Understanding CS Undergraduate Students' Professional Identity through the lens of their Professional Development

Amanpreet Kapoor
Computer & Info. Science & Engineering
University of Florida, Gainesville, FL, USA 32611
kapooramanpreet@ufl.edu

Christina Gardner-McCune
Computer & Info. Science & Engineering
University of Florida, Gainesville, FL, USA 32611
gmccune@ufl.edu

ABSTRACT

Academic institutions play a crucial role in the development of students' professional identities. However, we have limited knowledge of how computing professional identity develops. This paper aims to understand how CS undergraduate students develop their professional identity through analyzing students' reflection on their career goals, experiences in CS degree programs, and engagement in professional development. We present findings from qualitative analysis of 14 semi-structured interviews with CS undergraduate students in the United States. We found that CS undergraduates form their computing professional identity typically between Years 2-3 of their degree programs. We identified several reasons students are committed to a computing profession: intrinsic factors (e.g., interest and perception of ability), and discipline-specific factors (e.g. utility and growth). We also found several factors that shape their professional identity: coursework, informal activities like hackathons, and professional development activities including internships and conferences. These findings suggest that the development of computing professional identity is not limited to students' involvement in the academic degree programs but the engagement they have with the broader computing community.

CCS CONCEPTS

- **Social and professional topics** → Computing education

KEYWORDS

Professional identity, Professional development, Career choices

ACM Reference format:

Amanpreet Kapoor, and Christina Gardner-McCune. 2019. Understanding CS Undergraduate Students' Professional Identity through the lens of their Professional Development. In *Proceedings of 24th Annual ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE'19).* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3304221.3319764

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Permissions@acm.org.
ITiCSE '19, July 15–17, 2019, Aberdeen, Scotland UK.
© 2019 Copyright is held by the owner/authors. Publication rights licensed to ACM.
ACM ISBN 978-1-4503-6301-3/19/07...$15.00
https://doi.org/10.1145/3304221.3319764

1 INTRODUCTION

Professional identity enables a person to be technically competent, self-confident, and experience a sense of belongingness to the profession [9,26,34]. As academic institutions, our role is to create pathways for professional identity development through our degree programs to ensure students' have a solidified computing professional identity before they graduate. However, we have limited knowledge of factors that contribute to computing professional identity development and the role played by degree programs in supporting this process. Thus, CS Education researchers have expressed the need for a theory of computing identity development [33] and argued for domain-specific theories in computing [29]. Our broader research goal is to fill this gap by developing a grounded theory on the formation of computing professional identity. We defined computing professional identity as "*the transformation of a person's interest in computing into a person's self-identification as someone who engages in computing professionally through one or more computing sub-disciplines and career paths*" [17].

In this paper, we present findings from our exploratory study that answers the following research questions:

RQ1. To what extent do CS undergraduates feel committed to a computing profession?

RQ2. What factors contribute to CS students' exploration or commitment to a CS profession?

RQ3. What factors influence the process of computing professional identity formation in CS undergraduate students?

2 CONCEPTUAL FRAMEWORK

Identity theory research describes identity and identity development as multi-dimensional. The operational definition of identity put forth in the Handbook of Identity Development by Schwartz, Luyckx, and Vignoles [34] frames personal identity as "*the confluence of the person's self-chosen or ascribed commitments, personal characteristics, and beliefs about themself; roles and positions in relation to significant others; and their membership in social groups and categories*". Theories of personal identity tend to focus on individual-level processes and emphasize the agentic role of the individual in creating or discovering his or her own identity [21]. Social learning theories suggest that identity is constructed through the interactions an individual has with the community [22]. We use the following theories as a conceptual framework: James Marcia's *Identity Status Theory* [25] and Lent, Brown, and Hackett's *Social*

Cognitive Career Theory [23] to understand CS undergraduate students' career choices through social interactions and agency.

Marcia's Identity Status Theory suggests that professional identity is one facet of an individual's identity that forms usually between the ages of 17-23 and includes an individual's social, personal, and cultural identity [25]. Identity Status Theory suggests that identity changes over time based on a person's active or passive exploration and commitment to their chosen profession. The theory identifies four statuses to characterize individuals in identity development: (1) *Identity Diffusion*, when an individual is neither exploring nor committed to a career choice; (2) *Identity Foreclosure*, when an individual has not explored career options but is committed to a career due to influence or expectations of an external agent; (3) *Identity Moratorium*, when an individual is exploring career options but is not committed to a career choice; and (4) *Identity Achievement*, when an individual has explored career options and is committed to an identity after the exploration process. The theory proposes that identity development happens during active exploration highlighted by the *Moratorium* and *Achievement* statuses.

