



Applied Computing for Behavioral and Social Sciences (ACBSS) Minor

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Since her 2002 appointment as Don Beall Dean of SJSU's Charles W. Davidson College of Engineering, Belle Wei has led a college dedicated to educating engineers who can take on today's problems and produce tomorrow's solutions. Under Wei's leadership, the college has launched programs to enhance students' global awareness and enrich their professional networks. A signature program is the College's Global Technology Initiative (GTI), a two-week study-tour to Asia. Since its inception, GTI has sent student-teams to China, Taiwan, or India each year to meet global collaborators, competitors, and leaders through an intensely immersive learning experience that goes beyond classroom studies. Other programs reflecting Wei's international reach include the college's Poverty Alleviation/Service-Learning program and Engineers Without Borders. This global perspective is rooted in a vision of SJSU as a preeminent producer of forward-thinking problem-solvers. With this goal in mind, Wei has established the Silicon Valley Engineering Scholarship, a program that provides \$5,000 of annual support for high-achieving students to pursue engineering careers. Wei is also a Principal Contributor to CSU (California State University) Engineering Academies, a statewide program that helps high schools better motivate and prepare students for the rigors of engineering education. Moreover, she supports the creation of high-impact programs for first-year students and established a new SJSU Engineering Student Success Center to help engineering students thrive. Most importantly, Wei's commitment to expanding the sphere for student excellence has produced results that include increased access for women, African Americans, Latinos/Latinas, and other historically underrepresented communities to SJSU. Wei extends her service beyond SJSU through active engagement in national and international organizations. She serves on the Executive Board for the Engineering Deans Council of American Society for Engineering Education, chairing its Committee on Diversity. She has served on several National Science Foundation panels. And she has assumed numerous leadership roles on program committees for technical conferences. In 2006, Wei was invited by Congress to share her insights on the "Innovation Agenda," promoting strategies for the United States to maintain and advance its technological and economic leadership in an increasingly challenging and interdependent global arena. Wei also serves on the boards of Monte Jade and Vision New America and is a founding board member of U.S.-China Green Energy Council.

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Abstract

The growing digital economy creates unprecedented demand for technical workers, especially those with both domain knowledge and technical skills. To meet this need, an ACBSS (Applied Computing for Behavioral and Social Sciences) minor degree has been developed by an interdisciplinary team of faculty at San José State University (SJSU). The minor degree comprises four courses: Python programming, algorithms and data structures, R programming, and culminating projects. The first ACBSS cohort started in Fall 2016 with 32 students, and the second cohort in Fall 2017 reached its capacity of 40 students, 62% of whom are female and 35% are underrepresented minority students. Considering ACBSS students' interest in human behavior and society, pedagogical approaches using relevant examples and projects have been developed and integrated throughout the program. Preliminary assessments show that students appreciated learning programming skills with which to expand their career opportunities while gaining confidence in studying technical subjects. These results show that ACBSS, an interdisciplinary computing education program, offers a promising model in providing computing education to more diverse students for the 21st-century digital workplace.

1. Introduction

As the technology-based economy grows, so does its demand for technology professionals. The U.S. Bureau of Labor Statistics projects a growth of 1.1 million American jobs in computing and information technology by 2024—with only 450,000 graduates available to fill them [1]. In addition to technology professionals, more technology-capable workers are needed in the increasingly digitized workplace [1]. In all, the gap between the demand and supply of technology-educated workers slows economic growth while raising income inequality [2].

To address this problem, we have developed an Applied Computing for Behavioral and Social Sciences (ACBSS) minor degree program for behavioral and social sciences students at San José State University (SJSU). We considered three major factors for creating this program. First, with the emergence of big data, there is a strong demand for workers who have both domain knowledge and technical skills [3, 4]. Modeling human behaviors and social interactions through big data is a fruitful area for technology-capable graduates to pursue career opportunities and advanced studies. Second, a large number of students are studying behavioral and social sciences, both at SJSU and in universities across the nation. Indeed, behavioral and social science majors accounted for more than 1 out of 7 bachelor's degrees (i.e. 287,000 out of 1.8 million) in the U.S. in 2012 [5]. Third, women, African-Americans, and Latino/as are overrepresented in behavioral and social sciences at SJSU and yet underrepresented in engineering and computing majors. These are the very groups that we aim to better prepare for technology-related careers.

