ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE

Paper ID #37557

Social responsibility attitudes among undergraduate computer science students: an empirical analysis

Quintin Kreth (Doctoral Student)

I am a doctoral student in the Georgia Tech School of Public Policy. My research is primarily on the factors influencing faculty research productivity at mid-major research universities.

Daniel S. Schiff

PhD Candidate, Georgia Institute of Technology, School of Public Policy

Jeonghyun Lee

Ellen Zegura (Professor)

Social responsibility attitudes among undergraduate computer science students: an empirical analysis

Abstract

Scholars have called for improved ethics and social responsibility education in computer science degree programs in order to better address consequential technological issues in society. Indeed, rising public concern about computing technologies arguably represents an existential threat to the credibility of the computing profession itself. Despite these increasing calls, relatively little is known about the ethical development and beliefs of computer science students, especially compared to other science and engineering students. Gaps in scholarly research make it difficult to design and evaluate ethics education interventions in computer science effectively. Additional empirical study regarding the development of ethical attitudes in computer science students is a pressing need. Influenced by the Professional Social Responsibility Development Model, this study explores personal and professional social responsibility attitudes among undergraduate computing students at the Georgia Institute of Technology. Using survey results from a sample of 982 students (including 184 computing majors) who graduated between 2017 and 2021, we compare social responsibility attitudes cross-sectionally among computer science students, engineering students, other STEM students, and non-STEM students. Study findings indicate computer science students have significantly lower social responsibility attitudes than their peers in other science and engineering disciplines. In light of growing ethical concerns about the computing profession, this study provides evidence about extant challenges in computing education and buttresses calls for more effective development of social responsibility in computing students. We discuss implications for undergraduate computing programs, ethics education, and opportunities for future research.

1. Introduction

In recent years, computing and information technology have become objects of intense public concern due in part to ethical challenges and scandals related to artificial intelligence and social media [1]. In response, governments and computing thought leaders have considered regulatory and policy solutions to address problematic uses of emerging technologies. Within this discourse, scholars have argued that undergraduate computer science programs do not adequately teach students ethics and social responsibility concepts and associated skills [2]. Traditional degree programs are arguably failing to instill a robust sense of professional social responsibility [2], [3]. Given these concerns and the centrality of professional ethics to responsible computing practice, scholars have proposed various educational reforms, such as more robustly integrated ethics curricula [3]–[5].

However, despite broad, multi-sectoral calls for action, empirical evidence on the development of professional ethics in undergraduate computer science degree programs is limited [6]. Importantly, a field-level understanding of professional ethics attitudes amongst future computing professionals may be lacking, including how computing students and professionals may differ from their peers in other STEM and non-STEM fields. Without this knowledge basis, it is difficult to assess the severity of the professional ethics education problem in computer science specifically, much less to determine effective responses to address this challenge. To fill in some of these knowledge gaps, this paper seeks to develop a basis for comparison in professional ethics development between computer science and other disciplines. Additionally, we seek to better understand key sources of variation in professional ethics attitudes within the computing discipline, such as differences across student demographic characteristics. Establishing such a basis is a necessary precursor for the development, adaptation, and evaluation of effective professional ethics education interventions and reforms in computer science. Thus, this study examines two foundational research questions:

> Research Question 1: How do the attitudes of undergraduate computing students with respect to ethics and professional social responsibility compare to those of students in other disciplines?
>
> Research Question 2: To what extent do attitudes about ethics and professional social responsibility among computing students vary according to student demographics?

To address these questions, we adapted a tool used in the study of professional social responsibility development in engineering, the Engineering Professional Responsibility Assessment (EPRA) and its underlying framework, the Professional Social Responsibility Development Model (PSRDM) [7], [8]. The revised survey instrument developed by our research team, the Generalized Professional Responsibility Assessment (GPRA), uses forty-four Likert questions to assess student social responsibility attitudes along several domains. Below, we offer a brief review of the literature on the state of computing ethics education before turning to our research strategy and results.

2. Literature review

2.1 Professional ethics in engineering and computing

Computer science is a hybrid discipline, which contains many elements from engineering and mathematics and has considerable variation across individual computing programs [9]. At some schools, computer science is within a college of engineering; at others, it is part of the college of sciences, and, increasingly, universities are creating computing units at the same organizational level as engineering or sciences. Regardless of where computing originated within or is situated in a university, many curricular and pedagogical differences between computing and engineering education persist today. For instance, a common difference is the early inclusion of computing-specific courses taught within computing degree programs, beginning first semester of the freshman year, whereas engineering students often do not encounter major courses until their sophomore year or beyond. Identifying these similarities and differences is an important step towards understanding ethics and social responsibility development in computing.

Drawing on literature and assessment tools from engineering ethics can be a helpful starting point, as the study of professional ethics in engineering is more developed than in computer science [10]–[13]. One reason for this is the greater historical salience and cognitive immediacy of the potential consequences of ethical failures in engineering (e.g., large-scale technological disasters) [14], [15]. That is, when ethical failures in engineering affect the public, they tend to involve a single catastrophic event [16]–[18]. Yet, despite the ubiquity of computing systems in society, and arguably equally pressing negative impacts, including potential harm to large numbers of people (e.g., social media algorithms that may contribute to political polarization) [19], [20], computing failures can be less obvious. Failures in computing can manifest through slow-moving and less visible processes.

Computing artifacts like algorithms can also be difficult to understand, especially by the public, and may be only indirectly related to harms caused through complex sociotechnical processes. This can undermine not only the public's ability to assess the harms attributable to the computing profession—and whom to hold accountable for them—but can even make it challenging for computing professionals to recognize the ethical implications of their own work. The fact that computing ethics education syllabi cover a wide set of issues ranging from privacy to inequality to misinformation and environmental harms [21] speaks to the challenge of developing a robust sense of ethical awareness and sensitivity within computing professionals to address computing's vast societal implications.

The relatively recent development of computing ethics discourse and research may also be related to the newness of computing as a profession as compared to engineering [22], [23]. For example, the largest professional association focused on computing, the Association for Computing Machinery (ACM), developed its first professional ethics code in 1966 [24]. The first code of conduct for a comparable engineering-focused professional association, the Institute of Electrical and Electronics Engineers (IEEE) (previously the American Institute of Electrical Engineers), was adopted a half-century earlier, in 1912 [25]. An associated challenge is that the computing profession has traditionally been governed by self-regulation or voluntary industry standards. Yet, critics have highlighted the limitations of computing ethics codes and practices [26], [27]. Relatedly, business practices associated with "Big Tech" culture, perceived as a Wild West focused on innovation-without-boundaries, have come under increasing scrutiny [28], [29]. For instance, Ensmenger [30] claims that while engineers have a long-standing concern about safety, reflected in their professional technical standards and procedures, the excitement around computing products and services has arguably led some computing professionals to identify themselves as being closer to artists or eccentric innovators, rather than as traditional professionals.