Social Cognitive Career Theory (SCCT) provides a framework for understanding three intricately woven aspects of career development through the lens of an individual's agency as well as factors that enhance or hinder this agency. These aspects include: (1) the formation and elaboration of career-relevant interests; (2) selection of academic and career choice options; and (3) performance and persistence in educational and occupational pursuits [23]. SCCT posits that people are likely to develop interest and pursue a career if they have strong self-efficacy beliefs, outcome expectations, and environmental support for gaining professional competence. We believe these theories offer insight into the development of computing professional identity and hence they guided our research.

3 RELATED WORK

3.1 Computing Professional Identity

Research on computing identity is limited [33] and is largely focused on CS students' characteristics, attitudes, and interests in learning to program [32]. However, recent work on computing identity formation by Peter's study at Uppsala University [32] found that students begin degree programs with broader social interests and identities but end with strict technical identities, thus rejecting their broader identities.

Research on computing *professional* identity includes our prior work that found CS undergraduate students identifying themselves professionally as software development professionals, specialized CS professionals, and by their majors [17]. Other work in this domain includes McCartney and Sanders' case study which investigated significant school- and job-related events that affect computing students' professional identity [26]. They found peer interactions, courses, internships, and jobs influencing students' professional identity. In addition, Tomer and Mishra's found that software engineering students reported a major disconnect between their academic learning and their learning in industry. This experience in the industry "*morphed*" their professional identities [36]. In this paper, we aim to extend the computing identity literature with details of how CS students are developing their professional identity through exploration and commitment to computing professions.

3.2 Undergraduate Students' Choices in CS

While there is a lack of research on how CS students' make choices regarding computing professions, there has been significant research on CS undergraduate students' choices regarding computing major [2,4,11,24,28], specializations [15], learning resources [19], and coursework [14]. Prominent research includes Lewis, Yasuhara, and Anderson's paper on students' decision to major in CS. They found five factors using a grounded theory approach that contributes to this decision: ability, enjoyment, fit, utility, and opportunity cost [24]. Hewner and Guzdial found that CS students' pick a specialization based on enjoyment, misconceptions of a field, and lack of vision for their career [15]. Thus, in this paper, we focus on understanding the role of students' choices in their exploration of computing disciplines and their commitment to computing careers.

3.3 Professional Development in CS

Previous work on professional development in CS has largely focused on the professional development of teachers [13,27,30] and professional development of undergraduates through interventions including research [3,7], industry experiences [10,16,18], project-based courses [8], academic scaffolded professional development programs [1,5,12,20], and capstone projects [31]. However, most of this research focused on the implications of professional development on broadening participation, reducing student misconceptions of computing, or improving students' competence in computing. Thus, there is a lack of empirical studies that determine the role played by students' involvement in professional development activities on their computing identity formation and career choices. Our study tries to fill this gap by understanding the experiences of CS students' in various professional development activities.

4 METHODS

4.1 Study Design

We designed a cross-sectional mixed-method study using a Concurrent Triangulation Design [6] to understand how CS undergraduate students form their professional identity. In this design, both qualitative and quantitative data is collected concurrently. In addition, the data is analyzed separately for each phase and then compared and combined [6]. We used this study design to (1) recruit a mix of interview participants equally representing gender and academic standing from our survey participants to gather information-rich cases through purposeful sampling [6], (2) triangulate the data to ensure reliability, and (3) understand the research problem through exploration [6] before we collect data from multiple institutions on developing a computing professional identity theory.

4.2 Research Site

The study was conducted at the University of Florida in the United States in Spring 2016 after receiving the Institutional Review Board approval. At the time of the study, the university had a population of 1519 undergraduate CS and Computer Engineering (CE) majors. The CS undergraduate program allows students to major in CS or CE, but at the time did not offer a specialized track in any subdisciplines of CS. The students can choose a major when they start college but can change it at any time. The CS/CE undergraduate program offers tech electives which students choose during their Years 3-4.

4.3 Participants

We interviewed 14 CS/CE undergraduate students in this study. All participants were between the ages of 18 to 23 based on the average age range of enrolled undergraduate students at our university. We recruited participants by email, flyers, and a separate question at the end of our survey asking, "*If you are interested in being interviewed for the study, please provide your email address. If selected, you will be compensated $10".* A pool of 14 students was chosen from 56 students, ensuring that we had equal representation of gender, academic standing, and degree program (see Table 1). The participants were compensated with a $10 gift card. The 14 interviewed participants were CS majors (50.0%, n=7), CE majors (42.9%, n=6) or CS minors (7.1%, n=1). In addition, ten out of 14 interview participants felt they belonged to a computing major in the survey and one student felt she did not belong. The other three students in the interview sample did not complete this question on the survey. However, we gauged from the experiences shared during the interview that the remaining three students' felt they belonged to computing.

