Piazza Participation in Georgia Institute of Technology's Online Masters of Computer Science Program

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ABSTRACT
Participation and sense of belonging are important to student success. The official means of course participation in Georgia Institute of Technology's Online Master of Science in Computer Science (OMSCS) program is the Piazza forum. This paper investigates Piazza usage across different subgroups in a recent OMSCS course, as well as self-reported usage and experiences with the Piazza tool. Findings show that female students posted statistically significant fewer words per post as compared to male students. Overall, female students posted at a lower rate than male students in every category of post data analyzed. Few significant differences were found between posting activity of students working in IT and those working outside of IT. Self-reported data showed a variety of attitudes towards and experiences with the Piazza forum. Some students highly value the forum, others find it too 'chaotic' to effectively use, several commented that the usefulness of the forum varies greatly by course, and almost a third of survey respondents reported feeling personally disrespected or offended by another student's post on at least one occasion.

Author Keywords
MOOC, gender, social learning, online higher education.

ACM Classification Keywords
H.4.3 Communications Applications: Bulletin boards

K.3.2 Computer and Information Science Education: Computer Science Education

INTRODUCTION
The OMSCS program educates 4,515 students from over 90 countries ("The Numbers", 2017). The program offers a top-tier Computer Science Masters Degree entirely online. The online nature of the program makes it crucial for there to be effective mechanisms for remote collaboration and communication. There are several communication channels available to students within and across OMSCS courses. Most of these channels, such as Slack, email, and Google Plus communities are informally established and managed by students. Only one channel, the Piazza forum, is officially utilized by the university. Each course section has a dedicated Piazza forum that instructors use to post announcements, assignment information, and important course links. Students are able to post questions, notes, polls, and follow up responses. Posts may be public (available to all students and instructors) or privately designated to instructors only. Some courses have a participation grade that is based on Piazza participation, others do not.

This project is centered around two research-based assumptions. The first assumption is that social learning and a feeling of belonging are keys to success in academic programs (Wright, et al 2014; McKay 2017; Foltz, et al 2014; May & Chubin, 2003). The second assumption is that certain groups experience feelings of inadequacy that can negatively impact their academic performance and participation (Steele, 2010; Spencer, et al, 1999). Lower levels of personal confidence have been found specifically in females in higher education STEM programs (Chachra and Kilgore, 2009; Kamas, et. al. 1993; Fisher, et al 1997; Hayes, 2017). Imposter Syndrome is a well-studied phenomena relating lower confidence levels with high-achieving individuals in both professional and academic spheres. Clance & Imes first identified this condition in professional women in 1978. An individual experiencing Imposter Syndrome questions whether or not she belongs in a given context, thinking that she is not smart enough or does not have enough experience to successfully participate in a particular professional or academic environment. Imposter Syndrome is not based on actual deficiencies in the individual, but on self-perceived inadequacies.

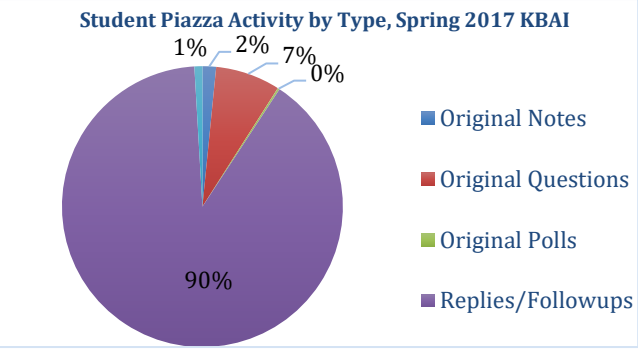
Based on research around Imposter Syndrome and stereotype threat, it is plausible that certain demographic groups are posting to Piazza at a lower than expected rate because of a lack of confidence and perceived feelings of not belonging in a top graduate CS program. If that is the case, then these groups' social learning opportunities are being limited and their academic outcomes may be lower than what they could be with full participation.

