

Factors Affecting Project Selection in an Open Source Capstone

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ABSTRACT

Free and Open Source Software (FOSS) projects operate transparently, providing excellent educational opportunities for computing students to acquire and practice both technical and softer skills that are in high demand. Humanitarian Free and Open Source Software (HFOSS) projects are FOSS projects that broadly but intentionally aim to improve the human condition. This paper analyzes data from five years of a two-semester capstone experience in which students consider a number of FOSS and/or HFOSS projects and choose one to engage with. Findings support assertions that projects with humanitarian goals are preferred by both women and students with lower confidence in their software development and teamwork skills. The data analysis is suggestive that African American, Black and Hispanic (ABH¹) students may also show preferences for projects with humanitarian goals. An exploratory analysis of pre-course survey data adds additional insight into how gender, race/ethnicity, student confidence and perceptions of community may influence project selection, helping to identify important directions for further investigation. Collectively the results presented here reinforce suggestions that incorporating HFOSS, or more generally computing with social value, holds potential for broadening participation in computing.

CCS CONCEPTS

• **Social and professional topics** → **Computing education**; *Computer science education*; *Race and ethnicity*; *Gender*;

KEYWORDS

open source, capstone, humanitarian, broadening participation

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¹As recommended in the Communications of the ACM Blog, ABH is an acronym for African American, Black, and Hispanic, which are the specific races/ethnicities represented in our sample [31].

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1 INTRODUCTION

There are many motivations for incorporating Free and Open Source Software (FOSS) into the undergraduate computing curricula. Because the “open” part of FOSS extends beyond the fact that the source code is freely available, FOSS provides exceptional educational opportunities [28]. The communities developing this software also operate transparently with design, discussion, feedback, and decision making occurring in public view (e.g., on GitLab or GitHub). Thus, not only can students study and engage with a full range of software development artifacts, they can also study, interact with and contribute to the project communities that developed them. Opportunities such as these foster learning of leading-edge software engineering tools and techniques, support the development of professional skills such as problem solving, communication, teamwork, critical thinking, and assessment (see [3] for many examples). Such experiences also have professional value for graduates entering a modern software industry where FOSS skills and experience are in high demand [13].

Engaging students in Humanitarian FOSS (HFOSS), a subset of FOSS projects that broadly aim to improve the human condition, also holds the potential to attract a more diverse group of students to computing [10, 25]. Students that have engaged in HFOSS have reported increased interest in computing [6] and lesser experienced students have reported more positive shifts in their perception of computing than more experienced students [16]. In some examples, female students and students from other underrepresented groups enrolled in HFOSS-based courses at higher rates than in traditional (non-HFOSS) computing courses [25]. A few studies have also found preliminary evidence that some positive effects of HFOSS engagement may be stronger in women than in men [7, 9], including a greater awareness of the potential for computing to benefit society [17]. A study of participants in HFOSS projects at an Open Source Day at the Grace Hopper Celebration of Women in Computing reinforces this [23]. This study found strong interest in humanitarian applications of computing among women across a variety of other demographic factors and that participation in HFOSS reinforced their interest in studying computing. These HFOSS specific results align well with more general findings that computing focused on communities, engagement and social good can be particularly appealing to both women and students from other groups that are underrepresented in the field [15, 18, 20, 21, 26, 30].

This paper adds to the above body of knowledge by analyzing preferences for FOSS or HFOSS projects demonstrated by students in a two-semester senior capstone course in computer science at Dickinson College. Specifically we test the hypotheses that (H1) women will demonstrate more interest in HFOSS projects than men, and (H2) African American, Black and Hispanic (ABH) students and (H3) Asian students will demonstrate more interest in HFOSS projects than White students. Furthermore, we present an

exploratory analysis that identifies additional factors that may differ by gender and/or race/ethnicity and may aid in understanding the demonstrated preferences for HFOSS vs. FOSS projects.

2 THE STUDY

Beginning with the academic year 2016-17 computer science majors at Dickinson have completed a required two-semester senior capstone course in which they engaged with and contributed to a FOSS or an HFOSS project (which we will refer to collectively as H/FOSS). This study is based on the five academic years between 2016-17 and 2020-21. During that time 74 students completed both the capstone and a pre-course survey. Based on self-reported demographic data from the pre-course survey, this population included 50 men, 24 women, 7 ABH students, 34 Asian students and 33 White students. While a free text option was provided for both gender and race/ethnicity information no participants used it during this period. The complete survey can be found in the materials at [2].

At the start of the course, students were introduced to FOSS principles, processes, tools and the developer and user communities that exist around them. Examples of HFOSS projects were also an intentional part of this introduction. During these weeks the students used a well-defined three-phase project selection process (see Section 2.1) to *explore*, *review* and ultimately *choose* an H/FOSS project, which they then engaged with for the remainder of the course. The types of projects (FOSS or HFOSS) that students considered during the phases of the selection process provide the data used to test H1-H3 (Section 3.2). Student responses to the pre-course survey provide the data for an exploratory analysis that identifies factors that may be predictive of project preferences for further study (Section 3.3).