Table 1: Demographics of Study Participants (N=14)

Academic Standing (By Year)				Gender	
Year 1	Year 2	Year 3	Year 4	Male	Female
21.4%, n=3	21.4%, n=3	21.4%, n=3	35.7%, n=5	57.1%, n=8	42.9%, n=6

4.4 Data Collection

The interview participants were asked 27 open-ended questions regarding their professional goals and identity, degree experience, professional experience, skills and social supports in an in-person interview by the first author. These interviews were semi-structured and guided by the research questions but were unstructured enough to allow the discovery of new information [35]. Some sample questions from the interview are shown in Table 2. The interviews were completed in 25 to 48 minutes (Mean=33.5, SD=6.7). The interviews were transcribed by a commercial transcription service and reviewed for accuracy by the first author. The generated transcripts resulted in a corpus consisting of 3357 to 9444 words per transcript (Mean=5474, SD=1424). We anonymized all participant names and student organization/club names to ensure confidentiality.

4.5 Data Analysis

We deductively coded the data for RQ1 to test the validity of Marcia's Identity Statuses [25] on CS undergraduate students' professional identity. We used Marcia's Identity Statuses and interpreted the students' commitment to a CS profession through their (1) association with a computing profession; (2) confidence in pursuing a computing profession; and (3) professional development and exploration. Since there is a lack of literature on how CS students explore and commit to computing professions, we coded the data for RQ2 and RQ3 using inductive content analysis and thematic analysis based on grounded theory (see Table 3) [35]. The primary codes were clustered to form categories, and these categories formed the basis of our codebook. After coding the data for each participant, we wrote memos regarding the participant's characteristics and compared the participant's categories with our existing categories. The codes and the categories were continually compared following the constant comparison method in grounded theory [35]. Through this process, we found that we reached theoretical saturation of our categories after coding 9 of our 14 interviews. This means that no new categories emerged after we coded the first nine transcripts at random.

Table 2: Some Questions from Interview Script that guided the Inquiry

Questions
How do you identify yourself professionally? Clarification: With many sub-disciplines in CS emerging like User Experience (UX), Web Development, etc., which discipline do you associate with?
Where do you see your career going in 3-5 years after graduation? Follow-up: What area do you want to work in? (e.g., Software, UX)
How are you preparing yourself to achieve your professional goals?

Table 3: Example of Inductive Content and Thematic Analysis (RQ2)

RQ2: What factors contribute to CS students' exploration or commitment to a CS profession?			
Raw Data	P1, male, senior: Because it's [Software Engineering] fulfilling and it's interesting and I think there's a lot of *growth* for that.	P5, female, junior: I like being able to *create something and see it happen*, like right away, immediately, when I'm making an app, it's just like it's there.	P12, male, sophomore: It's just cool [Augmented Reality]. I think people, in general, are really bad at everything. I think technology is cool, so *why not make people less inefficient.*
Primary Code	growth in discipline	Creating tangible artifacts	Improve people's efficiency
Category	growth	utility	
Theme	discipline specific factors		

We identified a total of 62 unique categories through our analysis. From these categories, two themes emerged for RQ1, two themes for RQ2, and four themes for RQ3. To ensure the reliability of these themes, the second author reviewed the first author's codebook until a consensus was reached about the categories, theme description, and accuracy. To validate our themes, we invited three researchers not associated with this project to code the interview data. Each researcher was assigned a random transcript, a codebook, and asked to identify the themes for RQ1 based on the codebook. They were asked to highlight the excerpts in their transcript which led to their assumption. All three researchers identified the themes in agreement with the first author. Their highlighted excerpts further helped us to better describe our themes in the codebook.

4.6 Positionality

An important aspect of qualitative research is to recognize the researcher's positionality to present their biases for ensuring transparency and validity of coded data [6]. The first author who coded the data is a doctoral student in Human-Centered Computing and holds bachelors and masters degree in CS. He has worked in the tech industry for multiple years and was actively involved in various student clubs during his education. This proactive involvement helped him in networking, learning, and gaining employment. Therefore, he believes there is value in active involvement outside the classroom.

The second author is an Assistant Professor at the University of Florida. Her research focuses on advancing the science of how people learn to program and develop computing identities. She is the Principal Investigator of the CS Identity project and reviewed the first author's coding scheme. From her interactions with students, she has noticed a trend towards working outside the curriculum for professional development and advancement.