This paper aims to determine whether certain sub-groups in the OMSCS population are under-participating in the Piazza forum, as well as to begin investigation into why some groups under-participate (if that is found to be the case). These sub-groups are females, students who did not major in CS, students who are not currently working in a Computer Science related field, students who have relatively few years of programming experience, students with limited English proficiency, and students who are newer to the OMSCS program (having completed 3 or fewer courses).

METHODOLOGY AND DATA

There are two main sources of data for this project.

The first data source is Piazza post data from the OMSCS Spring 2017 Knowledge-Based Artificial Intelligence course. This data was downloaded using an API (Faran et al, 2014). The original form of the data was one json file per post. The json files were converted to csv files for processing by a Python program that summed each original post and follow-up by unique Piazza user id. The following chart shows the makeup of student-generated activity for this section.



Once all posts were organized by type and user id, the user id's were coded by gender and current occupation.

Gender was determined using a combination of student name and photo associated with the ID. If the name was gender-specific and the photo clearly implied a gender then a gender code of male or female was assigned. In cases where the name could be associated with either gender and the photo did not imply a gender then a gender code of 'undetermined' was assigned.

Occupation was determined using the 'Introductions' posts that were created at the start of the class. In those posts a majority (184 out of 197) of the users identified themselves to the class. The introductory question prompt included career, so most replies include mention of occupation. If the respondent indicated a career directly related to Computer Science (software developer, software architect, software engineer, web developer, data scientist, db administrator or designer, computer security analyst) then an occupation code of "CS related" was assigned. If the respondent indicated an occupation other than those in the CS related category then an occupation code of "non-CS related" was assigned. If the occupation was not clear or not mentioned then an occupation code of "unknown/not specified" was assigned.

Once coding was complete, statistical analysis was run on the coded dataset.

Independent variables were:

- gender
- current occupation

Dependent variables were:

- total number of questions posted to the forum
- total number of notes posted to the forum
- total number of polls posted to the forum
- total number of replies posted to the forum
- total number of 'student answer' section submissions on the forum
- average words per post across all types of posts on the forum.

The second data source is survey responses from a Piazza usage survey that was open between June 26 and July 9, 2017. The survey was created using Google Forms. Data was downloaded into a csv file and analyzed.

Independent variables were:

- Gender
- number of OMSCS courses completed
- current occupation
- undergraduate degree
- English proficiency
- years of programming experience

Dependent variables were:

- self-reported original posting activity on Piazza (includes notes, questions, and polls)
- self-reported reply activity on Piazza (includes any follow-up or student answer section submission)
- confidence in posting to Piazza
- feeling of belonging in the OMSCS program
- use of tools outside of Piazza for communication with peers
- experiences of disrespect or offence by other students while using the Piazza forum

For both data sources the following tools were used for data analysis:

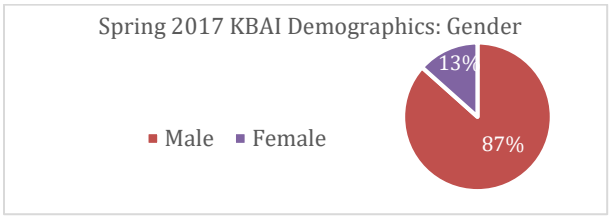
- R-Studio was used to compute Welch's t-test values, Mann-Whitney-Wilcoxon test values, Chi-square test values, Fisher exact test values, mean, and median; run multiple regression
- http://astatsa.com/FisherTest was used to verify Fisher and Chi-square test values
- Microsoft Excel was used to calculate student t-test values, verify means and create basic charts

The survey was implemented with Google Forms, and descriptive data pie charts from the survey were also generated by Google Forms.

Categorical data was evaluated using Chi-Square tests where possible (all data cells had a value >=5). When Chi-Square tests were not possible Fisher's Exact Test was used.

RESULTS – Spring 2017 KBAI Post Activity

Of the students for whom gender could be determined, the Spring 2017 OMSCS KBAI course had the following breakdown by gender. These are similar percentages to the overall OMSCS population ("The Numbers", 2017).