Despite these differences, some similarities are worth emphasizing between engineering and computing education, including aspects of how they approach ethics and professionalism. First, both appear to be subject to the pedagogical and professional bracketing (i.e., deemphasizing) of ethical concerns; this is due in part to a prevailing sense that technical education is more important than ethics education [4], [31]. Some computing and engineering professionals may engage in a "amoral calculation" related to their work and relegate ethical concerns as being outside their scope of responsibility [18], [32]. This sociotechnical divide is also associated with the idea of a meritocratic culture in STEM, which strongly emphasizes the link between competitive effort and success [33], [34]. Moreover, barriers such as lack of faculty interest in or preparation to teach ethics and social responsibility appear to permeate both fields [35], [36].

2.2 Social responsibility attitudes of undergraduate students

Tied to the above challenges are studies noting that engineering students experience flat or declining social responsibility attitudes over the course of their undergraduate education [37]–[39]. In response, various scholars and educators have proposed strategies such as enhancing ethics curricula integrated throughout undergraduate courses [40]–[42], robust community engagement experiences [43], and the teaching of social/racial justice concepts [44].

It is unclear which factors contribute to the low levels of social responsibility development within computer science students. It is thus important to understand which specific aspects of computing as a subject and profession positively and negatively influence ethical development. Additionally, the variation of social responsibility attitudes across demographic groups, including historically underrepresented groups in computer science, is largely unknown.

Quantifying and measuring ethics and ethical development has been a long-standing problem in the study of STEM education [45]. Over time, many different models and survey instruments have been devised to measure different aspects of ethics [46]. Our study is influenced by the PSRDM, a conceptual framework designed by Canney and Bielefeldt to help understand and quantify the development of professional social responsibility in engineers [7]. Professional social responsibility is the way in which one relates their vocation to concepts of ethics, understanding of social context, and awareness of broad social issues – a macroethical conception of professional work and conduct [26], [47]. The PSRDM framework has been used to explore key issues in engineering education, for example, those relating social responsibility development to factors such as gender, religion, and the influence of internships [38], [48], [49]. However, extensions of the PSRDM to other STEM disciplines, including computing, have been more limited [50].

The PSRDM uses three inter-related realms to explain the development of professional social responsibility: personal social awareness, professional development, and professional connectedness (Table 1). These realms are designed with multiple underlying dimensions and associated Likert-style questions embedded in Canney and Bielefeldt's EPRA survey instrument. Collectively, the intensity of agreement or disagreement with individual questions associated with these realms can be understood to reflect students' "social responsibility attitudes." Professional social awareness is defined as "the development of altruistic behavior," within an individual [7, p. 419]. It has three dimensions: awareness, ability, and connectedness. Professional development represents "The development of professional skills in relation to the need to solve social problems," [7, p. 420]. It also has three dimensions: base skills, professional ability, and analyze. Professional connectedness is "a sense of moral obligation to help others because of [one's own] professional skills," the cumulative cycle of development of professional social responsibility [7, p. 421]. It has two dimensions: (dimension-level) professional connectedness and costs/benefits. Table 1 below summarizes the three key realms and their associated dimensions.

Table 1. The Professional Social Responsibility Development Model (PSRDM)*		
Realm	Dimension	Description
Personal Social Awareness "The development of altruistic behavior"	Awareness	Knowledge of people or groups who are in need, and of the relationships and interconnections between complex social issues and those in need.
	Ability	Recognizing that they can do something to help others who are in need.
	Connectedness	A feeling of moral obligation to help others rooted in social norms.
Professional Development "The development of professional skills in relation to the need to solve social problems"	Base skills	The trade-specific skills necessary to be effective in one's profession.
	Professional ability	Recognizing that one's profession is able to help solve social or environmental problems that face society.
	Analyze	The ability to examine social issues from a professional perspective.
Professional Connectedness "A sense of moral obligation to help others because of [one's own] professional skills"	Professional connectedness	The cyclical development of stronger beliefs of personal and professional social responsibility through their exercise.
	Costs/Benefits	The degree to which an individual recognizes the various costs and benefits and how that affects their decision to act or not.
* Table and model based on work by Canney and Bielefeld [7, pp. 419-421]		

In the PSRDM's formulation, personal social awareness and professional development feed into professional connectedness. Professional connectedness then grows cyclically through the exercise of altruistic behavior but is moderated by the costs and benefits of utilizing professional skills to help others. One benefit of this model is its attention to both personal and professional aspects of social responsibility development and the relationship between those two realms. Moreover, the PSRDM model serves as the foundation for our adapted survey instrument, the GPRA. While the EPRA is specific to engineering, the GPRA is designed to be discipline neutral.

2.3 Research hypotheses

Studies of social responsibility attitudes in engineering have found that different engineering disciplines attract students with varying preexisting levels of social responsibility attitudes [47]. The highest social responsibility attitudes tend to be among students in environmental engineering (a field with clear connections to social responsibility), while the lowest tend to be among students in electrical and computer engineering, a field closely related to computing [51]. Given these findings and the literature on mindsets and culture within the computing profession discussed above, we hypothesize:

Hypothesis 1: Computing students will have lower social responsibility attitude scores than students in other academic fields.

Gender has also been an important predictor of social responsibility attitudes in engineering, with male students found to have consistently lower scores as compared to female students [48], [52]. This may be explained in part by findings that the strongest career motivation among female STEM professionals is a desire to contribute to the wellbeing of society [53, p. 5]. As computer science is as or more gender imbalanced in favor of men than many engineering disciplines [54], we expect this pattern to hold in computing as well.

Hypothesis 2: Male computing students will have lower social responsibility attitude scores than female computing students.

While there is clear evidence regarding the strength of the relationship between social responsibility attitudes and gender, less is known about the relationship between social responsibility attitudes and race/ethnicity. Some studies suggest that students who are members of racial/ethnic minority groups underrepresented in engineering will have more awareness of social problems [55], [56]. However, a study by Bielefeldt applying the PSRDM failed to find significant differences among engineering students of different racial/ethnic groups [52]. Thus, we do not have clear expectations regarding the relationship between the race/ethnicity of computing students and social responsibility attitudes, although we include these variables in our analysis.

