

An Analysis of Academic and Social Experiences of Transfer Students in Computer Science

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ABSTRACT

A major proportion of undergraduate students enrolled in Computer Science (CS) courses at four-year research-intensive universities are transfer students from two-year community colleges. Prior work has shown that while transfer students report that their previous institutions have prepared them well, they still tend to perform lower and have lower overall GPAs when compared to native students at four-year institutions. Although prior studies have identified some issues that CS transfer students face with their academic and social adjustment, fine-grained details about the academic achievement and social experiences of CS transfer students in introductory CS courses is still unknown. In this study, we seek to better understand transfer student experiences in CS using weekly surveys and course grades from three CS courses. Based on our analysis of the weekly surveys and students' grades, we found that in most cases transfer students report a lower prior programming experience than native students and also tend to perform lower than native students on all course components including programming assignments. We also found that transfer students felt comfortable reaching out to fewer students in introductory CS courses when compared to their native counterparts. We believe that our study will shed more light about the experiences of transfer students learning CS at a four-year research-intensive university.

CCS CONCEPTS

• Social and professional topics → Computer science education.

KEYWORDS

Transfer students; Native students; Academic performance; Social Experience; Prior programming experience; Computer science education

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1 INTRODUCTION

A large number of students in the United States enroll in 2-year institutions every year [10]. Students often apply to community colleges or other 2-year institutions because of the low costs and less

competitive open admission policy hoping that they would be as successful as their 4-year counterparts (native students). However, only 14-percent of the students who enrolled in community colleges completed a bachelor's degree within six years and only 33-percent of the students who enrolled in a community college joined a 4-year institution [13].

Transfer students are essential to the diversity of students in computer science. More than half of the women who get a bachelor's degree in computer science start from a community college [11]. Traditionally underrepresented groups in computer science (such as Hispanics and African Americans) are over-represented in community colleges [20]. Thus, community colleges and transfer students are the key to increasing the diversity of students studying CS and despite this, transfer students in STEM and CS often face significant difficulty while transferring to the 4-year institution [25]. Past studies have tried to explore how the GPA of transfer students get affected after transferring [12]. A meta-analysis of these studies showed that most studies concluded that transfer students do experience a decrease in their GPAs after transferring [12].

While many studies have focused on GPAs and overall course grades of transfer students in Computer Science [9, 12, 16, 24], to the best of our knowledge there are no studies that dive deep into various components of a CS course in an attempt to explore if there are certain aspects where transfer students might be performing differently in comparison to native students. In our study we explore in detail, the academic performance and social experiences of transfer and native students in introductory computer science courses at a 4-year research-intensive public university in the United States.

Our research questions are the following:

- (1) *Is there a difference in the prior programming experience of transfer and native students?*
- (2) *Is there a difference in the overall course performance between transfer and native students in introductory CS courses? How do transfer students fare in different components of CS courses when compared to native students?*
- (3) *Is there a difference in the social experiences of transfer and native students within different introductory CS courses?*

We use the student grades (on programming assignments, exams, and classroom participation) and survey data from a pre-survey and weekly surveys distributed throughout the quarter for answering our research questions.

Our study provides a fine-grained analysis on the academic performance and social experiences of transfer students in introductory computer science courses. We believe that our study contributes to a better understanding of the experiences of transfer students in computer science. We hope that our study will enable discussions among our computing education community to develop interventions to aid transfer students to be successful and to provide them a richer academic and social experience at a 4-year research-intensive institution.

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2 RELATED WORK

Harrison et.al. studied the social and academic experiences of transfer students in CS and how these experiences differed from those of native students [16]. They found that there was no significant difference in social adjustment but this was not the case for academic adjustment. More specifically, there was a 68 percent chance that a random native student found academic adjustment to be easier, and a 75 percent chance that a random third-year transfer student had a lower GPA compared to a third-year native student. Interview results showed that transfer students felt really confident in their previous institutions preparing them, yet the data still reflected difficulty in academic adjustment and lower overall GPAs.