Based on the gender make-up of the course, one would expect approximately 13% of each post type to be authored by female students and approximately 87% of each post type to be authored by male students. The descriptive statistics below show that this is not the case. For each category the percentage of activity by females was below 13%.

	Authored by Female Students	Authored by Male Students
Original Notes	4 (9.8% of total)	37 (90.2% of total)
Original Polls	0 (0% of total)	6 (100% of total)
Original Questions	22 (11.3% of total)	173 (88.7% of total)
All Replies	234 (10% of total)	2111 (90% of total)
Student Answer Section Submissions	1 (4.2% of total)	23 (95.8% of total)

The next analysis run was comparing the average, or mean number of each post type by gender. Several types of t-tests were run to determine significance. Three types of tests were run because not all data was normally distributed, and because the female sample size was smaller than the male sample size. The Mann-Whitney-Wilcoxon test was chosen because it does not assume normality and Welch's t-test was chosen because it does not assume a similar sample size across the groups being compared.

Dependent Variable	Average # per female	Average # per male	Student t-Test p-value	Mann-Whitney test p-value	Welch's t-test p-value
Original Notes	0.154	0.22	0.62	0.454	0.6156
Original Questions	0.846	1.03	0.66	0.59	0.6552
Original Polls	0	0.357	0.0139*	0.7712	0.01386*
All Replies	9	12.565	0.22	0.9834	0.221
Student Answer Submissions	0.0385	0.137	0.065**	0.2713	0.06456**
Average Number Words per Post	63.346	81.839	0.0216*	0.02303*	0.02155*

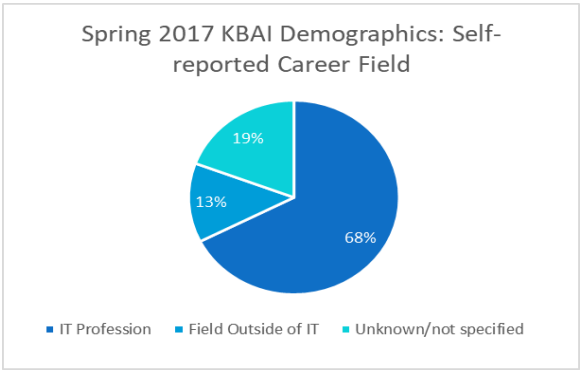
* significant at the 95% confidence interval

** significant at the 90% confidence interval

The average number of posts and average words per post for female students were lower than the averages for male students in every category. The difference in average words per post was found to be statistically significant at the 95% confidence interval in each of the three tests chosen. The difference in number of polls was found to be significant in two of the three tests, however since the number of polls was so low (6) the Mann-Whitney test correctly discounts the significance because of skewedness.

Student Answer submissions were statistically significant at the 90% confidence interval for two of the three tests. Nineteen male students posted to the Student Answer section (and of that group some posted more than once) while only 1 female student contributed to that section.

The next set of analysis was posting activity by self-reported occupation. The course had the following demographic.



The following data analysis was performed only on students for which occupation was known.

Dependent Variable	Average # per student working in IT	Average # per student working outside of IT	Student t-Test p-value	Mann-Whitney test p-value	Welch's t-test p-value
Original Notes	0.2273	0.2308	0.98	0.8729	0.9837
Original Questions	0.9015	1.3333	0.34	0.6384	0.4611
Original Polls	0.0455	0	0.0137*	0.7188	0.0137*

All Replies	12.7424	14.3461	0.74	0.7263	0.7381
Student Answer Submissions	0.106	0.1923	0.47	0.7642	0.5425
Average Number of Words per Post	80.28	68.615	0.1**	0.2842	0.1083

*at the 95% confidence interval

** significant at the 90% confidence interval

Very few differences were found between posting activity of those who work in IT and those who work outside of IT. Though poll activity appeared statistically significant, the low number of polls created removes its usefulness as a data point.

Multiple regression was run to see if there were any significant differences by gender or occupation when the variables were analyzed together. The only statistically significant difference found was in the Original Question category. The following shows the results from R-studio of this analysis.