2.1 Project Selection Process

A number of authors have written about the attributes of FOSS projects that make good candidates for student engagement (e.g. [5, 8, 11, 14, 24]). The Dickinson senior capstone course uses a three-phase project selection process including exploration, review and ranking & choice phases and is most closely modeled after [11]. The following sections briefly describe each of these phases. The complete assignments given to the students for project selection can be found in an earlier report on the course [2]. While not directly relevant to this study the above report also provides access to all of the materials used in the course, including the assignments that guide students through engaging with and contributing to their chosen projects during the remainder of the course.

2.1.1 Project Exploration. Project Exploration is the first phase of the project selection process and is completed individually by each student. In this phase students are pointed to several repositories of H/FOSS projects. Some of these repositories focus on HFOSS projects and communities, while others (e.g. GitHub / GitLab) are much more expansive. Most students choose at least four H/FOSS projects to explore. Typically, one to three students a year do independent research projects with faculty in place of the FOSS capstone project. These research students choose at least two H/FOSS projects to explore. It is permissible and common for a given project to be explored (reviewed or chosen) independently by multiple students both within and across years. During the exploration phase

students are asked to summarize what the project's software product does, who the user community is and what the benefits of the software are to that community. They are also asked to imagine themselves starting to work on the project as a new developer and to identify and evaluate the project's "getting started" resources from that perspective. Finally they are asked to summarize anything that they learned about the project or its communities (user/developer) that either increased or decreased their interest in the project.

2.1.2 Project Review. Following the Project Exploration, students are asked to individually complete a more thorough review of at least two (one for research students) of the projects that they explored. Students are also permitted to review projects that they did not explore, but they must go back and complete a Project Exploration first. The project review asks students for specific information about the project's communication channels, issue tracker, documentation, and project statistics. Students are instructed to assess communication channels based on how active they are, how quickly and helpfully the community responds to questions and the tone of communications. For the issue tracker students look at the volume of open issues and the rate of recent activity (new issues, comments, closed issues). When looking at project documentation, students are asked to assess the volume, currency, organization and helpfulness to project newcomers. They use the statistics provided by GitHub/GitLab and by Black Duck Open HUB [29] to find more details including the size of the code base, the amount of commenting in the code, the number of different recently active developers and the number of recent contributors that were new to the project.

2.1.3 Project Ranking & Choice. For the final phase, the instructor and students interactively cluster students into teams of 3-4 based on themes that emerge from the projects that have been explored and reviewed (e.g. education, gaming, medicine, automation, etc...). Each team considers the full set of projects that its members have explored and reviewed, assessing and ranking at least three of these projects based on the following dimensions:

- **Community:** How would it be for your team to work within this project's community?
- **Complexity:** How technically hard is it going to be for your team to work on this project?
- **Activity:** How active is this project?
- **Approachability:** How hard will it be for your team to get started?
- **Appeal:** How interested is your team in working on this project?

Each team is asked to briefly summarize the rationale for their ranking along each dimension. Finally, based on the project rankings and the team's own assessment of the relative importance of each dimension, the team chooses the project to engage with.

3 ANALYSIS

The analysis that follows looks first at the types of projects (FOSS or HFOSS) that were explored, reviewed and chosen (Section 3.2) and then at the pre-course survey responses (Section 3.3). The analysis of project exploration, review and ranking & choice data performs confirmative testing [19] of H1-H3 and uses a significance threshold of $p < 0.05$. The analysis of the pre-course survey data is

exploratory [19], using statistical tests not to accept or reject specific hypotheses, but to identify *potential* explanatory factors. For this analysis we wanted to avoid prematurely discarding factors that may be explanatory and thus adopted a more lenient threshold of $p < 0.1$. To be clear we are not claiming that the identified factors are explanatory based on this higher threshold, just that their predictive power for our sample is unlikely enough to have occurred by chance to make them worthy of further study.

3.1 The Generalized Linear Models

All of our analyses were performed using generalized linear models (GLMs) [1]. GLMs use regression to fit a set of sample data with a mathematical model that predicts a *response variable* (e.g. the type of project chosen, or response to a survey question) based on a set of *factors* (e.g. gender or race/ethnicity) and their interactions.

In analyzing the types of projects explored, reviewed or chosen, the response variable being predicted is the fraction [0...1] of HFOSS projects considered by a student and thus the GLMs use logistic regression. Because different students explored and reviewed different numbers of projects, the analysis for these phases also weighted each fraction by the total number of projects that the student considered. For example, a student exploring 4 projects with 3 being HFOSS and 1 being FOSS would have a 0.75 HFOSS fraction with a weight of 4 in the exploration analysis.