The ACBSS minor degree program, which began in Fall 2016, consists of four 3-unit technical courses with a focus on applications in the fields of behavioral and social sciences. They include:

1. ENGR 120 Programming Concepts for Behavioral and Social Science Applications (Python)
2. ENGR 121: Data Structures and Algorithms for Behavioral and Social Science Applications (Python)
3. ENGR 122: Data Technology for Behavioral and Social Science Applications (R)
4. ENGR 195E: Interdisciplinary Computing Project

Typically, behavioral and social science students begin this minor degree program in their junior year after completing their coursework in statistics, which is required as part of their majors and is a prerequisite for the first course in the minor series. The minor is designed to be completed over four semesters. Furthermore, students' respective majors generally include enough elective units for them to complete the ACBSS program without delaying graduation.

ENGR 195E is a student selected project. Students select a topic of interest and apply programming to the problem. They are encouraged to select a project that will look good on their resume, and assist landing a post education job or entering graduate school. For example, one selected topic was "Forecasting Ford Motor Company (USA) Sales". This project was implemented in R and used historical data, regression models, and a neural network. A second topic was an "Analysis and Model of Firearm Policy to domestic violence". This project was searching for a longitudinal relationship between changes in firearm policy, and changes in domestic violence rates. The project was implemented in Python. During the semester, students meet at least every two weeks with an adviser, write a proposal, perform algorithm and code reviews, and provided demos of data collection and analysis progress. The class concludes with a paper and presentation of performed work. An adviser grades the technical content, and a course administrator grades the presentations and writing.

With students' interests in mind, our ACBSS program is designed to both recruit and retain students for the digital workplace by providing them with active learning experiences and supportive learning communities of peers, faculty, and industry professionals in Silicon Valley. The program incorporates a series of curricular and co-curricular activities that reflect a balance of "high tech" and "high touch" educational practices. In particular, this program uses contextualized problem-based pedagogy in which students acquire relevant technical concepts and skills by solving real-world problems that are of interest of them. The course sequence is carefully designed to scaffold student learning by enabling them to acquire a well-organized body of knowledge and skills with the aid of a growth mindset that encourages them to persist in their learning.

2. Student recruitment and profile

A recent report from the Center on Education and the Workforce (2015) found that social science majors have among the highest unemployment rates of all college graduates. When recruiting social science students for the ACBSS program, we highlight this sobering statistic to encourage them to diversify their skill set and make them more marketable for technology-oriented careers. We frequently find, however, that many students fail to see the relevance of their social science interests to the tech industry. They assume that careers in tech require extensive programming experience, and they are largely unaware that tech companies value employees with interdisciplinary skills including knowledge of human behavior. To address these issues, our recruitment efforts aim to educate students about technology-oriented career paths such as user experience research and econometrics that are relevant to those with social science backgrounds. We emphasize that by supplementing their domain knowledge with computing skills, they can double the number of jobs available to them and raise their salaries by several thousand dollars [6].

As can be seen from Table 1, our recruitment efforts for the first course in the program (ENGR 120) have been successful thus far. Most classes at the university have an enrollment cap of 40 students, to which end our ENGR 120 enrollment numbers of 33 and 40 students in Fall 2016 and 2017, respectively, demonstrate a high level of interest in the course. On average, only 24% of enrolled students in engineering courses at the university are female, whereas almost half of ENGR 120 students in Fall 2016 and close to two-thirds of students in Fall 2017 were female. In addition, the percentage of underrepresented minority (URM) students in ENGR 120 in both Fall 2016 (21%) and Fall 2017 (35%) was higher than in the College of Engineering (16%). The percentage of females and minorities in the course increased from Fall 2016 to Fall 2017. The majority of students in both semesters were Psychology majors, followed by Economics majors. Additionally, a poll of enrolled students prior to the start of the Fall 2017 semester indicated that most had little to no programming experience prior to enrolling in the course: 56% had no programming experience, 34% had limited programming experience, and only 9% had moderate programming experience.