Mary R. Anderson-Rowland evaluated the success of an academic scholarship program that aimed to increase the retention rate of transfer students in CS [7]. The scholarship program placed additional focus on networking and support - this was done by conducting a graduate student panel and getting career service representatives to inform transfer students about internships. They found the overall retention rate to be 89.8 percent, which deemed the scholarship program a success.

Louise Ann Lyon et.al. conducted a study to better understand challenges and experiences of transfer students [19]. Surveys and interviews were administered to community college students to collect demographic data and find out details about CS transfer pathways and career opportunities available to students. Some key findings of the study were that transfer students struggled to complete all the CS prerequisites to transfer, they had limited knowledge of how to best prepare for internships and they weren't completely clear about transfer pathways (i.e - which classes and grades were required in order to transfer).

Sandra Katz et.al. conducted a study that looked at the correlation between exposure to specific programming skills and performance differences between men and women in CS classes [14]. Surveys were administered at the beginning and end of the courses to collect the required information. One of the key takeaways of the study was that earlier exposure to programming was a direct predictor of success for men, but not women. One reason for this was that prior programming experience for women often came at the expense of developing math skills. Women that developed both skills were found to have better performance in the CS courses.

Patricia E. Diaz conducted a meta-analysis of studies from the 20th century on the academic performance of transfer students [12]. 49 of the 62 studies showed that transfer students faced transfer shock (a decrease in their GPA after transferring). It was also observed that 33 of the 49 studies showed that there was some form of recovery made by transfer students after the first semester.

Our study builds on prior work as it considers the fine-grained details about the changes in academic and social experiences as transfer students enroll in successive CS classes at research-intensive universities. Our work also contributes new knowledge to computing education as it considers the role of prior experience and social interaction in a transfer student's adjustment and experience at a four-year university.

3 METHODOLOGY

3.1 Data Collection

In order to collect data about experiences of transfer and native students, a pre-survey and a weekly survey were designed. The pre-survey was sent out in the beginning of the quarter to collect demographic data about both groups of students - this included the students' race, ethnicity, gender and prior programming experience. The weekly surveys were designed to get information about the experiences of the students in the class - one question asked students to report how many people they felt comfortable reaching out to. (The complete surveys can be found here: <http://bit.do/fa19-surveys>) These surveys were sent across the three different CS courses for the Fall 2019 quarter: CS 1 - Introduction to Computer Science (Part I); CS 1A - Introduction to Computer Science (Accelerated); and CS 2 - Introduction to Data Structures. CS 1A is an accelerated course which covers the contents of CS 1 and CS 1.5 (Introduction to Computer Science Part II) in a single quarter. However, this study does not include CS 1.5 because the data collected for the course was incomplete.

The pre-survey explicitly asked the students "Did you enter the university as a transfer student from another (2-year or 4-year) college or university?". This was a required question and the students were given the options of "Yes" or "No" to respond. The data from the pre-survey along with the weekly surveys (which were distributed around eight to ten times during the ten weeks of the course) was collected for all the students. Additionally, the grades for all the components of the course which affected the overall grade were also recorded for the students in each of the three courses. We analysed the data from the surveys along with the grades of the students across different components of each course in an attempt to understand the academic and social experiences of transfer students in introductory computer science courses and to understand how it differed from that of native students.

3.2 Data Analysis

To find the difference in the prior programming experience of transfer and native students, the results from the pre-survey were used. The pre-survey required students to indicate their prior programming experience on a 5-point Likert Scale. A rating of 1 corresponded to no programming experience whatsoever before beginning at the current 4-year institution and a rating of 5 corresponded to a significant amount of programming experience. Due to the ordinal form of the data, we used the Mann-Whitney U Test to test for statistical significance between the responses of the two groups. We also removed the data for students who dropped out of the class so that any inferences made could focus on only those students for whom the entire component-wise course grade breakdown was available.

