Impact on Computing Attitudes and Career Intentions in a Common First Year Program Survey Course

Dr. D. Cenk Erdil, Sacred Heart University

Dr. Erdil has joined Sacred Heart University's School of Computer Science and Engineering in Fall 2017. Prior to SHU, he has held academic positions at Marist College, Columbia University Medical Center, and Istanbul Bilgi University. His research interests include using Cloud Computing as Artificial Intelligence Infrastructures, Cyber-Physical Systems and Internet-of-Things, Teaching coding to P-12 students, and Health Informatics. He is the author of numerous peer-reviewed journal and conference publications in grid and cloud computing. In the past, he designed and implemented a cloud-based public health informatics infrastructure. He is a founding member of the School of Engineering at Istanbul Bilgi University, and was the chair of its Computer Engineering Department. He also designed an adaptive resource-matching framework for large-scale, autonomous grid computing environments, using epidemic dissemination protocols. He is the founding director of Engineers Without Borders International, Turkey branch. At the industry, Dr. Erdil has worked in management and software engineering roles for more than a decade at various organizations, including Fidelity National Information Services (FIS), and Turkish Airlines. He is a senior member of the Association for Computing Machinery (ACM), and a senior member of Institute for Electrical and Electronics Engineers (IEEE); and a member of Engineers Without Borders International (EWB-I), American Society for Engineering Education (ASEE), and Association for Information Systems (AIS).

Dr. Darcy Ronan, Sacred Heart University

Impact on Computing Attitudes and Career Intentions in a Rotation-based Survey Course

Darcy Ronan
Isabelle Farrington College of Education
Sacred Heart University
Fairfield, CT, USA
ronand@sacredheart.edu

D. Cenk Erdil
School of Computer Science & Engineering
Sacred Heart University
Fairfield, CT, USA
erdild@sacredheart.edu

Abstract

An introductory collegiate survey course for several major programs in science and engineering presents the opportunity to impact computing attitudes and career intentions as well as knowledge of computer science (CS), computing, and engineering concepts. The course intervention in this study is a semester-long sequence of rotations in computer science, game design, cybersecurity, and engineering. Part of the common first year program in the school of computer science and engineering, this Fall semester course is required for any student interested in studying in one of the six undergraduate major programs. The impacts of this intervention are analyzed according to Social Cognitive Career Theory (Lent, Brown, & Hackett, 1994, 2000) which posits that beliefs about the self and knowledge about careers are socially influenced, amenable to intervention, and powerful drivers of the development of career interests, goals, and actions. A pre/post survey design including the items of the Computing Attitudes Survey (Dorne & Tew, 2015), major and career interests, as well as open-ended items. A qualitative analysis of student claims of field-based identities in both computer science and engineering and the rationale thereof yields drivers of field-based identity formation (e.g. enjoyment, interest, instrumentality) and conceptions of the field (problem-solving, creating). An overview for the survey course curriculum will be provided, drawing significantly from high-quality resources developed for K12 students.

Keywords

First Year Survey Course, Computer Science and Engineering, Computing Attitudes, Career Intentions, Social Cognitive Career Theory

1 Introduction

With a rapidly changing computer science and engineering landscape, a proliferation of high-quality resources and curricula aimed at K-12 students presents an opportunity to enrich and reimagine introductory college courses. For example, in computer science, the K-12 CS movement creates shifts in undergraduate student profiles with regards to previous CS familiarity, experiences, expectations, career interests, attitudes, and beliefs. While adhering to the ACM Computing Curricula '78 (Austing, et al., 1979) guidelines for CS1 and CS2 courses for CS majors, the need for a third, primer survey course has emerged (Bailey & Forbes, 2004; Brady, et al., 2004). Common objectives of a survey course are to (a) introduce the core concepts to students who are interested, but do not have any prior skills on that field, (b) support student success while adapting to college life, and (c) improve recruitment and retention using the 'Common First Year' theme of many STEM programs.

In addition, the proliferation of technology in academia and industry drives an increasingly diverse population in terms of majors, interests, and experiences towards introductory and advanced courses (Foster, et al., 2018; Erdil, et al., 2019). A thoughtfully-designed survey course can balance the needs of various subgroups and realize the potential to influence students' attitudes and beliefs, develop career intentions, and teach core concepts.