Table 1 - Student demographic data for ENGR 120.

Demographic	Category	College of Engineering	ENGR120: Fall 2016	ENGR120: Fall 2017
Number of Students		5,060	33	40
Gender	Female	18%	16 (48%)	25 (62.5%)
	Male	82%	17 (52%)	15 (37.5%)
Ethnicity	URM	23%	7 (21%)	14 (35%)
	non-URM	77%	26 (79%)	26 (65%)
Majors	Psychology	0	20 (61%)	21 (52.5%)
	Economics	0	7 (21%)	9 (22.5%)
	Other	100%	6 (18%)	10 (25%)

3. Faculty and pedagogical approaches

The ACBSS minor program is being supported by an interdisciplinary team of 11 faculty members, including the Assistant Vice President for faculty development as well as faculty members from the departments of Engineering (n = 4), Psychology (n = 3), Economics (n = 2), and Political Science (n = 1). The team meets once a month to discuss curricular development, pedagogical approaches, industry connections, student outreach, and advising. The team is actively involved in advertising the program on campus and providing information to other faculty members, advisors, and students, including informational videos and in-person information sessions for both current students and new community-college transfer students.

In Fall 2016, the first year of the ACBSS program, ENGR 120 was taught by an engineering faculty member. However, given that the program is designed for social science students, and based on student feedback from this first effort, the course was taught by a Psychology faculty member in Fall 2017. This change, along with revisions to course materials to be better tailored for social science students, improved students experience in the course (see Section 4.1).

As the first course in the ACBSS program, ENGR 120 requires no prior programming experience, to which end instructors gradually introduce basic programming concepts in Python using evidence-based learning practices. For example, decades of psychological research (e.g., [7]) indicate that information is better retained when it is generated by learners rather than provided to them. As such, the course is taught in a hybrid lecture-lab format, such that the first half of each class session involves learning relevant concepts, followed by in-class exercises in which students write their own code by working in pairs. Additionally, given that repetition is key to successfully encoding new skills and information [8], students are required to turn in weekly homework assignments in which they gain further practice with concepts learned in the prior week. Critically, given that spaced practice has been shown to be more effective for long-term retention of skills than massed practice (e.g., [9]), homework assignments also require students to practice programming concepts learned earlier in the semester, such that practice is spaced across multiple weeks. Finally, research shows that being tested, also known as retrieval practice, is in and of itself critical to successful learning [10]. For this reason, students take regular quizzes throughout the semester to enhance their learning and allow for feedback regarding areas needing additional practice.

Importantly, with respect to in-class exercises, homework assignments, quizzes, and the course's culminating project, all materials are designed to have social science relevance. Students are also introduced to relevant career paths and industry terminology, such that each class begins with a "Spotlight on X" segment, in which students learn about topics such as the applications of machine learning to consumer products. One of the class sessions is also dedicated to a career panel in which speakers with social science backgrounds who now work in the tech industry

discuss their educational and career paths, thus providing inspirational examples to students of the feasibility of working in Silicon Valley.

The second course in the series, Data Structures and Algorithms (ENGR 121), is designed to scaffold student learning by enabling them to acquire a well-organized body of knowledge and skills with the aid of a growth mindset that encourages them to persist in their learning. Whereas typical programming classes in an Engineering or Computer Science department rely heavily on examples and exercises pertaining to math and physics, this course pulls from a broad range of social science disciplines to create content more relevant to students. For example, students use data from the Bureau of Labor Statistics to identify and compare popular industries in different states. Students also engage in activities such as scraping content from social media sites and then applying natural language processing and sentiment analysis. Given that students better relate to programming as a discipline if it is tied to career paths relevant their social science interests, this course continues to place an emphasis on career development. For example, students are asked to find job postings for industry or graduate student positions to help ensure that they will be prepared for seeking out such positions upon graduating. This approach is common practice in typical engineering courses, and was extended for students in this course as well. The third course in the series, Data Technology (ENGR 122), continues with the abovementioned principles and introduces students to a second programming language, R, which is commonly used for data analysis purposes.

