Board 63: Work in Progress: Community College Student Experiences with Interdisciplinary Computing Modules in Introductory Biology and Statistics Courses

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Abstract

Interdisciplinary professionals with both domain and computing skills are in high demand in our increasingly digital workplace. Universities have begun offering interdisciplinary computing degrees to meet this demand, but many community college students are not provided learning experiences that foster their self-efficacy in pursuing them. The Applied Programming Experiences (APEX) program aims to address this issue by embedding computing modules into introductory biology and statistics courses at community colleges. Here, we describe an initial cohort of instructors who adopted APEX modules and then provide preliminary evidence of significant increases in students' interest and confidence in applied computing after experience with these modules. These findings suggest that embedding programming exercises in introductory biology and statistics classes can have a significant impact on students' perceptions of computing. We will continue to assess the experiences of both instructors and students as our program expands, in turn allowing us to improve the APEX program and encourage nationwide adoption of embedding computing into popular introductory community college courses.

Introduction

Recently, a number of four-year institutions have begun offering interdisciplinary computing degrees such as data science, bioinformatics, and applied computing for the social sciences. These programs are designed to provide students with both domain knowledge and computing skills to better prepare them for today's increasingly digital world. To benefit from these programs, however, students first need awareness that these opportunities exist. Furthermore, students majoring in non-computer science/engineering fields are often not provided with learning experiences that foster their self-efficacy in pursuing computing courses, thus limiting their future educational and career choices [1 - 3]. Students from historically marginalized communities, shown to be enrolled at higher rates in community colleges than in 4-year institutions, are particularly affected by this opportunity loss [4].

Motivated to address these issues, our interdisciplinary team developed the Applied Program Experiences (APEX) program (https://www.sjsu.edu/apex/) [5]. This program embeds Python programming modules into introductory biology and statistics courses at community colleges and also provides instructors with interdisciplinary computing promotional content. We chose to target these courses because they are a prerequisite for many upper-division courses and are thus taken by a large number of students. APEX biology modules provide students with hands-on experience with bioinformatics, helping them develop skills valued by life sciences and

biopharma companies. APEX statistics modules are designed to replace outdated or expensive technology and to support students in acquiring skills valued in jobs involving data analysis, visualization, and research. By bringing hands-on programming exercises to students in classes in which they are already interested and enrolled, we aim to demystify programming, help students better understand the relevance of programming to their chosen discipline, and inform their future educational and career choices.

To encourage adoption of APEX materials by biology and statistics instructors, our team actively recruits, trains, and supports instructors from community colleges across the state. We offer summer and winter workshops, support APEX faculty learning communities (FLCs), and host instructor training materials on Canvas. All APEX modules are formatted as Google Colaboratory notebooks that are publicly available on GitHub (Python training for instructors; Biology modules; Statistics modules). APEX biology modules include case studies on sickle cell anemia and breast cancer and three shorter data analysis modules. Eighteen APEX statistics modules span topics ranging from data and measurement to sampling and hypothesis testing. As we refine and expand our materials, we are also assessing the program's efficacy by surveying both instructors and students. The aim of this work-in-progress paper is to conduct a preliminary examination of whether and how student perceptions of interdisciplinary computing change as a result of engaging with APEX biology and statistics modules.

Methods

Faculty who planned to use APEX modules and/or be a part of an APEX FLC were invited to complete a survey prior to the beginning of the spring and fall 2023 semesters. They were asked to answer demographic questions and to rate their level of experience with several programming languages (Python, Java, C++, R, Go) on a scale from 1 (no experience) to 5 (great deal of experience). They next indicated their level of agreement on a scale from 1 (strongly disagree) to 5 (strongly agree) with several statements pertaining to their interest and confidence in applied computing (6 questions), as well as the importance and utility of applied computing (3 questions) [6 - 7]. Finally, they were asked to indicate which among several teaching practices they had used in the past year (e.g., active learning, group work). Twenty-seven instructors from five community colleges and one four-year university completed the survey. All institutions were located in the San Francisco Bay Area, with the exception of one community college located in Pasadena, CA. Four instructors completed the survey prior to both semesters; unless otherwise noted, all instructor data are from the first time they took the survey.

Students in introductory biology and statistics courses whose instructors adopted APEX modules were invited to complete a survey before and after completing the modules. A total of 354 students from three community colleges completed the pre-module survey (n = 160 biology, n = 135 statistics), of whom 189 (n = 84 biology, n = 105 statistics) also completed the post-module

survey. Below, we separately report demographic and survey data for biology and statistics students. Note that some survey responses were incomplete, such that sample sizes differed across each of several analyses.

For the pre-module survey, students were asked to answer demographic questions and questions pertaining to their educational and career plans. They were also asked to rate their experience with computer programming and whether they had previously taken a computer programming course. They were next asked to indicate their level of agreement on a scale from 1-5 with statements pertaining to their interest and confidence in applied computing, the importance and utility of applied computing, and their comfort and belonging in applied computing [5 - 6]. The post-module survey included the same questions to allow for a pre-post module comparison, as well as several new questions to assess students' experiences with the modules. Students were asked to indicate how the modules were completed (e.g., in class, as homework), whether instructors presented contextual information to motivate the module (e.g., why programming is relevant to the field, possible career paths), their enjoyment of the module and interest in future computing courses, and the degree to which the module helped them understand course concepts.

For the purposes of this work-in-progress paper, we chose to evaluate pre- to post-module changes across each of three subscales described below. For each subscale, we tallied responses across questions to give a single score for the subscale. Increases in scores pre- to post-module were then tested for each subscale using one-tailed paired-samples *t*-tests at an alpha level of .05.

