Ready or Not, Here I Computer Science: Trends in Preparatory Work Pursued by Incoming Students in an Online Graduate Computer Science Program

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ABSTRACT

Research on how students prepare for graduate computer science programs typically focuses on single, subject-specific interventions or relates to preparation for life as a graduate student. Preparatory work completed prior to enrolling in such a program can be particularly important for underrepresented minorities and those without technical backgrounds. We use survey data from incoming students in a large online graduate computer science program to answer three research questions: What are the backgrounds of students entering the program? How do students prepare for the program? And how does student preparation differ based on demographics and prior experience? We find that: male students are more likely than female students to enter the program with computer science qualifications; older students, female students, and those with non-technical degrees are more likely to pursue preparation; and students with no online learning experience are less likely to pursue preparation. These findings highlight the importance of student backgrounds when creating preparatory courses and indicate the value of preparatory courses in increasing diversity in large online graduate programs.

CCS CONCEPTS

•Social and professional topics~Professional topics~Computing education~Computing education programs~Computer science education •Social and professional topics~Professional topics~Computing education~Informal education •Social and professional topics~User characteristics

KEYWORDS

Online learning, MOOCs, Prep courses, Diversity, Underrepresented minorities

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1 INTRODUCTION

Knowledge and abilities may vary among students entering graduate computer science programs, and this is particularly true for such programs operating at scale, simply due to the size of the student population. Students with non-technical backgrounds—many of whom belong to groups that are underrepresented in the field—may struggle in or avoid these programs, which can undermine diversity. Resources to prepare incoming students for graduate studies in computer science can help reduce this imbalance, and understanding how students prepare can aid in promoting or creating such preparatory resources. We aim to address three research questions:

RQ1: What are the demographic and technical backgrounds of students entering the program?

RQ2: How do incoming students prepare for the program?

RQ3: How does student preparation differ based on demographics and prior experience?

2 BACKGROUND

Graduate school preparatory interventions have been studied in fields such as social work [14], psychology [11], and biomedical science [6] and have shown success in preparedness, motivation, and feelings of connection to the field and school. Other studies have examined non-subject-specific preparation [1][13]. Programs introducing undergraduates to graduate research have shown positive effects on student outcomes and retention [4][17]. Other studies have highlighted the importance of sociocultural factors in considering graduate school preparation [2][8][20].

Despite widespread efforts to increase higher education opportunities for students in marginalized groups, there are still gender and racial disparities in undergraduate and graduate STEM programs [18][3][19][5]. Representation of women and racial minorities in computer science has declined in recent years, and

these disparities are particularly apparent in graduate computer science education [10][16][15]. Increased educational preparedness contributes to increased interest in graduate computer science, which can lead to higher enrollment and retention of women and minority students [9].

Our research builds on this prior research in five ways. First, we focus on a graduate program operating at a large scale. Second, we focus on not one, but a variety of preparatory methods incoming students use. Third, we approach preparation from a content perspective rather than a graduate school familiarity perspective. Fourth, we examine how students prepare on their own, without university intervention. Finally, we examine preparation across different genders, ages, employment statuses, educational backgrounds, technical proficiencies, and online learning experiences to understand the relationship between student backgrounds and different preparatory approaches.

3 METHODOLOGY

This research took place in a large (11,533 students enrolled in Fall 2021) online graduate computer science program. Admission requires a bachelor's degree and enough computer science experience to allow for a student's success. Before Fall 2021, we surveyed newly admitted students about their educational backgrounds, qualifications, and program preparation methods.

4 RESULTS

1,607 of the 3,585 admitted students completed the survey. Of those, 1,521 indicated they planned to enroll in Fall 2021, so we used these students' responses for our analysis. Statistical significance was calculated using a two-sample binomial z-test for difference of population proportions.

4.1 Demographics

53% of respondents were between 26 and 35 years old. 74% were male, and 24% were female. 87% were working full-time, and the most common degrees students had earned were B.S. (71%), M.S. (19%), and B.A. (12%). Figure 1 shows respondents' prior computer science qualifications by gender. Most respondents were familiar with one or more programming languages, were working in the computer science field, or studied computer science in high school or college; only 1% had no prior computer science qualifications. Generally, higher percentages of male respondents than female respondents entered the program with computer science qualifications. Figure 2 shows respondents' prior experience with online learning. 45% of respondents had completed at least one MOOC, while 19% had no prior experience with online learning.

