

WIP: Diversifying the Computing Workforce – Rapid Development of Interdisciplinary Computing-Based Undergraduate Programs

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Abstract—This innovative practice WIP paper considers the remarkable growth of Artificial Intelligence (AI), Machine Learning (ML) and Data Science (DS) in recent years. This surge has sparked an urgent need for skilled workers in these highly-related areas, subject to growing calls for a diverse, inclusive technology workforce. This WIP paper presents an innovative approach in the rapid design and development of interdisciplinary undergraduate degree programs that are computing-based, with heavy emphasis in AI, ML, and DS while providing foundations for applications in specific domains. Located at the center of Silicon Valley, the Department of Computer Science (CS) at SJSU (San Jose State University) has been constantly bombarded by the speedy changes of technology and the corresponding need for skilled tech workers, and more recently, calls for a diverse tech workforce that matches the demographic of our community. As both an HSI (Hispanic Serving Institution) and AANAPISI (Asian American and Native American Pacific Islander Serving Institution), we understand that underrepresented groups face significant challenges. Prevailing stereotypes about computer scientists tend to reinforce the notion that women and minority do not have a place in this field. Trying to break through these stereotypes, we have reached out and develop interdisciplinary programs with majors that traditionally attract more women and minorities (such as majors in biology or the humanities). This paper first describes the success of two existing interdisciplinary, joint master degree programs: MS in Bioinformatics and MS in Data Science. Then, it illustrates how we rapidly developed a computing-based BS in Data Science (in one year), and concurrently a BS in Computer Science and Linguistics (in another year) that is jointly offered with the Department of Linguistics and Language Development (LLD). The paper presents the curriculum development approaches, ethical and social awareness components of the curricula, and uniqueness and success factors. Preliminary data show a significant increase in enrollment of women and low-income students in the first major core course of BS-DS. We believe that this paper will serve as a model initiative for rapidly developing a diverse technology workforce that meets the needs of emerging AI, ML and DS industries.

Index Terms—Curriculum development, data science, diversity, joint degree programs.

I. INTRODUCTION

The fields of Artificial Intelligence (AI), Machine Learning (ML), and Data Science (DS) have experienced rapid growth, profoundly influencing various sectors and generating a critical need for a skilled, diverse workforce [6], [10], [12]. This work-in-progress (WIP) innovative practice paper explores our swift approach to designing interdisciplinary, computing-based undergraduate programs that emphasize AI, ML, and DS, while applying these technologies in specialized domains. Our institution, located in a region deeply influenced by rapid technological changes in the tech industry, primarily serves Hispanic and Pacific Islander communities. We are keenly aware of the challenges that underrepresented groups face in tech fields, where stereotypes often deter women and minorities from pursuing computing careers [3], [8], [9]. To counter these issues, and supported in part by an Implementation Grant from the Center of Inclusive Computing that aims to increase the number of women and minority in computing, we have focused on developing interdisciplinary programs that traditionally attract diverse students.

We first briefly present our two existing interdisciplinary Master's programs, in both Bioinformatics and Data Science, which serve as a basis for our success in the quick development of our two new BS programs. We then describe the rapid design and establishment of our BS programs in Data Science (BS-DS), and in Computer Science and Linguistics (BS-CSL), including curriculum development and their emphasis on ethical and social awareness. We also discuss some preliminary data indicating an increase in enrollment among women, underrepresented minorities, and low-income students. Our

ongoing work aims to enhance our efforts through evaluation and curricular improvement, and to expand our offerings to include additional interdisciplinary programs, aiming to create a diverse tech workforce well-prepared for the demands of the burgeoning AI, ML, and DS industries.

II. EXISTING WORK

Our BS-DS degree program was successfully developed within one year by the CS Dept. This rapid success was due partly because of two existing MS programs that provided faculty members with DS expertise: MS in Bioinformatics and MS in Data Science, briefly described below.

A. MSBI Development

The MS Bioinformatics program was co-developed by Biological Sciences, CS, and Math and Statistics Departments at SJSU. Beginning with 4 male and 6 female students in 2019, our program has experienced steady, controlled growth, with 7 male and 20 female students as of 2024. Our efforts to enhance diversity and equity in computing with an inclusive environment seem fruitful, as the major also has higher Hispanic/Latinx and Black or African American representation than our MSCS degree.