Female Students = 1
NonIT Occupation = 1

```
Call:
lm(formula = mydata$OrigQuestions ~ factor(mydata$Gender) + factor(mydata$Job),
    data = mydata)

Residuals:
    Min      1Q  Median      3Q     Max
-2.0576 -0.9997 -0.9997  0.0003 18.9424

Coefficients:
                        Estimate Std. Error t value Pr(>|t|)
(Intercept)              0.9997     0.2008   4.977 1.72e-06 ***
factor(mydata$Gender)1  -0.9200     0.5412  -1.700   0.0912 .
factor(mydata$Job)1      1.0579     0.4933   2.145   0.0336 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.215 on 153 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.03949,    Adjusted R-squared:  0.02693
F-statistic: 3.145 on 2 and 153 DF,  p-value: 0.04586
```

The p-value of the overall model is 0.04586, which is statistically significant at the 95% confidence level. There is no statistically significant difference in the number of original questions posted by female students when controlling for gender (p = 0.0912). There is a statistically significant difference in the number of original questions posted by students working outside of IT when controlling for gender (p = 0.0336). When controlling for gender, students working outside of IT post on average 1.06 more questions than students working in IT.

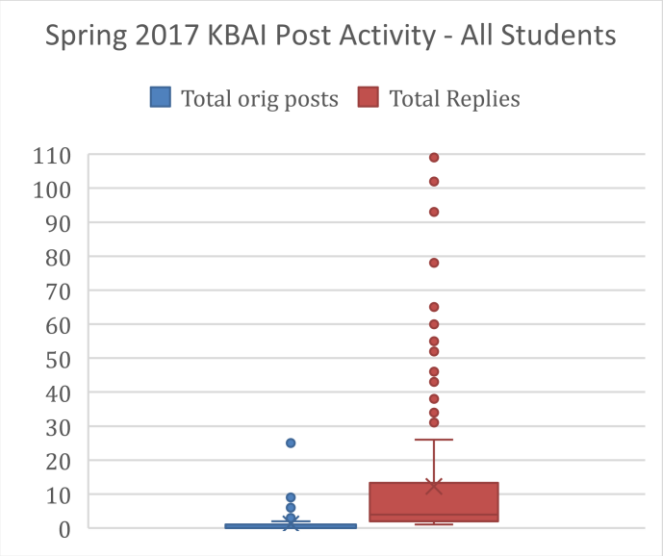
Perhaps the most surprising finding was the high percentages of students who did not participate at all, or who participated a small number of times. Fifty-eight percentage of female students and 55% of male students *never* posted an original note, question, or poll at any time during the semester. Fifty percent of female students and 53% of male students posted a reply/follow-up 4 or fewer times in the 17 week semester. When the introductions post was removed from analysis there were 45 students that never posted to the forum. This means that almost a quarter of the class (23%) had no interaction on Piazza outside of giving a brief introduction to themselves the first week of class. The data and box plots below show the distribution of posting across all students.

Spring 2017 KBAI Original Posts – All students

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
0.000	0.000	0.000	1.247	1.000	25.000

Spring 2017 KBAI Replies – All students

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1.00	2.00	4.00	12.21	12.75	109.00



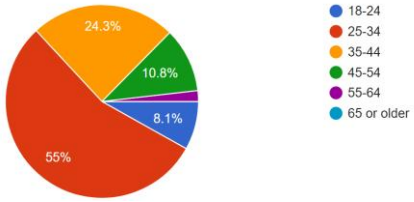
While there were some students who posted a great deal (ex: 6 students posted more than 75 replies each), the majority of students in the course posted replies less than once a month, and a majority never posted an original item to the forum.

RESULTS – Survey Data

A total of 111 current OMSCS students responded to the survey over the two week period it was open. The following charts show the demographic breakdown of the respondents.