The perspectives held by the authors might have influenced the data collection process as well as the potential representation of the findings. However, they have diligently tried to avoid confirmation bias by using rigorous qualitative research techniques and outside reviewers.

5 FINDINGS AND DISCUSSION

5.1 Commitment to one or more professions (RQ1)

Overall students were either interested or committed to becoming Computer Scientists/Computer Engineers (n=6), Software Development Professionals (n=7) or Specialized CS/CE Professionals (e.g., UX, Cyber Security, etc., n=7). Eight out of 14 students identified their interest or commitment to one profession and the remaining students indicated two professions. Using deductive coding categories derived from Marcia's Identity Status Theory, we interpreted the students' exploration of and commitment to a computing profession, i.e., their identity status. This analysis answers RQ1. *To what extent do CS undergraduates feel committed to a computing profession?* Two themes emerged from our analysis: *Moratorium* and *Achieved*.

5.1.1 Themes

Moratorium. In this theme, 57.1% of 14 CS students (n=8) had no or low commitment to a computing profession but were exploring various computing disciplines. Five students described their interest in two or more computing disciplines and three students shared that they had limited knowledge of computing professions. Students in this theme were involved in campus activities or were exploring computing disciplines to understand their likes and dislikes. Despite their exploration of their computing interest, students in this theme used low confidence phrases such as "not sure", "hopefully", "at this point", etc. when describing their career goals or commitment to a specific computing profession. These behaviors are characteristic of most students categorized as moratorium (high exploration and low commitment) [25]. We also noticed this trend among students in the early years (Years 1-2) of their computing programs. Responses from all three freshmen and all three sophomores were categorized to this theme. However, responses from one male junior and one female senior were categorized in this theme. P13, the male junior, was a transfer student who recently completed his two-year associate degree. He indicated that he had less experience in the degree program since he had only taken one computing course. On the other hand, P14, the female senior, was unsure of what she wanted to do after graduation. When asked about her career plans, she stated,

"*That's a question I've just been asking myself recently as I near graduation and as of right now, I find it kind of hard to decide. I would say I might be more interested in project management side if I go into industry. If I decide to go into a graduate school, I think I'm leaning more towards like human-computer interaction (HCI).*"

P14 chose a CS major through a process of elimination during her exploration in engineering disciplines. She looked at courses in mechanical engineering and recalled that "*they didn't seem very fun*". She had been exploring different disciplines in computing and had interests in natural sciences, HCI and project management. Her interest in natural sciences stemmed from her research experience at one of our university's research labs which subsequently led her to secure an internship at a national research lab in her last summer before she graduated. She came across HCI through a conference at the end of her junior year and got interested in the field's focus on "*constant thought for users*". In addition, she got interested in project management because she was not confident in her programming abilities but got a chance to manage a team. This interest was strengthened when she managed a team in a software engineering course. She concludes that she enjoys "*managing a project versus actually developing it*". Thus, she was exploring several computing career paths despite her upcoming graduation in less than six months. She argued that this uncertainty is due to her lack of exposure to various computing disciplines earlier in her degree program,

"*The track that I took as far as where I've been taking my classes, I feel that it's kind of too late, too late for me to get exposed to like different fields, so basically, I took most of my major course work and then left my tech electives for the end and I feel that that has hindered me because tech electives help you better understand like what track you wanna go into, in my opinion.*"

Achieved. In this theme, 42.9% of 14 CS students (n=6) were committed to a specific computing profession. Three of the six students were committed to a specific area (e.g. back-end programming) within a sub-discipline of computing (e.g. software engineering). Students in this theme talked about their engagement in their chosen discipline throughout the interview. They were focused on gaining technical competence through reading books, internships, hackathons, or other professional development activities. Further, they were confident about their career choices. These behaviors are characteristic of most students categorized as achieved (high exploration and high commitment) [25]. We also noticed this trend among students in the later years (Years 3-4) of their computing programs. Thus, they had a high commitment to a CS profession and explored the committed discipline to ensure competence. Responses from two of the three juniors and four of the five seniors were categorized in this theme. For example, P3, the female senior, identified herself as a "*software developer*" interested in "*work[ing] in back end development, especially web programming, APIs and lower level socket programming*". During the interview, she indicated that she intentionally selected this career path and described her deliberate preparation process for achieving her career goals which included courses, reading documentation, and canonical developer books:

"*I'm taking courses like object-oriented programming and design patterns that mainly focus on back-end development. [I use] Stack Overflow, the Javadocs, especially when I'm working with Java. I try to mostly understand the API that Java intended to put out, learn how to use it through them and actually use it. And the other thing I do is books. I have the Gang of Four Design patterns book and Meyer's Object-Oriented Programming, Martin Fowler's UML Distilled, so I like to keep my textbooks and refer back.*"

5.1.2 Discussion

This section demonstrates the utility of Marcia's Identity Status Theory [25] in understanding students' computing professional identity development. It also provides us with insights into the extent to which students are committed to a specific computing career. We found that CS undergraduates form their computing professional identity typically between Years 2-3 of their degree programs. As expected, most freshmen and sophomores are exploring computing professions but are not committed to a computing profession; and as hoped most juniors and seniors are committed to a specific computing profession and are focused on gaining technical competence in their career choice. However, we also found that transfer students, as well as some graduating students like P14, may be developing their computing professional identity later in their degree programs. There are multiple reasons for this delay including lack of exposure to different computing disciplines earlier in their degree programs, delayed course enrollment due to transferring, lack of confidence in their technical competencies, and/or indecision about committing to one specific computing profession. This poses an interesting problem for departments and for students if our goal is to ensure that students are developing appropriate technical skills and knowledge and are prepared for their careers upon graduation. If students are not being exposed to various computing disciplines until their junior and senior year when they take technical electives, then departments need to find ways to address these issues so that all students have a conducive environment for developing their computing professional identities.

5.2 Reasons for association with a profession (RQ2)

In the interview, we asked the students to explain their reasons for exploring or committing to a computing profession. This qualitative data was relevant for answering RQ2: *What factors contribute to CS students' exploration or commitment to a CS profession?* Two themes emerged from nine categories in our data analysis: *intrinsic factors* and *discipline-specific factors.*

5.2.1 Themes

Intrinsic factors. In this theme, 92.9% of the 14 students (n=13) stated that they were exploring or committed to a computing profession because of intrinsic characteristics. The five categories in this theme were self-interest (10), ability (6), personality (4), enjoyment (3), and satisfaction (3). Students self-evaluated their *abilities* through the lens of coursework, completion of projects, or performance in internships. We also found that CS students associated themselves with specific computing disciplines if they found the discipline "*fun*" or enjoyed working in an area. Students' perception of *self-interest* was based on their like or dislike for a certain computing discipline. In addition, three students stated that their *personality* matched or did not match a specific computing profession using phrases such as "*detailed-oriented*" for interest in product management or "*lack of patience*" for dealing with hardware. Three students also suggested that they were interested or committed to a specific computing discipline as their experience was "*fulfilling*" or satisfying. P1, a senior male, who belonged to the *satisfaction* and *self-interest* category said that he wanted to pursue software development after he graduates "*because it's fulfilling and interesting*".

Discipline-specific factors. In this theme, 85% of the 14 students (n=12) stated that they were committed to or exploring a specific computing profession because of factors pertinent to a computing profession. The four categories in this theme were applicability of multidisciplinary knowledge (7), utility (5), perception of disciplines' coolness (3), and growth (1). Seven students stated that they were exploring or committed to a computing profession as the discipline was at an intersection of multiple areas and offered them an opportunity to employ their *multidisciplinary knowledge.* Five students stated they associated with a discipline because of the field's *utility* in creating tangible artifacts or contribution to society. Three students associated with a computing profession because of the field's *coolness* and one student for opportunities to grow. Consider P2, a sophomore female interested in software engineering, web development and UX due to discipline-specific factors (applicability of multidisciplinary knowledge) as well as intrinsic factors (enjoyment, satisfaction, personality, and self-interest).

"*I've always been an **artsy** type of person, so I **love** design and all that stuff. I really **enjoyed** it, like I love Photoshop and Adobe Illustrator. So just the chance to kind of **integrate** what I know now with coding to those design things is a really **exciting** possibility for me. So, I hope to find like a career I can do a lot of that stuff. I mean ideally, I'd really like to do stuff with design. And like get my arts **fulfillment** in*".

5.2.2 Discussion

Our analysis was focused on understanding how CS students' make choices regarding computing professions throughout their exploration process. We found that students take into account both intrinsic as well as discipline-specific factors when exploring or committing to a specific computing discipline. Overall, we found 78.6% of 14 students (n=11) considered both types of factors when associating with a computing discipline. Two students explored or committed to a computing profession due to intrinsic factors and one student due to discipline-specific factors. Our study contributes to the CS Education literature an understanding of factors that impact students' choices to explore or commit to computing careers. Similar to the factors identified by Lewis et al. on how students pick a computing major [24], our findings confirm that CS students also take into account *ability*, *enjoyment*, and *utility* when exploring or committing to a computing profession. However, unlike previous work [24], we also find that CS students decide to explore a computing profession based on the *applicability of multidisciplinary knowledge* and *growth* in a specific computing profession.