The pre-course survey requested demographic information and asked students to rate their agreement with 51 statements using a five-point Likert scale. For analysis, the Likert scale responses to each question are treated as interval data and a GLM using normal regression is used to predict them. The Likert scale responses were converted to interval data as (6) Strongly agree, (4) Mildly agree, (3) Neutral, (2) Mildly disagree and (0) Strongly disagree. This coding creates more distance between the strongly agree/disagree and mildly agree/disagree responses than between the mild agreement/disagreement and neutral responses to account for the tendency of respondents to avoid the extremes of the scale (analogous to [1] p. 118 and [22]).

All of the GLMs compute significance levels for interactions and factors that reflect the importance of each in predicting the response variable. Significant interactions indicate that the effect of the factors involved are dependent upon each other. For example, a $\text{gender} \times \text{race/ethnicity}$ interaction in predicting the type of project selected would suggest that the effect that gender has on project choice differs by race/ethnicity. Our analysis begins with models that include terms for $\text{gender} \times \text{race/ethnicity}$ interactions to allow for intersectional effects. When an interaction is found to be significant in a model, the effects of the factors depend on each other and cannot be separated. In these cases the interaction is reported and the factors are not considered independently. However, when an interaction was not significant in a model the effects of the factors were considered to be independent and the model was rerun with the interaction term omitted [1].

3.2 Project Selection

The projects that students consider (i.e. explore, review or choose) naturally demonstrate their preferences. Thus, looking at the types

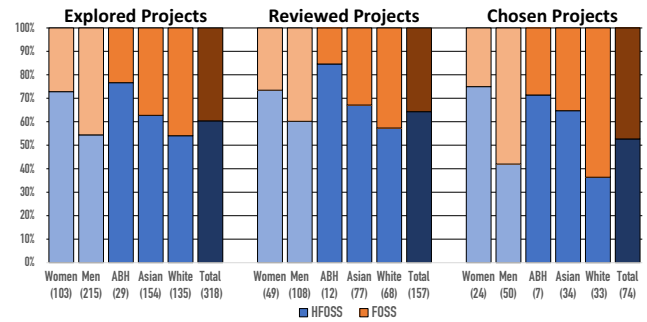


Figure 1: Project selection by gender and race/ethnicity. Numbers below bar labels indicate the total number of events represented (e.g. women explored 103 projects). The stacked bars show percentages of FOSS and HFOSS projects (e.g. about 75 percent of projects explored by women were HFOSS).

of projects (FOSS or HFOSS) considered by different groups of students provides insight into the types of projects that were appealing to the students in those groups. To do this the authors reviewed the definition of HFOSS given by Teaching Open Source: “Humanitarian FOSS, is open source software that somehow benefits the human condition in areas such as health care, economic development, disaster management, ecology, education and more.” [4] They then independently reviewed every project considered by the students and designated each as FOSS or HFOSS based on their shared understanding of the definition. There were no disagreements between the authors’ designations of the projects, so the analysis proceeded with those designations.

Figure 1 shows a break down of the types of projects that were considered in the exploration, review and ranking & choice phases by women, men, Asian, ABH, White and all students. Qualitatively, women were more likely to consider HFOSS projects than were men in all phases. ABH students were more likely than Asian students who were in turn more likely than White students to consider HFOSS projects in all phases. A detailed statistical analysis of the factors affecting project exploration, review and choice are presented in Sections 3.2.1 and 3.2.2. In all cases the analysis showed no significant $\text{gender} \times \text{race/ethnicity}$ interactions. We do not interpret this to mean that intersectionality is not an important factor in understanding project preferences more broadly, rather just that they were not statistically significant in our limited sample.

3.2.1 Gender Effects. The analysis showed gender to be a significant factor in both project exploration ($p=0.0005$) and project choice ($p=0.0100$). The odds of a woman exploring an HFOSS project was 2.4 times greater than for men and the odds of a woman choosing an HFOSS project was 4.1 times higher than for a man. While the odds of a woman reviewing an HFOSS was 2.4 times that of a man, gender was not a significant factor in predicting the percentage of HFOSS projects reviewed ($p=0.1233$). Likely reasons for this finding are as follows: the data showed that a large percentage of women (about 75%) reviewed exactly two projects. Of those who reviewed 2 projects, approximately 50% reviewed exactly one FOSS and one HFOSS project. This choice may have been made to equalize the

type of projects being reviewed (one of each, FOSS and HFOSS), even though they possibly had a greater preference for HFOSS. This possible explanation is further supported by the fact that close to 90% of the women who reviewed exactly two projects (one FOSS and one HFOSS) were on a team that ultimately chose an HFOSS project to work on. Given the significance of gender in project choice and the very low p-value for project exploration, where individual freedom was the greatest, this evidence on balance supports the acceptance of H1.