A first-year integrated college curriculum has been a common practice across many engineering and science disciplines for years (Cordes, et al., 1997; Bazylak & Wild, 2007). In these approaches for common curriculum design, all those first-year students admitted to programs of study in engineering, technology, applied sciences and other related fields are offered common courses during their first year of study. These common first-year courses become also beneficial as they are typically required for field-specific ABET degree accreditations (ABET, 2018), thus allowing across different engineering and technology fields to use a standard first-year curricula.

To orient students into college during their first-year of study (Ward-Roof, 2010), common first-year programs in many engineering and science programs are designed for students take introductory mathematics, science, English, and other general STEM courses, typically covering topics such as coding, data representation, engineering design, problem-based solving, teamwork, ethics, and effective communications. In addition, the common-first year programs may also include a series of survey courses, that give students an opportunity to explore various degree options, which might become particularly useful for those *undecided* students, who are generally interested in studying a STEM program, but have not necessarily declared their major yet. Another benefit of these survey-style courses is to make students aware of how particular learning styles they have been exposed to might fundamentally be different from college-level science education (Felder, 1993; Cunningham, et al., 2019), which helps increase retention in STEM-related programs.

2 Course Design

This section discusses the overall design of the course, with the context, goals and interventions, with rationale for each intervention.

2.1 Course Context

A pre-existing CS0 survey course, bypassed by those with CS experience, focused on abstract reasoning, yielding a "gate" course- viable for the few students with pre-existing abstract thinking and reasoning skills and a dull first encounter with CS for most. The missed opportunity to engage more students with CS, and also expose various computer science and engineering fields to more first year students interested in technology fields, and thereby contribute to program viability and growth, spurred curriculum renewal.

In addition, evolution of the academic unit, from a 40-year-old computer science department that offers a single undergraduate program with a selection of concentrations, to a school of computer science and engineering, which encompasses several new technology-focused programs, such as cybersecurity, game design and development, and computer and electrical engineering highlighted the need to redesign this survey course for those students who are interested in all technology-related undergraduate programs, as well as other first-year students in the STEM education major program, to learn about computer science and engineering in general.

Based on further discussions with other undergraduate program directors, a collective decision resulted in offering a one-credit school-wide rotation-based survey course in the first semester. The course is offered as multiple sections, with each section offered by a field-specific faculty expert, who are co-teaching the course on a rotational basis. Students, who could pick any of the sections based on their course schedule make two rotations during the semester. They spend a total of three weeks in each of the experiential learning facilities (laboratories and other learning environments), and working with a dedicated teaching team to get exposed to various project-based approaches in each field of study.

Following this model, a set of one-credit courses are also designed to be offered in the second semester, focusing on each particular undergraduate program. Therefore, in their first year, students not only know about other programs of study in the school, but also get experience with a deep-dive, program-specific survey course as a follow-up in their second semester of study. As an added benefit, those students who are undecided between various technology-focused programs, or who might be interested in studying multiple technology programs can also take a group of program-specific survey courses, which will give them more in-depth exposure to multiple programs of study. This approach also designed to increase retention within the school, making students aware of alternative engineering and technology programs within the same school.

Table 1 below provides details of a suggested first year of study for each student declared their major in a technology-related field, or undeclared but interested in one of the programs in school of computer science and engineering.

Table 1. Suggested first year of study for students in school of computer science and engineering

First Semester				Second Semester		
Code	Name	Credits		Code	Name	Credits
FYXX-125	First Year Seminar	3		CTL-125	Critical Thinking	3
CSE-125	CSE Explorations	1		[ ]-125	[Program] Explorations	1
MA-151	Calculus I	4		MA-152	Calculus II	4
HI-100	Western Civilization	3		MA-113	Discrete Mathematics	3
CS-111	Intro. to Structured Programming	3		CS-112	Data Structures	3
	Foundational Core	3			Foundational Core	3
	TOTAL	17			TOTAL	17

2.2 Course Goals

The core goal of this common course is to provide a collective overview of the six undergraduate programs in the school, namely: computer science, information technology, game design and development, computer engineering, cybersecurity, and electrical engineering.

Following a backwards curriculum design process (Wiggins & McTighe, 2005), desired endpoints and values were identified, leading to the evaluation and selection of aligned curriculum resources. This process ensures intentionality while being responsive to the emergence of highly engaging platforms and "toys". Design principles and desired outcomes were guided by both accreditation standards (ABET, 2018), and various curricula design, such as ACM Computing Curricula (Austing, et al., 1979), Code.org Professional Learning and Curriculum Values (2019), and K12CS Practices (2016).

