a 1 to 5 scale (midpoint = 3) with the exception of empathetic concern, which was on a 1 to 6 scale (midpoint = 3.5).
Note 4: ^{x} an $\alpha > 0.7$ is considered an acceptable level of reliability. Ethical responsibilities has no alpha because it is a single item.
Note 5: * indicates a significance level of at least $p < .01$ as required by Bonferroni correction.

applicable, a paired sample t-test was conducted to test for the difference in individuals' ratings between two constructs [41]. Cohen's d effect size estimates were calculated to estimate small (.01), medium (.06) or large (.14) differences between novice and advanced students. For each measure, the skewness and kurtosis was examined and confirmed that the data was normally distributed and a t-test was a valid analysis approach.

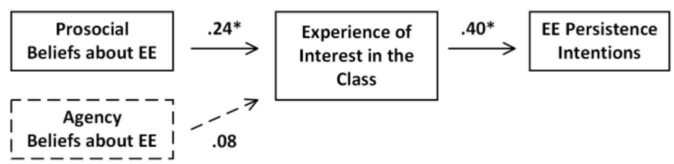

Fig. 1. Process analyses for the indirect effect of prosocial beliefs on novice students' motivational experiences in electrical engineering. Numbers represent standardized regression β. Significant indirect effect (bootstrapped; 95% CI: .01 to .34).

III. RESULTS

A. *Study 1 – Associations Between EE Affordance Beliefs and Intentions to Persist*

Table I shows the relevant results for study 1, providing the means, standard deviations, and effect sizes for the novice student group, and the one-sample t-test values testing the ratings against the neutral point.

1) Direct Effects: Novice students believed that electrical engineering allows opportunities to fulfill both agency and prosocial goals at levels significantly above the neutral point. Prosocial trait endorsement (ethical responsibility and empathic concern) among novice EE students were also significantly above the neutral point. Novice students reported high levels of interest in their class (above the neutral point), which is an indication of intrinsic motivation for studying electrical engineering. Persistence intentions were also significantly high for the novice students.

2) Indirect Effects: Multilevel regression modeling was used to test whether prosocial or agency beliefs of novice students were associated with intentions to persist in an engineering curriculum. The process was mediated through the experience of interest variable as shown in Fig. 1. In this figure, solid arrows indicate paths with significant indirect effects while dotted lines are insignificant. Results illustrate that there was *not* a significant indirect effect between stronger beliefs about electrical engineering affording agentic value, and intentions to persist. However, in line with hypotheses, results also showed that the more novice students believe that electrical engineering allows them to fulfill prosocial goals, the greater their experience of interest in the class, which in turn, was associated with greater persistence intentions in an engineering curriculum (95% CI: .01 to .34).

B. *Study 2 – Differences in Affordance Beliefs and Trait Endorsements Between Novice & Advanced EE Students*

Table II shows the relevant results for study 2. For the key variables, some results from for the novice students in Table I are duplicated for easy comparison to the advanced group.

1) Direct Effects: Agency affordance beliefs about electrical engineering were significantly above the neutral point for both novice and advanced students. Moreover, both were equally likely to believe that electrical engineering allows opportunities to fulfill agency goals (e.g., prestige and money).

Prosocial affordance beliefs about electrical engineering were also significantly above the neutral point for both samples of students. Compared to novice students, advanced students were significantly less likely to believe that electrical engineering offers opportunities to fulfill prosocial goals (e.g., work with and help others). Cohen's d illustrates this was a large difference between the two student samples with lower levels reported in advanced students.

Paired sample t-test results show that among advanced students, agency affordance beliefs were significantly higher than prosocial affordance beliefs ($t(51) = 2.69$, $p < .05$). In contrast, among novice students, prosocial affordance beliefs were significantly higher than agency affordance beliefs ($t(77) = 2.56$, $p < .05$). This confirmed a trend of lower perceptions of the prosocial affordance of the electrical engineering profession between first-year and senior students. There was no difference in the agency affordance of beliefs between novice and advanced students.

All students reported significantly high amounts of professional ethical responsibilities (compared to neutral). Moreover, novice and advanced students were equally likely to feel that ethical responsibilities were part of a successful career.

