Who I Am Becoming, Now: Toward a Computer Science Professional Identity Instrument

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***Abstract*—This paper presents preliminary findings from the pilot run of a survey instrument exploring professional identity formation in computer science. Students in computer science (CS) majors negotiate their concept of professional identity (PI) through coursework and engagement in legitimate practices of the computing profession, such as assignments, projects, and internships. Successful PI formation may occur without conscious effort for many CS students, while others struggle to form an authentic sense of identifying with the profession. Poor identity formation may contribute to withdrawal from the major or from the field. Assessing the impact of curricular and extracurricular offerings on students' PI formation may be difficult for educators. This paper presents development of a survey instrument for measuring PI and findings from its administration with 176 undergraduate CS majors. The survey development was informed by semi-structured interviews with 19 students. For the survey, participants identify job titles they would consider applying to in the future. They then respond to how well one of their possible future job titles describes them in their current role in academia, from their own perspective and from the perspectives of peers and a supervisor. Students who were more advanced in their major, had completed an internship, or participated in a capstone course, responded that the future job title described them more strongly than students earlier in their studies. The pilot data indicates no statistically significant difference in PI strength across gender, but PI was measurably different between Bachelors of Science and Bachelors of Arts CS students at our institution.**

I. Introduction

Professional identity (PI) is the sense of connection and belonging experienced by individuals with respect to a given profession. PI includes adoption of "roles, responsibilities, values, and ethical behaviors of the profession" [1] and is socially constructed through interactions with members of the professional community of practice [2]. The formation process of PI involves each individual reconciling the differences of values and ethics they experience between the various communities [2]. Development of PI during academic studies may begin as early as the decision to declare a major [3]. Identity formation can be thought of as navigating conflicting tensions from different communities, with students working through a process of reconciling those tensions during their transition from university to the work community [2].

Research into PI formation in early computer science (CS) undergraduate students notes that identity formation early in academic studies can positively influence their likelihood to persist with the computing discipline [4]. Students negotiate their concept of PI through coursework and engagement in legitimate practices of the computing profession. This may take the form of assignments, projects, and internships. For some, the formation of PI may seem to occur naturally on a subconscious level [5]. Others may struggle to form an authentic sense of identity with the profession, as evidenced by students responding that "I don't feel like I belong" when asked why they are changing majors out of CS [6].

Educators may struggle to reliably assess the impact of curricular and extracurricular offerings on students' PI formation. A study into *engineering identity* assessed an individual's strength of engineering PI with the question, "Do you consider yourself to be an engineer?", paired with student indications of what behaviors represent being an engineer [7]. This approach does not seem to consider that the social nature of identity involves more than the individual's self perception, but also their perceptions of how they fit into their social context (cf. "looking glass self" [8]).

This paper presents a quantitative survey instrument for measuring PI grounded in the social perceptions of each individual's possible future roles in computing, and findings from its pilot administration with 176 undergraduate CS majors. Survey development was informed by results from semi-structured qualitative interviews with 19 seniors about how their capstone in software engineering prepared them for a future professional role [9]. The quantitative survey focuses on how well a future job title describes students from their own perspective and from the perspectives of peers and a supervisor.

The paper is organized around the following research questions:

RQ1 How well does a future role in the computing profession describe the current professional identity of undergraduate CS majors?

RQ2 How does the current professional identity of undergraduate CS majors vary with respect to demographics and practical experiences?

The survey approach asks students to consider job titles they could imagine applying to in the future. We hypothesize that students may anticipate pursuing a variety of roles after completing their university studies, such that we would observe a diverse set of professional job roles supported by the CS major. We anticipate a correlation between whether

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a student claims a possible future job title and how strongly that job title might describe the student currently. We expect that it is more important that the job title is meaningful to the student than specifically which job title is being considered. For RQ2, we hypothesize that a valid PI instrument would demonstrate correlation between stronger PI and progression in the CS major courses, internships, and participation in a capstone course. We expect that the PI perceptions will be stronger in men than women, as would be consistent with previous work on cultural gender biases in CS [6], [10].

This study explores PI in the CS discipline based on preliminary data from the pilot run of the survey, informing our understanding of where university students perceive their future career trajectories possibly taking them. The novel approach of considering how well a future job title describes students from their own perspective and from the perspectives of peers and a supervisor offers a more cohesive situated measure of PI than just considering the self perception of PI. This method of assessing PI may be adapted in the future to improved insights into the PI formation of undergraduate CS students and how PI correlates to curricular and extracurricular offerings. This can inform decisions about how the CS educational space is crafted to support undergraduate learning and professional development, such as in balancing class time spent on theory versus practice.