Encompassing content and pedagogy the following course goals guided the selection of interventions:

1. Build familiarity with the tools, language, concepts and practices of computer science and engineering,
2. Prioritize the delivery of an engaging, positive experiences that convey the joy of applied technology through active, hands-on experiences,
3. Expose students to the fundamentals of engineering practices, with a particular focus on problem-based learning and problem-based solution development,
4. Introduce students to a wide range of technology applications and careers across various industries,
5. Include both computer-based and non-computer-based learning activities,
6. Provide a just, balanced view of early CS and engineering pioneers, and their historical role,
7. Explicitly address both gender and race-based underrepresentation in computer science and engineering, and the reciprocal effects of this underrepresentation in college students and industry,
8. Provide a wider view of how CS fits within other related common fields of study in college, with a particular focus on four core areas of study in the school, namely: computer science (including information technology), computer and electrical engineering, game design and development, and cybersecurity.

2.3 Course Sections and Rotation Schedule

As the course is offered to all first year students, each section is offered by an expert in the particular related field, divided into four sections:

- computer science and information technology,
- game design and development,
- computer and electrical engineering, and
- cybersecurity.

Each section is scheduled in a program-specific laboratory environment, providing students access to state-of-the-art equipment and exposure to latest technological advances and tools. Students in each section visit all these facilities, in two rotations. In the first rotation, each section spends two weeks in a particular laboratory, and moves on to the next one. All sections then have a one-week common group meeting for reflection and general exposure to school-wide programs (advising, major declarations, student programs, etc.). In the second rotation, each section spends one week in a particular laboratory. The semester ends with another common group meeting for overall feedback, and interdisciplinary activity involving all programs.

The rotation-based course includes a number of targeted modules in each section to address the above goals collectively. Each module is described below.

Computer Science and Information Technology: Mainly based on Code.org's Computer Science Principles (CSP), and the background story on steampunk graphic novel entitled *The Thrilling Adventures of Lovelace and Babbage,* by Sydney Padua. Code.org CSP content is designed as an advanced course for high school students, CSP uses a free digital platform to introduce foundational concepts of coding, and many related technology fields, including general computer science concepts, cybersecurity, gaming, as well as advanced fields such as artificial intelligence and machine learning. CSP challenges students to explore how computing and technology can impact the world. Fall rotation-based course incorporated the following units from CSP and other relevant creative-commons content provided on Code.org: The Internet, Digital Information, Building Apps, and Oceans for AI. Informational videos on the graphic novel on early career pioneers of computer science and engineering, Ada Lovelace and Charles Babbage develop students' understanding of the historical foundations and figures of CS, the design of mechanical computational machines, and the influence of gender roles in CS in the Victorian era and in modern times.

Computer and Electrical Engineering: This module initially introduces students to the basics of 3D printing, and fundamentals of electronics. Students go through several hands-on activities to get exposed to using 3D printers, as well as configure basic electronic circuits to build small projects to accomplish well-defined tasks. In the second week, students make engineering prototypes, and focus on improving their design, working on skills to make the end product more innovative. The last week in the second rotation allows students to introduce the prototypes to make the overall design better, with an ultimate goal to finish the product completely by the end of the session.

Game Design and Development: This is an introductory tutorial gaming module to teach students basic skills on building a game with the Construct3 tool, with a goal to complete a simple game at the end of the first class, which can then be used as the basis for a more ambitious game design. In the follow-up second week, students are encouraged to improve their initial design to improve functionality and features of the game, which concludes the first rotation. In the third week (second rotation) of the section, students are focused on refactoring and redesigning some of the aspects of the game.

Cybersecurity: This is a module that provides an overall introduction to the applied field of cybersecurity, with basics of security and privacy (password usage, protection, encryption, and so on) covered in the first week. In the following second week, concepts of hacking and coding, and social engineering are introduced with active discussions about ramifications of not using secured systems, which concludes the first rotation in this module. In the third week (in second rotation) students are further exposed to core cybersecurity applications and fields of study, by focusing on learning essential cybersecurity skills by completing security-focused fun activities.