One of the research questions tries to find the difference in the performance of transfer and native students for each component of the course along with their weekly performance. Apart from the overall course grades, we also compared the grades received by transfer and native students in weekly programming assignments, exams and lecture participation wherever applicable. We dropped the two lowest participation scores for all students because a similar policy was followed in the overall grade calculation by

the instructors. Since the grades received by transfer and native students rarely followed a normal distribution with similar standard deviations, the conditions required for an independent t-test were not satisfied. For instance, it was observed that the distributions of the PA scores for students in CS 1A were skewed with a large number of students scoring above ninety percent. Therefore, we decided to perform the Mann-Whitney U Test to test for statistical significance in the difference of the performance of the two groups in each course component. Also, students who had dropped the class were removed from the data set since dropping the class would mean that the student would get an automatic zero for all the assignments or exams they did not submit, which would bias the data.

To understand the social aspects of the experience of transfer students in computer science courses we used their response to the question "How many other students in the course do you feel comfortable reaching out to study with?" from the weekly survey. The results obtained from these surveys, however, contained some values larger than the number of students enrolled in the course and some negative values. After removing these junk values, we constructed box plots for the data to check for outliers. We found that in general values greater than twenty were shown as outliers, and chose twenty as the upper limit. A lower limit of zero seemed reasonable as it was plausible that some students were not comfortable reaching out to any other students in the class. We also computed the z-scores of the data-points to confirm if the values with an absolute value of z-score greater than 2.5 were somewhere around twenty in most cases. All numbers reported above twenty were removed from the data, since it could be safely assumed that most of these numbers were not reported by a student seriously. As we were dealing with discrete valued data, and the data values were not normally distributed and skewed towards the left the conditions for the t-test were not satisfied. Instead, we used the Mann-Whitney U Test to test for statistical significance in the difference between the two groups and recorded the weekly observations for all the three courses.

We used the following packages for data analysis: Pandas [2], NumPy [1], SciPy [4], Seaborn [5], and Pingouin [3].

4 RESULTS

In this section, we present all our findings from the data analysis. Our results are organized by the three research questions (RQs) we looked at. Each RQ compared different aspects of transfer (T) and native (N) students' academic and social experiences in three lower division CS classes: CS 1, CS 1A and CS 2. After considering a visual interpretation of the data, the Mann-Whitney U test was conducted to see if the data was statistically significant. All hypothesis testing used an alpha value of 0.05 for significance.

4.1 RQ 1: Is there a difference in prior programming experience of transfer and native students?

Since transfer students attend community college for two years where they would have enrolled in CS courses, we hypothesized that they should have more prior programming experience than native students.

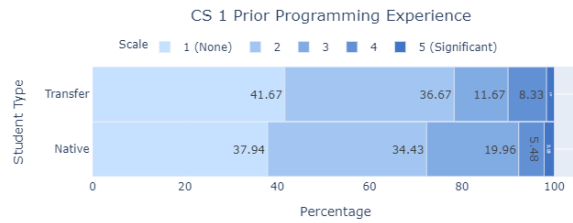


Figure 1: Number of transfer and native students that reported each level of prior programming experience in CS 1

Figure 1 shows that in CS 1, a higher percentage of transfer students self-reported that they had no prior programming experience, compared to native students.

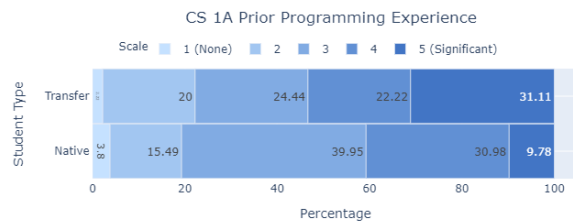


Figure 2: Number of transfer and native students that reported each level of prior programming experience in CS 1A

Figure 2 shows that in CS 1A, a higher percentage of transfer students self-reported that they had significant prior programming experience, compared to native students.