4.2 Student Preparation

Respondents were asked what types of preparation they pursued specifically to prepare for our program: self-study, college courses, boot camps, and/or MOOCs. Seven specific MOOC series offered by our university were included as distinct choices, in addition to an "other MOOCs" choice. Figure 3 shows the different types of preparation respondents pursued. The most common

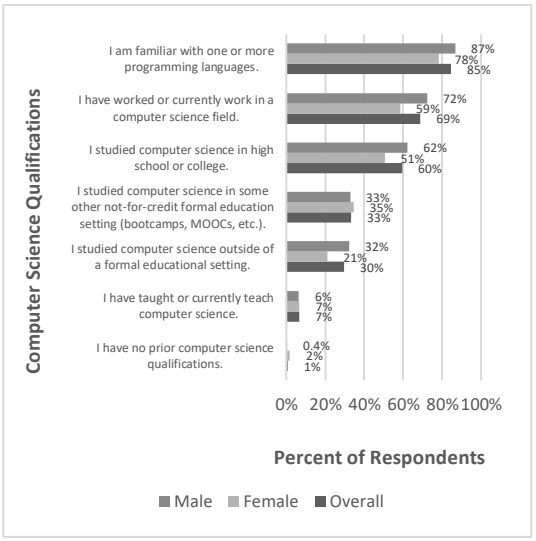

Figure 1. Respondent computer science qualifications

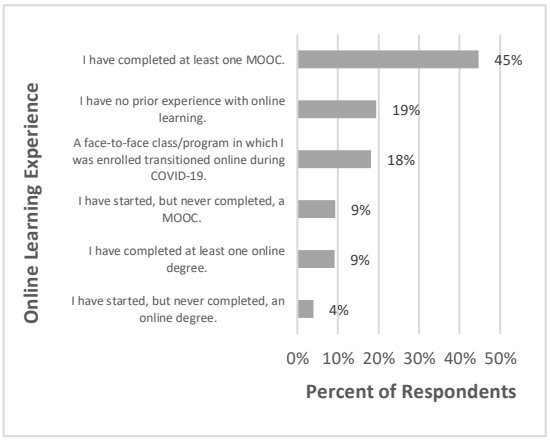

Figure 2. Respondent online learning experience

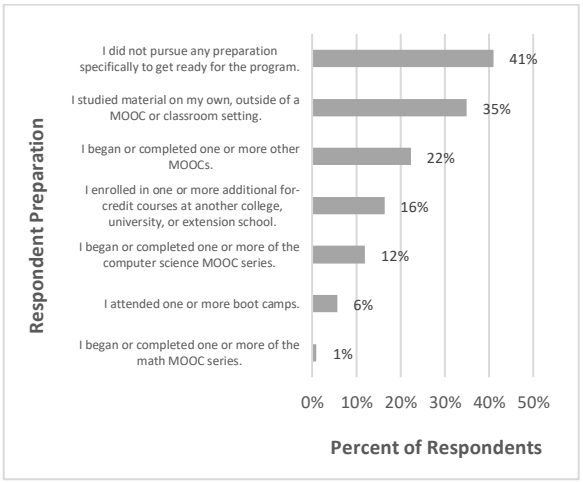

Figure 3. Respondent program preparation

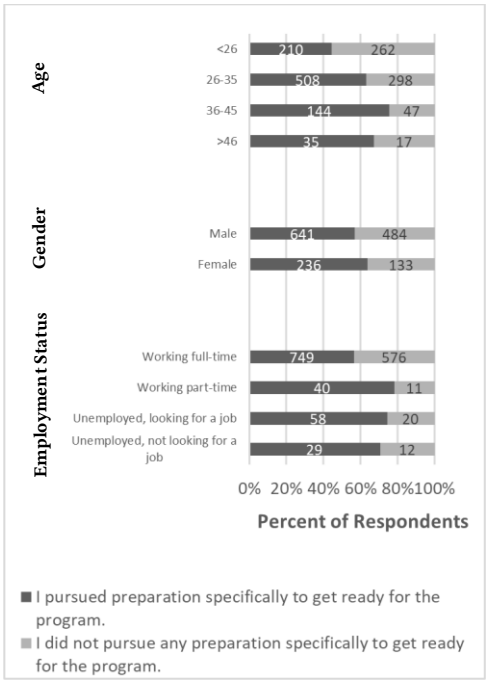

Figure 4. Program preparation by age, gender, and employment status

type was self-study, followed by MOOCs and for-credit college courses. Figures 4-7 show preparation broken down by various demographics. We present notable results shown in these figures.