II. Literature on Professional Identity

We briefly review the core construct of PI as building on social identity, followed by discussion of risks associated with breakdown in identity formation processes. Literature about CS PI is of relevance to this study, though limited resources about CS PI lead us to include an overview of PI studies in engineering and other academic settings.

A. The Social Construct of Identity

The literature review in [11] on engineering PI studies notes the importance of researchers being clear about their PI definitions. One PI definition highlighted is "perceptions of the self or the profession", and includes "believing oneself to be an engineer" and "by the individual identifying her- or himself as an engineer and by others identifying her or him as an engineer" [11]. As an example of an engineering PI instrument, [12] measure identity through "interest, performance/competence, and recognition". These constructs roughly map to the questions of *what do I want to do?* (interest), *how good am I at it?* (performance), and *what do others think I can do?* (recognition).

Identity formation is a social process occurring "in the core of the individual and ... in the core of his communal culture.... This process is ... for the most part unconscious" [5]. When identity formation is proceeding successfully along a trajectory of participation [13], the individual may not be aware of PI changes; yet when he or she struggles with her or his sense of identity, the resulting "identity crisis" [5] may have significant impact, including a decision to withdraw from participating in the professional community [14]. A persistence study of students who transferred out of the CS major noted "I feel I don't belong" as a reason cited for deciding to withdraw [6].

B. Influence of Professional Identity

Breakdown of PI may be manifest in a variety of ways, including impostor syndrome [15], a sense of not belonging [6], identity crisis [5], and burnout [16]. By contrast, "an optimal sense of identity ... is experienced ... as a sense of psychosocial well-being...., a feeling of being at home in one's body, a sense of 'knowing where one is going,' and an inner assuredness of anticipated recognition from those who count" [5]. PI may be linked to engagement and a feeling of inclusion [4].

C. Computer Science Professional Identity

Prior work into CS PI explored introductory student experiences to understand how CS1 students' sense of identity with the CS major may link to their intention to persist with the program [4]. This study focused on student essays and interviews for exploring student sense of identity [4]. Other research efforts targeted interviews about the senior capstone experience and PI formation occurring as students transition from an academic to a professional sphere [9], [17]. These qualitative data sets contribute to exploring student perceptions and reflections on their PI process, yet may benefit from a quantitative method for operationalizing CS PI.

Retention studies in CS indicate that computing culture may be a significant influence on whether students experience a sense of belonging [6]. The study noted the significance of "the culture of computer science in light of retention" [6], and posed the question, "is there energy within the [CS] departments to make room for people who want strong bonds with people?" [6]. A much earlier study examined introductions to computing in a university setting, and identified the experience for many students as an "experience consist[ing] of encountering an alien culture", complete with "culture clash" [18]. Consideration of PI as socially situated in computing culture adds support for this development of a CS PI instrument that integrates social perceptions of the student.

D. Professional Identity in Academic Settings

One institution focuses on freshman student perceptions of experience and its impact on PI in engineering [19]. The authors note that "people tend to choose behaviors whose meanings are congruent with their own self-meanings" [19]. The behaviors targeted by [19] are the decision to persist or withdraw from the undergraduate program, similar to CS retention studies. The engineering identity authors' findings "suggest that exposure to meaningful engineering-related experiences and engineers are critical in developing an engineering identity" [19].

A cross-sectional survey of undergraduate engineering students explored their willingness to claim the title of *engineer* as a proxy for engineering identity, and the behaviors associated with engineering [7]. The authors noted that "what you call students matters: [teachers] calling engineering students

engineers may reduce their isolation and enhance feelings of community toward engineering" in the classroom setting [7]. This raises a question when considering adapting their methodology for the CS discipline. What CS role would replace their use of 'engineer' as deriving from a major in engineering?

Engineering identity studies pair the individual's sense of connection to the discipline with behaviors relevant to the practice of the profession [7], [19]. Professional behaviors and practices are a second definition highlighted by [20] as appearing in the literature. This suggests that practical experiences in CS, such as internships and project work, may offer strong influence on PI formation.

Introduction of professional roles and practices through an educational space is consistent with "Fertile Zones of Cultural Encounter" [21], where the resulting shared project space has aspects that are legitimate to the professional setting while still being an educational space. This resulting shared space between academic and professional communities of practice creates a learning zone "to resolve culture clash and to facilitate the development by the students of a professional perspective on computing" [21]. A CS PI instrument would contribute to assessing how well professionalizing experiences such as internships and capstone courses contribute to the process of maturing students' sense of PI.

