

Learning Experiences of Social Science Students in an Interdisciplinary Computing Minor

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Abstract

The rapid growth of the digital economy and an associated increase in user-generated data has created a strong need for interdisciplinary computing professionals possessing both technical skills and knowledge of human behavior. To help meet this need and with funds from NSF IUSE, we developed an academic minor in Applied Computing for Behavioral and Social Sciences at San Jose State University. The minor involves a four-course sequence that includes programming fundamentals, data structures and algorithms, data cleaning and management, and a culminating project. At our institution and nationwide, social science students are more diverse than engineering students, with respect to gender, race, and ethnicity. By providing social science students with computing skills that complement their domain expertise, we aim to expand their career options and address the nation's need for a diverse, technology-capable workforce. We administered an exit survey on student learning experiences to two cohorts of students completing the minor. Given that the minor is new and that the first cohorts were relatively small, the number of students completing the survey was modest ($n = 15$). Results indicate that students were motivated to minor in Applied Computing by a desire to improve their data analysis skills and better prepare themselves for the job market / graduate school, as well as a belief that programming is a necessary skill for the future. A large majority of students indicated that their peers, instructors, and homework assignments supported their learning very well, whereas they found topics covered and course projects to be less supportive, followed by pacing of course content. With respect to career plans, a majority of students agreed that the minor provided them with their desired skills and allowed them to learn about careers in applied computing, and a large majority indicated that they planned to pursue a career utilizing applied computing. They expressed interest in fields such as human factors, data analytics, project management, teaching, clinical psychology, and various types of research. Finally, common themes that arose when providing advice to future students included not being shy in seeking help, tips for managing the level of course difficulty, encouragement to regularly practice, suggestions for how to master course content, and advice for adopting a successful mindset. These results will be instrumental in helping to optimize students' experiences in the minor, ranging from how we recruit new students to how we can better support their professional development. Given the largely positive experiences of our students and their plans to pursue careers involving applied computing, we believe that our approach of adding computing education alongside a social science degree demonstrates a promising model for meeting the increasing demand for diverse interdisciplinary computing workers in this digital age.

Introduction

The nation and its expanding digital workplace need more computing professionals [1] as well as computing-capable workers to fill interdisciplinary computing jobs [2] - [4]. These jobs require workers to have computing skills, such as managing and analyzing data, as well as knowledge in related domains [5], [6]. To ensure the nation's competitiveness, the US needs to grow its digital workforce beyond a relatively small computing community [3], [7] and to include more women and underrepresented minority (URM) groups (i.e., Black, Latinx, Pacific Islander, and American Indian students). Given that interdisciplinary computing jobs command an average 14% salary premium [4], an increasingly diverse computing-capable workplace will generate broader prosperity and reduce income inequality [8], [9].

To help meet the need for more computing professionals, universities have begun developing new interdisciplinary computing minor and major degree programs. Several institutions offer programs in computer science + X (e.g., University of Illinois, Lewis University), in which students enroll in existing CS courses alongside CS students, as well as in additional courses in a chosen domain. The rigorous math and CS coursework required in these programs may not be suitable for non-STEM students, such as those in the social sciences, whose training differs substantially from a typical CS student. Other institutions have developed degree programs involving new courses created specifically for non-CS and/or non-STEM students (e.g., the computational social science minor at UC San Diego and a computing minor being developed at the University of Maryland Baltimore County). In creating an interdisciplinary computing minor for social science students at San Jose State University (SJSU), we opted to take the latter approach. Our decision was motivated by studies demonstrating that prior programming experience and mathematical background have been shown to predict success in introductory programming courses, e.g., [10] - [12], whereas social science students typically have no programming and very little math background relative to CS majors. As described in greater detail below, our Applied Computing minor consists of a four course series that covers programming fundamentals, data structures, algorithms, data cleaning, and data management, all of which utilize content relevant to the behavioral and social sciences.

We chose to focus on social science students, in particular, given that a large number of diverse students are studying behavioral and social sciences, whereas computer science and engineering majors tend to lack such diversity, particularly with respect to gender [7], [13], [14]. The goal of the Applied Computing minor is to provide our students with a skill set that will expand their career opportunities and increase their income, in turn helping to address the need for a diverse workforce of interdisciplinary computing professionals. Funds from the National Science Foundation Division of Undergraduate Education (NSF DUE 1626600) have supported the

development of each course, professional development of instructors involved in these courses, and program assessment.

Program overview

The minor consists of a series of four courses designed to be taken serially, creating a cohort structure that helps provide students a sense of community. Brief descriptions of each course are below. Critically, none of the Applied Computing courses require advanced mathematical knowledge. Rather, the only prerequisite for the first course in the minor (ENGR 120) is introductory statistics, a course that is already required for most social science majors. In turn, ENGR 120 serves as the only prerequisite for the remaining courses in the series.