B. MSDS Development

In Fall 2018, the Dept. of Math and Statistics initiated the creation of an MS in DS (MSDS) with the CS Dept. We established a curriculum of nine core courses, one elective course, and two culminating experience courses (i.e., master thesis). Students must take at least four graduate Math courses and four CS courses, not counting the master project/thesis courses. The program's admission requirements include a long list of prerequisites courses, in both mathematics and CS. As a result of its stringent admission requirements and rather rigid curriculum, since Fall 2020, even though over 600 students applied each year, only 15-20 new students enrolled every year.

C. Differences between MSBI and MSDS

The MSBI and MSDS programs both aim to diversify their student populations and broaden access to computing education but they differ significantly in their ability to attract a diverse demographic. Bioinformatics naturally appeals to biologists seeking computational and statistical knowledge to analyze new biotechnological data, and attracts a gender distribution similar to biology: females constitute an average of 64% of the student body, (standard deviation 7.1%). DS, intersecting CS and mathematics, has numbers closer to those of CS, with 42% (5.9%) female students. The MSBI program also boasts an average URM enrollment proportion of 11% (5.6%), significantly higher than the MSDS program's average of 5% (4.8%). These results highlight the MSBI program's greater success in achieving gender balance and promoting diversity among underrepresented groups compared to the MSDS program. They have provided good reference and guidance for our development of interdisciplinary undergraduate degree programs, such as which programs to partner with,

based on the goal of increasing diversity and inclusiveness in the student body.

III. DEVELOPMENT OF BS IN DATA SCIENCE

Armed with the two existing interdisciplinary MS programs, including faculty members with expertise areas in AI/ML/DS, plus the lessons learned from our two MS programs outlined above, we were able to quickly develop BS in DS and BS in CSL programs, described here.

A. Motivation

Computer technologies and computing concepts have infused virtually every area of academic study. The BS in Data Science (BS-DS) is designed for students who wish to combine the study of computing and computers with data analysis. Three key reasons for offering the BS-DS program are explained below: (1) DS Career Outlook: The College Post [1] reported that "...According to the US Bureau of Labor Statistics, the job outlook for data scientists and other computer and information research is projected to increase by 15 percent between 2019 and 2029...[compared to all occupations, with] an average of 4 percent." (2) Market Demand for Data Scientists: As of May 2024, it was reported that the fastest-growing roles are Data Scientists and Advanced Analysts, which currently have an average annual salary of \$124,337 in USA [5]. (3) Lack of Rigorous, Balanced DS Programs: Many of today's universities have taken only small steps to respond to this growing market, by adding DS specializations or certificates under traditional disciplines. Accordingly, graduates from such programs lack adequate training in other supporting disciplines of DS. Our program offers essential coursework from both CS and math/statistics, specified for a technically sound and balanced education in this emerging field, to help fill the urgent market need for data scientists.

B. Curriculum Development

The BS-DS degree program is proposed by and hosted in the CS department. Building up from a strong CS foundation, the program utilizes existing resources of the CS department at SJSU by harnessing a wide array of courses already offered by the department and a broad scope of faculty expertise in CS, AI and ML. The BS-DS program also requires students to take core courses in math/statistics, and at least two domain-field-specified courses: two courses in a practical field a student is interested in, providing them a useful context for their data analysis. The core courses include lower-division, fundamental courses in CS, math, and statistics, plus (a) DS-specific upper-division (UD) courses including big-data processing, data visualization, AI, and ML, (b) CS-specific UD courses including advanced data structures and algorithms, and database management systems, (c) UD courses in math and statistics related to DS, and (d) two domain-field-specific courses. The electives include a wide array of courses in CS, math, and statistics. The detailed list of courses may be found online.

TABLE I
UNDERGRADUATE ENROLLMENT ACROSS DIFFERENT TIERS AT SJSU IN
FALL 2023

Headcounts	Total	URM	Female	Pell
SJSU	27,111	9,221 (34%)	12,973 (48%)	8,207 (30%)
Science	2,740	601 (22%)	1,186 (43%)	730 (27%)
CS majors	820	61 (7%)	200 (24%)	180 (22%)
DS major	222	22 (10%)	52 (23%)	46 (21%)

