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Development of an Alternate Pathway into STEM: A Progress Report

Denise Hum (Professor)

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1. Introduction

As noted in the 2019 Two-Year College Data Science Summit report, while community colleges generally serve a more diverse student population compared to four-year institutions, the challenges presented in designing curriculum "provide an opportunity to increase diversity in STEM by providing STEM career paths that students find exciting and engaging but which do not have many of the barriers to entry shared by other STEM disciplines." (Gould et al, 2018, p. 5). STEM classes, particularly introductory computer science and engineering classes, traditionally have few women (Kahn et al., 2017) and under-represented minorities enrolled (Kricorian et al., 2020). Skyline College, a Hispanic Serving Institution (HSI) in the San Francisco Bay Area, is no exception. A 2019 state-mandated shift in assessment and placement practices has resulted in more students who are decidedly non-STEM majors being placed directly into Introduction to Statistics. Historically, this has been a terminal math course designed for non-majors; however, Skyline College is using this new opportunity to increase the number and diversity of STEM students and improve STEM learning and teaching by bringing coding and project-based learning to statistics students. Instead of Introduction to Statistics being the last math class for students, it is serving as an onramp to data science, computer science, engineering, and other STEM disciplines.

2. Overview of Data Path Program

In Fall 2020, Skyline College was awarded an NSF IUSE grant to establish a new pathway into STEM through statistics and data science. The Data Path Program was initially launched in Spring 2021 with four math faculty members across five sections of Introduction to Statistics. The math department began paving the way for the Data Path in Spring 2019 by identifying local state universities with undergraduate data science programs and began conversations with them about creating courses we could offer that would articulate. In Fall 2020 Skyline created the Introduction to Data Science course modeled after UC Berkeley's popular DATA 8 class and got it articulated to both state university systems.

As a part of the Data Path Program, starting in Spring 2021, two to three full time or adjunct math faculty have been recruited each semester to teach the project-based statistics curriculum. They all have participated in at least one day-long training workshop from Dr. Lisa Dierker and Prof. Kristin Flaming from Passion Driven Statistics prior to the semester they started teaching the curriculum. Throughout the semester, bi-weekly Statistics Community of Practice meetings are held to discuss curriculum, pedagogy, and share thoughts and ideas. Previous cohorts of faculty continue to enjoy teaching the project-based course and participating in the Community of Practice. They have also helped to improve the course by continuing to collaborate to create and refine course content.

Data Path approached creating this new pathway into STEM by using a three-pronged approach:

1. Implementing project-based learning in Introduction to Statistics

2. Actively recruiting students, especially women and underrepresented minorities, for data and coding related events, as well as the math, data science, and computer science courses
3. Providing professional development for faculty.

Supported by evidence-based research, project-based learning is a key element of the project. In light of this evidence, we first undertook the task of redesigning the Introduction to Statistics course to incorporate project-based learning to engage students and spark an interest in a STEM pathway. The Statistics Community of Practice has been meeting on an on-going basis, engaging in professional development on implementing a project-based curriculum and pedagogy as well as coding, supporting each other in teaching the new curriculum. The Data Path project has given faculty the opportunity to break the norm of instructors working alone with limited communication with colleagues. As one faculty member said, "We want to create a new culture of collaboration among faculty."

Project-based learning has been shown to help students better develop problem-solving skills, critical thinking, ability to work with multiple representations and build confidence—all of which are necessary to succeed in mathematics and STEM pathways (Beier et al., 2019). By engaging students in this way, Skyline College is inspiring more students to want to learn more about data and STEM opportunities, including students who may not have seen themselves as STEM majors. Modeled after the Passion Driven Statistics (PDS) curriculum where the students are engaged in their own original research, the program is helping them to build confidence in their quantitative skills. (Dierker, Flaming, Cooper, Singer-Freeman, Germano, & Rose, 2018)

Faculty and support staff are instrumental in actively recruiting students, particularly women and underrepresented minorities, to continue on to data science, computer science, and engineering classes. After being fully articulated to both state university systems, the Introduction to Data Science was first offered in Summer 2021 with 24 students. In Fall 2021, the second semester it was offered, 29% of the Introduction to Data Science course came from statistics. In Spring 2022, over 80% of the students in the course have reportedly taken Introduction to Statistics class or an equivalent course.