3.2.2 Race/Ethnicity Effects. Identification as ABH was a significant factor in predicting the types of projects explored ($p=0.0145$) with the odds of an ABH student exploring an HFOSS project being 3.1 times those of a White student. Identification as ABH was not a significant factor in either the review ($p=0.0810$) or choice ($p=0.1054$) phases. However, in both of these phases the odds of an ABH student engaging with an HFOSS project as compared to a White student were even larger at 4.1 times for project review and 4.4 times for project choice. The sizable and consistent differences in odds ratios, the significance of ABH as a factor in project exploration, again when individual freedom was greatest, and limits due to the relatively small sample sizes for ABH during review ($n=29$) and choice ($n=7$) suggest that H2 is plausible, and should be investigated further.

The analysis showed identification as Asian as a significant factor in project choice ($p=0.0222$), with the odds of an Asian student choosing an HFOSS project being 3.2 times those for a White student. Identification as Asian was not significant in the exploration ($p=0.1024$) or review ($p=0.1900$) phases. However, the odds of Asian students considering an HFOSS project were greater than their White peers during both review (1.6 times) and exploration (1.5 times). These mixed results, and lower odds ratios, neither support accepting nor rejecting H3. Rather they suggest that further study is necessary to better understand the different factors (e.g. social or cultural) that may influence the types of projects considered by Asian students during each phase.

3.3 Pre-Course Survey

The eight questions from the pre-course survey shown in Table 1 were chosen for analysis in this context. These questions were chosen from the full set of 51 questions on the survey as they relate to student confidence and community, factors that are often reported to interact with gender and race/ethnicity in computing. The columns under the “Chosen Project Type” heading in Table 1 indicate significant results when using survey response (X), gender, race/ethnicity and their interactions as factors in predicting the type of project chosen. The columns under the “Pre-Course Survey Response (X)” heading show significant results when using gender, race/ethnicity and their interaction as factors in predicting the survey response.

3.3.1 Confidence. Seven of the eight questions in Table 1 relate to students’ self-reported confidence, either in their technical abilities (B8, DC2, DC5, DC6) or their teamwork skills (DC7, G1, SE10). When predicting the type of project selected, questions B8, DC5, DC6, DC7, G1 and SE10 show no significant interaction effects with race/ethnicity or gender but show survey response (X) as having an

ID	Question Text	Chosen Project Type				Pre-Course Survey Response (X)				
		X×G	X×ABH	X×A	X	G×ABH	G×A	G	ABH	A
B8	How would you characterize your programming ability?				0.027					0.040
DC2	I understand the tools and techniques used in large software projects.	0.071								
DC4	I believe that community is an important part of H/FOSS development.	0.098								0.025
DC5	I am confident in my ability to read and understand professional level software.				0.053					
DC6	I am confident in my ability to modify professional level software.				0.055					
DC7	I am confident in my ability to work with other software developers.				0.094					
G1	I feel confident about working with computing professionals				0.027	0.093				
SE10	I can participate in an HFOSS development team's interactions.				0.096					

Table 1: Table of pre-course survey questions and significance levels of regression factors and interactions. X indicates the Likert scale survey response (0–6). A × indicates an interaction term (e.g. X×G is an interaction between survey response and gender). Cells filled in dark green are significant at $p < 0.05$. Cells filled in light green are significant at $p < 0.1$. Empty cells had $p \geq 0.1$ or were not considered due to a significant interaction as described in Section 3.1.

independent effect. The GLMs for all of these questions have negative coefficients for the survey response (X) term, indicating that students expressing weaker agreement (lower confidence) with the statements were more likely to select HFOSS projects than those expressing stronger agreement (higher confidence). It is also worth noting that for survey question B8, Asian students, on average, rated themselves as having lower programming ability than did their White peers ($p=0.040$) and were more likely to select HFOSS projects than White students (see Section 3.2).

Based on this it seems that HFOSS projects are preferred by students with lower confidence in their abilities to work with software or software developers. It is possible that less confident students are more motivated by the ability to impact a social or humanitarian cause that they care about than by the often more technical purposes of FOSS projects. Alternatively, these students may anticipate feeling more comfortable interacting with and asking questions in the communities surrounding HFOSS projects, which some have suggested can be more benevolent and supportive than those around more technically focused FOSS projects [6, 17]. Regardless of the reason, the finding in [16] that HFOSS participation disproportionately improved the perception of computing among lesser experienced students suggests that the availability of HFOSS opportunities for students holds the potential to broaden participation in the field. Thus, further investigation into what specifically attracts less confident students to HFOSS communities and how they are affected by them is an important direction for further research.

The results for DC2 (“I understand the tools and techniques used in large software projects.”) show a significant survey response (X) × gender interaction ($p=0.0708$), adding nuance to the above findings. This interaction is illustrated in Figure 2, which shows that for men the likelihood of selecting FOSS projects increased as confidence in their understanding of software tools and techniques increased. However, for women the opposite was the case. The women with the most confidence in their understanding of software tools and techniques were more likely to select HFOSS projects.