4. Program Assessment

One of our programmatic concerns was to develop pedagogical practices that were best suited to the needs of students we aimed to attract. In order to monitor the impact of our efforts, we designed surveys and conducted focus groups to gather students' feedback about the courses and the ACBSS program in general. In this section, we briefly report assessment results including (1) surveys completed by ENGR 120 students at the end the of Fall 2016 and 2017 semesters, (2) focus group results conducted by an external evaluator for ENGR 121 in Spring 2017, and (3) focus group results for ENGR 122 in Fall 2017.

In addition to these more formal assessments, we were also curious to know more about the students themselves. Because these students' majors and associated coursework were different from those of the average computer science and engineering student. In Fall 2016 we invited ENGR 120 students to share opinions about themselves and their interests. For example, we asked students to describe their strengths and weaknesses as students, from which a word cloud representation was made. A number of students mentioned strengths in writing along with a number of different skills, such as research and organizational skills (Figure 1.a). As may be expected from social science students, they did not mention technical skills as a strength. With respect to weaknesses, students frequently mentioned difficulties with procrastination and time management (Figure 1.b).

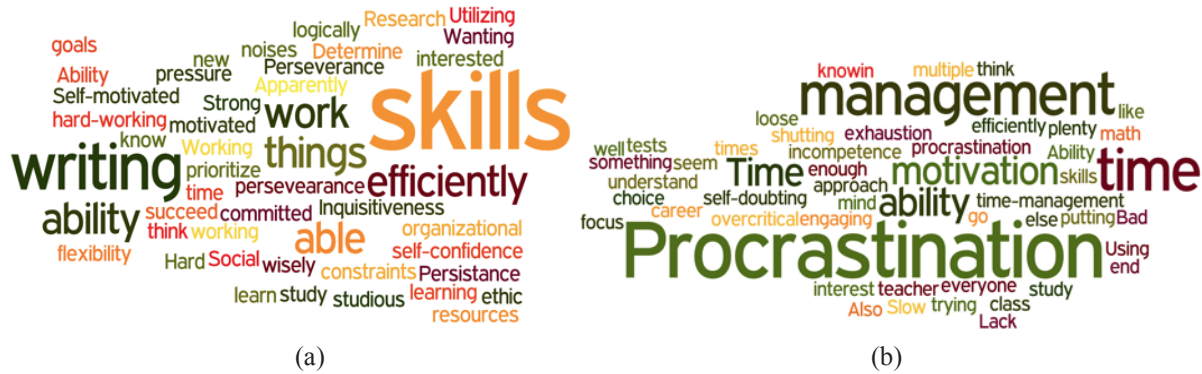


Figure 1 - Word cloud representation of responses regarding (a) strengths and (b) weaknesses as students.

Students were also asked to describe the most interesting fact or concept learned in a class inside and outside of their major, respectively. Figure 2.a represents a word cloud representation of answers pertaining to concepts learned inside their major. Interestingly, human-related topics were by far the most common answer provided, a pattern that is likely quite different than that observed in students taking standard programming or engineering courses. With respect to concepts learned outside of the major (Figure 2.b), technology was one of the most common responses. This pattern indicates that, although students' primary interests may lie within the social sciences, nonetheless they have an interest in learning technology -- potentially contributing to their motivation for enrolling in ENGR 120.



Figure 2 - Word cloud representation of responses regarding the most interesting fact or concept learned in classes (a) WITHIN and (b) OUTSIDE of students' majors.

The information garnered from this informal survey was used to shape the assignments and in-class activities during the second offering of the course in Fall 2017. As noted in the following section, these adjustments may have helped to enhance students' experience in the course.

4.1 End-of-semester survey feedback from students in ENGR 120 in Fall 2016 and 2017

In order to gauge students' overall reaction to the course, as well as course content, students were asked to complete an end-of-semester survey. Table 2 shows demographic data for survey participants from both semesters. The demographics of survey respondents were similar to those reported in Table 1 for all enrolled students.