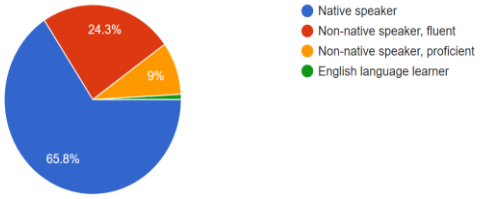
What is your age?

111 responses



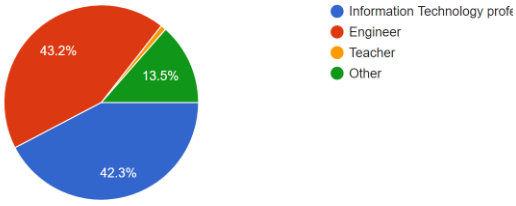
How would you describe your English language proficiency?

111 responses



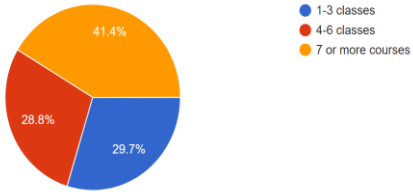
Which best describes your current occupation?

111 responses



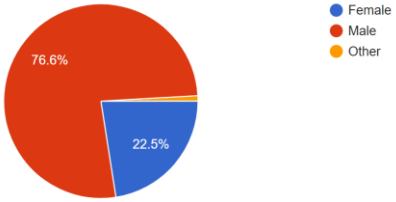
How many courses have you completed so far in the OMSCS program?

111 responses



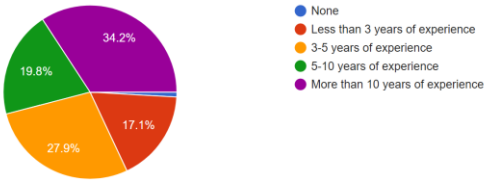
What is your gender?

111 responses



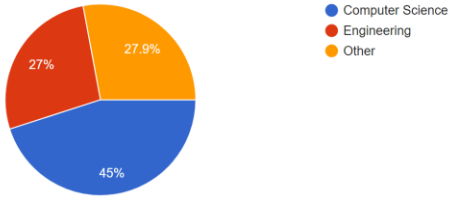
About how many years of programming experience do you have?

111 responses



What was your undergraduate major?

111 responses

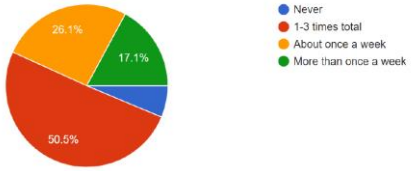


The next set of charts show the survey results.

Posting Activity

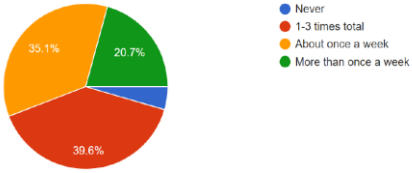
In your most recently completed OMSCS class, how many times did you post a question, note, or poll to the Piazza forum? If you completed two or more courses last semester please choose one course to base your answer on.

111 responses



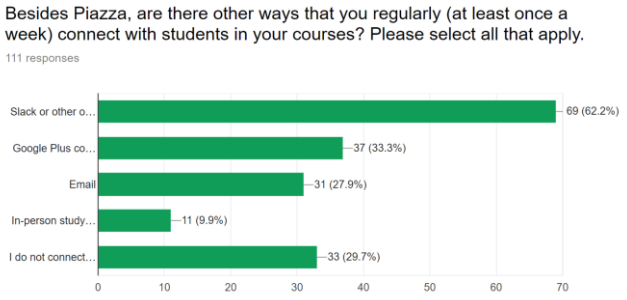
In your most recently completed OMSCS class, how many times did you reply to another student's question on the Piazza forum? If you completed two or more courses last semester please choose one course to base your answer on.

111 responses



There was no significant relationship found between posting activity and any of the independent variables.