3. Data and methods

3.1 Survey methods

This study, which is part of a larger research project, draws on data from a survey instrument completed by five cohorts of students at or near graduation from the Georgia Institute of Technology (Georgia Tech), collected between 2017 and 2021. The survey and research protocol were reviewed and approved by the Georgia Tech Institutional Review Board. The surveys were administered using the Qualtrics platform. An invitation link was embedded in a set of graduation surveys sent to all bachelor's degree recipients from Georgia Tech in the spring semesters of 2017, 2018, 2019, and 2020. In spring 2021, the survey was also administered to the entire cohort of students that entered Georgia Tech in fall 2017 and remained enrolled, as part of a related cohort study (i.e., during their 8th semester of undergraduate studies). These surveys were distributed to a combined survey sample frame of 11,019 students. There were some alterations in the survey over time, but here we focus on survey items that were the same across the years, including the core questions that constitute the PSRDM framework.

A total of 1,444 students began the survey. After excluding responses missing values for one or more of the questions used to construct the variables included in our analysis, a consistent sample of 982 respondents was obtained with an overall response rate of 8.9%. Although this response rate is somewhat low, it is not atypical for online surveys of university students with email invitations [57], [58]. Survey data were subsequently merged with enrollment and demographic data obtained from Georgia Tech administration, including gender, race/ethnicity, first-generation status, and major.

3.2 Variable construction

Social responsibility attitudes (Table 2) were assessed via the GPRA survey instrument, based on the PSRDM and adapted from its validated survey instrument [8]. The GPRA is similarly composed of three realms corresponding to different elements of personal and professional social responsibility: *Professional social awareness* (α = 0.89) is composed of thirteen survey items. *Professional development* (α = 0.70) is composed of nine survey items. Finally, *professional connectedness* (α = 0.94) is composed of twenty-two items. The full item wordings for all forty-four questions, along with construct and sub-construct details and reliability scores, are available in Appendix A.

Table 2. PSRDM Variables

Variable	Cronbach's alpha	Survey items	Range	All Students (n = 982)		Computing Majors Only (n = 184)		Sig
				mean	sd	mean	sd	
Personal Social Awareness	0.89	13	[1, 7]	5.84	0.77	5.61	0.84	***
Professional Development	0.70	9	[1, 7]	6.13	0.66	6.01	0.69	**
Professional Connectedness	0.94	22	[1, 7]	5.28	0.95	4.84	1.06	***

*** p < 0.001, ** p < 0.01, * p < 0.05

To create the study's independent variables, we transformed administrative data provided by Georgia Tech into categorical variables (Table 3). Major area of academic study was divided into four non-overlapping categories: *computing*, *engineering*, *non-STEM*, and *science*. Students with multiple majors were assigned to their primary major, as recorded by the Georgia Tech registrar. A full list of majors included in each category is available in Appendix B (Table B1). *First generation* student status was included as a proxy for low socio-economic status, a common practice in studies of higher education [59], [60]. Race/ethnicity was coded as: non-Hispanic *white*, *Asian*, and underrepresented minority (*URM*). While imperfect, this approach to variable coding was employed to maximize analyzability along meaningful dimensions while protecting respondent confidentiality. The underrepresented minority variable includes Hispanic/Latino, Black, Native American, and Native Hawaiian students. Mixed race students who were members of at least one underrepresented minority were coded as underrepresented minorities. Students who were both non-Hispanic whites and Asian (but not an underrepresented minority) were coded as Asian. We decided to analyze white and Asian students separately because, although Asians receive the majority of computer science degrees from American universities (and are therefore not underrepresented in computing) [54], there has been limited study of the experiences of Asian students in computing and how they may differ from those of their white peers [61].

3.3 Sample composition

Understanding the composition of our sample provides critical context for our study. In terms of our independent variables/demographics (Table 3), just over half (51%) of our respondents are engineering majors, reflective of the broader population of Georgia Tech. The remainder of the respondents are roughly evenly split between computing majors (19%), other (non-engineering or computing) science majors (15%), and non-STEM majors (15%). Approximately half of the full sample (48%) are men, while a large majority of computing majors are men (70%), typical of the computing discipline. A majority of respondents in the full sample are non-Hispanic whites (55%), with Asians (29%) being the next largest racial/ethnic group, and the remainder (15%) categorized as underrepresented minorities. Computing students are somewhat more racially diverse, with nearly equal numbers of whites and Asians (43%) but similar numbers of underrepresented minorities (14%) as compared to the full sample. Fairly few students in the sample were first-generation college students, both in the full sample (6%) and among computing majors (8%).

Table 3. Descriptive Statistics

Independent Variables

	All Students (n = 982)		Computing Majors Only (n = 184)	
	percentage	sd	percentage	sd
Male	48%	0.50	70%	0.46
White	55%	0.50	43%	0.50
Asian	29%	0.46	43%	0.50
URM	15%	0.36	14%	0.34
First generation	6%	0.23	8%	0.27
Computing major	19%	0.39		
Engineering major	51%	0.50		
Non-STEM major	15%	0.36		
Science major	15%	0.36		

3.4 Analytic methods

To evaluate our hypotheses and to identify trends in social responsibility attitudes, we present descriptive statistics and perform ordinary least squares (OLS) regression analysis. Social responsibility attitudes are assessed via the constructs associated with the PSRDM (Table 2) and the adapted survey instrument, the GPRA. Our descriptive statistics provide sample means for the three key social responsibility realms and test differences of means between the full sample and the subsample of computing majors. The regression models build on this analysis by additionally incorporating student gender, race/ethnicity, and first-generation status. These models are conducted for both the full sample and the subset of computing majors, in order to evaluate our primary comparative hypothesis. In particular, we compare students in computing to students in three alternative disciplinary categories: engineering, science, and non-STEM. We do so because, while our initial theoretical focus is on engineering students as a comparison point, it is also helpful to compare computing students to additional undergraduate disciplines in order to contextualize their social responsibility attitudes as broadly as possible.

Importantly, because these data come from a single observation of students near the end of their undergraduate education, we are not able to determine the causes of variation among groups in the regression analyses, nor how social responsibility develops over time. However, we can determine baseline social responsibility attitudes across academic disciplines and the presence of variation associated with student demographic characteristics.