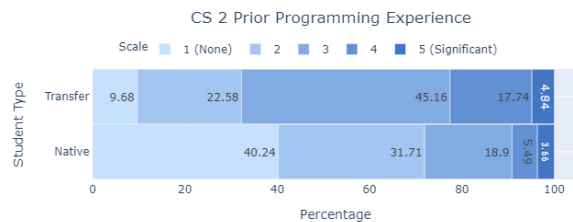


Figure 3: Number of transfer and native students that reported each level of prior programming experience in CS 2

Figure 3 shows that in CS 2, fewer transfer students reported having no prior programming experience and instead reported having prior experience of level three and above. It is interesting to note that many native students and a few transfer students report no prior experience even in CS 2.

Next, to see if the difference was statistically significant, we conducted the Mann-Whitney U test since the data was ordinal.

group	N	M	Mdn	SD	U	p	RBC
T 1	60	1.9	2.0	1.0	12942.5	0.473	0.054
N 1	456	2.0	2.0	1.0			
T 1A	45	3.6	4.0	1.2	6931.0	0.062	-0.163
N 1A	368	3.3	3.0	1.0			
T 2	62	2.9	3.0	1.0	2772.5	p < 0.001	-0.455
N 2	164	2.0	2.0	1.1			

T (transfer students) and N (native students) are followed by the class name. For example, T 1A indicates that the values correspond to transfer students in CS 1A; N is the number of transfer and students that completed the pre-survey and completed the entire course; M = mean, Mdn = median; SD = standard deviation; U = Mann-Whitney U test statistic; p = p-value; RBC = rank-biserial correlation effect size

Table 1: Summary of results for prior programming experiences of transfer and native students across all three CS classes

Table 1 summarizes the results of the Mann-Whitney U test. From Table 1 we can see that for CS 1 and CS 1A, there was no statistically significant difference in the prior experience reported by transfer and native students. However, for CS 2, this difference was statistically significant. Hence, transfer students had significantly greater prior programming experience than native students in one out of the three CS classes: CS 2.

4.2 RQ 2: Is there a difference in overall course performance between transfer and native students?

We analyzed four different components: the final exam, weekly PAs, class participation and overall weighted grade. We conducted the Mann-Whitney U test since our data was not normally distributed.

Our findings comparing the U test results for all transfer and native students across the three courses can be found in Tables 2, 3, 4, and 5.

group	N	M	Mdn	SD	U	p	RBC
T 1	60	66.0	72.0	23.4	7412.0	p < 0.001	0.462
N 1	459	81.4	85.3	16.6			
T 1A	43	81.5	84.2	15.8	5737.5	0.003	0.281
N 1A	371	87.3	90.0	9.0			
T 2	62	66.4	73.2	22.7	4196.5	0.043	0.175
N 2	164	72.3	77.6	19.3			

N is the number of transfer and native students that completed the entire course

Table 2: Summary of results for final exam of transfer and native students

From Table 2 we can see that transfer students perform lower than native students on the final exam for all three courses: CS 1, CS 1A and CS 2. This difference was shown to be significantly different for all three CS classes. We observe a decline in the RBC effect size for the final exam scores as we go from CS 1(A) to CS 2, indicating a bridging gap between the performance of native and transfer students. Next, we consider performance in the weekly PAs.

group	N	M	Mdn	SD	U	p	RBC
T 1	60	71.9	76.5	15.4	8602.0	p < 0.001	0.375
N 1	459	79.3	83.3	12.4			
T 1A	43	84.9	89.4	12.4	7460.5	0.437	-0.065
N 1A	371	88.5	90.0	4.3			
T 2	62	65.0	68.4	16.9	3452.0	p < 0.001	0.321
N 2	164	72.3	77.7	15.2			

Table 3: Summary of results of overall PAs scores earned by transfer and native students