5.3 Factors influencing professional identity (RQ3)

We asked the 14 interviewed students to describe their experiences in degree program and involvement in professional development activities. This qualitative data was relevant for analyzing RQ3. *What factors influence the process of computing professional identity formation in CS undergraduate students?* We found four themes that shaped students' computing professional identity development: *Coursework*, *People*, *Informal activities*, and *Professional development opportunities*.

5.3.1 Themes

Coursework. We found mixed responses regarding the role of coursework in shaping CS students' professional interests. For some students' courses played a key role in deciding their professional interests and career goals through exploration of different computing disciplines, development of their likes and dislikes, recognition of the utility of the discipline, and evaluation of their ability in a computing discipline. While for other CS/CE students the courses had a limited impact on their career choices or led them not to pursue a CS area. In addition, two students suggested a need for a course in freshman year to introduce students to various computing disciplines.

People. CS students were influenced by mentors, friends, parents, relatives, industry professionals, or other people in their broader support network regarding decisions related to their professional interests. Students suggested that parents and relatives advised them to pursue a computing major which further led to the development of interest in computing. Further, advice from elements of the support network led them to choose courses, prepare for professional development, and recognize expectancies in the industry regarding computing professions.

Informal activities (Clubs, Projects, and Hackathons). In this theme, CS students indicated that informal activities including clubs, personal projects, and hackathons shaped their professional choices. Students' got an opportunity to explore an unfamiliar computing discipline through participation in one or more informal activities. Students also mentioned that clubs helped them in developing their skills, meeting people and collaborating, finding mentors, or knowing professional expectations. Hackathons helped them in exploring the discipline and learning at a fast pace.

Professional development opportunities (Conferences, Internships, and Research). CS students in this theme shared vivid descriptions of how professional development activities influenced their career choices. Students described that internships reaffirmed their ability to continue pursuing a CS major and allowed them to explore new computing sub-disciplines. Similar to internships, other professional development opportunities including conferences and research also broadened students' understanding or perspective on the breadth of computing and led to their involvement in computing sub-disciplines which they were earlier unfamiliar with. P14, a female in her senior year explained that she came across "*human-centered computing*" through a computing conference for women at the end of her junior year and how it was "*an eye-opener*" for her. Another student, P10, a senior male who interned as a Software Test Engineering intern, explained that his internship took him "*from a computer science student to someone who has a bigger view, a bigger scope of the whole software development process"* and he realized that CS is not about "*sitting behind a computer all day and coding*".

5.3.2 Discussion

Our data analysis for RQ3 yields two contributions. First, the development of computing professional identity is influenced by students' engagement in informal and professional development activities outside of the classroom in the broader computing community. Second, early coursework in computing degree programs provide students with opportunities to evaluate intrinsic factors such as enjoyment and ability in programming but provide limited opportunities for students to explore discipline-specific factors such as the utility of various computing disciplines or to develop a broader view of computing. Students' recognize this broader view in the latter part of their degree programs through technical electives, industry experiences, or involvement in professional development activities. Thus, we suggest that CS departments include a preliminary course that provides students an opportunity to get an overview of the breadth of CS disciplines.

6 IMPLICATIONS

The findings from this research highlight the need for building students' confidence through course interventions or projects during Years 1-2 of computing degree programs. These interventions should provide students with opportunities to (1) learn different computing areas, (2) understand various computing careers, and (3) develop technical skills. Interventions in Years 2-3 should provide opportunities for job shadowing or mentoring that allow students to gain a greater understanding of computing careers and their interests. Programs like these need to target transfer students and students who are unclear about their computing career path. We recommend that departments allocate additional funds for professional development activities for students at every stage of their degree program so that they can participate in hackathons, conferences, and internships. Finally, we suggest that researchers studying computing professional identity focus on intrinsic and discipline-specific factors as they both influence students' professional identity development process.

7 LIMITATIONS

We attempt to address the validity of our qualitative inquiry through the transparency of our research process as well as recognizing the researcher's biases. Our findings represent a snapshot of the students' experiences taken from a small sample at a US-based university. Our findings may not generalize to large populations of students at similar or different institutions or experiences of CS students in other countries. We provided a description of our university to help the readers understand the context in which the findings were applicable.