4. Results

4.1 Descriptive results

The mean values of our dependent variables related to social responsibility attitudes varied meaningfully between computing majors and the full sample (Table 2). On average, computing majors score below the mean for all students in all three PSRDM realms (all variables range from 1-7, Table 2). Personal social awareness was significantly lower (diff. = -0.23, $p < .001$) for computing majors as compared to the average of all students in the sample. The results reveal an even larger (diff. = -0.39, $p < .001$) gap for computing majors with respect to professional connectedness. The gap in professional development between computing major and all majors was smaller, but still significant (diff. = -0.12, $p < .01$).

Additionally, we analyzed correlations between the variables in our study, available in (Table C1). There are many significant, yet low, correlations among the independent variables, suggesting that regression analysis is helpful to isolate the causes of variation in the dependent variables.

4.2 Regression analysis

We next conducted a series of OLS regression models (Table 4) with the PSRDM realms as dependent variables, controlling for student demographic characteristics and majors. The models were conducted for the entire sample to test Hypothesis 1, then repeated for only computing majors to evaluate Hypothesis 2. In all models, the reference group are white, female computing majors. The models had low R^2 values (0.046 to 0.163), indicating that our models only explain a small amount of the total variation in social responsibility attitudes.

The models in the full student sample show a strong predictive relationship between academic major and social responsibility attitudes. Supporting Hypothesis 1, and in line with the descriptive results presented above, computing majors have lower social responsibility attitudes than other STEM majors. Engineering majors have higher personal social awareness (coeff. = 0.174, $p < .001$), professional development (coeff. = 0.100, $p < .05$), and professional connectedness (coeff. = 0.356, $p < .001$) than computing majors. Science majors also have higher personal social awareness (coeff. = 0.425, $p < .001$), professional development (coeff. = 0.222, $p < .001$), and much higher professional connectedness (coeff. = 0.785, $p < .001$) than computing majors.

Table 4. OLS Regressions of PSRDM Variables						
	All Students (n = 982)			Computing Majors Only (n = 184)		
	Personal Social Awareness	Professional Development	Professional Connectedness	Personal Social Awareness	Professional Development	Professional Connectedness
Demographics						
Male	-0.221***	-0.223***	-0.338***	-0.312**	-0.215**	-0.506***
	(0.050)	(0.043)	(0.060)	(0.133)	(0.108)	(0.166)
First Generation	-0.005	-0.091	-0.014	0.206	-0.022	0.284
	(0.104)	(0.089)	(0.125)	(0.235)	(0.191)	(0.292)
Asian	-0.031	-0.039	-0.017	0.030	0.216**	0.055
	(0.055)	(0.048)	(0.066)	(0.132)	(0.107)	(0.164)
URM	0.045	-0.010	0.069	0.278	0.481***	0.405*
	(0.069)	(0.059)	(0.083)	(0.194)	(0.157)	(0.241)
Major						
Engineering	0.174***	0.100*	0.356***			
	(0.065)	(0.056)	(0.078)			
Non-STEM	0.138	-0.132*	0.377***			
	(0.085)	(0.074)	(0.102)			
Science	0.425***	0.222***	0.785***			
	(0.086)	(0.074)	(0.103)			
Constant	5.776***	6.192***	5.076***	5.765***	6.004***	5.094***
	(0.070)	(0.061)	(0.085)	(0.131)	(0.106)	(0.163)
R-squared	0.062	0.062	0.116	0.046	0.072	0.069
F-statistic	9.183***	9.135***	18.183***	2.149*	3.497***	3.321**
*** p < 0.001, ** p < 0.01, * p < 0.05						

Non-STEM majors have comparable personal social awareness (p > .05), lower professional development (coeff. = -0.132, p < .05), but higher professional connectedness (coeff. = 0.377, p < .001) than computing majors. Thus, all other disciplines have higher professional connectedness than computing majors, which is important, as professional connectedness is the dependent variable most closely associated with overall professional social responsibility attitudes. Overall, these findings tend to support Hypothesis 1. Computing students have lower social responsibility attitudes than peers in other STEM disciplines, though how they compare to non-STEM students is more mixed.

Results from the full sample also indicate that male students have lower personal social awareness (coeff. = -0.221, p < .001), professional development (coeff. = -0.223, p < .001), and professional connectedness (coeff. = -0.338, p < .001) than female students.

In order to identify if there are demographic trends specific to computing majors, we repeated the demographic analysis for the sub-sample of computing majors only. These models also included gender, first-generation status, and race/ethnicity, but do not account for student major, as the sub-sample includes computing students only.

Supporting Hypothesis 2, male students in computing have consistently lower PSRDM scores than female students, with larger gender-based gaps in personal social awareness (coeff. = -0.312, $p < .01$) and professional connectedness (coeff. = -0.506, $p < .001$) than in the full student sample and a comparable gap in professional development (coeff. = -0.215, $p < .01$). Thus, male computing students have lower social responsibility attitudes than female students. Moreover, the gaps in social responsibility attitudes associated with gender are more pronounced amongst computing students than for students overall.

Additionally, the results indicate differences related to race/ethnicity within the computing sub-sample, which is notable as similar trends are not evident in the full sample. In particular, we find that Asian (coeff. = 0.216, $p < .01$) and especially underrepresented minority (coeff. = 0.481, $p < .001$) computing students have higher professional development scores than white computing students. Underrepresented minority computing students also have greater professional connectedness than white computing students (coeff. = 0.405, $p < .05$).

5. Discussion

These findings lend empirical support to ongoing efforts to bolster ethics education in computing [4]. Most notably, we find that computing students have lower social responsibility attitudes than other STEM majors, indicating a less developed sense of professional ethics and lower awareness of social problems [7]. These findings are particularly concerning because these comparisons were performed against other STEM majors at the same university, where one might expect conceptions of professional ethics to be similar due to shared institutional practices, academic culture, and regional factors.

This study shines a light on key issues in computing ethics and indicates a need for further research on ethics development and education in computing, including an examination of specific educational interventions, influential demographic and experiential factors, and unique aspects of computing that may influence social responsibility development. Moreover, knowledge gaps remain regarding what changes to social responsibility and ethics education in computing via curricular or extracurricular approaches are likely to nurture social responsibility attitudes. Although studies have shown the need for stand-alone ethics courses [62], the extent to which they can (or should) be enhanced by integrated ethics modules in regular computing classes remains a key question.