From Table 3 we can see that transfer students perform lower than native students on PAs in all three CS courses: CS 1, CS 1A and CS 2. However, this difference was only shown to be significantly different for CS 1 and CS 2. We can also observe that while the mean for transfer students is much lower than that of native students, the medians are somewhat similar. This along with the negative RBC effect size and the high standard deviation for CS 1A imply that there is a small group of transfer students who performed very poorly although most of them were at par with native students [15] Next, we consider differences in class participation.

group	N	M	Mdn	SD	U	p	RBC
T 1	60	82.3	86.4	20.3	10036.0	p < 0.001	0.271
N 1	459	89.5	100.0	19.2			
T 1A	43	89.5	100.0	20.8	6873.0	0.061	0.138
N 1A	371	97.0	100.0	8.2			

Table 4: Summary of results for class participation by transfer and native students

From Table 4 we can see that transfer students perform lower than native students in class participation for CS 1 and CS 1A. However, this difference was only shown to be significantly different for CS 1. Class participation data was not available for CS 2. Next, we compare the differences in the overall weighted grade.

group	N	M	Mdn	SD	U	p	RBC
T 1	60	80.4	84.1	14.0	6871.0	p < 0.001	0.501
N 1	459	89.8	93.2	10.5			
T 1A	43	89.1	93.4	13.2	5229.5	p < 0.001	0.344
N 1A	371	94.1	95.8	5.5			
T 2	62	72.7	75.0	19.3	3756.5	0.002	0.261
N 2	164	79.8	85.0	16.4			

Table 5: Summary of results for overall weighted grades

From Table 5 we can see that the overall weighted grade was lower for transfer students than native students. This difference was also shown to be significantly different for all CS classes.

As PAs were administered weekly, we explored this in more detail as shown below.

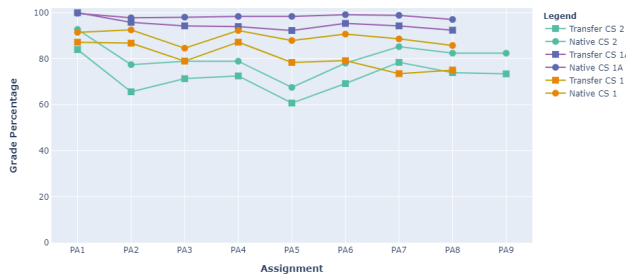


Figure 4: Average Weekly PA scores earned by transfer and native students in CS 1, CS 1A and CS 2.

Figure 4 shows that for all CS classes, transfer students performed lower on all PAs with the exception of PA1 in CS 1A, where both groups performed the same. Since the data did not follow a normal distribution, the Mann-Whitney U test was performed to find statistical significance.

PA#	G	M	Mdn	SD	U	p	RBC
1	T	87.2	90	19.4	11848.0	0.055	0.140
	N	91.5	100	15.5			
2	T	86.8	95	23.0	11462.5	0.021	0.168
	N	92.5	100	14.6			
3	T	79.0	85	23.2	11438.5	0.030	0.169
	N	84.6	90	20.2			
4	T	87.2	95	21.7	11685.5	0.039	0.151
	N	92.3	100	15.9			
5	T	78.4	90	27.7	10377.0	p < 0.001	0.246
	N	87.9	100	22.0			
6	T	79.1	90	30.7	9486.5	p < 0.001	0.311
	N	90.7	97.5	20.8			
7	T	73.5	95	36.5	9567.0	p < 0.001	0.305
	N	88.6	100	24.3			
8	T	75.1	92.5	32.1	11642.5	0.049	0.154
	N	85.7	95	23.8			

N (transfer students) = 60 and N (native students) = 459

Table 6: Summary of results for Weekly PAs in CS 1

Table 6 shows that for CS 1, transfer students scored lower than native students on all PAs. This difference was also shown to be statistically significant across each PA except PA1.

A similar analysis was conducted for CS 1A and CS 2. In CS 1A, we found that transfer students performed significantly lower than native students for six out of the nine PAs. The three PAs where they did *not* perform significantly lower were PA1, PA4 and PA6. Lastly, for CS 2, a similar trend followed. Transfer students performed significantly lower for six out of nine PAs, and the three PAs where they did *not* perform significantly lower were PA4, PA5 and PA9.