- ENGR 120. This is an introductory programming course for social science students with no prior programming experience. It introduces them to basic Python programming concepts (e.g., data types, conditional execution, iteration, functions, data analysis, web scraping) via a hybrid lecture-lab format.
- ENGR 121. Also taught in Python, this data structures and algorithms course teaches students to represent and analyze social science data and to use data structures and related algorithms to solve social science problems.
- ENGR 122. Our Data Technology course introduces students to R with an emphasis on data analysis techniques, including basic statistics, linear and non-linear curve fitting, clustering, natural language processing, neural networks, databases, Structured Query Language (SQL), and data cleaning and management.
- ENGR 195E. The final course involves a capstone project in which students apply their computing skills to solving problems or generating insights in their chosen area of study. Students work in self-selected teams and define their own project topics.

The current paper focuses on survey data collected at the end of the capstone course, ENGR 195E. This course requires student teams to identify a behavioral or social science problem, apply computing skills to the problem, and present the results. Examples of past projects include: analysis of 1.6 million Twitter comments to identify possible signs of depression, sentiment analysis of 3 million Amazon reviews to gain new insights in consumer behavior, and administration and analysis of a questionnaire regarding drug use among college students. By surveying students at the end of this capstone course, we aimed to assess their opinions about and satisfaction with the minor, as well as their future career plans.

Student profile

A demographic profile of students enrolled in the final course in the minor, ENGR 195E, can be found in **Table 1**. The table reflects data for all students who have completed the minor to date, as well as a subset of students who completed the exit survey. At SJSU, as well as nationwide,

social science students tend to be more diverse than engineering students [13], [14]. This pattern is reflected in the demographics of students completing the minor, such that a higher percentage of Applied Computing students are women and underrepresented minorities relative to students in the College of Engineering, in which 19% are women and 22% are URM [13]. The most popular major among Applied Computing students is Psychology, followed by Economics. Less common majors include Business, Sociology, Behavioral Science, Communication Studies, and Linguistics.

Table 1: ENGR 195E student profiles

Demographic	Category	All	Survey respondents
# Students		44	15
Gender	Women	50.0%	60.0%
	Men	50.0%	40.0%
Ethnicity	URM	36.4%	26.7%
	non-URM	59.1%	73.3%
Major	Psychology	36.4%	60.0%
	Economics	25.0%	13.3%
	Other	35.1%	26.7%

Note: Percentages may not sum to 100% given that some students preferred not to disclose demographic information

Program assessment

Our approach to assessment includes internal evaluation conducted by faculty and external evaluation conducted by a nonprofit education research agency. In this paper we focus on the former, describing results of an exit survey administered to students on their final day of instruction in ENGR 195E, the capstone course for the minor. The survey included questions pertaining to mindset, attitudes about and confidence with programming, motivation for enrolling in the minor, factors supporting their learning while taking the minor, future career plans, and advice for future students. These data have served as a useful complement to standard assessments of academic performance, and they will function as a critically important feedback loop for how best to recruit and retain students, optimize our courses, and improve students' experiences.

Methods

Participants

Participants included students enrolled in the final course (ENGR 195E) of the Applied Computing minor at SJSU, which is a large, minority-serving public university. Students were invited to voluntarily complete an exit survey administered during the final class meeting. Participants gave informed consent in line with procedures approved by our university's Institutional Review Board. Fifteen students completed the survey. See **Table 1** for demographic data, noting similarities between survey respondents and the broader population of students enrolled in ENGR 195E.

Survey

The survey was administered online via Qualtrics and included seven sections. The first section included a series of statements pertaining to growth mindset; three were taken from Dweck [15], and the remainder were filler questions from Fabert [16]. Participants were asked to rate their level of agreement with each statement. The second section included 26 statements adapted from the Computing Attitudes Survey [17] to use the word “programming” rather than “computing.” Once again, participants were asked to rate their level of agreement with each statement. The third section contained five questions regarding programming abilities, with participants indicating their level of confidence in each. Data from these first three sections will be used in a future study to examine longitudinal changes in growth mindset, programming attitudes, and confidence in programming abilities by comparing responses from this survey and a similar survey administered in ENGR 120, the first course in the minor. The number of students fully completing both surveys is currently too small to warrant statistical analysis. As such, the focus of this paper is on a qualitative analysis of the fourth through seventh sections of the survey.