The findings of this study also raise interesting questions about gender in the context of computing ethics. Male students had significantly lower social responsibility attitudes than female students in every model, and this difference was especially pronounced among computing students. This strong and consistent effect adds to a growing body of literature indicating that men have consistently lower social responsibility attitudes than women [48]. Concerningly, these differences in ethics and values may represent another facet of the hostile culture or "chilly climate" many women face in computing and other STEM educational settings and workplaces [63]. In light of research indicating stronger preferences amongst women for socially engaged computing, these findings also suggest an opportunity for creating a more gender-balanced computing workforce. An increased emphasis on ethics could not only help to address retention and representation problems in computing, but also lead to greater concern for social issues in the computing profession overall [52].

A surprising finding is that racial/ethnic differences in social responsibility attitudes exist within computing, despite the absence of similar differences among students generally. While our study was not designed to determine why white computing students have particularly low social responsibility attitudes; this may be due to numerous factors, such as personal, cultural, or family characteristics. More detailed information is needed to identify what factors are most important in the development of social responsibility attitudes. These results suggest there are interesting research questions to be addressed at the intersection of diversity, equity, and inclusion efforts and ethics and social responsibility education in STEM [56].

6. Limitations

There are significant limitations to this study. The data presented here reflect a single point-of-observation, non-equivalent control study, conducted at a single U.S. university. Further, our findings, low R^2-values, and the literature indicate that there are a complex set of factors, beyond demographics, which influence social responsibility attitudes. In other portions of our research, we attempt to examine some of these factors, such as pre-college experiences, student participation in extracurricular clubs, and experiences with internships and work related to social responsibility development [50].

Notably, our study did not directly examine differences in ethics curricula between the degree programs, limiting our ability to understand institutional factors at play. For instance, some degree programs feature in-house ethics courses, while others require students to take a course outside of their major that satisfies an ethics requirement. In addition, because the data reported here were collected in a single observation at the end of students' undergraduate programs, we do not know the extent to which variation by major in social responsibility attitudes may reflect pre-college attitudes, rather than influences attributable to the major or other college influences. Indeed, studies within engineering have shown differences by major in pre-college social responsibility attitudes [47], suggesting that self-selection into majors may play a significant role.

Further study at other universities, including minority-serving institutions, is needed to review these findings and enhance generalizability. Social responsibility development should also be studied among computing graduate students, where graduate-entry master's degree programs are rapidly growing [64], [65] and more diverse than undergraduate computing programs [66]. We recommend researchers incorporate additional data on demographic, socio-economic, institutional, and other factors to better understand the root causes of variation in social responsibility attitudes among students. Additional studies with multiple, longitudinal observations and qualitative studies can help researchers disentangle the causal effects of curricula versus other college experiences and influences on social responsibility development. The research team associated with this paper is working to address these and other issues with longitudinal, mixed methods as part of a broader research agenda.

7. Conclusion

Findings from our survey indicate that social responsibility attitudes among undergraduate computer science students tend to be rather low as compared to their peers at the same institution. This lends credence to the view that there is a need for greater focus on ethics in computing degree programs, such as by embedding ethics throughout the computing curriculum. Computing is in a situation not unlike the one that faced engineering twenty years ago, when Woodhouse [67] described how the profession could move beyond minimalist compliance with professional ethics guidelines towards actively thinking about how the profession can proactively and conscientiously work to enhance the common good. Today, computing must move beyond minimalist, compliance-based ethics (e.g., "Don't be evil.") to a more robust macroethical and social responsibility framework. Computing degree programs could seize the opportunity to nurture a mindset within future professionals of sincere interest in protecting the public. If not, computing risks diminishing the reputation of the profession even further, increasing regulatory scrutiny, and exposing the public to greater harms. New educational initiatives and bold changes to long-standing curricular models may be necessary to maintain the integrity and credibility of the computing profession.

8. Acknowledgments

The authors would like to thank the students who took the time from their busy schedules to complete the survey. We also thank the Georgia Tech Registrar's Office for their assistance in data acquisition. This material is based on work supported by the National Science Foundation Cultivating Cultures for Ethical STEM Program (Award # 1635554). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

9. Bibliography

[1] E. Akinwotu, "Facebook's role in Myanmar and Ethiopia under new scrutiny," *The Guardian*, London, UK, Oct. 07, 2021. Accessed: Feb. 02, 2022. [Online]. Available: https://www.theguardian.com/technology/2021/oct/07/facebooks-role-in-myanmar-and-ethiopia-under-new-scrutiny

[2] K. Pham, "Want to fix big tech? Change what classes are required for a computer science degree," *Fast Company*, May 28, 2019. Accessed: Feb. 02, 2022. [Online]. Available: https://www.fastcompany.com/90355969/want-to-fix-big-tech-change-what-classes-are-required-for-a-computer-science-degree

[3] B. J. Grosz *et al.*, "Embedded EthiCS: integrating ethics across CS education," *Commun ACM*, vol. 62, no. 8, pp. 54–61, 2019.

[4] L. Cohen, H. Precel, H. Triedman, and K. Fisler, "A New Model for Weaving Responsible Computing Into Courses Across the CS Curriculum," in *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*, 2021, pp. 858–864.

[5] S. Vakil, "Ethics, Identity, and Political Vision: Toward a Justice-Centered Approach to Equity in Computer Science Education," *Harvard Educational Review*, vol. 88, no. 1, pp. 26–52, Mar. 2018, doi: 10.17763/1943-5045-88.1.26.

[6] D. Prioleau, B. Richardson, E. Drobina, R. Williams, J. Martin, and J. E. Gilbert, "How Students in Computing-Related Majors Distinguish Social Implications of Technology," in *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*, 2021, pp. 1013–1019. doi: 10.1145/3408877.3432456.

[7] N. Canney and A. Bielefeldt, "A framework for the development of social responsibility in engineers," *International Journal of Engineering Education*, vol. 31, no. 1B, pp. 414–424, 2015.

[8] N. E. Canney and A. R. Bielefeldt, "Validity and reliability evidence of the engineering professional responsibility assessment tool," *Journal of engineering education*, vol. 105, no. 3, pp. 452–477, 2016.

[9] P. J. Denning, "Is computer science science?," *Commun ACM*, vol. 48, no. 4, pp. 27–31, 2005, Accessed: Jan. 26, 2022. [Online]. Available: https://doi.org/10.1145/1053291.1053309

[10] M. W. Martin, "Rights and the meta-ethics of professional morality," *Ethics*, vol. 91, no. 4, pp. 619–625, 1981.