While we only needed to create one new course specific for this program (Senior Project in Data Science), fairly extensive changes were made in our entry-level preparatory coursework, which is key to prepare students having diverse background to succeed in the new BS-DS program. They have to prepare to take the same CS courses as our BS-CS students, many of whom already have a strong programming background. The changes include: (a) CS 0 (Python for Everyone) has been developed into a General Education (GE) course [7]. CS 0 can be used by BS-DS students as a required course, and is also a gentler introduction for those who just want to try out a computing course. As a GE class, it promotes diversity and inclusiveness for the program. (b) An additional 1 unit CS 1 workshop (CS 1W) for students taking CS 1 who lack a strong programming background, who will take CS 1 with others who have a deeper background. (c) A new 1-unit CS class, which may be used instead of the existing 3-unit transitional course for Java-specific material, was created for students who did not have CS 2 in Java. This provides a more efficient pathway for a wide variety of transfer students with diverse programming language training.

In all, besides our GE class and two new workshops, prerequisites were changed for at least four other classes to accommodate our new, broadened pathways into computing. This allows better, more effective customization, with at least 5 different, efficient routes into our upper division courses for a wide variety of student needs.

C. Impact

Proposed in Fall 2021 and approved as a new major in Fall 2022, our BS-DS program started accepting internal change of major students in Fall 2022, and accepting new students from outside in Fall 2023, when 222 new students enrolled. Almost half of them (108) came in as transfers from community colleges. We consider varying demographics at SJSU in Fall 2023 (Table I). The BS-DS program shows an increase in enrollment of URM students compared to the BS-CS, while the percentages of women and Pell recipients are virtually identical between the two programs in the Fall 2023 data.

D. Social awareness

One of the key pillars of our interdisciplinary undergraduate computing programs is the promotion of social awareness. Our program stands out for its unique approach to fostering inclusiveness and diversity within the computing workforce. We address bias and discrimination through ethics education,

engage students in community building and global perspectives, and foster ethical leadership and advocacy skills. For example, students in both BS-DS and BS-CSL programs are required to take an Ethics in Science which covers interactions between scientific and lay communities, the historical development of norms of responsible research, and cultural influence on scientific values. We aim to equip students with the knowledge and skills needed to navigate the complex social and ethical challenges of the modern computing landscape while promoting positive societal impact.

IV. DEVELOPMENT OF BS IN CS AND LINGUISTICS

In an effort to further diversify the student body and the future workforce in CS-related fields, coupled with the fact that natural language processing (NLP) has become extremely useful in developing AI tools, and that the Dept. of Linguistics and Language Development (LLD) at SJSU has already got an 18-units certificate in NLP, we developed another program BS in Computer Science & Linguistics (BS-CSL), with the LLD Dept, which traditionally has a high female enrollment. The BS-CSL program aims to prepare students with foundational knowledge and skills for the combination of CS and Linguistics careers. It features a computing-based curriculum, instructing students in the theory and practice of language, linguistics and applied linguistics, CS, and DS, to prepare them for job careers in AI, ML, automated text analysis, machine translation, grammar checking, speech synthesis & recognition, and more.

We were able to develop this new degree program within one year, without developing any new courses, using CS Dept. experience in developing our BS-DS program, and an existing four-course undergraduate certificate offered by the LLD Dept. which forms the core of their linguistics training for this program.

Other computing based courses include CS 1, CS 2, data structures and algorithms, AI, ML, etc. Compared to BS-CS students, BS-CSL students get more experience applying their skills to analyze and model language data in particular. They get specific courses in speech technology, computational linguistics, natural language processing, and linguistic data analysis. This deepens students' understanding of the field of computational linguistics since linguistics relies heavily though implicitly on data structures, algorithms, and modeling, and has been closely tied to CS since the discipline began.

V. UNIQUENESS AND SUCCESS FACTORS

This section highlights the uniqueness and key success factors of our new degree programs when compared to those offered by similar universities.

1) *Key Factors in BS - Data Science*: SJSU is one of 23 campuses in the California State University system (CSU), the country's largest four-year public university system. SJSU has taken the lead in offering a Bachelor degree in Data Science within the CSU system. Our program underwent a soft launch in Fall 2022. By Fall 2023, 222 students were enrolled. The only other CSU campus that currently offers a Bachelor degree

in Data Science is California State Polytechnic University, Humboldt. That program, hosted by the Math department, debuted in Fall 2023 with 5 enrolled students [4]. Other CSU campuses offer various Data Science minors [11] and certificates [2].

