

Work in Progress: Effect of pre-college academic activities on the sense of belonging of first-year engineering students

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Effect of pre-college academic activities on a student's sense of belonging as they transition into college

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Abstract

This **Work in Progress** paper describes the effect of Homework 0 (HW 0), an activity offered at Western University designed to support Science, Technology, Engineering, and Mathematics (STEM) students' successful transition to the first year of college. This transition is a critical time as students face several personal and academic challenges [1] or most, college means a new lifestyle and level of independence [1]. Pre-college academic activities are positively correlated with a student's persistence and graduation [2] because these activities can support the development of a student's sense of belonging [3] to the university, their academic community, their profession. Sense of belonging, or a feeling of mattering [4], is a well-researched and documented predictor of retention and success [5]. Relationships and social networks are critical elements to success in the first year [3] of college. Researchers urge university personnel to engage early and frequently with first-year students to cultivate their social capital further in college [6].

Taken together, these theoretical lenses served as the foundation for the pre-college activity, HW 0. HW 0 consists of three asynchronous academic assignments students completed in the summer before their first full-time semester and follow up activities are completed during the first semester. These assignments were designed to provide a way for the student to learn about resources, activities, and engagement opportunities as well as to reflect on the challenges they are going through and to define strategies to face these challenges. The main research question guiding this study is how does engagement in a pre-college activity influence a student's sense of belonging, thus, success. Survey data collected in these activities has been analyzed to identify patterns among students and thus, identify the needs among them and define better programs to support them. Results from the 2021 program offering, included in this paper, indicate students who participated developed a greater sense of belonging.

Introduction

First-year college students face several personal and academic challenges during their transition to college and may be more likely to depart college in response to those challenges. College means a new lifestyle and a new level of independence and responsibility that some students are not totally ready to accept and face and this has a direct impact on their overall college experience [7]. Retention in Science, Technology, Engineering, and Mathematics (STEM) majors remains a national priority to meet the employment demands within the STEM fields [8]. To provide support to these students during this phase of their life, pre-college academic activities, specifically, engaging with active learning activities and fostering learning communities have been identified as programmatic elements to support student persistence [9]. Furthermore, transition activities which foster belonging and connectedness to staff and faculty are more successful than those which simply focus on trying to support a student in addressing their gaps or deficiencies [10].

This paper presents a work in progress describing the effect of the implementation of Homework 0 (HW 0), an pre-college activity designed to provide early insights, resources, and tips to help STEM first-year students at a Western University, located in the United States, during the summers and falls 2020 and 2021 to better understand the expectations from the university, to get to the needed mindset to face college, and to develop sense of belonging.

HW 0, consisted of three academic assignments which students completed in the summer before their first full-time semester. A survey was deployed at the end of the student's first semester to get the perception of the students about the program and analyze metrics related to sense of belonging. The main research questions guiding this study is how engagement in a pre-college activity influences a student's sense of belonging and persistence into their second semester. The specific research questions addressed in this work were:

1. Do students who complete HW 0 see an increase in overall sense of belonging?
2. Among ethnic groups, does HW 0 completion relate to an increase in sense of belonging?
3. Among gender groups, does HW 0 completion relate to an increase in sense of belonging?
4. Does sense of belonging differ based on ethnicity?
5. Does sense of belonging differ based on gender?
6. Does student sense of belonging relate to significant differences in cumulative GPA?
7. Does student sense of belonging relate to enrollment in the subsequent semester?

This paper is organized by various sections: the first section offers an overview on the concepts related to sense of belonging as a component for students' success during the transition process to college, the second section covers the details of the design of HW 0 activity as well as the instruments used to collect information from the two cohorts of students included in this work, the third section includes the data analysis and comparison of the two cohorts of students, the the discussion section offers more insights on the effect of HW 0 over the transition process to college, and the paper ends with conclusions which includes the lessons learned and their limitations and implications.

Background

Sense of belonging is defined as “a psychological measure of integration in the college community and attachment to an institution” [11, p. 3]. Research has linked feelings of belonging with higher rates of student persistence [12]. Sense of belonging has been operationalized as engagement academic and social experiences which promote belonging [13]. The researcher identified the value of diverse interactions with peers, grades, and time spent studying as the greatest predictors of a students' sense of belonging with the institution [13]. Furthermore, other researchers describe how students internalize interactions which either reinforce or reduce their own hypothesis that they do not belong in college [14]. Once a student begins to feel disconnected, each subsequent interaction reinforces those feelings of disconnection, changing the feeling of belonging uncertainty into a hypothesis that the student may not belong at all [14].