Connecting Outside of Piazza

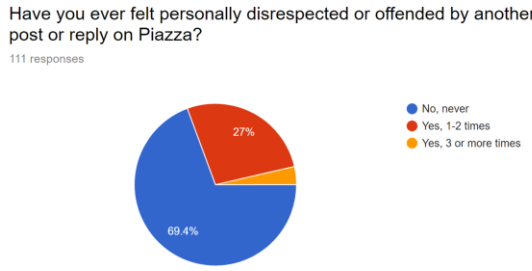


Thirty percent of respondents reported that they do not connect outside of Piazza, while 70% connect via Slack (or similar platform), Google Plus, email, or in-person study groups. There was no statistically significant relationship found between connecting outside of Piazza and any of the independent variables, meaning that students appear to connect outside of Piazza at the same rate regardless of demographic group.

Confidence in Posting

A large majority of respondents (78%) reported being moderately to extremely confident in posting to the forum. Only 6% of respondents reported being "not at all confident". There was no statistically significant relationship found between confidence in posting and any of the independent variables.

Negative Experiences on Piazza

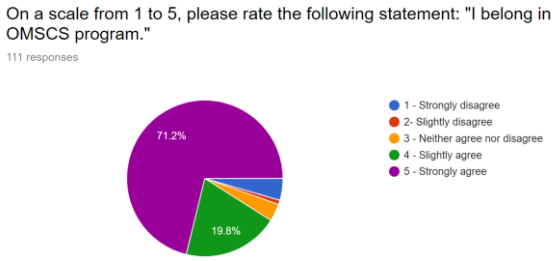


Almost a third (31%) of respondents reported feeling personally offended or disrespected by another student's Piazza post. There was a statistically significant relationship found between undergraduate major and feeling of disrespect. The Fisher Exact Test p-value was 0.037, and the Chi-Square test output is below.

```
> tbl = table(surveyData$Undergrad, surveyData$Disrespected)
> summary(tbl)
Number of cases in table: 111
Number of factors: 2
Test for independence of all factors:
        Chisq = 6.708, df = 2, p-value = 0.03494
```

Engineering majors had a higher than expected number of students reporting one or more incidence of disrespect, while students with non CS and non Engineering majors had a lower than expected incidence of reported disrespect.

Feeling of Belonging



A large majority (91%) of respondents feel that they belong in the OMSCS program.

Fishers Exact Test showed that feeling of belonging and undergraduate major were not independent at the 95% confidence level with a p-value of 0.036. Computer Science majors had a higher than expected sense of belonging while students from non CS and non Engineering majors had lower than expected sense of belonging. Such a small percentage of students reported feeling low levels of confidence (5 out of 111) more research would be needed to confirm results.

DISCUSSION

There were few statistically significant differences in posting activity by gender or by occupation. Though the results were not statistically significant, females posted at a lower than expected rate in every category studied when the percentage of females in the course was used as the expected rate. Considering the already low percentage of females in the OMSCS program, it is concerning that less than 10% of the forum notes, 10% of the forum replies, less than 5 % of the student answer submissions, and none of the polls were authored by female students. In addition, female students posted significantly fewer words per post when compared to male students.

Hayes' research (2017) showed that female students enter OMSCS with fewer years of programming experience as compared to male students, therefore one may expect female students to ask more questions on the Piazza forum. That was not the case in the data analyzed, female students on average asked fewer questions than male students in Spring 2017 KBAI. Lack of confidence could be one of the factors leading to lower participation levels. Hayes' research also showed that females in OMSCS have statistically significant lower levels of confidence as compared to male students. When one is not confident in his/her knowledge or ability, or when one feels that he/she does not belong in a given context, one may be reluctant to engage with peers.

Spring 2017 KBAI is only one of almost 30 courses in the OMSCS program. In order to get a wider picture of student Piazza usage and experiences across the entire program, the more qualitative Piazza usage survey data proved extremely helpful.

Survey results showed no statistically significant relationships between self-reported posting activity and gender, age, coding experience, number of OMSCS courses completed, or undergraduate major. There was also little relationship between demographics and confidence in posting, and between demographics and connecting outside of Piazza. There were some statistically significant findings between undergraduate major and feeling of belonging in OMSCS, as well as undergraduate major and experience of disrespect on Piazza. The number of students who reported being English Language Learners was too low to fully analyze the relationship between lower English proficiency and the dependent variables studied.