Advanced students reported significantly low levels (below the neutral point) of empathic concern for others whereas novice students reported significantly high levels of empathic concern. Indeed, compared to advanced students, novices reported significantly higher levels of empathic concern. Cohen's d illustrates that this was a very large difference between samples, indicating that empathy was much lower among advanced students. The standard deviation of empathetic concern being highest for advanced students ($SD = 1.13$) is not problematic for the analysis, because it does not change the pattern of the results.

All students reported high levels of interest in their class (above the neutral point), although compared to advanced students, novices were significantly more likely to experience interest. Cohen's d illustrates this was a very large difference between student samples.

IV. Discussion

The results of these studies revealed that novice students view electrical engineering as having high levels of both agency and prosocial goal affordance. A key finding of the first study that contributes to the professional formation of engineers is the association between prosocial goal affordance (rather than agency) and intentions to persist in the engineering curriculum. Coupling this with the finding of study 2 that prosocial affordance beliefs were lower in advanced students may help explain why engineering programs see such high rates of attrition (50%) between the first and final years [14]. Additionally, the association between prosocial affordance beliefs and intentions to persist may also extend to the workforce, which could also explain why so many people (47%) who receive engineering degrees do not choose an engineering career [43]. Taking steps to increase student prosocial affordance beliefs about engineering may help to retain students, both in their degree programs and ultimately in the workforce. These steps could potentially be implemented through low-cost UV interventions throughout the EE curriculum. Simple learning activities that make the students intentionally think about the prosocial value of the course material could result in significant improvements to year-to-year persistence.

Study 2 revealed that advanced students maintain high affordance beliefs about electrical engineering with regards to agency, but not to prosocial values. These important results set the stage for future research into why this is the case. For example, it might be that students who believe electrical engineering affords prosocial value leave the program before entering their senior year, or it could be that students' beliefs about prosocial affordance are altered during their time in the program. These questions cannot be answered with a cross-sectional study at a single institution since the students were not a paired sample nor did they reflect views across different university types. However, these results do mirror some of Cech's findings, so it could be inferred that trait endorsements are being altered (perhaps through curriculum emphases, or peer socialization, or some other process). These findings are only the first step in understanding goal affordance beliefs about the electrical engineering profession and suggest that a good next step is a longitudinal study. Nevertheless, from just these cross-sectional results there are grave concerns about their implications for the professional formation of engineers. If students who view electrical engineering as affording prosocial value leave the curriculum, the profession is losing the very people who are needed to create solutions that help all of society. If students' beliefs about the prosocial goal affordance of electrical engineering are actually being altered during their time in college, this indicates that higher education is furthering a stereotype that the profession is not one that helps others or benefits society. Since goal congruity theory has demonstrated that most people want a career that does afford prosocial value, electrical engineering curriculums may be unintentionally driving students away from the profession through promotion of an inaccurate stereotype.

Study 2 also supported prior research—that student prosocial traits are being diminished during their time in colleges—by replicating a portion of Cech's culture of disengagement findings. While study 2 did not track the same cohorts longitudinally, it did reveal that at a single point in time, advanced electrical engineering students had lower prosocial trait endorsement (empathy) than novice students. That students enter the electrical engineering profession with low prosocial trait endorsement is of great concern, given the growing societal dependence on electrical power, computers, and communication systems. The electrical engineering workforce of the 21st century must be keenly aware of the impact of its decisions on public welfare to create technological solutions that do not harm some parts of society for the benefit of others.

There were very few women and URM students in either of the tested samples, mirroring national statistics in EE. These underrepresented student groups typically endorse prosocial traits, and are often more motivated to pursue careers that afford prosocial values [17]–[19]. The findings of these two studies being particular to men is compelling and important. Some might think that only women or URM students care about prosocial values, but these results show that prosocial values are important to majority novice students as well. Thus, results suggest that above and beyond gender or ethnicity, prosocial values within EE are likely important for *all* students, and may, as research suggests, have especially important implications for women and minorities [17]–[19].

Finally, the lower prosocial affordance beliefs of the advanced students in study 2 represent electrical engineers about to enter the workforce. These engineers will serve as the role models to future students considering the profession. If these engineers don't view their profession as one that works with or helps others, they will perpetuate the stereotype that electrical engineering does not afford prosocial value, and make it unappealing to those who could strengthen the workforce through diversification.