In a study of PI in health and social care students, researchers asked participants to "say how they currently identify themselves along a scale between 'first day student' and 'qualified doctor/nurse/social worker etc.' when engaged in professional activity" [22]. The authors noted that this approach purposefully avoided giving participants a definition of PI, instead leaving it "in a 'black box' into which respondents might read their own tacit perceptions" [22]. The approach yielded stronger PI indications correlated with progression in the program, and higher levels of PI in participants with greater previous experience [22]. From a study of pre-service teachers, the perception of future roles with the profession was identified as an important factor to consider when assessing PI for educators [23]. The proposed CS PI instrument invites participants to consider a future role in CS as a 'black box' concept that can then be applied as a proxy for PI.

III. CS Professional Identity Survey

This section presents the method of our approach for operationalizing CS PI. At a high level, we review the pertinent theories about social PI and their influence on how the survey instrument was designed. We conclude this section with an overview of the context where we conducted the pilot run of the CS PI survey instrument.

A. Operationalizing CS Professional Identity

A survey instrument exploring PI of engineers (referred to as engineering identity) used the question, "Do you consider yourself to be an engineer?" with response options *yes*, *in some ways yes and in some ways no*, and *no* [7]. The survey was conducted with engineering students who had declared their major to be Engineering [7].

To adapt this method from engineering identity to a CS PI instrument, two concerns must be addressed. First, is there a single general title for Computer Science majors that mirrors "engineer" for Engineering majors? Second, can the instrument integrate the social insights from multiple points of view, rather than relying solely on the participant's self consideration alone?

CS college students may not consciously be aware of their own identity formation process [5]. In a survey instrument exploring PI for health and social care students, the authors "made no attempt to define or elucidate the nature of professional self-identity. Instead, we left it in a 'black box' into which respondents might read their own tacit perceptions" [23].

Future self concept is an effective method for assessing a person's current affinity for a professional role, and represents a key concept to an individual's sense of identity and current anticipated future direction [23]. The survey method used in this study is presented in figure 1. To address the first concern, the approach used in our survey is to consider a relevant future role as a substitute for the profession label. Instead of an attempt to derive a generic label for all professional roles in the CS profession, our survey invites each participant to engage their own conceptualization of roles in computing.

The second concern from the engineering survey is that the individual is only asked about their personal consideration of their identity. By considering social development of PI across the individual, interpersonal, and community settings [24], it is appropriate to ask participants how well their future professional role "fits" them from their self perspective (individual), from the perspective of their peers (interpersonal), and from a supervisory role in their disciplinary practice (community). This approach captures a more comprehensive social identity by focusing on the individual's perceptions of how they may be perceived by peers and supervisors [5], [8], [11]. According to [14], feedback from these social settings strongly influences whether an individual will feel that their presented identity is accepted, or whether they will feel the need to change their behaviors or withdraw.

In summary, the approach for operationalizing CS PI is to invite participants to identify possible future job titles they might consider as relevant for their career. Once one or more job titles are identified, the title is then used to explore how well that job title describes them from their personal point of view, from their perceptions of their peers, and from a supervisor's point of view.

B. Survey Design Process

It is important for survey design to consider possible question order effects [25]. Priming refers to use of "early questions to bring to mind material that is then more accessible for answering later questions", leading to "assimilation: answers across questions become more similar" [25]. When exploring CS PI, we want participants to focus on their internal (and