Here are some key factors we believe that set SJSU apart in this endeavor, and made it possible to successfully design and implement the degree so quickly:

(i) *Championed and hosted by the CS department:* This not only guarantees a robust computing foundation but also leverages existing resources and expertise within the department. The development of the new major was embraced by the department faculty and funded in part by a Center for Inclusive Computing Implementation Grant in an effort to improve diversity. System-wide transfer students have decreased since the pandemic, but a more than robust demand by students applying to the CS department likely encouraged administrators to fast-track our new degree programs.

(ii) *Curriculum Design:* The DS program was designed to draw on a variety of CS and Math courses that were already offered as electives to CS majors, including ML, AI, Big Data Processing, and Data Visualization. DS majors receive the same rigorous education as CS majors with a different mix of CS, and more rigorous Math/Statistics courses. This helped market the DS major as a viable and competitive alternative to the CS major.

(iii) *Transfer Pathways:* SJSU's articulation agreements with community colleges for existing lower-division courses (CS 1, CS 2, Discrete Math, Calculus I, Calculus II and Linear Algebra) made it easier for transfer students to seamlessly transition into the DS major. This approach facilitates access to higher education for a broader range of students and helped us attract over 100 DS transfer students in Fall 2023.

2) *Key Factors in BS - Computer Science and Linguistics:* SJSU is also the only campus in the CSU system to offer a degree in CS and Linguistics. We partnered with the LLD Dept. and followed the same approach we piloted with the BS-DS degree to develop an interdisciplinary program that has a robust computing foundation and draws from our existing courses in AI, ML, Statistics and Linguistics, and an existing four-course certificate in natural language processing offered by LLD. The program has attracted many applicants, especially those who are normally unreachable by traditional CS programs, as well as those who would not be accepted into our CS program at SJSU due to our impactation (i.e., student enrollment is limited). The Fall 2024 admission process was able to attract 120 applicants (comparing with only about 10-15 students normally applied to BA - Linguistics), it is expected to have about 40 enrolled students in Fall 2024. We also expect to have a significantly higher percentage of women, low-income, and URM students than those our traditional CS program.

3) *Affordability and Inclusiveness:* Other private and public universities in the area that offer DS or similar programs, but those programs all come with a much higher price tag. Our BS-DS and BS-CSL (and BS-CS) degrees are the most affordable

BS programs in our region, offering CS, AI, and ML courses in an area with a high demand for technology workers, and we are well-placed to serve and train low-income students for these lucrative positions.

VI. CONCLUSION AND ONGOING WORK

A. Conclusion

This WIP in Innovation Practice briefly outlines our initiative effort in diversifying the computing workforce by developing two new computing-based, interdisciplinary undergraduate degree programs: BS-DS and BS-CSL. The key features of the two programs have been described, along with the unique factors leading to swift establishment of the programs, and their early promising result in attracting a more diverse student body than the existing CS program.

B. Ongoing Work

1) *Curriculum Evaluation and Enhancement:* The new BS-DS program officially started in Fall 2023 and we have obtained some initial assessment (evaluation) results (partially reported in Section 3). The BS-CSL program will start in Fall 2024. We will continue with extensive assessment to identify the effectiveness of the two new programs in increasing women and URM students, with metrics such as ratio of women and URM in study body, their success rates in critical courses and in graduation, etc., and to search for ways to enhance the curricula to further improve the programs' diversity and inclusiveness.

2) *Developing New Interdisciplinary Programs:* We are currently developing an innovative BS program: CS + Biology, based on the great relationship we have with the Biology Dept due to our existing MSBI program, plus the strong women presence in the Biology Dept (in terms of both student and faculty bodies), with the goals to make CS education more accessible and to provide budding biologists with vital computing skills. Similarly, we have developed a potential curriculum with the Geology Department to implement a BS in CS + Geology, which would offer valuable computing skills to geology scientists as well as provide extensive, exciting geology and earth science knowledge for computer scientists. Based on the evaluation results of the two new programs (BS-DS and BS-CSL), we will continue to improve the design of these two and other potential interdisciplinary programs. The challenges include (1) supporting these programs (with different admission standards) in the same Dept, offering the same set of CS courses and (2) deciding the best times and ways to offer these program in the midst of severe budget limitations experienced at SJSU, to ensure our success in promoting diversity and inclusiveness in student body, and thus in computer and AI tech workforce.

VII. ACKNOWLEDGMENT

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