4.3 RQ3: Is there a difference in the social interactions of transfer and native students?

This RQ looked at the social interactions that transfer and native students were having throughout the quarter and the number of

people that they felt comfortable reaching out to. As described in the methodology, we decided to remove any outliers before conducting the analysis. We then conducted the Mann-Whitney U test since discrete values were being reported. The corresponding graph summarizing our results can be found in Figure 5

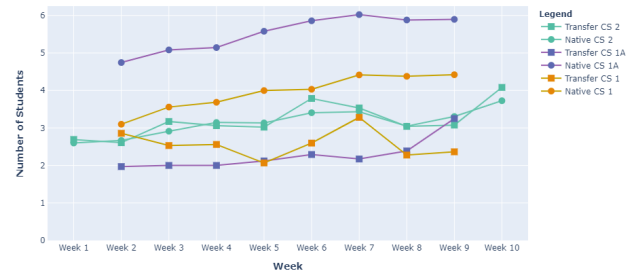


Figure 5: Number of people that transfer and native students felt comfortable reaching out to across CS 1, CS 1A and CS 2

Figure 5 compares the number of people that transfer and native students felt comfortable reaching out to for studying within the three CS classes. For CS 1 and CS 1A, transfer students had formed fewer social connections. In CS 2, however, this difference had minimized. Trendlines for transfer and native students were closer together, indicating that both groups felt comfortable reaching out to similar number of people. There were even some weeks that transfer students felt *more* comfortable reaching out to people than native students did. Next, we wanted to find out if this difference was statistically significant.

week	G	N	M	Mdn	SD	U	p	RBC
2	T	56	2.9	2.0	3.9	8891.5	0.038	0.169
	N	382	3.1	2.0	2.8			
3	T	49	2.5	2.0	3.2	7097.0	0.002	0.272
	N	398	3.6	3.0	3.3			
4	T	50	2.6	2.0	3.4	6518	p < 0.001	0.343
	N	397	3.7	3.0	3.1			
5	T	45	2.1	2.0	1.8	5051.5	p < 0.001	0.409
	N	380	4.0	3.0	3.4			
6	T	52	2.6	2.0	2.2	6981.5	p < 0.001	0.290
	N	378	4.0	3.0	3.4			
7	T	46	3.3	2.5	4.0	6563.5	0.003	0.265
	N	388	4.4	3.0	3.7			
8	T	36	2.3	2.0	1.9	3741	p < 0.001	0.410
	N	352	4.4	3.5	3.7			
9	T	44	2.4	2.0	2.0	5433	p < 0.001	0.383
	N	400	4.4	3.0	3.7			

Table 7: Summary of the number of people that transfer and native students felt comfortable reaching out to in CS 1

Table 7 shows that for CS 1, transfer students felt comfortable reaching out to fewer people than native students throughout the quarter. This difference was shown to be statistically significant for all weeks. A similar analysis was conducted for CS 1A and CS 2. Our Mann-Whitney U test results showed that in CS 1A, transfer students felt significantly less comfortable reaching out to

people for all eight weeks of the quarter in which data was collected. However, in CS 2, there was no significant difference in the number of people that transfer and native students felt comfortable reaching out to.

5 DISCUSSION

5.1 Interpretation of Results

In our study, we found that there was no significant difference in prior programming experience between transfer and native students for two out of the three CS classes: CS 1 and CS 1A. However, transfer students still performed lower than native students across all three classes and all course components. Since there was no correlation between prior programming and academic performance, we interpreted that transfer students might be performing lower because they need more time to adjust to their four-year university. Our findings from this RQ (see section 4.1) matched the findings of prior studies which concluded that transfer students felt extremely confident in how well their previous institutions prepared them but still had lower overall GPAs compared to native students [16, 17].