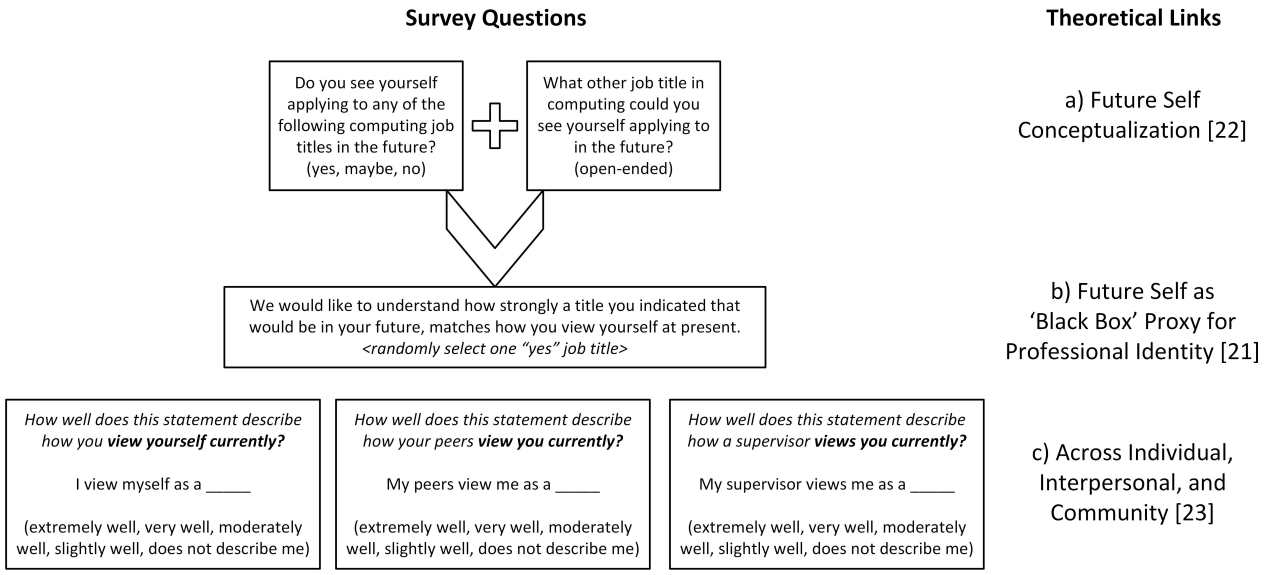

Fig. 1. Computer Science Professional Identity (CS PI) operationalizes a future self conceptualization as a proxy for professional identity. The participant indicates which possible future roles in computing they would consider applying to (a), then considers how one role matches how they are perceived currently (b). This self-perception is gathered for the individual, for peers, and for a supervisor (c).

possibly subconscious [5]) concept of a future role in the computing profession, and then to use that conceptualization to assess whether that future role might be applied to the participant in their current role as a student.

Gender priming may occur depending on where the demographics questions are placed in a survey instrument [26]. We anticipate some influence from gender identity on our investigation into CS PI because of the many studies into gendered imbalances in the CS discipline (e.g., [27]). We designed our survey instrument by beginning with future professional roles and how well they fit, then included computing behavioral questions, and concluded with demographics questions. This approach may help to minimize possible gender priming effects while gathering responses to both sets of questions. This paper focuses solely on the PI questions and not the questions about behaviors.

Nonresponse bias occurs when responders differ significantly from nonresponders. The pilot run of this survey was not funded, so did not include incentives to motivate responses. The outreach emails encouraged the target audience to consider their responses as giving back to and improving the CS department.

C. Survey Procedures

Semi-structured qualitative interviews were previously conducted with 19 students in the CS Senior Projects course by the principal investigator. Thematic coding of the qualitative data focused on student perceptions of the successes and failures of their capstone projects [28]. The work highlighted the role of professionalizing experiences such as capstones in building student confidence and identifying possible future roles [28], prompting further work in the form of this survey development.

The survey was laid out according to the design process depicted in figure 1. Per the recommendation of [25], the survey was pretested with four CS students for extra credit. The students completed the survey questionnaire while being observed by the principal investigator, and responded to questions about their thoughts on the survey format and question phrasing. Comments from the pretest students resulted in some rewording of question formats and adjustments to pacing of the survey instrument. Pretest responses suggested that the approach for designing the survey questions may be successful in operationalizing CS PI.

Following recommendations for survey construction from [25], the survey instrument was set up with minimal required response questions, meaning that participants could skip any question they were not comfortable answering.

For the pilot study, the survey was administered through Qualtrics, a web-based survey site. An email invitation to participate was distributed by the CS department undergraduate advisors, with the expectation that the advisors' involvement would lend legitimacy to the invitation to participate in the study and improve performance [25]. We included a follow-up reminder 1 week later, and a final call for participation at 2 weeks into the study. The study was closed at the end of the third week. Most participants completed the survey in 15 minutes or less. Participation in the survey was not compensated.

1) Future Professional Self Concept: Participants first considered what future job titles they might consider applying to, marking each suggested job title *yes*, *maybe*, or *no*. The initial list was informed in part by qualitative interviews performed as a separate study [9], augmented by job labels from a public

blog post about computing professions[1], and additional job titles such as *computer scientist* and *assembly programmer* suggested by our research team. The full list appears in figure 2. The question included a response field for "Other" to allow participants to provide their own future professional role. The survey randomly selected one of the *yes* job titles for how well a future job title describes the participant from their own perspective and from the perspective of peers and a supervisor, as follows:

1) Self: I view myself as a _____.
2) Peer: My peers view me as a _____.
3) Supervisor: My supervisor views me as a _____.