Table 2 - Participant demographics for the ENGR 120 survey

Demographics	Fall 2016	Fall 2017
Participants	13	38
Gender - Female	5 (38%)	22 (58%)
Gender - Male	7 (54%)	14 (37%)
Gender - Not given	1 (8%)	2 (5%)
URM	2 (15%)	12 (31%)
non-URM	11 (85%)	25 (66%)
Ethnicity - Not given	0	1 (3%)
Major - Psychology	8 (62%)	20 (52%)
Major - Economics	4 (30%)	9 (24%)
Major - Other	1 (8%)	8 (21%)
Major - Not given	0	1 (3%)

Of the 33 students enrolled in ENGR 120 in Fall 2016, 13 participated in the survey -- approximately 39% of enrolled students. Due to this relatively low participation rate, we changed our survey administration strategy for Fall 2017. In Fall 2016, students were asked to participate in the survey after grades were posted and the semester was over. In 2017, however, we asked students to participate in the survey during the final class session. The researchers explained that the survey was voluntary and would not impact their grade, and that their instructor would not have access to the results until after grades had been posted. This strategy increased survey participation to 95%.

In the survey, students rated their level of agreement with a series of statements about the course on a scale from *strongly disagree* (1) to *strongly agree* (5) (see Table 3). Overall, enthusiasm for the course was high across both semesters -- students generally agreed that course material was interesting, was different from what they studied before, and made them think in new ways.

Table 3 - Overall reaction to ENGR 120

Item (Agreement Level: Strongly disagree=1, Strongly Agree=5)	Fall 2016	Fall 2017	<i>p</i>
The class provided me with a positive learning environment.	3.92	4.82	0.016
The class provided me with a feeling of belonging to a community.	3.23	4.53	< 0.001
The material we covered in ENGR 120 was interesting.	4.31	4.84	0.079
The material we covered in ENGR 120 was hard.	4.23	2.92	< 0.001
The material we covered in ENGR 120 was different from the kinds of things I've studied before.	4.77	4.37	0.066
The material we covered in ENGR 120 made me think in new ways.	4.15	4.55	0.207

Note: *p* values reflect the results of independent-samples t-tests assuming unequal variance

Adapting the curriculum to better align with students' backgrounds, however, seemed to enhance students' experience: Students in Fall 2017 agreed more strongly than students in Fall 2016 with the statements that the class provided a positive learning environment ($t(49) = -2.713$, $p = 0.016$) and a feeling of belonging to a community ($t(49) = -4.159$, $p < 0.001$). Responses also differed with respect to the statement that material covered in ENGR 120 was hard, such that course

content was deemed to be significantly more challenging in 2016 than 2017 ($t(49) = 6.839$, $p < 0.001$). We speculate that changes in course content and pedagogy to include greater social science relevance, as well as having an instructor with a social science background, resulted in a course better tailored to the needs of non-STEM students.

4.2 Focus Group for ENGR 121 (Spring 2017)

Near the end of the Spring 2017 semester, an external evaluator conducted a focus group in which five ENGR 121 students participated, all of whom completed ENGR 120 the previous fall. Students discussed a variety of topics including their overall satisfaction with these courses, their motivation for enrolling in these courses, how these courses compared with similar computer science courses, and their career paths.

Overall, students appreciated their experiences in ENGR 120 and ENGR 121, and found the courses beneficial for their educational and professional goals. Students expressed four reasons for enrolling in ACBSS courses: (a) encouragement by professors and friends, (b) trends they have seen in industry and at internships, (c) a perceived need for computing skills when working in Silicon Valley, and (d) a desire to learn more programming languages. They saw computing knowledge as marketable for the analytical careers they wish to pursue. As one student commented:

My economics professor heavily recommended we take the class and I'm interested in data and analytics and I feel like being in Silicon Valley you need to have some sort of programming experience.