Interactions with peers [14] staff and faculty [12] have been shown to support student feelings of belonging [10]. [15] describes how “local guides and emerging agents within the university, who

share privileged knowledge and local resources serve as bridges” for students (p. 109). These interactions promote a student’s development of networks, navigational skills, and efficacy. Shared experiences and fostering connection between students and peers and staff contribute to stronger feelings of belonging [10, 16]. Further research indicates how seeking information from peers and assessing their own levels of competence and readiness reduce feelings of uncertainty during the pivotal first semester as students transition to college [12].

Thus, HW 0 was designed to create early connections for students with peers, upper-level students, and staff while they were also introduced academic concepts and expectations. By receiving input from peers, staff, and faculty, they received reinforcement that they do belong and there are resources in place to support their success. The students developed *active* coping strategies through the activities within HW 0, which precedes student belonging [16] thus mediating belonging uncertainty while supporting student retention [14].

Method

Design overview

A survey-based study was conducted to assess the hypothesis mentioned above related to the impact of the pre-college activity, HW 0, and the activities in the introductory course during their first full semester on student’s sense of belonging and their transition process to college.

This pre-college activity, HW 0, was completed by two cohorts of first-year students during the summer 2020 and summer 2021 semesters. The assessment also includes the comparison of these two cohorts of students.

HW 0 was presented to the students during the orientation process. Students were enrolled in a mandatory summer non-credit course where the main goal is to complete the three activities included in HW 0. Students could complete these activities in any order; and the due date to complete them was set to be one week prior to the beginning of the fall semester. These assignments were reviewed, and feedback was provided by staff, faculty, and peers. The completion of these assignments was part of the grade of the introductory course during the first full semester.

Even though the pre-college activity was mandatory, consent was requested from students to include their information and responses to the survey, which reduces the number of students included in the study.

Participants

The target population for this study were Science, Technology, Engineering, and Mathematics (STEM) first-year students who had been accepted and had been enrolled in a Western University.

For the 2020 cohort, an assessment survey was distributed to all incoming first year students (n=3085) during the final two weeks of the fall 2020 semester. The response rate, of those who consent to be included in the study, was 29.8% (918 responses). Of these 918 students, 100 were removed due to incomplete responses and failure to answer attention check questions correctly, bringing the total to 818. Within this group, 616 were males and 202 females. The students

represented diverse ethnicity groups including white (311), Hispanic or Latino (180), Asian (149), nonresident alien (84), two or more races (40), no group reported (29), black or African American (21) and American Indian or Alaskan native (4). Results from that assessment informed the design and implementation for Fall 2021 delivery.

For the 2021 cohort, an assessment survey was distributed to all incoming first year students (n=3380) during the final two weeks of the Fall 2021 semester. The response rate, of those who consent to be included in the study, was 34.4% (1163 responses). Of these students, the sample size was pared down to 596 students who fully completed the survey and passed the attention check questions. Of these 596 students, 570 completed the HW 0 assignment. From those 596 students, 443 were males and 153 were females. The students represented diverse ethnicity groups including white (215), Hispanic or Latino (110), Asian (116), nonresident alien (76), two or more races (25), no group reported (35), black or African American (10), native Hawaiian/Pacific islander (2), and American Indian or Alaskan native (7).

Material

The pre-college online asynchronous academic activity, HW 0, consisted of three academic assignments students completed in the summer before their first full-time semester. This activity is the starting point of a set of activities completed during the fall semester introductory course where all the first-year students are enrolled.

The first assignment was a 44- multiple choice question online scavenger hunt in which students sought information on resources, activities, and engagement opportunities beyond the academic programs through the university website. Students can navigate the university website as they complete the scavenger hunt. At the end of the scavenger hunt, the system provided the total points earned by the student.

In the second assignment, students composed 10 open questions; five directed towards peers and five directed towards faculty, seeking their insight, information, and mentoring on the transition to college. Students were provided with a template that included some example questions; students must submit their questions in a PDF formatted file. These questions are used to guide other activities part of complementing pre-college events as well as academic modules part of the introductory course.