3 Theoretical Framework

Social Cognitive Career Theory (SCCT- Brown & Lent, 1996; Lent, Brown, & Hackett, 1994, 2000) is an application of Social Cognitive Theory (Bandura, 1977) to the development of career intentions. This theoretical framework was developed in the field of career counseling to illuminate how learning experiences can impact career ambitions. It has been previously applied to STEM undergraduates (e.g. Carpi, Ronan, Falconer, Lents, 2017). SCCT posits that social conditions, life experiences, and supports/barriers can change a student's career ambitions by driving self-efficacy, outcome expectancies, and career-related interests, goals and actions. The theorized components and their interactions are illustrated in Figure 1.

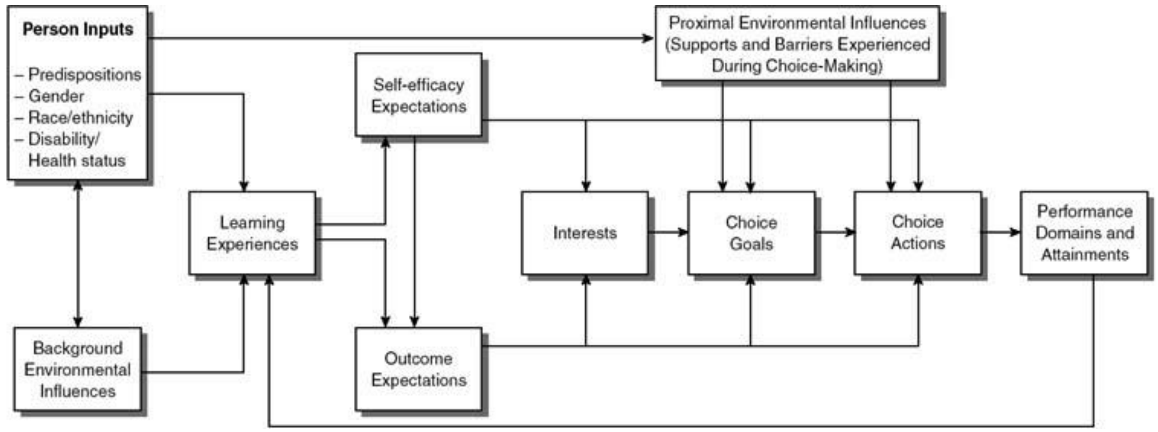

Figure 1. Social Cognitive Career Theory (SCCT)

University courses in CS are an opportunity to engage in behaviors that drive the career intentions, by (1) providing learning experiences that can lead to self-efficacy, (2) refining students' CS-career related outcome expectations. Self-efficacy refers to the extent that a person believes they can achieve some action. Outcome expectations refer to a person's perceptions of the outcomes associated with an action or goal. For example, a student with high self-efficacy for CS believes they can successfully complete a CS major. A student's outcome expectation may be that completing such a major will lead to a desirable high-paying job. While self-efficacy and career goal-setting are internal processes, SCCT theorizes career selection and pursuit as a dynamic and social process. A student's perception of available CS careers and how well those careers match his/her interests and identities is based on knowledge from both academic and non-academic settings. As such, outcome expectations can be faulty. Learning experiences, such as the introductory course, provide feedback to the learner which stimulating self-efficacy beliefs, negative or positive. Career content and epistemological content in an introductory learning experiences develops students' CS outcome expectations.

A student identifying a CS career as their career ambition would be considered a Choice Goal in the SCCT framework and likewise declaring a major in CS would be considered a Choice Action. While Career Actions are desired, they are relatively distant impacts of a Learning Experience in the SCCT framework. Additional insight can be gained by closely tracking intermediate mediators like interests, attitudes, and outcome expectations. By examining students' CS attitudes and beliefs it is possible to track and characterize influences on their self-perceptions vis-a-vis CS. We hypothesize that student develop CS-aligned attitudes and beliefs as they build self-efficacy, develop robust outcome expectations, and establish career intentions.

As such, the following research questions guide this study:

RQ1: Does the rotation-based introductory course impact attitudes and beliefs about computing?
RQ2: How satisfied are the students with each module of the rotation-based course
RQ3: Does the rotation-based course impact career ambitions?
RQ4: Do students in the rotation-based course see themselves as Computer Scientists and/or Engineers?