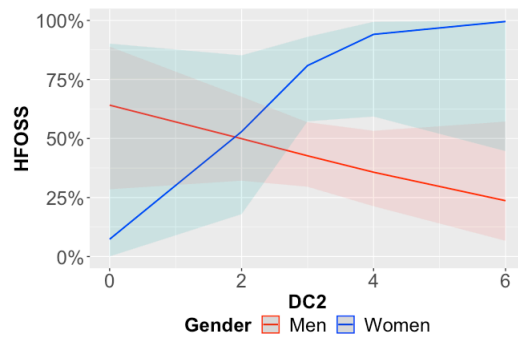


Figure 2: DC2 × gender interaction in predicting the choice of an HFOSS project. Shaded areas show 95% confidence intervals.

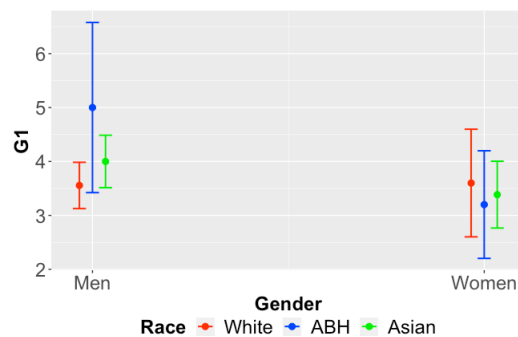


Figure 3: Gender × race/ethnicity interaction in predicting the response to G1. Error bars show 95% confidence intervals.

The analysis of Question G1 (“I feel confident about working with computing professionals”) shows a gender × race/ethnicity interaction that is significant ($p=0.0930$). This interaction is illustrated in Figure 3. For both White and Asian students, men and women expressed similar levels of confidence in working with computing professionals. However, among the ABH students men expressed greater confidence in working with computing professionals than did women. While suggestive and important for further investigation, this observation should be interpreted with extra care as the number of ABH students in the sample is small ($n=7$, with 2 men and 5 women). For example, it may be that by chance the two ABH men in G1 have had opportunities that the women did not to complete internships or may have been positively influenced by factors that otherwise helped them build their confidence.

3.3.2 Community. The analysis of DC4 (“I believe that community is an important part of H/FOSS development”) shows a significant survey response (X) × gender interaction ($p=0.0977$) in predicting the type of project chosen. This interaction is illustrated in Figure 4. The GLM for this question revealed that for men the likelihood of choosing HFOSS decreased as the agreement with the statement increased, while for women the relationship was the opposite. A plausible explanation for this could be that there is a difference in the perception of what constitutes community in the context of H/FOSS between men and women. It is possible that

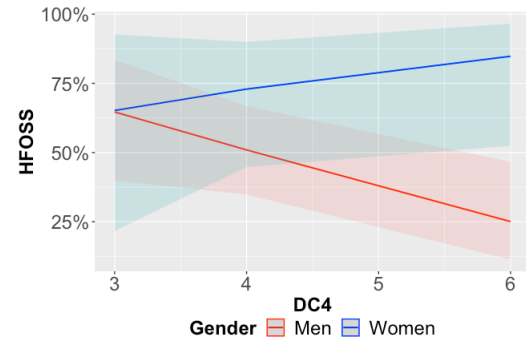


Figure 4: DC4 × gender interaction in predicting the choice of an HFOSS project. Shaded areas show 95% confidence intervals.

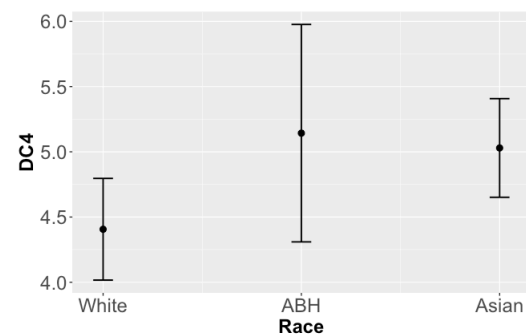


Figure 5: Effect of race on prediction of the agreement with the statement DC4. Error bars show 95% confidence intervals.

men perceive a strong H/FOSS community as one with members making numerous technical contributions. While women, on the other hand, may think of a good H/FOSS community as one with a culture that encourages new members and offers them support in understanding the project and making contributions. More nuanced research to better understand what underlies this observed effect is an important area for future work.

The same question (DC4) shows a significant primary effect of identification as Asian on agreement with the statement. This effect is illustrated in Figure 5. On average, ABH and Asian students indicated greater agreement that community is an important part of H/FOSS development than did White students. The difference between Asian and White students was significant ($p=0.0251$), while the difference between ABH and White students was not ($p=0.1148$). The much higher variance among the responses of ABH students may be a product of the smaller sample size, but may also suggest a wider range of interpretations of H/FOSS community among the ABH students. Thus, overall there seems to be a difference in how the role and value of community in H/FOSS projects is perceived by different racial/ethnic groups. As suggested for the earlier effect by gender (see Figure 4) this is an important area for further research.