In the third assignment, students followed a step-by-step guided process to identify the major challenges they are facing in their transition to college as well as to define an initial strategy to tackle them. Through this process, student started by identifying and ranking 10 challenges pertaining to transition to college; then, for their top three, they have to define a strategy, informed by the information they have gathered from the scavenger hunt, to address, respond, or manage them; finally, students discuss in detail the top challenge (following the principles of Entrepreneurial Mindset [17]) providing a deeper and detailed description of the challenge, considering who else might be facing a similar challenge as well as considering who else could be interested in the possible strategy or solution to tackle this challenge. Current students, staff, or faculty reviewed this assignment and provided comments and answers to the students' submissions with their knowledgeable insights and suggestions to improve those strategies, as well information of resources at the university to improve the strategy. This assignment is used

later during the first full-semester introductory course as a starting point to define what is called a 2-year plan that each student define considering their current challenges as well as the competencies that they need to develop in the 2 years coming in order to be succeed academically and to be more eligible to apply to diverse programs such as studying abroad, internships, research initiatives, special academic programs, to mention some of them.

The survey completed by the students at the end of the semester includes questions related to student's perception of the pre-college activity, HW0, as well as the activities part of the full-semester introductory course. Beside these questions, the survey included questions related to student's sense of belonging and how each of the activities pre- and during the semester have an impact in this sense of belonging.

Metrics

The main goal of this study is to analyze the impact of the pre-college academic activity on their sense of belonging. Based on the information from the survey, the sense of belonging metric was defined as a compound variable. [11] validated three questions as indicators of a student's overall sense of belonging. The original questions were (p. 342):

- I see myself as part of the campus community
- I feel that I am a member of the campus community
- I feel a sense of belonging to the campus community

For the Fall 2021 assessment, these questions were modified to the following three questions:

“Overall, the HW 0 activity during the summer helped me to:

- see myself as part of the Western University Engineering community
- feel like a member of the Western University Engineering community
- feel a sense of belonging to this Western University Engineering community”

Each of these three items were endorsed on a seven-point Likert-type scale, ranging from “Strongly disagree” to “Strongly agree” Sense of Belonging was then created by summing these three items; the aggregate scores then range from 3 (low Sense of Belonging) to 21 (high Sense of Belonging)

Results

To answer the following questions, a least squares random effects model was fitted to the data collected from students in the Fall 2021 cohort [see 18]. A random effects model was chosen because the factors of interest are all categorical variables with random factor levels sampled from a population.

- Do students who complete HW 0 see an increase in overall sense of belonging?
- Among ethnic groups, does HW 0 completion relate to an increase in sense of belonging?
- Among gender groups, does HW 0 completion relate to an increase in sense of belonging?
- Does sense of belonging differ based on ethnicity?
- Does sense of belonging differ based on gender?

This model attempted to form a relationship between ethnicity, gender, HW 0 completion, and the Sense of Belonging outcome variable. This model included main effects, as well as the interactions between ethnicity and HW 0 completion and between gender and HW 0 completion.

To answer the sixth question,

- Does student sense of belonging relate to significant differences in cumulative GPA?

a linear regression model was fitted to first year students' cumulative fall GPA with sense of belonging as the independent variable. This method was chosen because [18] recommends regression analysis when attempting to determine a relationship between a continuous variable and one or more regressor variables. The final question,

- Does student sense of belonging relate to enrollment in the subsequent semester?

This question was addressed using a binary logistic regression model [18]. This method was chosen because a relationship between a categorical dependent variable and a continuous regressor was the relationship of interest.

The statistics package JMP was used for analysis in this paper due to its simplicity and diverse selection of statistical models. Initial results from the least squares model in JMP indicated that all main effects were significant to the model, while the interaction terms were not. The results are shown in the table below.

TABLE I
FALL 2021 - SENSE OF BELONGING RANDOM EFFECTS MODEL

| Random Effect | Var Ratio | Var Component | Std Error | 95% Lower | 95% Upper | Pct of Total |
|---------------------------------------|-----------|---------------|-----------|-----------|-----------|--------------|
| Ethnicity | 0.10 | 1.98 | 1.21 | 0.79 | 10.86 | 8.77 |
| Gender | 0.00 | 0.09 | 0.25 | 0.01 | 5.84E+11 | 0.38 |
| Completed HW0 During Summer | 0.03 | 0.51 | 0.88 | 0.09 | 11081.38 | 2.27 |
| Gender*Completed HW0 During Summer | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ethnicity*Completed HW0 During Summer | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Residual | | 20.01 | 1.17 | 17.90 | 22.51 | 88.58 |
| Total | | 22.58 | 1.92 | 19.24 | 26.89 | 100.00 |

Despite their significance, the variance components of the terms were unequal. Of the three, ethnicity had by far the largest percent contribution to the variance of the model with 8.77 percent. Completion of HW0 during the summer and gender were a distant second and third at 2.27 percent and 0.38 percent, respectively. Once the analysis was complete, box plots were created to supplement the analysis. In Fig. 1 below, the comparison of gender and sense of belonging for the Fall 2021 cohort is displayed. While women appear to have a higher sense of belonging on average; the difference, if one exists, is very small.