V. Future Work

The findings in this paper point to the need to track students longitudinally in a randomized controlled trial. This type of study will answer the emerging research questions about diminishing prosocial affordance beliefs and diminished prosocial trait endorsement. Of specific interest is the question of whether students with high prosocial beliefs and traits leave the EE program, or if the EE curriculum or some other process negatively impacts the students. A second motivation for a longitudinal study is that the prosocial UV interventions that have been successful in the sciences can be tested within the EE curriculum.

VI. Conclusion

This paper presented two studies that contribute to the body of knowledge on the impact of work-goal affordance beliefs and personal trait indorsement on motivation to pursue electrical engineering as a profession. It revealed that prosocial value affordance (and not agency) was associated with intentions to persist among novice students. This finding is a unique contribution to the field, as EE students are typically assumed to be more motivated by agentic values. It further showed that prosocial affordance beliefs and prosocial trait endorsement (empathy) were lower in advanced students than in novice students, albeit in a cross-sectional analysis. These findings reveal that the professional formation of engineers may be hindered by a lack of prosocial goal congruity surrounding electrical engineering. If higher education seeks to strengthen the electrical engineering workforce through expansion and diversity in problem solving, steps must be taken to infuse the prosocial goal affordance of the profession throughout its curriculums.

Acknowledgment

The authors would like to thank the Montana Engineering Education Research Center (MEERC) for facilitating this study.

References

[1] J. J. Duderstadt, "A roadmap to 21st century engineering, engineering in a changing world," Millennium Project, Univ. Michigan, Ann Arbor, MI, USA, Rep. TA160.4.D8, 2008.

[2] D. F. Radcliffe, "Forward," in *Creative Ways of Knowing in Engineering*. Cham, Switzerland: Springer, 2017, pp. 5–8.

[3] D. Riley, "Engineering and social justice," in *Synthesis Lectures on Engineers, Technology, and Society*. San Rafael, CA, USA: Morgan & Claypool, 2008, pp. 1–152.

[4] National Academy of Engineering, *The Engineer of 2020: Visions of Engineering in the New Century*. Washington, DC, USA: Nat. Acad. Press, 2004.

[5] National Academy of Engineering, *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*. Washington, DC, USA: Nat. Acad. Press, 2005.

[6] D. Riley, "Professional formation of engineers," presented at the Directorate Eng. Advisory Committee Meeting, Arlington, VA, USA, Apr. 2014.

[7] National Academy of Engineering, *Rising Above the Gathering Storm, Revisited*. Washington, DC, USA: Nat. Acad. Press, 2010.

[8] D. R. Brown, "National science foundation investments in STEM education and workforce development," presented at the Rural Community College Alliance, Washington, DC, USA, Feb. 2010.

[9] *STEM Attrition: College Students' Paths Into and Out of STEM Fields*, U.S. Dept. Educ., Nat. Center Educ. Stat., Washington, DC, USA, Rep. NCES 2014-001, Nov. 2013.

[10] J. McFarland *et al.*, "The condition of education 2018," U.S. Dept. Educ., Nat. Center Educ. Stat., Washington, DC, USA, Rep. NCES 2018-144, May 2018.

[11] T. Grose, *DataBytes: Retention Range: The Wide Variation Among 2007 Freshman*, ASEE Connections, Washington, DC, USA, Feb. 2016.

[12] E. Seymour and N. Hewitt, *Talking About Leaving*. Boulder, CO, USA: Westview Press, 1997.

[13] R. Marra, B. Bogue, D. Shen, and K. Rodgers, "Those that leave: Assessing why students leave engineering," in *Proc. 37th ASEE/IEEE Front. Educ. Conf.*, Honolulu, HI, USA, 2007, pp. 1–14.

[14] B. N. Geisinger and D. R. Raman, "Why they leave: Understanding student attrition from engineering majors," *Int. J. Eng. Educ.*, vol. 29, no. 4, pp. 914–925, 2013.

[15] A. Bandura, *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ USA: Prentice-Hall, 1986.

[16] R. W. Lent, "A social cognitive framework for studying career choice and transition to work," *J. Vocat. Educ. Res.*, vol. 21, no. 4, pp. 3–31, 1996.

[17] A. H. Eagly and W. Wood, "Social role theory," in *Handbook of Theories of Social Psychology*, P. A. M. Van Lange, A. W. Kruglanski, and E. T. Higgins, Eds. Thousand Oaks, CA, USA: Sage, 2012, pp. 458–476.