4 LIMITATIONS AND DISCUSSION

There are several factors that should be considered in interpreting the results of this study. First, this was a modest size study involving students at a single institution that promotes contribution to the greater good as part of its mission. While the study involved a reasonable number of students ($n=74$) and a large selection of distinct projects (FOSS: $n=80$, HFOSS: $n=47$), the number of ABH students is small ($n=7$, Women: $n=5$, Men: $n=2$). Thus, while there are both statistically significant results and encouraging trends with respect to ABH students, it is important that these results be interpreted with caution at this point. Second, the students in the study have self-selected into this type of institution, and thus may not necessarily represent the inclinations of the broader population of computing students. For example, the findings may be different if conducted at a more technically focused or research university where students may self-select into the institution for different reasons.

Our results also suggest that that women, Asian and ABH students may perceive community in ways that differ from men or White students respectively (see Section 3.3.2). The emphasis placed on the community factor in the project selection process could influence the decisions of a student when exploring, reviewing and choosing a project. For example, a woman or ABH student may support their team in choosing a FOSS project while originally being inclined toward HFOSS if they observe the FOSS community to be more active. That ABH students showed a significantly greater preference for HFOSS (over FOSS) than White students in the project exploration stage, when they had the greatest individual freedom, but not in the review and ranking & choice stages could be indicative of this effect. It seems equally likely that other factors such as social pressures, friendship groups and the perceived skills and compatibility of teammates also have an important effect, particularly in the review and ranking & choice stages. Finally, students in this study were already in the senior capstone course. This means that they had not only entered the discipline but had already persisted through a complete computer science major. Thus, while it provides some compelling evidence that women and both ABH and Asian students exhibit preferences for projects with humanitarian goals, it is an inference that an earlier exposure to these types of projects will broaden participation by drawing a more diverse audience to computing.

5 SUMMARY AND FUTURE WORK

For the past five years, students in the senior capstone at Dickinson College have engaged with Free and Open Source Software projects. The types of projects (FOSS or HFOSS) that they engaged with through the project selection process were analyzed. This analysis showed that women demonstrated greater interest in pursuing humanitarian projects than did men. Both Asian and ABH students showed greater interest in engaging with humanitarian projects than did White students. However, the significance of identification as ABH and Asian varied across the project selection phases, possibly due to factors including differences in how H/FOSS communities are perceived by different ethnic/racial groups. The mixed results and the small sample sizes for our ABH group suggest that further research, likely incorporating qualitative methods, is an

important area of future work. More specifically, a detailed qualitative analysis of documents, such as reflective blogs and wiki pages, that are produced during the project selection process may provide deeper insights into the causes underlying the effects reported here.

An analysis of pre-course surveys suggests areas for further investigation. Overall, students who were less confident in their abilities were more likely to choose HFOSS projects. However, these preferences may differ by gender. Women with high confidence in this area showed a greater likelihood of selecting HFOSS while men indicated a preference for FOSS as confidence increased. Women also showed a higher preference for HFOSS as their belief in the importance of community strengthened, while men preferred FOSS as their recognition of community significance increased. Responses to several questions also suggest that race/ethnicity and intersectional effects of gender and race/ethnicity may also be important in understanding the relationships between confidence, perception of community and project preferences.

Overall, our results resonate with those cited in Section 1, adding support for claims that that opportunities for HFOSS engagement may broaden participation in computing by appealing to women, to Black, Indigenous, and People of Color (BIPOC) and to lesser experienced students. Interpreted more broadly, the results reported here also add support for claims that women and BIPOC are particularly motivated by projects and applications with social value. In fact, our experiences with H/FOSS in the capstone, its potential for broadening participation in computing and for improving both the technical and soft skills of students have motivated changes to the curriculum at Dickinson. At the time of this study, the capstone was the first formal exposure to FOSS and HFOSS in our curriculum. We have since introduced a number of new courses or content that include exposure to HFOSS, focus on the development of skills and practices necessary for FOSS engagement and provide experiences of participation in an HFOSS community [27]. Students in our first course are exposed to the ideas of FOSS and HFOSS projects as examples that exemplify the power of computing to drive positive social change. A sequence of courses at the intermediate level provide experiences with FOSS tools and processes and give students experience in participating in a locally hosted HFOSS project [12]. Students arriving at the senior capstone will thus be better prepared to engage more quickly and more deeply with H/FOSS projects of their own choosing. These changes will provide us an opportunity to study both the diversity and the attitudes/perceptions of the students in our major and minor programs over time.