An articulation agreement with California State University, East Bay's statistics department for a bachelor's of science degree in statistics with a concentration in data science was formalized in Fall 2021. To meet the lower division requirements to transfer to CSUEB, Introduction to Computer Programming in Python was created and is being offered for the first time in Spring 2022 to a fully enrolled class. CSUEB was selected to create an articulation agreement with first because they offer a statistics degree with a concentration in data science that does not require calculus. They describe their program as "Touch data, compute-more, calcu-less" – a good fit for non-traditional STEM-students who previously did not see themselves as "math people" yet have a strong curiosity and interest in data. Skyline students can satisfy transfer requirements to CSUEB's data science concentration with just a transfer level math class such as Introduction to Statistics, Introduction to Data Science, and Introduction to Computer Programming in Python. This appeals to Skyline students entering the Data Science pathway since many have not enjoyed or have had much success in math until they took the project-based Introduction to Statistics class. For students that wish to transfer to other universities that require calculus or major in other STEM disciplines such as computer science or engineering, Skyline offers MathJam, a

free, one-week intensive math tutorial, to help prepare them for the calculus pathway, as well as other programs such as the Engineering and Tech Scholars to support them through it.

Now in its third semester, we have been able to recruit nine full-time and adjunct math faculty from Skyline in addition to two more math faculty from a sister college to teach statistics in a project-based format and participate in the Statistics Community of Practice. Through the Data Path project, we have brought coding to over 800 decidedly non-STEM students in a variety of modalities – online synchronous, online asynchronous, face-to-face, and hybrid.

> *"The introduction to coding and learning it was very useful and made me decide to switch majors."*
>
> -- Introduction to Statistics student in Fall 2021

3. Preliminary Results on Diversifying STEM

Preliminary results from two semesters of project-based learning in Introduction to Statistics shows that students are enjoying learning math by working with real world data. While the majority of students (65%) in the project-based Introduction to Statistics classes came into the class feeling nervous about coding, they were receptive to learning how to do it. In Fall 2021, 42% of exit survey respondents felt coding/SAS was the most useful thing they learned in the class. Nearly 40% of statistics students wanted to learn more coding, and about 35% wanted to learn more statistics. Over the course of the semester, the percentage of students who felt nervous about coding decreased by 5%, while 2% of students felt less nervous about statistics.

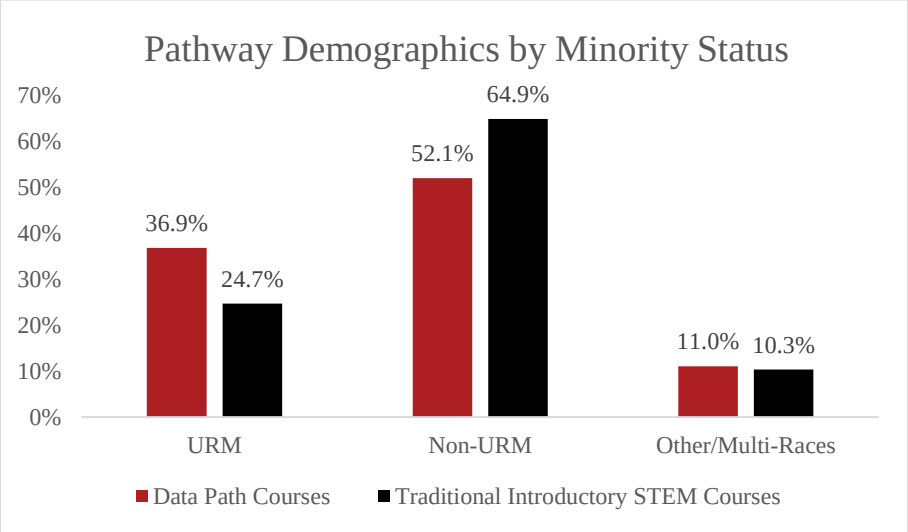
Table 1. Pathway Demographics by Gender for Spring and Fall 2021

	Female	**Male**	**Unreported**	**Total**
Data Path Courses	365 **(50.4%)**	347 **(47.9%)**	12 **(1.7%)**	724
Traditional Introductory STEM Courses	26 **(14.9%)**	145 **(83.3%)**	3 **(1.7%)**	174

Introduction to Data Science and Introduction to Engineering were only offered in Fall 2021

A much more diverse student group is learning how to code in the Data Path courses – project-based Introduction to Statistics and Introduction to Data Science compared to the Traditional Introductory STEM courses – Introduction to Object Oriented Programming and Introduction to Engineering classes. Table 1 and Figure 1 show that the Data Path courses reach a lot more students than traditional introductory computer science and engineering classes, combined. In particular, 50.4% (out of 724 students) of Data Path students identify as female compared to just 14.9 % (out of 172 students) in the traditional introductory courses during Spring and Fall 2021. Introduction to Engineering was only offered in fall semesters, and Introduction to Data Science was not yet offered in Spring 2021 since it debuted over the summer. An informal survey of several Introduction to Statistics classes in Fall 2019 showed that 100% of students have little to no coding experience. By incorporating beginning computer programming skills in the Introduction to Statistics course, many more students are learning to code – an important skill for many jobs and disciplines.

