Humanitarian Applications Increase Interest and Motivation of Women in Computing

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ABSTRACT

The persistent lack of women in computing programs leads to some key questions about how to engage more women in computing. Although prior research has shown that women self-report they are motivated by the potential "doing good" nature of computing, this paper describes a more focused study designed to investigate if there are differences in women's interest and motivation in developing humanitarian vs. non-humanitarian applications.

376 introductory computing students completed a survey about what applications they would find interesting and motivating to develop. Students were asked to choose which of two applications, one humanitarian and one non-humanitarian, they would be more interested in developing. For example, would they rather write an application to track seasonal flu patients or pizza deliveries. Students were also asked to rate how motivating they would find writing various humanitarian and non-humanitarian applications. For example, students rated their motivation to write applications to find available shelter space for the homeless and to find profitable locations for new stores.

Results of 364 usable surveys of introductory computing students demonstrate that women are more interested in humanitarian applications as opposed to non-humanitarian and women are more motivated by humanitarian applications than non-humanitarian. One way to engage more women in computing may be to frame programming examples and assignments with a humanitarian focus and eventually have students contribute to projects for social good.

CCS CONCEPTS

• Social and professional topic • User characteristic • Gender

KEYWORDS

computing for social good, diversity in computing, HFOSS

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1 INTRODUCTION

Computing instructors look for examples that are interesting to students and will motivate them. For over a decade, a community of faculty has used humanitarian open source projects to spark student interest and has found some evidence that the humanitarian element is particularly motivating to women [5, 12-13, 18-19,30,43]. Existing investigations into this motivating factor have involved upper-level undergraduate students in software engineering and capstone classes where students contribute to humanitarian open source projects. However, there are very few women students in these classes, which makes studying the impact on women difficult. In addition, these previous studies have asked questions regarding the impact of **contributing** to humanitarian projects as opposed to **general interest** in humanitarian vs. non-humanitarian applications. This distinction is important because introductory students do not have the technical skills required to contribute to existing projects, but understanding their interests and what motivates them may help to both attract and retain women students.

This study builds upon the prior work on the observed motivation of upper-level students and explores whether introductory students show preferences for working on computer applications related to social good [12, 18, 19]. The intention is to document whether humanitarian applications are interesting and motivating to introductory students, specifically women. Two research questions will be addressed in this paper:

***R1**: Are women more interested in developing humanitarian applications than non-humanitarian applications?*

***R2**: Do women find humanitarian applications more motivating than non-humanitarian applications?*

The goal of surveying students in introductory classes was two-fold. First, it provided a larger pool of students, specifically

underrepresented students, which allowed for statistical analysis of the data. Second, introductory students do not understand the complexity of how an application would be developed, so their preferences could be expected to be based primarily on the domain of the application, not how difficult they believe it will be to develop.

2 Background

While the number of women in computing degree programs has gradually increased over the past several years, women still only comprise 22% of students in undergraduate computing programs [10]. Clearly there is still much work to be done to increase the diversity of students enrolled in undergraduate computing programs. Despite the commonly held belief that women and other underrepresented groups will be drawn to the social good aspects of computing, no studies have explicitly and statistically demonstrated that women are interested in and motivated by development of humanitarian applications of computing.

There are few statistically-based studies, however evidence exists that suggests the importance of having a positive social impact differs by gender and race/ethnicity outside of the context of computing. Some studies suggest that demonstrating the positive impact of computing is a key factor in attracting women to computing [1-3, 8-9, 13, 20, 25, 41] and, more widely, minority groups [4, 7, 22, 27, 41]. Tamer indicates that women are interested in careers with social impact [38]. Pearl reports on a study of 130 first year undergraduate student responses to the Volunteer Functions Inventory (VFI) [29]. Pearl reports that females are more strongly motivated, possibly due to the opportunity service-learning provides, to express positive attitudes towards social responsibility. Women find working on service-learning projects engages them in both their courses and the college environment. Guzman reports on a study conducted with the MIT Inclusive Innovation Challenge of more than 14,000 entrepreneurs on responses of entrepreneurs to messages of money and social impact [17]. The study found that women responded more strongly to the messages of social impact and less to the money messages. Mousa reports on an investigation into the motivation of volunteers who redistribute surplus food to low-income populations. The results indicate that women were more highly motivated than men when volunteering [28].