For each perspective statement, Likert-scale responses included *Describes me extremely well*, *Describes me very well*, *Describes me moderately well*, *Describes me slightly well*, and *Does not describe me*.

2) Engagement with Professional Practices: The survey includes questions exploring professional practices, including community interactions (in person and on-line), definition of code completion, and confidence in activities related to computing practices. For brevity and focus of this study, we exclude analysis and discussion of the professional practice questions.

3) Demographics: Demographic data includes gender identity, age range, degree pursued (BS or BA), major, and number of semesters into the program. The survey asked participants whether they have completed an internship and a senior capstone course.

D. Survey Context

Our CS PI survey was conducted during the spring semester of 2017 with undergraduate CS students enrolled in a public research university in the United States. The university offers both a Bachelor's of Science (BS) degree and a Bachelor's of Arts degree (BA) in Computer Science. As undergraduate CS majors progress in their studies, their projects and assignments offer legitimate experience with professional practices. Many students opt to complete internship experiences as an additional path to demonstrating their readiness for professional roles and responsibilities.

[1]http://www.rasmussen.edu/degrees/technology/blog/what-can-you-do-with-computer-science-degree/

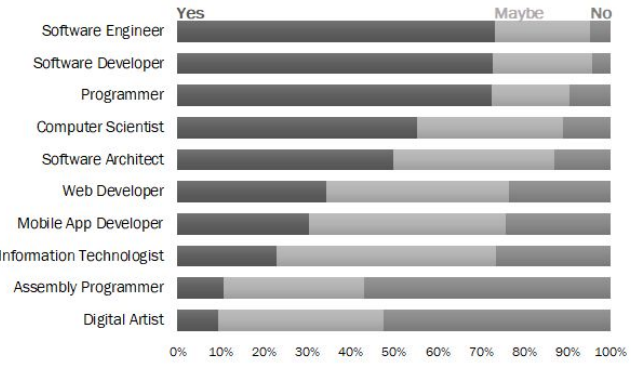

Fig. 2. Responses to question, "Do you see yourself applying to any of the following computing job titles in the future?" sorted by *yes* response rate.

TABLE I
DEMOGRAPHIC BREAKDOWN OF RESPONDENTS BY GENDER, YEAR IN PROGRAM, AND DEGREE TYPE (BS OR BA).

		Female	Male	Total
BS	**Senior**	10	19	29
	Junior	4	8	12
	Sophomore	3	12	15
	Freshman	2	14	16
BA	**Senior**	9	11	20
	Junior	4	4	8
	Sophomore	3	5	8
	Freshman	2	10	12
Total		**37**	**81**	**118**

For BS students, a degree requirement includes a two-semester capstone experience during their senior year. BA students may elect to participate in a capstone experience, but are not required to do so. The BA program is marketed towards students who may not identify as engineers [29]. The BA program does not have as strong of math and science requirements, and may be perceived as a "lighter" degree than the BS program [30]. In previous interviews, some BA students indicated that they opt to complete the capstone experience as a way to show future employers that their BA degree has as much weight as a BS degree [28].

1) Population: All declared CS majors (1500 students) in the BS (616 students) and BA (884 students) degrees were invited to complete the Web-based survey during the last month of the Spring 2017 semester. 176 responses (11.7%) completed at least one question, with 117 responses (7.8%) that reached the end of the survey. This is lower than the 25-50% expected for a Web survey [7], [25] and thus limits any findings or claims from this work.

IV. Data Analysis and Results

Figure I presents a breakdown of respondent demographics by gender, year in program, and degree type (BS or BA). Race, ethnicity, and first-year student status were not collected. Demographics questions were placed on the final page of the survey and were optional, allowing participants to skip any question they were uncomfortable answering.

Data analysis sections are guided by the research questions for this study.

A. Future-Self Roles

The survey question about future job titles the participant might consider applying to in the future was the first page of the survey. This introduces professional roles as a core concept of the study, and implicitly invites participants to focus on their conceptualization of PI. Response options were *yes*, *maybe*, or *no* for each job title presented. Participants were given an "Other" field in which they could write any alternative title.

TABLE II
COMPARISON OF WHETHER WILLINGNESS TO CONSIDER A POSSIBLE FUTURE JOB CORRESPONDS TO THE JOB TITLE DESCRIBING THE PARTICIPANT.