Figure 1. Pathway Demographics by Minority Status for Spring 2021 and Fall 2021



Introduction to Data Science and Introduction to Engineering were only offered in Fall 2021

In the first regular semester offering in Fall 2021, the Introduction to Data Science class had 22 students, and on the first day of Spring 2022, 19 students were enrolled, despite significantly lower overall college enrollment than previous years due to the Covid-19 pandemic. For Spring 2022, Introduction to Computer Programming in Python was introduced for the Data Science pathway with a full class of 40. There are a significant number of students in these new classes that came from Introduction to Statistics which is not typical for computer science classes. In Fall 2021, 29% of Introduction to Data Science students came from Introduction to Statistics. In Spring 2022, over 80% of students in Introduction to Data Science and over 50% in Introduction to Computer Programming in Python reported to have taken Introduction to Statistics or an equivalent course. Students in the data science and Python classes come from a variety of majors and have many different reasons for taking the classes – from major exploration to career change. At least 60% of the Introduction to Data Science students and 55% of the Python students are at least somewhat interested in transferring to obtain a bachelor's degree in data science.

4. Lessons Learned and Challenges

While preliminary results show that the Data Path Project is helping to diversify STEM, student recruitment and success rates remain challenging. Three semesters into the project, faculty are now very excited about teaching coding and using project-based learning, but because of the new skills and pedagogies required to do this, faculty recruitment was initially a challenge.

Learning to code in an Introduction to Statistics class for non-STEM majors is challenging since most students have little to no experience with coding. Similarly, most math faculty have not had recent programming experience. The first faculty cohort had three faculty members with substantial programming experience, including one with a lot of SAS experience, and one that was new to coding. There were a lot of bumps in the road the first semester, but Community of Practice meetings and lots of emailing each other really helped to discuss challenges, get help, and share what was working.

The first semester there was a low success rate (55.1%) relative to regular statistics (73.6%) classes. Granted, this was in Spring 2021 during the second fully online semester due to the Covid-19 pandemic. Upon reflection, we made a number of pedagogical and curricular changes the following semester to improve student success and retention. In preparation for Fall 2021, both the new, second faculty cohort and the original cohort met almost daily during the month leading up to the start of the semester to work on common curriculum and syllabus. As a result, a Canvas shell with the core curriculum was made available for new and existing faculty to copy. Additions to the course included more time and activities designed to help students select a viable research question early on in the semester. We also added more scaffolding to coding activities and more skills practice. For example, instead of teaching coding and data analysis together, students were first asked to interpret data and SAS output first. Then they were taught to plan out the coding, and then finally code. And in light of the on-going pandemic, student services such as Personal Counseling were brought in to make class presentations and connect students directly with their services. Now in its third semester of offering, prior cohorts of project-based Introduction to Statistics faculty are regularly developing new activities and modifying existing ones to increase student learning and engagement.

Most students at Skyline, including computer science majors, have not heard of data science. So getting students enrolled in Introduction to Data Science has been challenging. More than half, 51.2% of Introduction to Data Science students heard about the class from a professor, counselor, or retention specialist. It takes a lot of personal contact and intentional recruitment from faculty and staff to tell students that they might be well suited for data science or computer science, particularly if the students are not STEM majors to begin with. Going forward, the instructional team has plans to develop a more strategic and intentional recruitment strategy.

5. Future Plans

As we return to campus, the instructional team will partner with the college's STEM Center to plan Data Scholars events and activities. Part of the Data Path Project is to create the Data Scholars – building community support and data-related activities to recruit and support students into a data science pathway. While not a formal student organization, the idea is to host data-related activities, workshops, and talks, some of which are interdisciplinary. For example, the physics department is interested in creating workshops around analyzing their data with Python. Skyline and CSUEB have been in talks to have students from both campuses meet – for Skyline students to tour CSUEB and meet statistics faculty, and have CSUEB students come to Skyline to work with students on a data-related activity like a hackathon.

6. Conclusion

The work for the Data Path Project has been challenging yet exciting. We have seen students who have had life-long fears of math excel at statistics and coding want to pursue Data Science and learn Python. Our faculty have been excited to teach this new curriculum, learn new skills like SAS, change their approach to teaching math, and most importantly, to collaborate with each other within the department and across different colleges.

By meeting students where they're at and teaching introductory computer science skills in a math class for decidedly non-STEM majors, we are able to generate some excitement and curiosity about data and coding. But since statistics is very interdisciplinary, faculty from other STEM

disciplines such as engineering, physics, and biology that have courses that do data analysis could partner with math faculty to create some hands-on labs where students can work together to collect data and then analyze to generate excitement about their classes. Bring STEM to statistics students, meeting them where they are. If they can get excited about computer programming, they can also develop interest in other STEM disciplines like engineering, biology, and physics. We are turning a historically terminal math class into an on ramp to a much more diverse STEM pathway.

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