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REFERENCES

- [1] Alan Agresti. 1990. *Categorical data analysis*. Wiley, New York [u.a.], XV, 558 S. pages.
- [2] Grant Braught. 2019. Dickinson H/FOSS Capstone. <https://github.com/braught/DickinsonHFOSS-SFC-Materials>
- [3] Grant Braught, John McCormick, James Bowring, Quinn Burke, Barbara Cutler, David Goldschmidt, Mukkai Krishnamoorthy, Wesley Turner, Steven Huss-Lederman, Bonnie Mackellar, and Allen Tucker. 2018. A Multi-Institutional Perspective on H/FOSS Projects in the Computing Curriculum. *ACM Trans. Comput. Educ.* 18, 2, Article 7 (July 2018), 31 pages. <https://doi.org/10.1145/3145476>
- [4] Heidi J. C. Ellis. 2022. Teaching Open Source, Instructors and open source communities supporting teaching open source. <http://teachingopensource.org/hfoss/>
- [5] Heidi J. C. Ellis, Gregory W. Hislop, Mel Chua, and Sebastian Dziallas. 2011. How to Involve Students in FOSS Projects. In *Proceedings of the 2011 Frontiers in Education Conference (FIE '11)*. IEEE Computer Society, Washington, DC, USA, T1H-1-1-T1H-6. <https://doi.org/10.1109/FIE.2011.6142994>
- [6] Heidi J. C. Ellis, Gregory W. Hislop, Stoney Jackson, and Lori Postner. 2015. Team Project Experiences in Humanitarian Free and Open Source Software (HFOSS). *Trans. Comput. Educ.* 15, 4, Article 18 (Dec. 2015), 23 pages. <https://doi.org/10.1145/2684812>
- [7] Heidi J. C. Ellis, Gregory W. Hislop, S Monisha Pulimood, Becka Morgan, and Ben Coleman. 2015. Software Engineering Learning in HFOSS: A Multi-Institutional Study. *122nd ASEE Annual Conference and Exposition 26* (2015), 1–12.
- [8] Heidi J. C. Ellis, Gregory W. Hislop, Michelle Purcell, and Lori Postner. 2013. Project Selection for Student Participation in Humanitarian FOSS. *J. Comput. Sci. Coll.* 28, 6 (jun 2013), 16–18. <http://dl.acm.org/citation.cfm?id=2460156.2460162>
- [9] Heidi J. C. Ellis, Gregory W. Hislop, Josephine Sears Rodriguez, and Ralph Morelli. 2012. Student Software Engineering Learning via Participation in Humanitarian FOSS Projects. In *2012 ASEE Annual Conference & Exposition*. ASEE Conferences, San Antonio, Texas. <https://peer.asee.org/21949>
- [10] Heidi J. C. Ellis, Ralph A. Morelli, Trishan R. de Lanerolle, Jonathan Damon, and Jonathan Raye. 2007. Can Humanitarian Open-source Software Development Draw New Students to CS?. In *Proceedings of the 38th SIGCSE Technical Symposium on Computer Science Education (SIGCSE '07)*. ACM, New York, NY, USA, 551–555. <https://doi.org/10.1145/1227310.1227495>
- [11] Heidi J. C. Ellis, Michelle Purcell, and Gregory W. Hislop. 2012. An Approach for Evaluating FOSS Projects for Student Participation. In *Proceedings of the 43rd ACM Technical Symposium on Computer Science Education (SIGCSE '12)*. ACM, New York, NY, USA, 415–420. <https://doi.org/10.1145/2157136.2157260>
- [12] FarmData2. 2022. The FarmData2 Project. <https://github.com/DickinsonCollege/FarmData2>
- [13] The Linux Foundation. 2021. The 2021 Open Source Jobs Report: 9th Annual Report on Critical Skills, Hiring Trends and Education. <https://www.linuxfoundation.org/tools/the-2021-open-source-jobs-report/>
- [14] Edward F Gehringer. 2011. From the manager's perspective: Classroom contributions to open-source projects. In *Frontiers in Education Conference (FIE), 2011*. IEEE, IEEE Computer Society, Los Alamitos, CA, USA, F1E-1.
- [15] Michael Goldweber, John Barr, and Elizabeth Patitsas. 2013. Computer Science Education for Social Good. In *Proceeding of the 44th ACM Technical Symposium on Computer Science Education (SIGCSE '13)*. Association for Computing Machinery, New York, NY, USA, 15–16. <https://doi.org/10.1145/2445196.2445208>
- [16] Gregory W. Hislop, Heidi J. C. Ellis, and Ralph A. Morelli. 2009. Evaluating Student Experiences in Developing Software for Humanity. In *Proceedings of the 14th Annual ACM SIGCSE Conference on Innovation and Technology in Computer Science Education (ITiCSE '09)*. ACM, New York, NY, USA, 263–267. <https://doi.org/10.1145/1562877.1562959>