Consider Job?	Count	Median	Spread Average	Spread Std. Dev.
Yes	139	Describes me moderately well	.62 scale points	.74 scale points
Maybe	78	Describes me moderately well	.62 scale points	.65 scale points
No	42	Does not describe me	.33 scale points	.69 scale points

1) Descriptive Data about Future Job Titles: 166 survey participants provided responses on most job titles. All questions were optional, and some participants chose not to respond to some job titles. In addition to the list of provided job titles, participants could optionally write in an additional job title they felt was missing. 46 participants elected to write in an alternate job title.

Both RQ1 and RQ2 explore how the questions about future professional perceptions may serve as a proxy for PI. The focus is on the influence a possible future self may have for the respondent in their current role as a student, and not on specific job titles. Additional depth of analysis into types of future job labels is not included here.

B. Future Job Titles as Current Descriptions

RQ1 investigates whether future job titles can serve as a conceptual 'black box' for participants to consider against their current maturity towards that professional role. Responses to the initial question about future job titles invited participants to focus on their conceptualization of PI. The survey then presents questions about the self perception of how well the job title describes the participant (*"I view myself as a"*), the peer perception (*"My peers view me as a"*), and the supervisor perception (*"My supervisor views me as a"*). Responses were on a 5-point Likert-scale from *Describes me extremely well* to *Does not describe me*.

The objective for using these future job titles is to have each survey respondent use their selected future jobs as conceptual placeholders for considering current PI formation. For this usage, the specific job title serves as a concrete placeholder for each participant, yet acts as a "black box" for the questions about how they are maturing into any future role in the computing profession.

1) Correspondence between Future Role and Social Fit: To understand the impact of attempting to combine responses about the social fit of job titles, our analysis examines the correspondence between whether the participant considered a position and the median of how well the title described themselves. All participants were asked to respond for a *yes* job title. If a participant selected multiple *yes* titles, the survey randomly selects one title.

Rather than relying solely on *yes* job titles, the survey was configured to ask a random subset of participants about a *maybe* job title and a *no* job title. Results are presented in table II. When working with Likert-scale data, we are careful to consider all analysis in terms of the Likert scale points, and not as representing distinct scalar values.

Yes and *maybe* job titles both received a median score of *Describes me moderately well*, with similar spread of Likert scale points between the three perceptions (self, peer, and supervisor). In contrast, *no* job titles received a median score of *Does not describe me*. This may suggest that *yes* and *maybe* job titles successfully capture a PI concept that is authentic for participants, while *no* job titles may not align well with participants' PI concept.

C. Cross-Tabulation of PI with Demographics

RQ2 targets the three perceptions (self, peer, and supervisor) for how well a future job title describes each participant, and explores how those distinct perspectives might interact for different demographics. The demographics of primary interest in this phase of the study are gender, degree type (BS vs. BA), progression in the degree, participation in an internship, and completion of a capstone course. Progression in the degree was indicated by year in school using labels "freshman", "sophomore", "junior", and "senior" for fourth year or longer.

The decision to make most fields in the survey optional may have improved participant experience in answering questions they felt comfortable responding to, and may have increased the overall completion rate for this pilot run of the survey instrument. This also contributed to a data set with missing data. The analysis of differences in responses about how well a job title describes the participant used χ^2 tests, comparing the ordinal Likert-scale responses with nominal variables such as gender and degree type, or with the ordinal variable of year-in-program. A broader survey response rate would be needed to conduct more fine-grained factor analysis, hence referring to this data set as a pilot study exploring the CS PI construct. Key results of the χ^2 tests are presented in table III. We apply the Bonferroni correction [31] because the five demographics tests represent multiple comparisons on the same data set, such that the significance value of p <= .05 is divided by 5, indicating significance only when p <= .01.

1) Comparing Perspectives: RQ2 considers variations in the PI responses of how well the *yes* job title describes the participant, with respect to demographics and practical experiences. Of particular interest is how the different perspectives (self, peer, and supervisor) might interact. An engineering identity survey similar in purpose to this study relied only on the self perspective with their question, "Do you consider yourself to be an engineer?" [7].