[18] J. Eccles, "Expectations, values, and academic behaviors," in *Achievement and Achievement Motivation*. San Francisco, CA, USA: W. H. Freeman, 1983.

[19] A. B. Diekman, E. R. Brown, M. A. Johnston, and E. K. Clark, "Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers," *Psychol. Sci.*, vol. 21, no. 8, pp. 1051–1057, 2010.

[20] D. B. Thoman, E. R. Brown, A. Z. Mason, A. B. Harmsen, and J. L. Smith, "The role of altruistic values in motivating underrepresented minority students for biomedicine," *BioScience*, vol. 65, no. 2, pp. 183–188, 2015.

[21] A. B. Diekman, M. Steinberg, E. R. Brown, A. L. Belanger, and E. K. Clark, "A goal congruity model of role entry engagement, and exit: Understanding communal goal processes in STEM gender gaps, *Pers. Soc. Psychol. Rev.*, vol. 21, no. 2, pp. 142–175, 2017.

[22] C. Morgan, J. D. Isaac, and C. Sansone, "The role of interest in understanding the career choices of female and male college students," *Sex Roles*, vol. 44, nos. 5–6, pp. 295–320, 2001.

[23] J. M. Harackiewicz *et al.*, "Closing the social class achievement gap for first-generation students in undergraduate biology," *J. Educ. Psychol.*, vol. 106, no. 2, pp. 375–389, 2014.

[24] J. L. Smith, E. Cech, A. Metz, M. Huntoon, and C. Moyer, "Giving back or giving up: Native American student experiences in science and engineering," *Cultural Diversity Ethnic Minority Psychol.*, vol. 20, no. 3, pp. 413–429, 2014.

[25] A. Bardi and S. H. Schwartz, "Values and behavior: Strength and structure of relations," *Pers. Soc. Psychol. Bull.*, vol. 29, no. 10, pp. 1207–1220, 2013.

[26] S. J. Priniski, C. A. Hecht, and J. M. Harackiewicz, "Making learning personally meaningful: A new framework for relevance research," *J. Exp. Educ.*, vol. 86, no. 1, pp. 11–29, 2018.

[27] E. R. Brown, D. B. Thoman, J. L. Smith, and A. B. Diekman, "Closing the communal gap: The importance of communal affordances in science career motivation," *J. Appl. Soc. Psychol.*, vol. 45, no. 12, pp. 662–673, 2015.

[28] S. Cheryan, V. C. Plaut, C. Handron, and L. Hudson, "The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women," *Sex Roles*, vol. 69, nos. 1–2, pp. 58–71, 2013.

[29] S. Cheryan, A. Master, and A. N. Meltzoff, "Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying stereotypes," *Front. Psychol.*, vol. 6, no. 11, p. 49, 2015.

[30] K. L. Boucher, M. A. Fuesting, A. B. Diekman, and M. C. Murphy, "Can I work with and help others in this field? How communal goals influence interest and participation in STEM fields," *Front. Psychol.*, vol. 8, p. 901, May 2017.

[31] E. A. Cech, "Culture of disengagement in engineering education?" *Sci. Technol. Human Values*, vol. 39, no. 1, pp. 42–72, 2014.