[11] J. H. Schaub, K. Pavlovic, and M. D. Morris, "Engineering professionalism and ethics," 1983.

[12] C. E. Harris Jr, M. Davis, M. S. Pritchard, and M. J. Rabins, "Engineering ethics: what? why? how? and when?," *Journal of Engineering Education*, vol. 85, no. 2, pp. 93–96, 1996.

[13] J. R. Herkert, "Future directions in engineering ethics research: Microethics, macroethics and the role of professional societies," *Sci Eng Ethics*, vol. 7, no. 3, pp. 403–414, 2001.

[14] M. Dyrud, "Ethics education for the third millennium," in *1998 Annual Conference*, 1998, pp. 3–264.

[15] L. Xie and Z. Qu, “On civil engineering disasters and their mitigation,” *Earthquake Engineering and Engineering Vibration*, vol. 17, no. 1, pp. 1–10, 2018.

[16] E. Englehardt, P. H. Werhane, and L. H. Newton, “Leadership, Engineering and Ethical Clashes at Boeing,” *Science and Engineering Ethics*, vol. 27, no. 1, p. 12, 2021, doi: 10.1007/s11948-021-00285-x.

[17] N. Barakat, “Engineering ethics: A critical dimension of the profession,” in *2011 IEEE Global Engineering Education Conference (EDUCON)*, 2011, pp. 159–164. doi: 10.1109/EDUCON.2011.5773130.

[18] W. T. Lynch and R. Kline, “Engineering practice and engineering ethics,” *Science, technology, & human values*, vol. 25, no. 2, pp. 195–225, 2000.

[19] R. Srinivasan and G. Sarial-Abi, “When Algorithms Fail: Consumers’ Responses to Brand Harm Crises Caused by Algorithm Errors,” *Journal of Marketing*, vol. 85, no. 5, pp. 74–91, Feb. 2021, doi: 10.1177/0022242921997082.

[20] M. de Choudhury, E. Kiciman, M. Dredze, G. Coppersmith, and M. Kumar, “Discovering shifts to suicidal ideation from mental health content in social media,” in *Proceedings of the 2016 CHI conference on human factors in computing systems*, 2016, pp. 2098–2110.

[21] C. Fiesler, N. Garrett, and N. Beard, “What do we teach when we teach tech ethics? A syllabi analysis,” in *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*, 2020, pp. 289–295.

[22] L. E. Grinter, “Responsibility in engineering education,” *The Journal of Higher Education*, vol. 25, no. 5, pp. 258–261, 1954.

[23] E. T. Layton Jr, *The Revolt of the Engineers. Social Responsibility and the American Engineering Profession.* ERIC, 1986.

[24] D. B. Parker, “Rules of ethics in information processing,” *Commun ACM*, vol. 11, no. 3, pp. 198–201, 1968.

[25] J. Herkert and J. Borenstein, “Responsibilities to the Public—Professional Engineering Societies,” in *The Routledge Handbook of the Philosophy of Engineering*, Routledge, 2020, pp. 592–606.

[26] J. R. Herkert, “Future directions in engineering ethics research: Microethics, macroethics and the role of professional societies,” *Sci Eng Ethics*, vol. 7, no. 3, pp. 403–414, 2001.

[27] C. D. Martin and D. H. Martin, “Professional codes of conduct and computer ethics education,” *ACM SIGSAC Review*, vol. 8, no. 3, pp. 1–12, 1990.

[28] K. Cook, *The psychology of Silicon Valley: Ethical threats and emotional unintelligence in the tech industry*. Springer Nature, 2020.

[29] J. Metcalf and E. Moss, “Owning ethics: Corporate logics, silicon valley, and the institutionalization of ethics,” *Social Research: An International Quarterly*, vol. 86, no. 2, pp. 449–476, 2019.

[30] N. Ensmenger, “‘Beards, sandals, and other signs of rugged individualism’: masculine culture within the computing professions,” *Osiris*, vol. 30, no. 1, pp. 38–65, 2015.

[31] E. Cech, “Trained to disengage? A longitudinal study of social consciousness and public engagement among engineering students,” in *2010 ASEE Annual Conference & Exposition*, 2010, pp. 15–1274.

[32] D. Vaughan, *The Challenger launch decision: Risky technology, culture, and deviance at NASA*. University of Chicago press, 1996.

[33] J. H. Lim, B. D. Hunt, N. Findlater, P. T. Tkacik, and J. L. Dahlberg, “‘In Our Own Little World’: Invisibility of the Social and Ethical Dimension of Engineering Among Undergraduate Students,” *Science and Engineering Ethics*, vol. 27, no. 6, p. 74, 2021, doi: 10.1007/s11948-021-00355-0.

[34] E. A. Cech and H. M. Sherick, “Depoliticization and the Structure of Engineering Education,” in *International Perspectives on Engineering Education: Engineering Education and Practice in Context, Volume 1*, S. H. Christensen, C. Didier, A. Jamison, M. Meganck, C. Mitcham, and B. Newberry, Eds. Cham: Springer International Publishing, 2015, pp. 203–216. doi: 10.1007/978-3-319-16169-3_10.

[35] M. Polmear, A. R. Bielefeldt, C. Swan, and D. Knight, “Undergraduate Engineering Students’ Exposure to, and Valuation of, Ethics Through the Lens of Socialization,” 2021.

[36] A. R. Bielefeldt, P. Madeline, K. Daniel, S. Christopher, and C. Nathan, “Intersections between Engineering Ethics and Diversity Issues in Engineering Education,” *Journal of Professional Issues in Engineering Education and Practice*, vol. 144, no. 2, p. 04017017, Apr. 2018, doi: 10.1061/(ASCE)EI.1943-5541.0000360.

[37] E. A. Cech, “Culture of disengagement in engineering education?,” *Science, Technology, & Human Values*, vol. 39, no. 1, pp. 42–72, 2014.

[38] A. R. Bielefeldt and N. E. Canney, “Changes in the social responsibility attitudes of engineering students over time,” *Sci Eng Ethics*, vol. 22, no. 5, pp. 1535–1551, 2016.

[39] E. A. Cech, “The (Mis)Framing of Social Justice: Why Ideologies of Depoliticization and Meritocracy Hinder Engineers’ Ability to Think About Social Injustices,” in *Engineering Education for Social Justice: Critical Explorations and Opportunities*, J. Lucena, Ed. Dordrecht: Springer Netherlands, 2013, pp. 67–84. doi: 10.1007/978-94-007-6350-0_4.