In addition to the studies that point to women's preference for socially relevant projects, several authors have identified additional factors that positively impact women's perception of computing, and more broadly the preference of underrepresented groups for such projects. One essential step to addressing the lack of diversity in computing education is the establishment of a diverse community of educators [23], however, this solution will take time to both implement and to impact the diversity of the students. Tracy identifies three pedagogical approaches to help reduce equity gaps including role modeling, highlighting stereotype threat, and modeling productive failure [39]. Zeitz discusses a repository of computing education assignments that support student engagement with issues of diversity, inclusion, and accessibility while highlighting their pervasiveness in computing [45]. Ihorn describes a successful interdisciplinary computing minor designed to improve diversity in computing which utilizes cohorts, peer and near-peer mentors, and small class sizes to support underrepresented students [21]. Kröhn describes a successful program which also uses mentoring to reduce the gender gap in undergraduate and master's computing programs [26].

On a larger scale, Ying [44] describes results of a study that indicates that many undergraduate students are unaware of the gender gap in computing, and those that are aware do not fully understand the cause of this gap. Washington broadens this need for training with a call for cultural competence within all university computing departments as a way to create a more diverse and inclusive community of computing educators and undergraduates [42]. Pournaghshband highlights the need to include aspects of race, age, socioeconomic class and gender in a multidimensional approach to supporting diversity efforts [32]. However, Tychonievich and Cohoon identify that such wholesale change requires time and effort [40].

Focusing on undergraduate engineering and computing students, several efforts have provided evidence that computing for social good motivates underrepresented groups to participate in computing. Dym [11] reports on bringing underrepresented groups into computing via engagement with computation to empower their own communities. Bielefeldt [4] presents a study that investigated the attitudes of female engineering students at the mid-point of their freshman year. Results indicated that the majority of women identified that helping people was their primary motivation for choosing the major. Shukla studied the attitudes of undergraduate business students toward community learning [37]. The study involved 209 students across all four years of an undergraduate degree. Results indicate that more women are interested in volunteering than men, and women were also more supportive of having class assignments related to community service than men.

This paper uses interest and motivation as the lens for looking at the issue of diversity in computing. Educational researchers have investigated the relationship between student interest and motivation and how they relate to student engagement [33, 35-36]. Renninger and Hidi [34] define interest as "the psychological state of a person during engagement as well as the cognitive and affective motivational disposition of that person to reengage with particular content … over time." whereas motivation "refers to the desire or will to do something and may or may not be due to a developing interest." If a student is interested in a topic, they will be motivated to learn it. But a student can be motivated even if they are not interested. Using the theories of interest and motivation provided a framework for this study.

The need to diversify the population of computing students is well-known, and there is broad evidence that women students find societal benefit of computing attractive. Within that context, this study focuses on a) looking separately at interest and motivation, b)

considering computing for social good as a context for assignments, which is possible in almost any computing course, and c) gathering data from introductory computing students.

3 METHODS

This section discussion how the prior work of the authors influenced the current study. The instrument creation and format are described, and the methods of data collection are explained.

3.1 Prior Work

The survey used in this study is a modification of a pilot survey conducted by the authors of this paper [13]. Results of this survey showed that women were more likely to choose humanitarian applications in their top three domains of interest than men. But review of the survey results raised questions about how to interpret the data since the technologies that would be needed for the various domains varied widely.

Based upon the analysis of that survey, the instrument was revised to more clearly identify students' interest and motivation to develop humanitarian computing applications. The pilot survey provided a list of 20 possible examples/programming assignments and asked students to pick the 3 they would be most interested in. The choices ranged widely from disaster management to password security to solar power making it difficult to determine if students were drawn to the humanitarian nature of the choice or the technological nature. The revised survey used several of these choices, but refined the questions into two parts, one to determine student interest and the second to determine student motivation. The choices in each part had pairs that used the same technology but had one humanitarian application of that technology and one non-humanitarian. The goal was to be able to make the choices technically equivalent, only differing in how that technology was used.