REFERENCES

[1] Lingma Acheson and Ryan Rybarczyk. 2016. Integrating career development into computer science undergraduate curriculum. In *2016 11th International Conference on Computer Science & Education (ICCSE)*, 177–181. DOI:https://doi.org/10.1109/ICCSE.2016.7581576

[2] Amnah Alshahrani, Isla Ross, and Murray I. Wood. 2018. Using Social Cognitive Career Theory to Understand Why Students Choose to Study Computer Science. In *Proceedings of the 2018 ACM Conference on International Computing Education Research - ICER '18*, 205–214. DOI:https://doi.org/10.1145/3230977.3230994

[3] Christine Alvarado and Neil Spring. 2018. Successfully Engaging Early Undergraduates in CS Research. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education - SIGCSE '18*, 1050–1050. DOI:https://doi.org/10.1145/3159450.3162365

[4] Lecia J. Barker, Charlie McDowell, and Kimberly Kalahar. 2009. Exploring factors that influence computer science introductory course students to persist in the major. In *Proceedings of the 40th ACM technical symposium on Computer science education - SIGCSE '09*, 153. DOI:https://doi.org/10.1145/1508865.1508923

[5] Kristy Elizabeth Boyer, E. Nathan Thomas, Audrey S. Rorrer, Deonte Cooper, and Mladen A. Vouk. 2010. Increasing technical excellence, leadership and commitment of computing students through identity-based mentoring. In *Proceedings of the 41st ACM technical symposium on Computer science education - SIGCSE '10*, 167. DOI:https://doi.org/10.1145/1734263.1734320

[6] John W. Creswell and J. David Creswell. 2017. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches.*

[7] Teresa Dahlberg, Tiffany Barnes, Audrey Rorrer, Eve Powell, and Lauren Cairco. 2008. Improving retention and graduate recruitment through immersive research experiences for undergraduates. In *Proceedings of the 39th SIGCSE technical symposium on Computer science education - SIGCSE '08*, 466. DOI:https://doi.org/10.1145/1352135.1352293

[8] Christopher Dean, Thomas D. Lynch, and Rajiv Ramnath. 2011. Student perspectives on learning through developing software for the real world. In *2011 Frontiers in Education Conference (FIE)*. DOI:https://doi.org/10.1109/FIE.2011.6142904

[9] Jennifer Dempsey, Richard T. Snodgrass, Isabel Kishi, and Allison Titcomb. 2015. The Emerging Role of Self-Perception in Student Intentions. In *Proceedings of the 46th ACM Technical Symposium on Computer Science Education - SIGCSE '15*, 108–113. DOI:https://doi.org/10.1145/2676723.2677305

[10] Sebastian Dziallas and Sally Fincher. 2016. Aspects of Graduateness in Computing Students' Narratives. In *Proceedings of the 2016 ACM Conference on International Computing Education Research - ICER '16*, 181–190. DOI:https://doi.org/10.1145/2960310.2960317

[11] Sebastian Dziallas and Sally Fincher. 2018. "I told you this last time, right?": Re-visiting narratives of STEM education. In *Proceedings of the 2018 ACM Conference on International Computing Education Research - ICER '18*, 223–231. DOI:https://doi.org/10.1145/3230977.3230989

[12] Meg Fryling, MaryAnne Egan, Robin Y. Flatland, Scott Vandenberg, and Sharon Small. 2018. Catch 'em Early: Internship and Assistantship CS Mentoring Programs for Underclassmen. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education - SIGCSE '18*, 658–663. DOI:https://doi.org/10.1145/3159450.3159556

[13] Joanna Goode, Jane Margolis, and Gail Chapman. 2014. Curriculum is not enough. In *Proceedings of the 45th ACM technical symposium on Computer science education - SIGCSE '14*, 493–498. DOI:https://doi.org/10.1145/2538862.2538948

[14] Michael Hewner. 2014. How CS undergraduates make course choices. In *Proceedings of the tenth annual conference on International computing education research - ICER '14*, 115–122. DOI:https://doi.org/10.1145/2632320.2632345

[15] Michael Hewner and Mark Guzdial. 2011. How CS majors select a specialization. In *Proceedings of the seventh international workshop on Computing education research - ICER '11*, 11. DOI:https://doi.org/10.1145/2016911.2016916

[16] Amanpreet Kapoor. 2019. Deconstructing Successful and Unsuccessful Computer Science Undergraduate Interns. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education - SIGCSE '19*, 1297–1297. DOI:https://doi.org/10.1145/3287324.3293711

[17] Amanpreet Kapoor and Christina Gardner-McCune. 2018. Understanding Professional Identities and Goals of Computer Science Undergraduate Students. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education - SIGCSE '18*, 191–196. DOI:https://doi.org/10.1145/3159450.3159474