1. **Interest and confidence in applied computing**: 7 questions, score range 7 - 35, Cronbach's alphas $\geq .84$ for pre- and post-module surveys
2. **Importance and utility of applied computing**: 3 questions, score range 3 - 15, Cronbach's alphas $\geq .84$ for pre- and post-module surveys
3. **Comfort and belonging in applied computing**: 6 questions, score range 6 - 30, Cronbach's alphas $\geq .82$ for pre- and post-module surveys

Results

Of the 27 instructors who completed the survey, 19 (70.4%) taught introductory statistics courses and 8 (29.6%) taught introductory biology courses. When asked to indicate their level of experience with several programming languages on a scale from 1 (no experience) to 5 (great deal of experience), 15 (55.6%) rated a 3 or higher for at least one language. However, only five instructors (18.5%) indicated prior experience with Python. Programming experience varied across statistics instructors as well as across biology instructors. For the statement, "I am interested in learning more about applied computing," 25 agreed or strongly agreed (92.6%), one strongly disagreed (3.7%), and one did not respond (3.7%). For the statement, "Basic knowledge of applied computing is likely important for my students' future career," 24 agreed or strongly agreed (88.9%), one selected neutral (3.7%), one strongly disagreed (3.7%), and one did not

respond (3.7%). The instructor who strongly disagreed with both statements in spring 2023 subsequently strongly agreed with both statements in fall 2023.

Table 1: Student profile (pre-module survey)

Biology (n = 160)		Statistics (n = 135)	
Demographic category	Percentage	Demographic category	Percentage
Sex		Sex	
Female	56.3%	Female	57.8%
Male	38.8%	Male	38.5%
NB/SD/PNR	5.1%	NB/SD/PNR	3.7%
Race and ethnicity		Race and ethnicity	
Asian	39.6%	Asian	20.9%
Black	5.7%	Black	1.4%
Hispanic/Latinx	15.1%	Hispanic/Latinx	30.2%
Multiracial	7.6%	Multiracial	13.7%
Native HI/Pac Island	0%	Native HI/Pac Island	2.9%
White	22.6%	White	22.3%
Other/PNR	7.1%	Other/PNR	8.6%
Top three majors		Top three majors	
Biology	26.9%	Business	19.3%
Nursing	12.5%	Psychology	11.9%
Psychology	8.8%	Nursing	10.4%
Programming experience		Programming experience	
No prior prog course	78.5%	No prior prog course	80.0%
No/very little Python	74.1%	No/very little Python	88.0%

Note: NB: Non-binary, SD: Self-described, PNR: Prefer not to respond, HI: Hawaiian, Pac Island: Pacific Islander, prog: Programming

Demographic data for student participants can be found in **Table 1**. The race and ethnicity profile of the sample broadly reflects that of the California community colleges from which students were recruited. We next evaluated changes in students' perceptions as a result of engaging with APEX modules. Biology students' interest and confidence in applied computing significantly increased ($t(60) = 1.80$, $p < .05$) from the pre-module survey ($M = 21.77$, $SD = 5.60$) to the post-module survey ($M = 23.69$, $SD = 6.96$). Neither perceived importance and utility of applied computing ($t(61) = 0.77$), nor comfort and belonging in applied computing ($t(60) = 1.27$) significantly increased pre-module (importance: $M = 11.32$; $SD = 2.73$; comfort: $M = 21.08$, $SD = 5.02$) to post-module (importance: $M = 11.68$, $SD = 2.41$; comfort: $M = 22.25$, $SD = 5.29$).

The pattern of results was similar for statistics students, such that their interest and confidence in applied computing significantly increased ($t(57) = 1.72$, $p < .05$) from the pre-module (M = 17.76, SD = 7.37) to post-module survey (M = 19.24, SD = 7.25). Neither perceived importance and utility of applied computing (t(56) = 1.18), nor comfort and belonging in applied computing (t(56) = -0.34) significantly increased pre-module (importance: M = 11.32; SD = 2.47; comfort: M = 16.32, SD = 5.74) to post-module (importance: M = 10.54, SD = 2.90; comfort: M = 16.60, SD = 5.81). Finally, there were no significant differences in subscale scores for either biology or statistics students with respect to gender, race, and ethnicity.

Discussion

This work-in-progress paper describes preliminary assessment results of the APEX program, which embeds computing modules into introductory biology and statistics courses at community colleges. An initial cohort of 27 instructors introduced APEX modules into their courses and provided students with the opportunity to complete optional pre- and post-module surveys, with 189 students completing both. Results provide initial evidence of the positive impact of APEX modules on students' interest and confidence in applied computing. However, no significant increases were found with respect to students' perceptions regarding the importance and utility of applied computing, nor to their comfort and belonging in applied computing.

At the time the student surveys were collected, a limited number of biology and statistics modules were available to instructors, such that students had relatively limited exposure to Python programming exercises. We now offer multiple biology modules (n = 5) and a large number of statistics modules (n = 18) that span an entire semester's worth of content. By creating more rich and varied opportunities for students to engage with APEX content, we hope to more effectively influence their perceptions surrounding applied computing.

We only briefly describe instructor data in this paper given the limited size of our initial cohort. As we partner with new community colleges and support additional APEX FLCs, our sample size, as well as the diversity of our sample, will increase and enable us to assess instructors' experiences in greater depth. In turn, more students will gain experience with APEX materials, allowing us to launch a comprehensive research plan that examines (a) potential changes in students' educational and career plans, (b) which elements of the APEX program most strongly relate to student outcomes, and (c) factors influencing instructor satisfaction with FLCs.

The APEX program aims to deliver computing education to diverse community college students, better preparing them for today's increasingly digital workplace. Continued expansion and assessment of the program will allow us to improve the experience of both students and instructors, and to encourage nationwide adoption of embedding computing experiences into introductory community college courses.

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