[40] J. Saltz *et al.*, “Integrating ethics within machine learning courses,” *ACM Transactions on Computing Education (TOCE)*, vol. 19, no. 4, pp. 1–26, 2019.

[41] M. Skirpan, N. Beard, S. Bhaduri, C. Fiesler, and T. Yeh, "Ethics education in context: A case study of novel ethics activities for the CS classroom," in *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*, 2018, pp. 940–945.

[42] J. Borenstein and A. Howard, "Emerging challenges in AI and the need for AI ethics education," *AI and Ethics*, vol. 1, no. 1, pp. 61–65, 2021, doi: 10.1007/s43681-020-00002-7.

[43] S. S. Chivukula, Z. Li, A. C. Pivonka, J. Chen, and C. M. Gray, "Surveying the Landscape of Ethics-Focused Design Methods," *arXiv preprint arXiv:2102.08909*, 2021.

[44] Y. Kafai, C. Proctor, and D. Lui, "From theory bias to theory dialogue: embracing cognitive, situated, and critical framings of computational thinking in K-12 CS education," *ACM Inroads*, vol. 11, no. 1, pp. 44–53, 2020.

[45] J. Borenstein, M. Drake, R. Kirkman, and J. Swann, "The test of ethical sensitivity in science and engineering (tesse): A discipline specific assessment tool for awareness of ethical issues," 2008.

[46] A. L. Antes *et al.*, "A Meta-Analysis of Ethics Instruction Effectiveness in the Sciences," *Ethics & Behavior*, vol. 19, no. 5, pp. 379–402, Sep. 2009, doi: 10.1080/10508420903035380.

[47] N. E. Canney and A. R. Bielefeldt, "Differences in engineering students' views of social responsibility between disciplines," *Journal of Professional Issues in Engineering Education and Practice*, vol. 141, no. 4, p. 04015004, 2015.

[48] N. E. Canney and A. R. Bielefeldt, "Gender differences in the social responsibility attitudes of engineering students and how they change over time," *Journal of Women and Minorities in Science and Engineering*, vol. 21, no. 3, 2015.

[49] A. R. Bielefeldt and N. E. Canney, "Relationships between religion, spirituality, and socially responsible engineering," *Engineering Studies*, vol. 8, no. 1, pp. 66–90, 2016.

[50] D. S. Schiff, E. Logevall, J. Borenstein, W. Newstetter, C. Potts, and E. Zegura, "Linking personal and professional social responsibility development to microethics and macroethics: Observations from early undergraduate education," *Journal of Engineering Education*, vol. 110, no. 1, pp. 70–91, Jan. 2021, doi: https://doi.org/10.1002/jee.20371.

[51] A. R. Bielefeldt and N. E. Canney, "Humanitarian aspirations of engineering students: Differences between disciplines and institutions," *Journal of Humanitarian Engineering*, vol. 4, no. 1, 2016.

[52] A. R. Bielefeldt, "Intersectional Complexities of Race/Ethnicity and Gender in Engineering Students' Professional Social Responsibility Attitudes," 2021.

[53] S. A. Hewlett *et al.*, "The Athena factor: Reversing the brain drain in science, engineering, and technology," *Harvard Business Review Research Report*, vol. 10094, pp. 1–100, 2008.

[54] National Science Board, “Science & Engineering Indicators,” Alexandria, Virginia, 2018.

[55] M. S. Tooley and E. E. Umphress, “Work in progress-the ethics of diversity: Addressing diversity issues in undergraduate engineering ethics education,” in *2009 39th IEEE Frontiers in Education Conference*, 2009, pp. 1–3.

[56] J. L. Hess, A. Whitehead, B. K. Jesiek, A. Katz, and D. Riley, “WIP: Intersections Between Diversity, Equity, and Inclusion (DEI) and Ethics in Engineering,” in *2021 IEEE Frontiers in Education Conference (FIE)*, 2021, pp. 1–5.

[57] D. D. Nulty, “The adequacy of response rates to online and paper surveys: what can be done?,” *Assessment & evaluation in higher education*, vol. 33, no. 3, pp. 301–314, 2008.

[58] A. Petrovčič, G. Petrič, and K. L. Manfreda, “The effect of email invitation elements on response rate in a web survey within an online community,” *Computers in Human Behavior*, vol. 56, pp. 320–329, 2016.

[59] T. J. Espenshade, A. W. Radford, and C. Y. Chung, *No Longer Separate, Not Yet Equal: Race and Class in Elite College Admission and Campus Life*. Princeton, NJ: Princeton University Press, 2009.

[60] M. L. McGann, “First generation college students and selective college admission: a quantitative examination of class-based affirmative action.,” Boston, Massachusetts, 2017.

[61] I. Ruthotto, Q. Kreth, J. Stevens, T. Clare, and J. Melkers, “Lurking and participation in the virtual classroom: The effects of gender, race, and age among graduate students in computer science,” *Computers & Education*, 2020, doi: 10.1016/j.compedu.2020.103854.

[62] A. L. Antes *et al.*, “A meta-analysis of ethics instruction effectiveness in the sciences,” *Ethics & Behavior*, vol. 19, no. 5, pp. 379–402, 2009.

[63] M. Roldan, L. Soe, and E. K. Yakura, “Perceptions of chilly IT organizational contexts and their effect on the retention and promotion of women in IT,” in *Proceedings of the 2004 SIGMIS conference on Computer personnel research: Careers, culture, and ethics in a networked environment*, 2004, pp. 108–113.

[64] Professional Science Master’s, “Current PSM Programs in the STEM Field of Study,” 2018. [Online]. Available: https://www.professionalsciencemasters.org/reports-statistics/current-psm-programs-stem-field-study

[65] J. Goodman, J. Melkers, and A. Pallais, “Can online delivery increase access to education?,” *Journal of Labor Economics*, vol. 37, no. 1, pp. 1–34, 2019.

[66] I. Ruthotto, Q. Kreth, and J. Melkers, “Entering or advancing in the IT labor market: The role of an online graduate degree in computer science,” *The Internet and Higher Education*, vol. 51, p. 100820, 2021, doi: https://doi.org/10.1016/j.iheduc.2021.100820.

[67] E. Woodhouse, “Curbing overconsumption: Challenge for ethically responsible engineering,” *Technology and Society Magazine, IEEE*, vol. 20, pp. 23–30, Feb. 2001, doi: 10.1109/44.952762.