3.2 Instrument

The survey consisted of four parts. Part 1 had six questions, each of which provided students with a general type of app/program they might write and two options for a specific application, one with a humanitarian focus and the other non-humanitarian. Students were asked to choose which application they were more interested in developing. Sample questions are:

If you were working on an app for location tracking, would you rather write it to track:

- *Seasonal flu patients by location*
- *Pizza deliveries by location*

If you were writing an app to ensure data security, would you rather write it to protect:

- *Bank accounts of high profile clients*
- *Medical records of people with mental health issues*

The choices were designed so that one option had a business focus, whereas the other had a social impact. A list of the options is provided in Table 3. The question order and options were randomized for each survey taken. These questions will be referred to as **Would you rather (WYR)** questions and measured student **interest**.

Part 2 asked the respondent to rate how motivating they would find working on eight different applications as part of their programming course on a 5-point Likert scale: Not at all (1), A little (2), A moderate amount (3), Quite a bit (4), Extremely (5). Sample humanitarian items are:

Providing supplies to an area impacted by a natural disaster

Finding available shelter space for the homeless

and non-humanitarian items are:

Finding profitable locations for new stores

Managing a fantasy sports league

Once again, the choices were designed with a clear difference in focus between business and societal impact. A list of the options is provided in Table 4. The order of the items was randomized for each survey taken. These questions will be referred to as **Motivation to learn programming (MLP)** questions and measured student **motivation**.

Part 3 utilized questions from CRA's Data Buddies Survey [6] and asked participants to indicate the importance of various factors in one's career choice using the same 5-point Likert scale as Part 2. For example:

Work independently

Have a social impact

This data is still being analyzed.

Part 4 collected demographic information about the participant regarding major, age, gender identity, race/ethnicity, prior computing experience and status as a first-generation college student.

Questions were constructed in consultation with our social science consultant. Based upon the results of the pilot survey we designed questions where the technology use was constant and the application domain differed. A series of questions was developed and analyzed in aggregate.

3.3 Data Collection

Four institutions participated in the study: a community college, a small liberal arts college, a private university, and a public state university. All four institutions obtained IRB approval before the survey was distributed to students in undergraduate introductory computing courses that included some programming. Students were primarily in the early years of their undergraduate studies. The audience for the courses included both computing majors and students from other majors. The survey was conducted online at the beginning of the fall and spring terms during the 2020-2021 academic year. Students were told participation was voluntary and

that the purpose of the survey was to understand the attitudes of introductory students toward computing. A total of 376 students completed the survey, which resulted in 369 partially usable surveys. If a respondent chose not to answer the gender or answered it in a manner that did not allow for analysis (for example, they self-described their gender) their data was not used in this analysis.

4 DATA ANALYSIS

Of the 376 participants, seven students were under the age of 18 and were removed prior to data analysis. The remaining 369 respondents answered the gender identity question with 103 identifying as Woman, 254 as Man, 7 as Non-Binary, 4 preferred not to disclose and 1 self-described. The gender analysis includes the 364 participants who identified as Woman, Man or Non-Binary.

4.1 Humanitarian vs. Non-Humanitarian

The humanitarian choices were rated higher for the entire study population than the non-humanitarian options for both the **Would you rather** and the **Motivation to learn programming** questions. For the **Would you rather** questions, where students indicated their interest in either a humanitarian or non-humanitarian option, students chose an average of 4.13 humanitarian options out of 6, which means that the humanitarian options were chosen 68.9% of the time. A one-tailed, paired t-test was performed on the **Motivation to learn programming** questions which showed that students were more motivated by the humanitarian as opposed to the non-humanitarian options (hum mean = 3.65, non-hum mean = 2.79, $t(358) = 15.42$, $p<.001$). The Cohen's d result shows a significant large effect (0.931) that students were more motivated by the humanitarian computing options over the non-humanitarian. Knowing that students, regardless of their gender, were interested in and motivated by humanitarian applications is important as choosing examples that resonate with one group but not another would not be beneficial to the class as a whole.