4 Methodology & Data Sources

4.1 Data Sources

A pilot study was crafted to monitor the impact of the rotation-based course on identified outcomes of interest during the Fall 2020 semester using a pre-post-survey design. We build upon the work of a prior study (Erdil & Ronan, 2019) that tested the applicability of the SCCT theoretical framework and tested survey items measuring students' career intentions (pre and post) and course satisfaction (post). Desiring to measure additional internal mediators related to self-efficacy and outcome expectancies, the items of the Computing Attitude Survey (CAS) were embedded in pre- and post-surveys to specifically probe student attitudes and beliefs about CS (Dorne & Tew, 2015). The CAS is a previously validated instrument that measures computing attitudes and beliefs such as undergraduates in introductory CS courses. The CAS consists of 25 statements about the nature and practice of CS to which respondents agree or disagree. Responses are then compared with expert ratings and a percent agreement score is determined. The CAS items encompass five domains, reported as subscores for Transfer (T), Personal Interest (PI), Problem Solving Strategies (PS), Real World Connections (RW) and Fixed Mindset (FM). Additional items probed major, career interests, and identity in the fields of computer science and engineering including the open ended prompt, "Do you see yourself as a Computer Scientist/Engineer? Why/Why not?".

4.2 Setting & Participants

Participants in this study are undergraduate students (N=60) in the Fall 2020 rotation-based introductory course at Sacred Heart University (SHU) in suburban Fairfield, CT. The second-largest Catholic university in New England, SHU has experienced sustained growth over the last decade in campus facilities and enrollment. SHU has offered CS programs for over 40 years, with degrees in Computer Science, Information Technology, Game Design, Computer and Electrical Engineering, and Cybersecurity. Participation in the surveys was both voluntary and anonymous and students were assured that the course instructor (the second author) would not review the responses until the conclusion of the semester. Participation rates were 90% (N=54) and 63% (N=38) for the pre- and post-surveys, respectively. For the quantitative analysis of the CAS, responses were paired and invalid responses were eliminated (the CAS contains an item designed to detect random answering), only 20 pairs of responses remained for complete analysis.

Given inherent biases associated with self-study, the validity of this pilot study was enhanced by the involvement of the first author (an education faculty member) who did not know the students or the curriculum. Open-ended items were coded by the first author and compiled into categories.

5 Findings

This section provides overall results and outlines our findings based on student responses to research questions.

5.1 Computing Attitudes

RQ1: Does an introductory rotation-based course impact attitudes and beliefs about computing as measured on the Computing Attitudes Survey (CAS)? Students' agreement with expert opinions about computing was measured at the beginning and end of the CS0 course and reported in Table 2. Overall, agreement with expert computing opinions was steady, with no statistically significant differences between pre- and post-scores, overall and for each of the CAS subscales. There were also no statistically significant differences among student subgroups on the basis of primary major.

Table 2. CAS Scores from pre/post survey

	Overall	Transfer	Personal Interest	Problem-Solving	Real World Connections	Fixed Mindset
	% Agreement					
Initial	66%	48%	81%	72%	78%	60%
Final	71%	55%	79%	79%	74%	69%
p value	*.436*	*.520*	*.776*	*.323*	*.665*	*.240*

5.2 Course Satisfaction

RQ2: How satisfied are the students with each module of the rotation-based course? Satisfaction with course modules was gauged using items both acquisition of skills and enjoyment of course content for each of the course module. Student major subgroup was used to further analyze the data. Table 3 displays the satisfaction score for each module is provided overall, for those students indicating that major as their primary interest, and the remainder of students. The only statistically significant difference in satisfaction between subgroups was seen between the engineering students and others on the question of gaining "skills and knowledge of Engineering" wherein the students with a primary interest in engineering reported a greater gain of skills in engineering. In every other area, those with a primary interest in that field and the remainder of the students reported a similar level of satisfaction. Cybersecurity was the highest rated course module in terms of satisfaction and game design the lowest.

Table 3. Satisfaction Scores from the introductory course survey

Module	Computer Science		Engineering		Game Design		Cybersecurity	
	Skills	Enjoy	Skills	Enjoy	Skills	Enjoy	Skills	Enjoy
Overall	4.24	4.16	4.16	4.05	3.78	3.41	4.30	4.30
Primary Interest Group	4.28	4.28	4.83	4.83	4.25	4.50	4.33	4.33
Remaining students	4.21	4.05	4.03	3.90	3.73	3.27	4.29	4.29
p value primary vs remaining	*.770*	*.495*	***.036***	*.101*	*.381*	*.064*	*.899*	*.903*

5.3 Career Intentions

RQ3: Does the rotation-based course impact career ambitions? Over 90% of all students agreed or strongly agreed on the final survey that CS skills would be needed in their intended career.