All students agreed that ACBSS courses increased their interest in computing. They enjoyed applying course concepts to real-world problems, which they could not easily do in standard courses for their respective majors. Although they found the courses challenging, they reported that the content pushed them to think in new ways. They noted that the support they received in class was key to sustaining this interest. Students also commended professors and teaching assistants, who sometimes spent hours helping students outside of class, for their availability and approachability. Several students also appreciated that professors spent time carefully explaining topics in class and allowed them to make errors, which seemed to differ from the experiences of their peers in other computing courses. For example, one student said:

The learning is challenging, but we don't have the same expectations as a straight up CS or CE student, so we have a little more room to error, versus when I took C++ the drop rate was probably 2 or 3 [students] per week.

Concerning their career aspirations, none of the students wanted to pursue careers as computer programmers; rather, they saw computing as supplemental to their training. Most students wished to pursue analytic careers (e.g., business analyst).

4.3 Focus Group for ENGR 122 (Fall 2017)

The external evaluator also met with ENGR 122 students near the end of Fall 2017 semester, and conducted a focus group in which eight students participated, six of whom had previously completed both ENGR 120 and ENGR 121. Their majors included Economics (n = 5), Psychology (n = 2), and Communications (n = 1). Most participants were either third year students (n = 3) or seniors (n = 4); one student was in graduate school. Students discussed a number of topics including why they enrolled in the program, their career paths, their perception of other computing courses, and their overall satisfaction with the program.

Students expressed a variety of reasons for enrolling in ACBSS courses, such as encouragement from faculty, the need to develop skills for their future careers, and a desire for a structured learning environment. Similar to students interviewed in Spring 2017, one participant mentioned difficulty in pursuing computing courses offered through the computer science department: *I looked at opportunities within the computer science department to see if I could take a few courses...they exclude anybody who's not in their program. This is the only opportunity to do this path with Python.*

Another student, who plans to pursue a career as a financial analyst, mentioned the experience of her cousin as a motivator for enrolling in ACBSS courses. Specifically, she hoped to avoid the challenges her cousin encountered while on the job due to a lack of programming skills: *My cousin [works as a financial analyst] and they require you to have Python and R. She never took these classes and she struggles.*

Three focus group participants discussed the ways in which their perceptions of computing changed since beginning the ACBSS course sequence. One student described how he initially viewed computing as focused mostly on syntax, but now sees the discipline as more focused on problem solving:

One thing that I think a lot of people gloss over is the creativeness...I was hoping it was just syntax, or maybe like a foreign language where you learn sentence structures and words and phrases. But it's problem solving at the end of the day.

Lastly, one student described how he began the ACBSS course sequence feeling confused and discouraged, but that his interest and confidence with the courses increased as he continues with the sequence and applied his new knowledge to course projects.

Overall, the focus group revealed that students are very satisfied with the ACBSS minor. While they find the courses challenging, they believe the minor is valuable for their career preparation. Multiple students lauded the support provided by the course instructor, commenting that his availability and approachability helped them complete the ACBSS courses. The students' comments highlighted one area worthy of greater attention in upcoming semesters: incorporating industry connections into the minor. Several students mentioned trends in industry as a motivator

for pursuing the ACBSS minor, and they talked about ways in which their projects might apply to current jobs or to jobs they would like to have in the future. As such, in the future it will be useful to include additional paths for students to be exposed to industry, such as inviting more guest speakers, providing help finding internships, and providing help creating a professional online presence via sites like LinkedIn.

5. Conclusion

There is an urgent need to recruit more -- and more diverse -- students into the ever-expanding universe of tech fields, and to develop educational pathways that will appeal to and prepare these students for the job market. Though our results are relatively preliminary given that we launched the ACBSS minor in 2016, the data we have gathered thus far suggest the following: *First*, the program has, indeed, succeeded in drawing interest from a broad range of students, including students whose backgrounds are traditionally underrepresented in tech courses. *Second*, the pedagogical adjustments made to the first course in the series (ENGR 120) appear to have struck a successful balance between content that is accessible and challenging, while also opening up new career aspirations and pathways to students. *Third*, the model of bringing together faculty from STEM and social science fields as an interdisciplinary professional learning community has proven to be an effective method for creating these educational experiences.

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