The PI survey presented in [22] considered a correspondence between strength of PI and the year in the program as an indication that the survey instrument is measuring PI, as we hypothesize that students are progressing in the strength of their preparedness to enter their chosen profession as they complete more of the coursework. Similarly, [7] noted a distinction between freshmen in engineering and all students in later years of their studies. For our analysis, we compare freshmen and sophomores against juniors and seniors. In

TABLE III

COMPARISON OF CROSS-TABULATION RESULTS BETWEEN PI (AS MEASURED BY HOW WELL A FUTURE JOB TITLE DESCRIBES THE PARTICIPANT CURRENTLY ACROSS DIFFERENT PERSPECTIVES) AND DEMOGRAPHICS. DEMOGRAPHICS CONSIDERED ARE GENDER, DEGREE TYPE, PROGRESSION IN ACADEMIC STUDIES (FRESHMEN AND SOPHOMORES VS. JUNIORS AND SENIORS), INTERNSHIP, AND CAPSTONE. P <= .05/5 = .01*, P <.001**

Perspectives Considered	Demographics	Relation	χ^2	Degrees of Freedom (df)	Significance (p)	N
Self	Gender	*unclear*	4.30	6	p = .64	97
	Degree Type	*unclear*	12.55	6	p = .05	98
	Fresh/Soph vs Junior/Senior	*unclear*	12.55	6	p = .05	93
	Internship	Yes greater than No	18.56	6	**p <.01***	139
	Capstone	*unclear*	9.62	6	p = .14	96
Peer	Gender	*unclear*	3.27	5	p = .67	97
	Degree Type	*unclear*	10.44	5	p = .06	98
	Fresh/Soph vs Junior/Senior	*unclear*	10.97	5	p = .05	93
	Internship	Yes greater than No	14.55	5	**p = .01***	138
	Capstone	*unclear*	14.05	5	p = .02	96
Supervisor	Gender	*unclear*	5.02	5	p = .41	97
	Degree Type	*unclear*	10.60	5	p = .06	98
	Fresh/Soph vs Junior/Senior	*unclear*	12.06	5	p = .03	93
	Internship	Yes greater than No	23.00	5	**p <.001****	137
	Capstone	Yes greater than No	16.37	5	**p <.01***	96
Self & Peer	Gender	*unclear*	8.18	9	p = .52	97
	Degree Type	BS greater than BA	22.42	9	**p <.01***	98
	Fresh/Soph vs Junior/Senior	*unclear*	14.73	9	p = .10	93
	Internship	*unclear*	19.12	10	p = .04	139
	Capstone	*unclear*	14.10	9	p = .12	96
Self & Supervisor	Gender	*unclear*	6.52	9	p = .69	97
	Degree Type	*unclear*	19.71	9	p = .02	98
	Fresh/Soph vs Junior/Senior	*unclear*	13.01	9	p = .16	93
	Internship	Yes greater than No	22.22	10	**p = .01***	139
	Capstone	*unclear*	13.68	9	p = .13	96
Self, Peer & Supervisor	Gender	*unclear*	4.02	4	p = .40	97
	Degree Type	*unclear*	11.25	4	p = .02	98
	Fresh/Soph vs Junior/Senior	*unclear*	12.18	4	p = .02	93
	Internship	Yes greater than No	21.23	4	**p <.001****	139
	Capstone	Yes greater than No	14.20	4	**p <.01***	96

addition to progression of PI corresponding to progress in academic studies, we expect a viable PI operationalization to show correspondence between practical experiences such as participation in an internship and completion of a capstone course.

χ^2 test results are presented in table III, with an overview of the perspectives considered here.

The self and the peer perspectives showed statistically significant correlations for internships, but not for any other factor. The supervisor perspective provided the expected correlation for both internships and capstone, while the year in program factor was close but not below the significance threshold. This may suggest that student assessment of their supervisor's perspective may support a viable measure of their CS PI progression.

As an additional step, we consider the pairing of self and peer perceptions, as well as self and supervisor perceptions. Finally, we examine the combination of self, peer, and supervisor perspectives.

For the combined perspective of self and peer, there is a correlation for type of degree (BS as having stronger PI than BA). Similarly, the combined perspective of self and supervisor shows a significant correlation for internship, but not for any other factors considered. The combination of all three perspectives (self, peer, and supervisor) yields the key factors of both internships and capstones as statistically significant in their correlations to strength of CS PI, with year in program and degree type (BS over BA) approaching the significance threshold.

V. DISCUSSION

A. RQ1: Future Roles as Current Descriptions

The exploration of future job titles considered by students guides them to focus on a conceptualization of PI, to ask how well that future job title describes them now. This may suggest that the concept of future self is acting as a placeholder or proxy for PI, supporting the hypothesis of RQ1. With divergent trajectories all being supported by CS education [32], it may not be feasible to preselect a single role in a computing profession that would be considered as relevant by all students. Our approach of asking participants to consider relevant future roles in computing may be viable for implicitly focusing on personal CS PI for the assessment questions of how well a future role fits them currently.