Table 4. Career thinking changes reported on survey

	Percent of student responses
This course made me feel more strongly about my existing career ambitions	43%
This course helped me get more specific about my career ambitions	30%
This course has not changed by career ambitions	16%
This course made me less certain about my career ambitions because I'm now considering new paths	3%
This course changed my career ambitions to a different path than I was considering previously	8%

5.4 Career Identities

Two of the survey prompts provided a window into students' developing career identities and, more significantly, what they consider components of developing a career identity. These items were phrased as "Do you see yourself as a Computer Scientist? Why or why not?" and "Do you see yourself as an Engineer? Why or why not?". All responses (N=88) were used as a basis for analysis, including those students who did not complete both surveys and did not provide valid data on CAS items but did provide a thoughtful answer to these open-ended items. Qualitative analysis of their responses yielded 8 categories across both domains which illustrate what these undergraduate students consider relevant in developing career identities. A priori categories were not used, rather the categories emerged from the data. However, categories that reflected components of the SCCT theoretical framework and related constructs were named as such. It is important to note that categories were evidenced by both positive and negative responses- for example both an interest in a field and a lack of interest in a field were coded as reflecting the importance of interest in developing a career identity. The overall number of coded segments for each category are summarized in Table 5 below, followed by descriptive analysis of each category. It was not assumed that the same categories would emerge from both the Computer Science Identity and Engineering Identity responses, however it became immediately apparent in reviewing the data that the same categories applied to the students' conceptions of both fields. The ninth category "epistemology" emerged from the engineering responses but was not evident in the computer science responses.

Table 5. Coded segments for emergent categories regarding field-based identities

Category	Coded segments from Computer Science Identity question	Coded segments from Engineering Identity question	Total coded segments
Enjoyment of the field	26	21	47
Interest in the field	10	13	23
Self-efficacy in the field	10	9	19
Knowledge/Prior experience in the field	12	6	18
Instrumentality	9	6	15
Problem-solving	10	5	15
Creating	2	11	13
Family assets	1	2	3
Epistemology boundaries	0	4	4

Enjoyment of the field

The most frequently cited reason for having or not having a career identity was enjoyment of the field. This category captured all emotion-based language students used to express their relationship to the field such as enjoyment, passion, desire, fun, and love with enjoyment being the most common expression. A sample response reflecting an emphasis on emotion-based language for expressed a Computer Science identity is "Yes, I do as this has been something I have desired to be for a very long time. I love computers and some of my greatest passions can only come to fruition through computer science". (Initial survey)

Interest in the field

The next most frequently cited reason for having or not having a career identity was interest in the field. Unlike the emotion-based language above, this category reflected students' statements of being cognitively drawn in my field. “Interest” was by far the most frequently used language to express this category, both positively and negatively. Boredom was considered an antonym of interest and therefore also coded for this category for example, this conflicted response for engineering identity “I do because I enjoy creating things but I do not because there is a boring side to it”. This response contains both emotion-based language (“enjoy”) and interest-based language (“boring”).

Self-Efficacy in the field

Several students described aspects of themselves that they believed made them a better or worse fit for the proposed career identity, contributing to their estimation of their own self-efficacy for the field. Responses coded for this category reflected language ideas such as confidence, suitability, and personality. It is interesting to note that students expressed these as fixed, established aspects of themselves rather than potentially malleable ones, for example “No, I’m not good at working with computers” (Initial survey). A positive response expressing self-efficacy is “Sure I can see myself as a computer scientist. I’m pretty technical when it comes to understanding how electronics work and how to operate them.” (Initial survey)

Knowledge/Prior Experience in the field

Many students expressed that their ability to develop a career identity was linked with their degree of knowledge and experience in that field. Responses coded towards this category referenced previous formal coursework and experiences as well as informal learning and experiences like being a competent user and trouble-shooter of technology and devices. A sample positive response for experience-based computer science identity is “Yes, because I have a good knowledge of coding” whereas a negative experience-based rationale was “No, no experience or training.”