Key Survey Finding 1: Many students, regardless of demographic, are not regularly using the Piazza forum. For the purpose of this paper 'low participation' will be defined as 0-3 original posts total a semester and 0-3 replies/follow-ups a semester. These values were chosen assuming a 17 week semester. A student posting 3 times in a 17 week semester is posting on average once every 5.7 weeks, or less than once a month. By this definition, nearly 57% of respondents have low original posting activity and 44% respondents have low reply/follow-up activity.

One of the intents of the Piazza forum is to simulate the discussions that would occur in-person in the traditional classroom. Just as in the traditional classroom, some students are not comfortable contributing ideas, thoughts, answers, or their own questions to the larger group. What is different from the traditional classroom is that in the traditional classroom a professor can call on specific students who are not volunteering, give students class time to discuss a concept in pairs/small groups, and encourage participation with nonverbal cues such as eye contact and proximity. The online classroom relies mostly on students choosing to participate, and clearly many are choosing not to.

One explanation for low Piazza usage could be that 70% of survey respondents reported that they connect with peers outside of Piazza. Thirty percent, however, reported that they do not use a tool or platform outside of Piazza. This means that there are students who rarely, if ever, interact with their classmates. Some may argue that low participation is not a problem, and that there is no harm in some students choosing not to contribute or ask questions. Social Learning theory, however, would caution that much is lost when groups of students avoid classroom interaction. The students choosing not to participate are losing out on their classmates' knowledge and insights. Perhaps less obvious is that students who are participating lose out on the full breadth of skills and experience of the class when some choose not to post.

Key Survey Finding 2: More than 30% of respondents have felt personally offended or disrespected on Piazza by another student. The survey did not ask about feeling personally offended or disrespected by an instructor, however one respondent volunteered in the comments section the following: "I have had a professor respond with an inappropriate response, both privately and publicly on Piazza, which is not reflected in your survey. It was extremely inappropriate but unfortunately, I did not know of the correct avenue to report it.". A different student offered this comment: "too many professors either ignore or are assholes on piazza questions."

Another student's comments indicated fear of 'being mocked' on the forum. The student wrote: "refrain from making questions on piazza to avoid being mocked by the know it alls in the class, professors expect experts in the class so if we are novice in a subject avoid posting anything."

In a program made up of students from all over the world there are many cultural differences that could result in misunderstandings. Issues can also ensue from the online/impersonal nature of the forum. Finally, there are many OMSCS students for whom English is not their first language. These students may misinterpret something that was not meant to offend, or say something themselves that is misinterpreted. If a student has felt offended or disrespected in the past, whether the incident was intentional or innocent, there will likely be hesitancy to use the forum again.

Key Survey Finding 3: Some students find Piazza valuable and follow forum activity regularly, however this seems to depend on the course and instructor. More than one respondent self-identified as a 'lurker'… meaning that he or she did not generate or reply to posts but viewed others' posts and used them as part of the learning experience. Other students mentioned specific courses where they found Piazza helpful. Some mentioned the importance of the instructor in establishing the tone and usefulness of the Piazza environment.

Key Survey Finding 4: Multiple students reported that Piazza is chaotic and hard to follow. This was especially true, according to respondents, for the larger courses that serve 400-500 students per section. Some comments that reflect this are: "Piazza does not scale well. In larger classes, it is a nightmare to keep up or find relevant information." "Too many posts! I use it as a reference to look up answers to questions I have, but there are so many posts it's impossible to read them all. Especially because so many of them are repeats of each other." "Piazza is really good for discussions and comments. The only issue i face with piazza is that for longer discussions its not well organized and its really easy to get lost in comments while reading a long page."

Based on Spring 2017 KBAI usage data and survey results the following initial conclusions can be made.