B. RQ2: Cross-Tabulation of PI with Demographics

In examining the cross-tabulation of PI with the various demographics of respondents and their participation in practical experiences (internship and capstone), the combination

of self, peer, and supervisor perspectives yields the CS PI correspondences closest to what was hypothesized would accompany a viable CS PI instrument. This suggests that the construct may be measuring CS PI effectively. Two areas that merit further discussion are correspondence of CS PI with degree type (BS vs BA), and lack of correspondence with gender.

1) CS PI Strength Corresponding with BS over BA Degrees: The CS department web page for our BA program indicates that ideal students are those who "may not identify themselves as engineers" [29]. Some discussion about BA programs in CS note a goal of recruiting students from the Arts and Humanities who can augment a primary degree with a dual degree in CS or with minors to supplement the CS coursework [30]. The BA program may also be looked down on or perceived as being inferior to the BS program (cf. [30], especially comment threads). This may contribute to our preliminary results that suggest BS students exhibit stronger PI when considering future roles in computing than do BA students. BA students may perceive themselves first as, say, a social scientist who has skills with computing, rather than a computing professional who is versed in social science. Or they may believe that their future roles in computing are somehow less than those roles available to BS students.

The preliminary result might also indicate that the BA students would benefit from additional support in forming CS PI. Review may be needed within our CS department on whether BA students are required to complete a capstone experience in CS. There may be larger cultural differences of expectations or other ways that BA students feel they are perceived that would contribute to degraded PI formation.

2) CS PI Strength Not Corresponding with Gender: None of the CS PI perspectives correlated with gender, which may be surprising given the prevalence of studies into gender bias in CS (e.g., [6], [27]). It is possible that the placement of gender identity questions at the conclusion of our survey instrument helped students disassociate gender identity from PI. By considering cultural encounters with professional computing within the university classroom [21], the efforts to create equitable learning environments may be achieving success at supporting female students on their paths into the computing profession. Another factor may be that by allowing survey participants to conceptualize their own future roles that they believe are viable rather than imposing a predefined role, women respondents feel greater affinity and are able to operationalize their sense of belonging and identity. This could be consistent with granting legitimacy to a wider range of roles in the community of practice [2].

On the other hand, we acknowledge that self-selected participants may reflect women students who are more likely to have persisted with their computing major despite gender-biased classrooms and experiences. Respondents may be more likely to persist, perhaps because their CS PI formation is more mature than students who have already withdrawn or are uncomfortable participating in our survey. Further investigation with a broader response rate would help explore these and other possible explanations.

C. Limitations

Our pilot survey was conducted at a single public research university in the western United States, and as such may be limited in its generalizability to other institutions and programs. The survey was conducted without any monetary incentives, near the end of an academic semester. These factors may have contributed to the low response rate observed. Survey respondents self-selected to participate, and may represent individuals with greater personal motivation to express their feelings about their undergraduate education. As a pilot study, preliminary findings suggest possible insights into the potential for operationalizing PI with declared CS majors.

VI. Conclusion

This paper presents an approach for surveying PI and preliminary findings from its administration with 176 undergraduate CS majors. The survey explores how well a future job title describes students from their own perspective and the perspectives of peers and a supervisor. Our goal is to create a CS PI instrument that can inform future work on the influence of CS educational practices on PI formation.

Similar work in an engineering identity study used the question, "Do you consider yourself to be an engineer?" to operationalize PI [7]. Our preliminary findings are consistent with our hypothesis that there is no single future professional role or title that would be meaningful for all CS students. As participants identify their own conceptualization of their future professional role, RQ1 examines whether that conceptualization can be transferred to the question "Do you consider yourself to be *<that job title>* now?". Our hypothesis that a correspondence may exist between acceptance of the possible future job title and how strongly the title currently describes each student may be supported. From RQ1, this suggests that focusing participants on their future professional self can support assessing their current PI.

Based on the understanding of identity as spanning both self and social perceptions, the survey asked participants to consider how well the future job title describes them from their own perspective and the perspectives of peers and a supervisor. We feel this offers a more cohesive social measure of their sense of PI that may be developing. RQ2 findings suggest that this cohesive measure of PI is correlated with year in the program, participation in an internship, and completion of a capstone. These three factors can all be considered as indicators of progression in professional preparation and accompany maturing PI.

In exploring a survey instrument of PI in the CS discipline, we offer a cohesive measure of student PI formation as individual perceptions of how a future role in a computing profession describes them across self, peers, and supervisor perspectives. Future work is needed with broader participation to check validity of the survey instrument, and may explore how this measure of PI correlates with specific professional practices and experiences.

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