In our study, CS 1A was the only class where transfer students did not perform significantly lower than native students on the weekly PAs. This was also the only class that used multiple short programs (MSPs), compared to other classes which used regular large PAs that required implementation by reading a long specification. Based on our findings, we believe that shorter weekly PAs is a way to make programming assignments more equitable to transfer students who deal with many things during their first year (e.g., transfer shock [12]). Our findings are aligned with prior work by Joe et.al. which suggests that MSPs are at least as effective as large assignments. Therefore MSPs may be ideal to bridge the gap between transfer and native students in intro CS courses [6].

Our findings also showed us that transfer students' overall performance was significantly lower than those of native students including the final exam, PAs, class participation and overall weighted grade. Our results were similar to the study conducted by Harrison et.al [16] but contradictory the study conducted by Jacqueline et.al, which concluded that differences in overall GPA between transfer and native students in engineering were negligible [21].

We also found that while transfer students initially face some difficulty with social interactions, they eventually form their own connections or integrate into existing study groups. Our results for RQ 3 indicate that transfer students have significantly fewer people they feel comfortable reaching out to in CS 1 and CS 1A. However, by the time they enroll in CS 2, there's no longer a significant difference. This could indicate that transfer students use the first few quarters to form social connections - this could be in the previous introductory classes they have taken, by joining student clubs/organizations or by meeting students at tutoring/office hours held. This indicates that the gap in social interaction is not permanent and eventually minimizes as transfer students adjust. Our study contradicts prior work that concluded there were no differences in social engagement when a student initially transfers [16, 18].

An alternative explanation of our results could be that there is no connection between prior programming experience and academic performance. As prior studies suggest, it may instead be connected with other external factors such as adjusting to a new

environment [8, 22, 23, 26]. However, it is also possible that transfer students under-report prior experience because they do not feel confident enough in their abilities or prepared enough for the class. This could explain why some students continued to report no prior experience at all in CS 2, which is a successive introductory class and cannot be taken without completing the pre-requisites.

We believe that our findings may be valuable to other four-year universities that aim to minimize transfer shock and for instructors looking to design assignments that are more equitable to transfer and native students

5.2 Limitations of Results

Some limitations of our study include the lack of qualitative data. While we have quantitative data for answering each RQ, conducting interviews to gain better insight about transfer students' experiences in CS would have been beneficial.

We also don't know if transfer students took these courses within their first quarter at their four-year university. This can make it harder to compare data across courses - it is not necessary that a transfer student enrolled in CS 2 has also taken CS 1/1.5 or CS 1A. It's possible that some transfer students were placed directly in CS 2 because of the number of CS credits they came in with.

Data analysis was only conducted for three introductory CS classes, which means we currently have a narrow view of transfer and native students' performances and experiences across these courses. It is possible that within a year or two of attending their four-year university, transfer students perform exactly the same or better than native students, and so analyzing the data from upper-level CS courses could give us a more complete picture.

5.3 Future Work

Possible directions of future work could include conducting similar data analysis but for successive CS classes (after CS 2). This would give us a better idea of the trend and could help us see if the gap between transfer and native students (in terms of academic and social experiences) minimizes or gets larger over time.

Conducting weekly interviews with transfer and native students could also help us better understand their experiences in these CS classes. Sometimes, it can get hard to quantify social engagement and experiences, and different students might interpret survey questions and options differently. Asking free-response questions might give transfer students the freedom to include more details. Lastly, further studying the learning practices of transfer students (such as time management and study habits) could give us further insights into why transfer students tend to under-perform when compared to native students.

6 CONCLUSION

We conclude that transfer students have similar prior programming experiences as native students. However, they still earn lower grades overall and across all course components in introductory CS courses. We also found that transfer students struggled to form social connections more than native students in the initial introductory courses, but this gap minimized in successive CS courses. We believe that more studies are needed in this direction to truly understand the academic and social experiences of transfer students in CS and foster a more inclusive and diverse environment for them.

7 ACKNOWLEDGEMENTS

Section removed for dual-anonymous review process.

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