Specifically, the fourth section asked students to identify factors that motivated them to enroll in the minor and asked them if they acquired their desired skills. Additionally, they were asked how well their learning was supported by different aspects of the minor such as homework assignments, instructors, etc., with responses ranging from not well to very well. The fifth section asked students to rate how much they learned during the minor about careers in applied computing, with response options ranging from none to a great deal. We then asked them to indicate whether they planned to pursue a career that makes use of the Applied Computing minor, and to describe their career or graduate school plans upon graduating. The sixth section included an open-ended question asking students about what advice they would offer to students new to the Applied Computing minor. Finally, the seventh section included a series of demographic questions pertaining to gender, ethnicity, and major.

Results

Motivation for enrolling in the minor

Students were asked to select one or more options that reflected their motivation to enroll in the minor. All respondents (n = 15) indicated that they were motivated to improve their data analysis skills, 93.3% (n = 14) wanted to better prepare themselves for the job market, 86.7% (n = 13) believed that programming is a necessary skill for the future, 73.3% (n = 11) wanted to learn one or more programming languages, 53.3% (n = 8) wanted to better prepare themselves for graduate school, 33% (n = 5) noted that a professor recommended the course, and 13.3% (n = 2) could not enroll in other CS courses given that they were not CS majors. When asked whether they acquired their desired skills in the minor, 73.3% of respondents (n = 11) replied “yes,” 26.7% (n = 4) replied “somewhat,” and no students selected “no.”

Learning support

With respect to the minor as a whole, students were asked to indicate how well each of the following supported their learning: homework assignments, final projects, pacing of lessons, topics covered, instructors, and peers. See **Table 2** for a summary of their responses, ranked in order of most to least supportive of learning.

Table 2: Factors supporting student learning

	Very well	Somewhat well	Not well
Peers	73.3% (n = 11)	20% (n = 3)	6.7% (n = 1)
Instructors	66.7% (n = 10)	26.7% (n = 4)	6.7% (n = 1)
Homework	66.7% (n = 10)	26.7% (n = 4)	6.7% (n = 1)
Topics	53.3% (n = 8)	46.7% (n = 7)	0.0% (n = 0)
Projects	53.3% (n = 8)	46.7% (n = 7)	0.0% (n = 0)
Pacing	33.3% (n = 5)	60.0% (n = 9)	6.7% (n = 1)

Career plans

When asked how much they learned about career options in applied computing as part of the minor, 40% (n = 6) indicated that they learned a great deal, 60% (n = 9) indicated that they learned some, and no students selected that they learned very little or none. With respect to their plans upon graduating, 86.7% (n = 13) reported that they planned to pursue a career or graduate program that makes use of their Applied Computing minor.

In an open-ended question regarding their specific career plans, Psychology majors (n = 8) reported two distinct types of career plans. The first involved graduate school, either in traditional career pathways for psychology students (clinical psychology or neuroscience: n = 3) or in human factors (n = 1). Students in the second pathway intended to immediately enter the workforce: two students intended to apply for data analytic positions in a company, and one student intended to use their technical knowledge to teach K-8th grade students about coding and cybersecurity. One Psychology major intended to become a physician's assistant.

Four students in this sample were majoring in Economics (n = 3) or Business (n = 1). Three students reported planning to directly use their Applied Computing minor. One Economics major intended to pursue a Master's degree in Computer Science and another Economics major intended to find employment in data analytics/business operations. The Business major intended to find employment in supply chain management that is data intensive. The third Economics major intended to pursue an unspecified Master's degree.

The remaining three students were Communication studies majors (n = 2) and a Sociology major (n = 1). The Sociology major's plans followed a traditional sociology pathway, that is, engaging in social research. However, the two Communication Studies majors reported intending to pursue business and technology relevant career pathways, with one seeking employment involving project management, measuring performance and other operations, and the other intending to seek an advanced degree in Human Factors and/or work in a company that would make use of their computing skills.

Advice for future Applied Computing students

Students provided a range of advice and helpful suggestions that mapped onto five themes, with several students offering more than one piece of advice. One clear theme was to advise students to ask for help, seek support from their peers, and attend office hours (n = 4). The second theme related to helping students manage the level of difficulty in the minor courses (n = 4). Some students suggested spacing out the classes, whereas others talked about setting realistic goals. Another theme was to advise future students to engage in regular practice (n = 3), such as trying additional problems and different methods of solving problems, as well as experimenting with the content. A fourth theme involved practical advice regarding how to master the skills taught in the minor, with suggestions ranging from taking the material step-by-step to buying additional manuals (n = 3). The fifth theme was more abstract, as the advice was about one's mindset for succeeding in class, ranging from reminding future students that they need to think in a new way to being a proactive student and realizing they need to study regularly (n = 3). Finally, an additional suggestion was offered by only one student, who provided practical advice about career preparation (i.e., choosing projects relating to one's desired career). Taken together, advice

to future students was positive and supportive, providing practical suggestions for how to succeed and get the most out of the minor.