- [17] Gregory W. Hislop, Heidi J. C. Ellis, S. Monisha Pulimood, Becka Morgan, Suzanne Mello-Stark, Ben Coleman, and Cam Macdonell. 2015. A Multi-Institutional Study of Learning via Student Involvement in Humanitarian Free and Open Source Software Projects. In *Proceedings of the Eleventh Annual International Conference on International Computing Education Research (ICER '15)*. ACM, New York, NY, USA, 199–206. <https://doi.org/10.1145/2787622.2787726>
- [18] Beryl Hoffman, Ralph Morelli, and Jennifer Rosato. 2019. Student Engagement is Key to Broadening Participation in CS. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education (SIGCSE '19)*. Association for Computing Machinery, New York, NY, USA, 1123–1129. <https://doi.org/10.1145/3287324.3287438>
- [19] Robert G Jaeger and Tim R Halliday. 1998. On confirmatory versus exploratory research. *Herpetologica* 54 (1998), S64–S66.
- [20] Nazish Zaman Khan and Andrew Luxton-Reilly. 2016. Is Computing for Social Good the Solution to Closing the Gender Gap in Computer Science?. In *Proceedings of the Australasian Computer Science Week Multiconference (ACSW '16)*. Association for Computing Machinery, New York, NY, USA, Article 17, 5 pages. <https://doi.org/10.1145/2843043.2843069>
- [21] Colleen Lewis, Paul Bruno, Jonathan Raygoza, and Julia Wang. 2019. Alignment of Goals and Perceptions of Computing Predicts Students' Sense of Belonging in Computing. In *Proceedings of the 2019 ACM Conference on International Computing Education Research (ICER '19)*. Association for Computing Machinery, New York, NY, USA, 11–19. <https://doi.org/10.1145/3291279.3339426>
- [22] Matteo Lionello, Francesco Aletta, Andrew Mitchell, and Jian Kang. 2021. Introducing a Method for Intervals Correction on Multiple Likert Scales: A Case Study on an Urban Soundscape Data Collection Instrument. *Frontiers in Psychology* 11 (2021), 3943. <https://doi.org/10.3389/fpsyg.2020.602831>
- [23] Cam Macdonell, Heidi J. C. Ellis, Darci Burdge, Lori Postner, and Gregory Hislop. 2018. The Use of HFOSS Projects in the Grace Hopper Celebration of Women in Computing Open Source Day. In *2018 ASEE Annual Conference & Exposition*. ASEE Conferences, Washington, DC, USA. <https://doi.org/10.18260/1-2--31131>
- [24] Bonnie MacKellar, Mihaela Sabin, and Allen Tucker. 2014. Bridging the Academia-Industry Gap in Software Engineering: A Client-Oriented Open Source Software Projects Course. In *Overcoming Challenges in Software Engineering Education: Delivering Non-Technical Knowledge and Skills*, Ligu Yu (Ed.). IGI Global, Hershey, PA, USA, Chapter 19, 373–396. <https://doi.org/10.4018/978-1-4666-5800-4.ch019>
- [25] Ralph Morelli, Allen Tucker, Norman Danner, Trishan R. De Lanerolle, Heidi J. C. Ellis, Ozgur Izmirlir, Danny Krizanc, and Gary Parker. 2009. Revitalizing Computing Education Through Free and Open Source Software for Humanity. *Commun. ACM* 52, 8 (Aug. 2009), 67–75. <https://doi.org/10.1145/1536616.1536635>
- [26] Patricia Ordóñez, Kavita Krishnaswamy, Renetta G Tull, Dan Ding, and Mary Goldberg. 2014. Assistive technology research as a mechanism to broaden the participation of women, underrepresented minorities, and persons with disabilities. In *12th Latin American and Caribbean Conference for Engineering and Technology*. The Latin American and Caribbean Consortium of Engineering Institutions, Boca Raton, FL, USA.
- [27] Dickinson Computer Science. 2022. Dickinson Computer Science Curriculum. https://www.dickinson.edu/homepage/402/computer_science_curriculum
- [28] Diomidis Spinellis. 2021. Why Computing Students Should Contribute to Open Source Software Projects. *Commun. ACM* 64, 7 (June 2021), 36–38. <https://doi.org/10.1145/3437254>
- [29] Synopsys. 2020. Black Duck Open Hub. web. <https://www.openhub.net/>
- [30] Joanna Weidler-Lewis, Wendy DuBow, and Alexis Kaminsky. 2017. Defining a Discipline or Shaping a Community: Constraints on Broadening Participation in Computing. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education (SIGCSE '17)*. Association for Computing Machinery, New York, NY, USA, 627–632. <https://doi.org/10.1145/3017680.3017776>
- [31] Tiffani L Williams. 2020. 'Underrepresented Minority' Considered Harmful, Racist Language. <https://cacm.acm.org/blogs/blog-cacm/245710-underrepresented-minority-considered-harmful-racist-language/fulltext>