4.2 Gender Identity

When looking at a single gender identity, the percent of **Would you rather (WYR)** questions, where the humanitarian choice was selected, was over 50% for all genders (Table 1), but women selected the humanitarian option 81% of the time, showing a strong interest in the options that promote social good.

Table 1: Results of within gender identity analysis of student interest in humanitarian application (Would you rather) questions

Gender	WYR Averages (max = 6)	WYR Percent
Woman	4.85	81%
Man	3.80	63%
Non-Binary	5.43	91%

On the **Motivation to learn programming (MLP)** questions, women rated the humanitarian options as more motivating than the non-humanitarian and the difference between those options is large (Table 2). A MANOVA was conducted with two dependent measures, preference for humanitarian applications and preference for non-humanitarian applications related to motivation to learn programming. Gender was the only independent variable with two levels. Wilks' criterion was used to demonstrate that there was a significant effect of the interaction between gender and the humanitarian versus non-humanitarian preferences, $F(1,346)=65.60$, $p<.001$. The results reflect a strong effect.

Table 2: Results of within gender identity analysis of student motivation of humanitarian options (Motivation to learn programming) H: Humanitarian, NH: Non-humanitarian

Gender	MLP – H Averages (max = 5)	MLP – NH Averages (max = 5)	MLP – H vs. NH One-tailed, paired t-test	MLP – H vs. NH Cohen's d effect size
Woman	3.91	2.45	$t(98) = 16.07$, $p<.001$	1.46, large effect
Man	3.53	2.94	$t(248) = 9.86$, $p<.001$	0.59, medium effect
Non-Binary	4.21	2.18	$t(7) = 5.15$, $p<.05$	2.04, large effect

One tailed, paired t-tests conducted on the **Motivation to learn programming (MLP)** questions rejected the null hypothesis of no difference in motivation between the humanitarian and non-humanitarian choices and indicate that students were significantly more motivated by the humanitarian options as opposed to the non-humanitarian. For women and men the results were at the $p<.001$ level and for non-binary students it was at the $p<.05$ level. Cohen's d were performed and revealed large effect sizes for women and non-binary students and a medium effect size for men (Table 2).

Across both the **Would you rather** and the **Motivation to learn programming** questions, the computing for social good aspect resonates with students, and women show a clear preference for humanitarian choices.

4.3 Individual Question Analysis

The survey was designed to provide questions about humanitarian applications across a variety of domain areas, including health care, natural disasters, education, homelessness, driver safety, wildlife preservation and human trafficking. The data revealed that not all humanitarian options held equal appeal.

The **Would you rather** question analysis revealed that 93% of women would prefer to work on a game to help hard of hearing children learn sign language as opposed to playing chess online. In addition, 93% of women would prefer to work on a registration app to register people to provide assistance for victims of an earthquake as opposed to registering people attending corporate training events. Table 3 shows the percentage of participants by gender who chose the humanitarian option (listed first in each pair of domains).

Table 3: Percent of students who chose the humanitarian domain over the non-humanitarian domain in the Would you rather questions

Domain	Woman	Man	Non-Binary
Flu vs. pizza delivery	68%	54%	86%
Mental health records vs. bank account records	81%	53%	100%
Sign language game vs. chess	93%	68%	71%
T-shirts for endangered wildlife vs. concert ticket purchase	82%	69%	86%
Registration for assistance for earth-quake victims vs. corporate training	93%	77%	100%
Advertising a blood drive vs. a new restaurant	69%	59%	100%

The **Motivation to learn programming** question analysis revealed that women were most motivated by the human trafficking, shelter space for the homeless, and supplies for natural disaster applications and least motivated by the fantasy sports league (Table 4).

The analysis by individual questions shows some interesting variations, which indicate that future work exploring the appeal of domains' applications would be interesting. At the same time, the preference for most of the humanitarian application domains supports the idea that humanitarian applications are broadly appealing to students.