Appendix A: Full variable construction

Table A1. Personal Social Awareness Construction

	Cronbach's alpha	mean	sd
Personal Social Awareness	0.89	5.84	0.77
Awareness	0.77	6.27	0.76
(R) America does not have communities that need help		6.58	0.99
Community groups need our help		5.90	1.05
(R) There are not people in the community who need help		6.29	1.30
There are people who have needs which are not being met		6.40	0.98
There are needs to address in the community		6.19	0.96
Ability	0.77	5.61	0.89
I can make a difference in my community		6.00	0.97
I can have an impact on solving problems that face my local community		5.73	1.02
My contribution to society will make a real difference		5.42	1.13
(R) I cannot have an impact on solving problems that face underserved communities internationally		5.31	1.41
Connectedness	0.85	5.60	1.05
(R) It is not my responsibility to do something about improving society		5.63	1.43
It is my responsibility to take some real measures to help others in need		5.40	1.24
I feel an obligation to contribute to society		5.56	1.30
I think I should help people who are less fortunate with their needs and problems		5.80	1.04
(R) ⇒ Scale reversed for item			

Table A2. Professional Development Construction			
	Cronbach's alpha	mean	sd
Professional Development	0.70	6.13	0.66
Base skills	n/a	6.44	1.02
Professional ethics (ensuring all of your work follows professional codes of conduct)		6.44	1.02
Professional ability	0.60	6.15	0.78
People in my intended profession have contributed greatly to fixing problems in the world		6.16	1.08
(R) The skills in my intended profession are not useful in making the community a better place		5.72	1.49
(R) Technology does not play an important role in solving society's problems		6.41	1.02
People in my intended profession can have a positive impact on society		6.35	0.99
Analyze	0.55	5.74	0.85
Cultural awareness / understanding (of your culture, and those of others)		5.76	1.41
Societal context (how your work connects to society and vice versa)		6.12	1.16
(R) I would not change a design or recommendations because they conflicted with community feedback		4.91	1.47
It is important for people in my intended profession to consider the potential broader impacts of technical solutions to problems		6.16	1.09
(R) ⇒ Scale reversed for item			

Table A3. Professional Connectedness Construction			
	Cronbach's alpha	mean	sd
Professional Connectedness	0.94	5.28	0.95
Professional connectedness (dimension level)	0.92	5.18	0.98
Volunteering (for professional and personal reasons)		5.04	1.49
Volunteer experiences have changed the way I think about spending money		4.75	1.51
It is important to me to have a career that involves helping people		5.72	1.36
(R) Service should not be an expected part of my intended profession		4.90	1.60
I will use the skills gained from my intended profession to help others		5.80	1.19
(R) I view my intended profession and community service work as unconnected		4.39	1.71
I feel called to serve others through my intended profession		4.80	1.67
(R) The needs of society have no affect on my choice to pursue my intended profession		4.78	1.69
I feel called by the needs of society to pursue my intended profession		4.38	1.70
(R) I doubt that volunteer work will ever have much affect on my career		4.86	1.60
I think it is important to use the skills gained from my intended profession to serve others		5.56	1.32
People in my intended profession should use their skills to solve social problems		5.52	1.37
It is important to use my professional abilities to provide a useful service to the community		5.62	1.27
I believe that I will be involved in social justice issues for the rest of my life		4.59	1.77
(R) I do not think it is important to use skills gained from my intended profession to serve the greater community		5.48	1.47
I think people who are more fortunate in life should help less fortunate people with their needs and problems		5.92	1.18
I believe it takes more than time, money, and community efforts to change social problems: we also need to work for change at a national or global level		5.82	1.29
It is important to me to have a sense of contribution and helpfulness through participating in community service		5.32	1.33
Costs/Benefits	0.77	5.34	1.03
I would be willing to have a career that earns less money if I were serving society		4.57	1.59
My professional skills are strengthened through participation in service opportunities		5.01	1.49
I believe my life will be positively affected by the volunteering that I do		5.79	1.15
I believe that extra time spent on community service is worthwhile		5.97	1.04
(R) ⇒ Scale reversed for item			

Appendix B: Majors by category

Table B1: Majors by Analytic Category
Computing
Computational Media
Computer Engineering
Computer Science
Engineering
Aerospace Engineering
Biomedical Engineering
Chemical & Biomolecular Engineering
Civil Engineering
Electrical Engineering
Environmental Engineering
Industrial Engineering
Materials Science & Engineering
Mechanical Engineering
Nuclear & Radiological Engineering
Undeclared Engineering
Non-STEM
Applied Languages & Intercultural Studies
Architecture
Business Administration
Economics
Economics & International Affairs
Global Economics & Modern Languages
History
Industrial Design
International Affairs
International Affairs & Modern Languages
Literature, Media, & Communications
Music Technology
Public Policy
Science
Applied Physics
Biochemistry
Biology
Chemistry
Earth & Atmospheric Sciences
Mathematics
Neuroscience
Physics
Psychology

Appendix C: Correlation matrix

To better understand the interrelation of the variables in our sample, we present a correlation matrix (Table C1). Unsurprisingly, the PSRDM variables are strongly internally correlated, as they all measure concepts related to the social responsibility development. Note that engineering majors make up a slim majority (51%) of the sample and thus drive the sample mean.

Table C1. Correlation Matrix

	Variable	A.	B.	C.	D.	E.	F.	G.	H.
A.	Personal social awareness	1							
B.	Professional development	0.56***	1						
C.	Professional connectedness	0.80***	0.53***	1					
D.	Male	-0.19***	-0.19***	-0.24***	1				
E.	First generation	-0.01	-0.04	-0.02	0.03	1			
F.	White	0.03	0.03	0.04	-0.08*	-0.08**	1		
G.	Asian	-0.05	-0.04	-0.06*	0.07*	0.05		1	
H.	Underrepresented Minority	0.03	0.01	0.03	0.02	0.06			1
I.	Computing major	-0.14***	-0.09**	-0.22***	0.21***	0.04	-0.12***	0.15***	-0.02
J.	Engineering major	-0.01	0.04	-0.01	0.05	0.02	-0.05	0.01	0.06
K.	Non-STEM major	0.01	-0.11***	0.02	-0.09**	-0.04	0.14***	-0.11***	-0.06
L.	Science major	0.17***	0.14***	0.23***	-0.21***	-0.03	0.06	-0.07*	0.00

*** p < 0.001, ** p < 0.01, * p < 0.05