While most respondents under the age of 26 did *not* pursue any preparation, the majority of each other age group did, with group 36-45 having the highest percentage. Female respondents were statistically significantly ($p < 0.05$, $z = 2.3627$) more likely than male respondents to pursue preparation, but we did not find gender-based differences in the *type* of preparation pursued.

Respondents working full-time had the lowest percentage of people who pursued preparatory work (57%), while respondents working part-time had the highest (78%). Respondents employed full-time were statistically significantly ($p < 0.01$, $z = 4.5299$) less likely than unemployed or part-time employed respondents to pursue preparation. Additionally, while self-study was the primary choice for respondents in all employment groups, those who were employed favored this choice more strongly. On the other hand, among unemployed respondents, 39-40% pursued self-study and 33-37% began or completed a MOOC. It was less common for employed respondents to have begun or completed a MOOC, and 15% of full-time workers enrolled in for-credit college courses to prepare, compared to 26-27% of each other group.

Regarding degrees earned, the groups with the highest percentages of respondents who pursued preparation were Ph.D. (84%), MBA (76%), M.A. (76%), and M.S. (75%). The groups with the lowest percentages were B.S. (56%), Bachelor of Technology (56%), and Bachelor of Engineering (57%). Those with associate and/or art degrees enrolled in preparatory, for-credit college courses in higher percentages (28-31%) than those with STEM degrees (2-

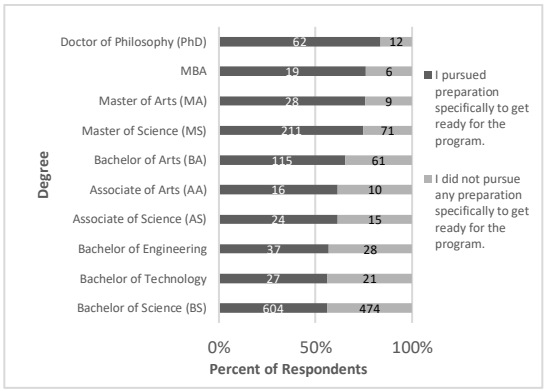

Figure 5. Program preparation by degree earned

21%). Respondents with STEM degrees more strongly favored self-study and MOOCs.

Those who studied computer science in a not-for-credit formal education setting or informal setting, and those who had no prior computer science qualifications, pursued preparation in higher percentages (66-77%) than those who studied computer science in high school or college, taught or worked in computer science, or were familiar with a programming language (50-59%).

Respondents who had started and/or completed at least one online degree, along with those who had completed at least one MOOC, pursued preparation in higher percentages (67-77%) than those whose experience with online learning was related to COVID-19, those who had started but never completed a MOOC, and those with no prior online learning experience (36-54%).

5 DISCUSSION

RQ1: Many respondents had technical backgrounds, and most had computer science qualifications; however, more male than female students had such qualifications. This difference hints at opportunities to attract students with diverse backgrounds to the program and perhaps create preparatory resources tailored to students with non-technical backgrounds, which may be particularly valuable for female students. Additionally, a sizeable percentage of students had no online learning experience, which suggests a potential need to orient students to online learning.

RQ2: Our data suggest that incoming students favored low-effort, informal preparation (e.g., self-study or MOOCs), possibly influenced by factors such as cost and flexibility. Many students did not prepare for the program at all; they may not have felt a need to prepare, due to already having technical backgrounds, or simply due to assuming no preparation was needed for the program. Alternatively, these students may not have known they would need to prepare or, if they did, *how* to prepare.

RQ3: Our data show that students older than 25 and female students were more likely than younger students and male students to pursue preparation, suggesting that in-house, program-specific preparatory opportunities may be important components in the success of older and underrepresented students and may help increase the diversity of the program.