Table 4: Average Likert scale preference (max = 5) for humanitarian (first four items) vs. non-humanitarian (last four items) options, grouped by gender

Domain	Woman	Man	Non-Binary
Human trafficking	4.19	3.58	4.43
Shelter space for homeless	4.06	3.43	4.57
Supplies for a natural disaster	4.08	3.66	4.43
Dangerous traffic intersections	3.32	3.45	3.43
Fantasy sports league	1.80	2.74	2.29
eCommerce app	2.40	3.03	1.57
Locations for new stores	2.76	3.27	2.57
Renting textbooks	2.86	2.71	2.23

5 DISCUSSION

Broadening participation in computing is the focus of substantial effort by the computing education community. This study focused on two research questions related to this effort:

R1*: Are women more interested in developing humanitarian applications than non-humanitarian applications?*

R2*: Do women find humanitarian applications more motivating than non-humanitarian applications?*

The results from this study answered "Yes" to both questions. For R1, women chose the humanitarian options over the non-humanitarian 81% of the time, demonstrating their interest in the social good aspect of computing. With regard to R2, women rated the humanitarian applications as being more motivating than the non-humanitarian options at a $p<.001$ level with a large effect size. Since both interest and motivation are critical to engagement, documenting both aspects are important when making decisions about how to engage all students, and women in particular.

Although not the focus of this paper, the preliminary results of non-binary student interest and motivation indicate that humanitarian applications are highly rated. However, the sample size for the non-binary group was small, making statistical testing less conclusive. Specifically, the Cohen's d test may amplify the effect size for small sample sizes. Further research should be done in this area.

The data set includes race/ethnicity information about the participants. This data is being analyzed to see if there are interest and motivation differences among groups. Preliminary results indicate that woman across all races/ethnicities are interested in and motivated by humanitarian applications, but the extent may differ among groups.

When looking at the individual questions, it is important to consider if preferences might be linked to issues of current events, culture and/or access. For example, were students not particularly interested in tracking the flu because the survey was administered during the COVID pandemic and flu seemed irrelevant? Or perhaps they were tired of hearing about illness? Women chose a game for hard of hearing students over a chess game. Is this because they were interested in sign language or disinterested in chess? There were general areas of interest in the humanitarian choices (disaster help and human trafficking) and general areas that lacked interest in the non-humanitarian choices (chess and fantasy sports). Although the survey was designed to incorporate a broad range of areas, the individual choices may have impacted the results. The survey tried to mitigate that possibility by asking multiple questions and averaging the choices together.

An additional limiting factor of the study is that the survey was administered only to schools in the US. It is difficult to know if students in other countries would have similar interests. The survey has not been validated which is also a limiting factor.

As the number of women completing degrees in computing is substantially lower than their male counterparts, choosing application areas that demonstrate the ability of computing to help others may be useful in engaging additional women while still motivating students of all genders. Making the social impacts of computing visible can be as simple as re-framing existing assignments with a humanitarian focus [7, 14-17, 24, 31] or as comprehensive as having students contribute to a humanitarian open source project [5, 12-13, 18-19,30,43]. Providing introductory computing students with projects that address societal issues, such as refugees, homeless shelters, food insecurity, or disaster management allows students to see how learning computing can help their communities. Incorporating humanitarian open source projects into software engineering or capstone courses allows students to gain first-hand experience with having a positive impact

on others. Contributing to projects that help people on their campus, their local communities, or globally, may encourage women to persist in computing because they see how their skills will directly help others.

6 CONCLUSIONS AND FUTURE WORK

Incorporating humanitarian examples and assignments into early computing courses can be interesting and motivating for students and particularly for women. This may encourage women to pursue a degree in computing. Involving students in open source projects for social good may improve retention of women students and provide them with motivation to complete their computing degrees and stay in the field.

An analysis of the race/ethnicity results from this study will help identify if the humanitarian nature of computing resonates with various groups of students. Understanding the impact on underrepresented groups may increase the incentive to choose humanitarian contexts for computing examples.

Additional studies need to be conducted with a larger sample to determine if the trends among non-binary students can be better substantiated. Future research should focus on which humanitarian application domains are of most interest to students. This would help educators design assignments that would engage their students and potentially motivate underrepresented groups in particular.

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