[32] A. B. Diekman, E. K. Clark, A. M. Johnston, E. R. Brown, and M. Steinberg, "Malleability in communal goals and beliefs influences attraction to STEM careers: Evidence for goal congruity perspective," *J. Pers. Soc. Psychol.*, vol. 101, no. 5, pp. 902–918, 2011.
[33] R. Rosenthal, "Experimenter outcome-orientation and the results of the psychological experiment," *Psychol. Bull.*, vol. 61, no. 6, pp. 405–412, 1964.
[34] E. R. Brown, J. L. Smith, D. B. Thoman, J. Allen, and G. Muragishi, "From bench to bedside: A communal utility value intervention to enhance students' science motivation," *J. Educ. Psychol.*, vol. 107, no. 4, pp. 1116–1135, 2015.
[35] K. Pohlmann, "Agency- and communion-orientation in life goals: Impacts on goal pursuit strategies and psychological wellbeing," in *Life Goals and Well-Being: Towards a Positive Psychology of Human Striving*. Ashland, OH, USA: Hogrefe and Huber, 2001, pp. 68–84.
[36] P. G. Devine and A. J. Elliot, "Are racial stereotypes really fading?" *Pers. Soc. Psychol. Bull.*, vol. 21, pp. 1139–1150, Nov. 1995.
[37] J. Allen and J. L. Smith, "The influence of sexuality stereotypes on men's experience of gender-role incongruence," *Psychol. Men Masculinity*, vol. 12, no. 1, pp. 77–96, 2011.
[38] M. H. Davis, *Empathy: A Social Psychological Approach*. Boulder, CO, USA: Westview Press, 1994.
[39] A. F. Cabrera, M. B. Castañeda, A. Nora, and D. Hengstler, "The convergence between two theories of college persistence," *J. High. Educ.*, vol. 63, no. 2, pp. 143–164, 1992.
[40] J. L. Smith, C. Sansone, and P. H. White, "The stereotyped task engagement process: The role of interest and achievement motivation," *J. Educ. Psychol.*, vol. 99, no. 1, pp. 99–114, 2007.
[41] K. R. Murphy, B. Myors, and A. Wolach, *Statistical Power Analysis: A Simple and General Model for Traditional and Modern Hypothesis Tests*, 1st ed. Mahwah, NJ, USA: Lawrence Erlbaum, 1998.
[42] D. P. MacKinnon and A. J. Fairchild, "Current directions in mediation analysis," *Current Directions Psychol. Sci.*, vol. 18, no. 1, pp. 16–20, 2009.
[43] National Science Foundation, *The Engineering Workforce: Current State, Issues, and Recommendations*. Washington, DC, USA: Nat. Acad. Press, May 2005.

Brock J. LaMeres (M'98–SM'09) received the B.S. degree in electrical engineering from Montana State University (MSU), Bozeman, MT, USA, in 1998, the M.S. degree in electrical engineering from the University of Colorado, Colorado Springs, CO, USA, in 2001, and the Ph.D. degree in electrical engineering from the University of Colorado, Boulder, CO, USA, in 2005.

He is currently the Director of the Montana Engineering Education Research Center and a Professor with the Electrical and Computer Engineering Department, MSU, where he was appointed as the Boeing Professor of engineering education in 2016, and he oversees programs to enhance the professional skills of engineering students. He conducts research on engineering education with specific focus on student motivation and e-learning environments. He has published over 90 papers and 5 textbooks in the area of digital systems and engineering education and has been granted 13 U.S. patents in the area of digital signal propagation.

Dr. LaMeres is a member of the IEEE Education Society and the American Society of Engineering Education. He is a Registered Professional Engineer in Montana and Colorado.

Maxwell S. Burns received the B.S. and M.S. degrees in psychology from Montana State University, Bozeman, MT, USA, in 2013 and 2015, respectively.

He is currently an Instructor of psychology with Montana State University. His research examines how to change social psychological aspects of situations in ways that improve academic and workplace experiences for historically marginalized people.

Mr. Burns is a member of the Society of Personality and Social Psychology.

Dustin B. Thoman received the B.S. degree in psychology from Middle Tennessee State University in 2002, and the M.S. and Ph.D. degrees in social psychology from the University of Utah in 2005 and 2008, respectively.

He is a member of the Center for Research in Mathematics and Science Education and an Assistant Professor of psychology with San Diego State University. He conducts research on student motivation and broadening participation in STEM. His research is funded by both the National Science Foundation and the National Institutes of Health. He has published over 30 papers in psychology and education.

Dr. Thoman is a member of the American Educational Research Association, Association for Psychological Science, Society of Personality and Social Psychology, and Society for the Study of Motivation.

Jessi L. Smith received the B.A. degree in psychology from the University of Colorado at Colorado Springs, and the M.S. and Ph.D. degrees in psychology from the University of Utah.

She was a Professor of psychology with Montana State University, Bozeman, MT, USA. She is currently an Associate Vice Chancellor for Research with the University of Colorado, Colorado Springs. Her research examines how to change social psychological aspects of situations in ways that improve academic and workplace experiences for historically marginalized people. She has over 60 peer-reviewed publications and one book to her credit. Her research has been supported with over $5 million in external funding from the NIH and NSF.

Dr. Smith is a Fellow of the American Psychological Association, the Association for Psychological Science, and the Society for Personality and Social Psychology.