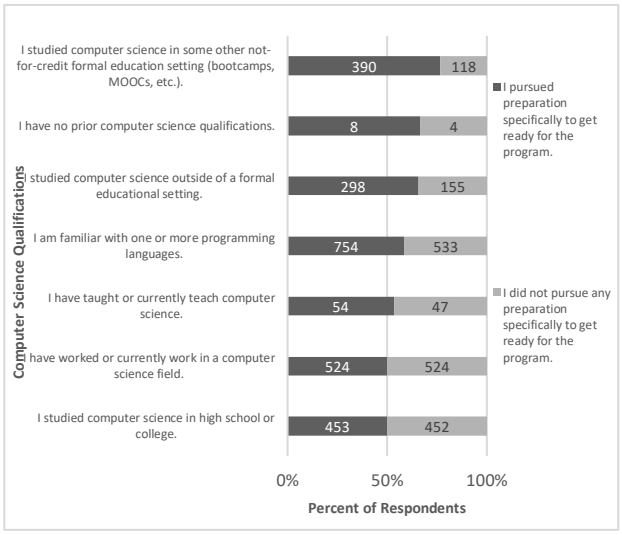

Figure 6. Program preparation by CS qualifications

Employed respondents favored self-study, which is unsurprising since they likely have limited time to devote to preparation. However, given that 87% of respondents were working full-time, preparatory resources tailored to them may help prevent employment from hindering their success or deterring them from enrolling in or applying to the program.

Students with non-STEM degrees and little to no formal computer science qualifications were more likely to pursue preparation than those with STEM degrees or computer science backgrounds. While those with STEM degrees who chose to prepare favored self-study and MOOCs, those with non-STEM degrees pursued more structured preparation, suggesting a desire among them to get on an equal level with their peers, a need for formal guidance in their preparation, and a preference for comprehensive preparatory courses.

Students with strong prior online learning experience pursued preparation more often than those without such experience. The latter group would presumably benefit from exploring the online format in advance; however, they may assume online learning is easier than in-person learning, while the former group may recognize that both can be equally rigorous, leading them to prepare the same as they would for an in-person degree.

6 IMPLICATIONS

Our research has three main implications. First, program-specific preparatory resources for an online MSCS program may mitigate knowledge gaps that may be especially significant at scale. While most of our students prepare prior to enrolling, they still enter the program with varied knowledge and backgrounds, so dedicated preparatory resources can promote equal chances of success.

Second, the creation of preparatory courses for an MSCS program should account for the likely audience. In our program, female students, older students, and students with non-technical backgrounds pursue preparation more frequently. Additionally, different *types* of preparatory courses seem to attract different

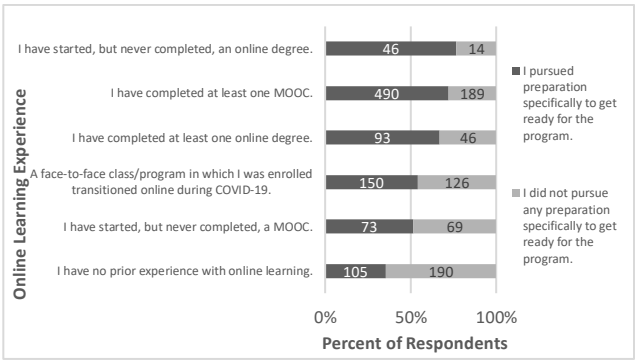

Figure 7. Program preparation by online learning experience

demographic audiences who likely approach such courses differently, which will impact the design of the courses.

Third, our research highlights the importance of preparatory resources in promoting diversity. Students from underrepresented groups use such resources frequently, hinting at their importance in student success. Availability and promotion of these resources may attract students from underrepresented groups and thus increase diversity in the field of computer science.

7 LIMITATIONS

This research is specific to an online MSCS program and may not generalize to programs: in other fields; at other levels of education; with different admission requirements; or not fully online. Additionally, certain types of preparation may be unavailable to or infeasible for students, or they may be unaware of the types of preparation available. These peripheral factors suggest that the type of preparation a student *chooses* may not necessarily be the *best*. Lastly, while our data certainly contain trends, we are largely left to infer the factors behind those trends.

8 FUTURE WORK

Our future work involves correlating students' preparation with academic performance to help identify the most valuable types of preparation. Specifically, we plan to study the impact of completing one or more of the MOOC series offered by our university on grades, withdrawals, and other variables.

We also want to understand the factors driving the trends we observed. We want to study why certain types of preparation are more popular than others by defining and isolating the common properties for each type and analyzing the properties of the more popular types. We also want to study why certain types of preparation are more popular among students from certain demographic or educational groups by soliciting direct feedback, and by correlating existing research on commonalities within each group with the types of preparation they tend to pursue.

Lastly, we plan to merge our Fall 2021 and Fall 2022 data to observe trends over time, which may indicate where to focus efforts for creating future preparatory resources.

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