Instrumentality

The category instrumentality was coded when students referenced a computer science or engineering identity as useful (or not useful) to some goal they have for themselves, such that computer science or engineering are an instrument for or means to some other end. Some of the goals cited were academic and career goals, “In order to be an effective Computer Engineer I imagine I’d need to learn Computer Science, but I don’t see myself as a Computer Scientist now, no.” (Initial survey) Students showed a conception of these fields as bestowers of a certain set of valuable skills. This is separate from- perhaps a step towards or an alternative to an identity in the field. Students viewed engineering as generally useful, “It is not directly required with my career ambitions but there will be opportunities where those skills come in handy.” (Final survey) Students viewed computer science as pertinent to specific pursuits including game design and more generally to “future goals”. Some students expressed altruistic goals. This was only found in the engineering identity responses including, “I like being involved in a career path that changes everyday and has the ability to help shape the world into a better place.” (Initial survey) Altruistic goals were associated with both problem solving “I like the thought of being able to solve problems that are important to me and society” (Initial survey) and creating “Yes, because I’ve always wanted to create something that helps people.” (Final survey). It is interesting to note that the altruistic instrumentality statements were associated with positive field identities, whereas the more transactional ones were associated with negative statements of field identity. In other words, some students want to *be* engineers in order to meet these larger altruistic goals whereas other students want to learn computer science and engineering in order to *be* some other field identity.

Problem-solving

Students cited their disposition towards problem-solving as the rationale for their positive or negative career identities for both computer science and engineering. It is interesting to note that there were twice as many references to problem-solving among the computer science identity responses than the engineering identity responses, suggesting that students associated problem-solving more closely with computer science than engineering. Problem-solving as a topical area was often used in a language construction alongside a statement of associated emotion or interest, such as “I enjoy solving problems” (Initial survey) or statements of experience, “Based off of personal experience, I can consider myself as a computer scientist. I know how to assess problems related to software, and can find help if needed.”(Final survey) This sample response shows how the various coded categories interact, as this student’s rationale for a computer science identity claim rests on his/her background experiences as leading to self-efficacy in the specific domain of problem-solving. A positive engineering identity is also associated with problem-solving, “Yes, I like the thought of being able to solve problems that are important to me and society.” (Initial survey)

Creating

The category of creating was also evident in both computer science and engineering identity responses, however in this case the balance of coded segments was strongly tilted towards engineering, with 11 of the 13 total coded segments for this category. Similar to problem-solving, students used both emotion-based and interest-based language to express their dispositions about creating. Some students also expressed a linkage between problem-solving and creating, “I would. I enjoy creating things and finding solutions to problems in unique ways.” (Final survey) Whereas this student’s response highlights the creativity aspect of creating, other responses emphasized a construction aspect of creating, for example “Yes, because I like to build and make things.” (Final survey) It is also interesting to note that all of the creating responses were associated with positive language. Even students who went on to explain their lack of or lesser interest in a given field used positive language around creating.

Family/Community assets

While small in numbers, some students expressed a strong association between their computer science or engineering identity and a family connection to the field. Because this area was not probed specifically, it is very possible other students have family connections with these fields, though they did not explicitly mention them as being tied to their rationale for computer science or engineering identity. An example of a computer science identity closely tied to a family identity is, “I am really try[ing] to pursue my career in IT managing. It really runs in the family. My mom is an IT manager and my grandma was an IT manager.” (Initial survey) Another student was not clear in defining the individuals as family or not but stated, “Yes, because I closely relate myself with other computer scientists in my life.” (Initial survey)

Epistemology

This category was only evident in engineering identity responses and was coded when the student included in their response a question, nuance, or push-back on the notion of defining the field of engineering. As if the decision over whether to express an engineering identity hinged on the precise definition of engineering utilized. For example, “If you consider game designers engineer, then yes.” (Initial survey). For one student an epistemological association was a barrier to an engineering identity, “No, I understand engineering, but I closely relate engineering with industrial machinery” (Initial survey). Some students provided their own definition of engineering in the process of claiming and defending an identity, “‘Engineer’ is subjective to everyone. You don’t need a career in construction or engineering to be considered as one. As long as you have the ambition to make something, you are an engineer. As for the question, yes, I am an engineer associate level because of my training in mechanical engineering.” (Final survey) One of the goals of the rotation-based courses is to help students understand what defines each field and how they interrelate, so it is not surprising that the students are developing their own understandings of field boundaries and relationships and consider them in positioning their own identity in the field.