[18] Amanpreet Kapoor and Christina Gardner-McCune. 2019. Understanding CS Undergraduate Students' Professional Development through the Lens of Internship Experiences. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education - SIGCSE '19*, 852–858. DOI:https://doi.org/10.1145/3287324.3287408

[19] Daniel Knox and Sally Fincher. 2013. Where students go for knowledge and what they find there. In *Proceedings of the ninth annual international ACM conference on International computing education research - ICER '13*, 35. DOI:https://doi.org/10.1145/2493394.2493399

[20] Deborah Knox. 2016. Guiding Career Development Prior to Capstone Experiences (Abstract Only). In *Proceedings of the 47th ACM Technical Symposium on Computing Science Education - SIGCSE '16*, 698–698. DOI:https://doi.org/10.1145/2839509.2850571

[21] Jane Kroger and Kathy E. Green. 1996. Events associated with identity status change. *J. Adolesc.* 19, (1996), 359–380. DOI:https://doi.org/10.1006/jado.1996.0045

[22] Jean Lave and Etienne Wenger. 1991. *Situated learning : legitimate peripheral participation.* Cambridge University Press.

[23] Robert W. Lent, Steven. D. Brown, and Gail Hackett. 2004. Towards a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance. *J. Vocat. Behav.* 45, (2004), 79–122.

[24] Colleen M. Lewis, Ken Yasuhara, and Ruth E. Anderson. 2011. Deciding to major in computer science. In *Proceedings of the seventh international workshop on Computing education research - ICER '11*, 3. DOI:https://doi.org/10.1145/2016911.2016915

[25] James E. Marcia. 1966. Development and validation of ego-identity status. *J. Pers. Soc. Psychol.* 3, 5 (1966), 551–558. DOI:https://doi.org/10.1037/h0023281

[26] Robert McCartney and Kate Sanders. 2015. School/Work: Development of Computing Students' Professional Identity at University. In *Proceedings of the eleventh annual International Conference on International Computing Education Research - ICER '15*, 151–159. DOI:https://doi.org/10.1145/2787622.2787732

[27] J. McGrath Cohoon and Feng Raoking. 2013. Professional development for mid-career women in computer science and engineering. In *2013 IEEE Frontiers in Education Conference (FIE)*, 618–622. DOI:https://doi.org/10.1109/FIE.2013.6684899

[28] Catherine Mooney, Brett A. Becker, Lana Salmon, and Eleni Mangina. 2018. Computer science identity and sense of belonging. In *Proceedings of the 1st International Workshop on Gender Equality in Software Engineering - GE '18*, 1–4. DOI:https://doi.org/10.1145/3195570.3195575

[29] Greg L. Nelson and Andrew J. Ko. 2018. On Use of Theory in Computing Education Research. In *Proceedings of the 2018 ACM Conference on International Computing Education Research - ICER '18*, 31–39. DOI:https://doi.org/10.1145/3230977.3230992

[30] Lijun Ni and Mark Guzdial. 2012. Who AM I?: understanding high school computer science teachers' professional identity. In *Proceedings of the 43rd ACM technical symposium on Computer Science Education - SIGCSE '12*, 499. DOI:https://doi.org/10.1145/2157136.2157283

[31] Rick Parker. 2018. Developing Software Engineers: A study of professionalization in a CS Senior Capstone. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education - SIGCSE '18*, 276–276. DOI:https://doi.org/10.1145/3159450.3162326

[32] Anne-Kathrin Peters. 2018. Students' Experience of Participation in a Discipline—A Longitudinal Study of Computer Science and IT Engineering Students. *ACM Trans. Comput. Educ.* 19, 1 (September 2018), 1–28. DOI:https://doi.org/10.1145/3230011

[33] Sarah L. Rodriguez and Kathleen Lehman. 2017. Developing the next generation of diverse computer scientists: the need for enhanced, intersectional computing identity theory. *Comput. Sci. Educ.* 27, 3–4 (October 2017), 229–247. DOI:https://doi.org/10.1080/08993408.2018.1457899

[34] Seth J. Schwartz, Koen Luyckx, and Vivian L. Vignoles. 2011. *Handbook of Identity Theory and Research.* Springer Science & Business Media.

[35] Anselm Strauss and Juliet Corbin. 2008. *Basics of Qualitative Research.* SAGE Publications, Inc.

[36] Gunjan Tomer and Sushanta Kumar Mishra. 2016. Professional identity construction among software engineering students. *Inf. Technol. People* 29, 1 (March 2016), 146–172. DOI:https://doi.org/10.1108/ITP-10-2013-0181