- Most OMSCS students do not post to Piazza regularly
    - This is *not* likely due to lack of confidence or lack of sense of belonging in the OMSCS program
    - This is *not* likely due to occupation, undergraduate major, number of OMSCS courses completed, or years of programming experience
    - There may be linkages between gender and Piazza activity, especially in the length of posts
    - Use of tools outside of Piazza (Slack, Google Plus, etc) is likely contributing to lower Piazza usage
    - Perceived 'noise' and disorganization of Piazza is likely contributing to lower Piazza usage
    - Bad experiences on Piazza, for instance being personally offended or disrespected in the past, could be suppressing Piazza usage
- Piazza can be extremely valuable, however it can also be misused. Students' experiences with the tool vary widely.

LIMITATIONS

The first limitation of this study was the small subgroup sizes of the survey respondents. A total of 111 students responded to the survey, however the number of students in English Language Learner and age > 55 sub groups were so small that the data in these categories was not able to be fully analyzed using Chi-Square tests. In the case of age, the >55 sub-group was collapsed with the 45-54 sub-group. There was no way to collapse English Language Learners with another category to fully understand the impact of limited language proficiency on participation, so this is still an unexplored relationship.

The second limitation was use of photo and name to determine gender. Preferably this information would have been self-reported, however survey data with this information was not available. In order to mitigate the risk of incorrectly coding a user's gender various websites were consulted in which a name is entered and the typical gender associated with the name is returned. Photos were then used to confirm gender, and in cases where gender was not clear the user was not included in gender analysis.

RECOMMENDATIONS

The primary recommendation coming out of this research is to improve the effectiveness of the Piazza environment for all students. There are four suggestions for achieving this based on this paper's findings.

First, larger sections can be broken down into smaller Piazza groups for each course. Instead of 500 students posting to the same forum, 5 smaller forums of 100 students each could be established. This would allow students to 'get to know one another' more easily as compared to a course with hundreds of other students. This change would address the criticism related to the 'noise' on Piazza. It may also encourage a stronger sense of community as students recognize one another more often in their posts.

Second, instructors should be active on the forums. This engagement involves posting original notes, follow ups to student notes/questions, and regular evaluation of posts to ensure that all students are respectful of their peers. The instructor role need not be filled just by professors, TAs should be utilized as much as possible to interact and monitor course activity. Over 30% of survey respondents have felt personally disrespected or offended by another student on Piazza. If instructors are regularly monitoring posts and replies, and if students feel comfortable enough to report offensive or disrespectful posts, then hopefully this number can be reduced greatly.

Sadly some of the negative experiences on Piazza are because of instructors' comments. Therefore it is recommended that Georgia Tech CIOS survey include specific language related to Piazza and each instructor's activity on the forum. Currently the survey only asks students to rate the instructor's "respect and concern for students", and the only question related to Piazza asks students to rate "Degree to which learning was facilitated by course-related interactions with peers occurring in or out of class". It is recommended that more direct questions be asked of students about instructors' effective and respectful activity on Piazza, and about the tone and climate of Piazza throughout the course. The university should take seriously any CIOS results that show specific instructors or courses associated with a climate of disrespect on Piazza.

Finally, meaningful Piazza participation should be encouraged in OMSCS courses. Participation grades are one way of doing this, however participation should not be judged simply by number of posts or number of words posted. With smaller Piazza groupings and dedicated instructors per group it should be possible to judge truly meaningful posts from those intended simply to increase user statistics. In order to stimulate Piazza activity instructors can pose thoughtful and relevant questions to the class, create polls, and post interesting or controversial articles.

It is also recommended that further research be done on a variety of OMSCS courses to determine the relationship between posting activity and gender, as well as posting activity and English language learners. Instead of having students self-report English language proficiency it is

recommended that a standard measure such as TOEFL score be used as the independent variable. This will allow for more robust analysis on any relationships.

The goal of OMSCS should not be 100% Piazza participation. Some students will naturally prefer other ways of communicating with their peers, and some will always choose to work in isolation. The goal should be that all students who want to connect feel comfortable doing so on Piazza, and that Piazza has meaningful and organized content that students value in the learning process.

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