Discussion

To better understand and in turn improve students' experiences in the minor, we administered an exit survey to students in ENGR 195E, the capstone course in the minor. Results indicate that students were most strongly motivated to minor in Applied Computing by a desire to improve their data analysis skills and better prepare themselves for the job market. A large majority of students indicated that their peers, instructors, and homework assignments supported their learning very well, whereas they found topics covered and course projects to be less supportive, followed by pacing of course content. With respect to future career plans, a majority of students agreed that the minor provided them with their desired skills and allowed them to learn about careers in applied computing, and a large majority indicated that they planned to pursue a career utilizing skills developed in the Applied Computing minor. They expressed interest in fields such as human factors, data analytics, project management, teaching, clinical psychology, and various types of research. Finally, common themes that arose when providing advice to future students included not being shy in seeking help, tips for managing the level of difficulty in the courses, encouragement to regularly practice, suggestions for how to master course content, and advice for adopting a successful mindset.

These results will be instrumental in helping to optimize students' experiences in the minor, ranging from how we recruit new students to how to better support their professional development. With respect to recruitment, our current materials aim to (a) encourage students to expand their skill set and increase their marketability, (b) educate students about careers in interdisciplinary computing that value social science knowledge, (c) reassure them that the minor is built specifically for social science students with no prior programming experience, and (d) emphasize that course materials were crafted to align with their interests [18]. Based on student feedback, we are revising these materials to more clearly highlight the ability to improve one's skills in data analytics and visualization.

With respect to factors that best support student learning, we were pleased to see that interactions with peers and instructors were very supportive, as were homework assignments. However, students found that the topics covered in their courses and the projects they completed were less supportive, indicating that instructors should more clearly describe how the concepts and skills being taught can be applied to the social sciences and to careers in which students are interested. This is particularly critical for the second and most technically challenging course in the minor, ENGR 121, which covers data structures and algorithms. We are currently revising this course to place a greater emphasis on application rather than theory. Finally, a majority of students

indicated that the pacing of course content was only somewhat supportive of their learning. Informal conversations with students suggest that they find the content in ENGR 121, in particular, to be too fast given its highly technical content. We hope that by revising the course to more strongly emphasize applications to the social sciences, students will find the pacing to better support their learning.

We were extremely encouraged to find that 87% of students completing the survey plan to pursue a career path that utilizes their Applied Computing minor, suggesting that the minor has been successful in expanding their career options and making them enthusiastic about joining the digital workforce. That said, when asked how much they learned about relevant career options, 40% of students indicated that they learned a great deal, and 60% indicated that they learned some. The majority of professional development content currently occurs in the first course in the minor series, ENGR 120, in which instructors start each lecture with a “spotlight” that focuses on topics ranging from career paths to industry jargon. The course also features an alumni panel in which former students describe their career journeys after graduating. We plan to add similar professional development activities in each of the other courses, with an emphasis on the capstone course, in particular. As the number of cohorts completing the minor continues to grow, we look forward to following their career trajectories via a LinkedIn group created for this very reason.

In addition to providing more professional development opportunities, we also plan to pilot a peer mentoring program — a decision motivated by two factors. First, as evidenced by students’ responses to questions about factors best supporting their learning, they find their peers to be highly supportive. Second, when asked to provide advice for future students in the minor, survey respondents gave very practical, actionable suggestions. We hope that by making peer mentors available to students taking the first course in the minor, this information will be more readily communicated. We are particularly interested in encouraging women and URM students to serve as peer mentors in an effort to foster a sense of belonging and inclusion among our diverse cohorts.

Indeed, a major goal in developing the Applied Computing minor has been to enhance diversity in computing education. The demographic data for the capstone course clearly indicate greater participation of both women and URM students relative to other courses in the College of Engineering. Together with a prior report published by our group [19] describing demographic data and survey results from the first course in the minor, our findings demonstrate that we are successfully recruiting and retaining a diverse population of students. These results mirror those of other interdisciplinary computer degree programs reporting an increased number of women and URM students relative to typical Engineering and CS courses [20], [21]. As we continue to graduate more students and as our sample size increases, we plan to disaggregate our data to

focus on how student experiences and outcomes differ according to factors such as major, gender identity, race, and ethnicity.

Given the largely positive experiences of our students and their plans to pursue careers utilizing skills developed in the Applied Computing minor, we believe that our approach of adding computing education alongside a social science degree demonstrates a promising model for meeting the increasing demand for diverse interdisciplinary computing workers in this digital age.

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