5 Discussion & Implications

The findings of this study have implications for designers and instructors of introductory undergraduate courses as well as all those interested in cultivating identities and career interests in fields like computer science and engineering. First, the insignificant results of the Computing Attitudes Survey suggest that the rotational-course model did not provide an experience of sufficient duration or intensity to significantly change students' attitudes and beliefs about computing in a measurable way. This cohort of students will be measured using the CAS again at the conclusion of a semester-long CS0 course and the results will be reported at the ASEE conference in June.

Through their claims about computer scientist and engineer identities, the students revealed the various components, considerations, and drivers that matter to them in developing an identity in an academic/career field. If the goal of a rotation-based introductory course is to provide the basis for field-discernment and identity development then the categories which emerged from this analysis should be considered. Opportunities to define and practice creating and problem-solving in both computer science and engineer fields should be included and their processes made explicit. Through an exercise like asking about field-based identities, course designers can compare the students' impressions of the field with the message about the field they were attempting to convey and recalibrate as necessary. Defining the boundaries and sub-fields of computer science and engineering would further address students' epistemological qualifications and concerns.

As they experience dimensions of these fields it is important for the students to be made aware of how they are reacting to these experiences, such as through reflection. Given that enjoyment and interest were the most frequently cited identity consideration, it would be tempting to design the course to maximize these pleasurable outcomes. However it is easy to see how this could devolve into a curriculum that does not validly represent the fields. Rather, designers should plan experiences that are authentic windows into each field, experiences that those with established career identities would find enjoyable, scaffolded as needed. Following such an experience, students should be prompted to reflect- Did you find this enjoyable? Did it interest you? This encourages the student to gauge their own drivers and reveal authentic attraction to the essence of a field.

Students, as a matter of their individual personalities, have different pre-dispositions to adopting a field-based identity. Some students view a field-based identity as a logical extension of their natural, fixed characteristics which endow them with a sense of self-efficacy as related to the field. Having identified this aspect of themselves, they are able to take on and express the field-based identity. Other students view experience and skills as necessary pre-conditions for unlocking that self-efficacy and/or demonstrating enough competency to have access to the field-based identity. Further, deeper qualitative research is needed to better understand the psychological processes and characteristics that influence these dispositions towards identity. It is safe to assume that a class of undergraduates will be heterogeneous in this regard and instructors should both plan for and react appropriately to both modalities as they arise.

Based on the emergent finding of instrumentality, course experiences should also make visible the current and frontier applications of each field. These end-goals can appeal to students on a practical and/or altruistic level. Balancing motivations is important, based on the course designer's impression of what already motivates their student population, and what associations the students may already have between the field and external goals. In addition, some students already possess identities and goals outside of the field and are more interested in transferable skills than in field-discernment or identity formation. Skill acquisition is also pertinent to identity formation for those students described above who consider knowledge and competence as precursors to qualifying for a field-based identity as well as for the refinement of students' intentions and/or the openness to new developments.

The findings of the field-based identity analysis can also be understood as a particular manifestation of components of the SCCT framework. While the survey did not probe these dimensions specifically or explicitly, student responses to the field-based identity questions demonstrate alignment with known influences to career decision-making. First, the family and community assets category represents a background influence according to the SCCT. Self-efficacy is both a named attribute of SCCT and also factors into the SCCT as a personal input, as some students brought an innate sense of themselves as well-suited to the field as a personal characteristic, unmitigated by the influence of a learning experience. That said, learning experiences, formal and informal, were shown as important for identity formation by the knowledge/prior experience in the field category. Instrumentality aligns with the SCCT category outcome expectations- those external ends associated with a particular career path. In computer science and engineering, those outcome expectations are closely aligned with the students' understanding of the epistemology and scope of a given field, as well as the broader landscape of applications. The category of interests aligns with the same-named component of the SCCT and we argue that the enjoyment category should reside there as well, thereby broadening the more rational construct of "Interests" to a sense of being attracted or connected to a field/career, in a way that is not as specific as possessing a "Choice Goal". The more distal components of the SCCT- goals, actions, and performance are beyond the scope of the introductory rotation-based course but will be germane to longitudinal study of these students as undergraduates.

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