FALL 2021 - STUDENTS SUMMER SENSE OF BELONGING VS GENDER

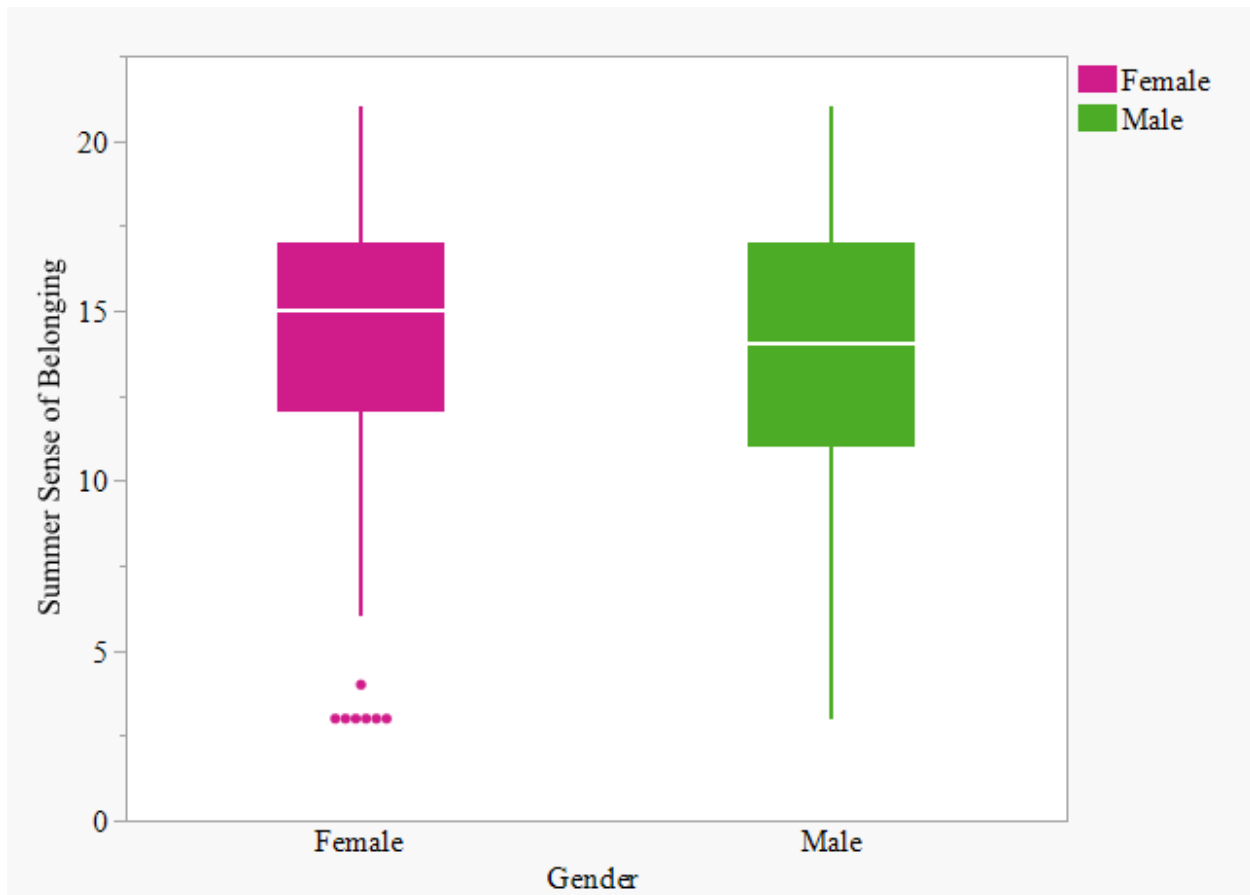


Fig. 1. Comparison of male and female students' reported sense of belonging for the Fall 2021 cohort.

The comparison table for sense of belonging by ethnicity can be seen in Fig. 2. This chart reveals some interesting information that sheds light on the results of the model analysis above. The average reported Summer sense of belonging among students of different ethnic categories was fairly consistent around the grand average of 13.52. Students in the non-resident alien category notably reported higher sense of belonging than students in the other categories, with an average of 16.32. The box plot of the data makes it clear that drawing conclusions about a relationship between students' sense of belonging is difficult to do with certainty since there is a relatively high amount of variance in the model within each ethnic category.

FALL 2021 - STUDENTS SUMMER SENSE OF BELONGING VS ETHNICITY

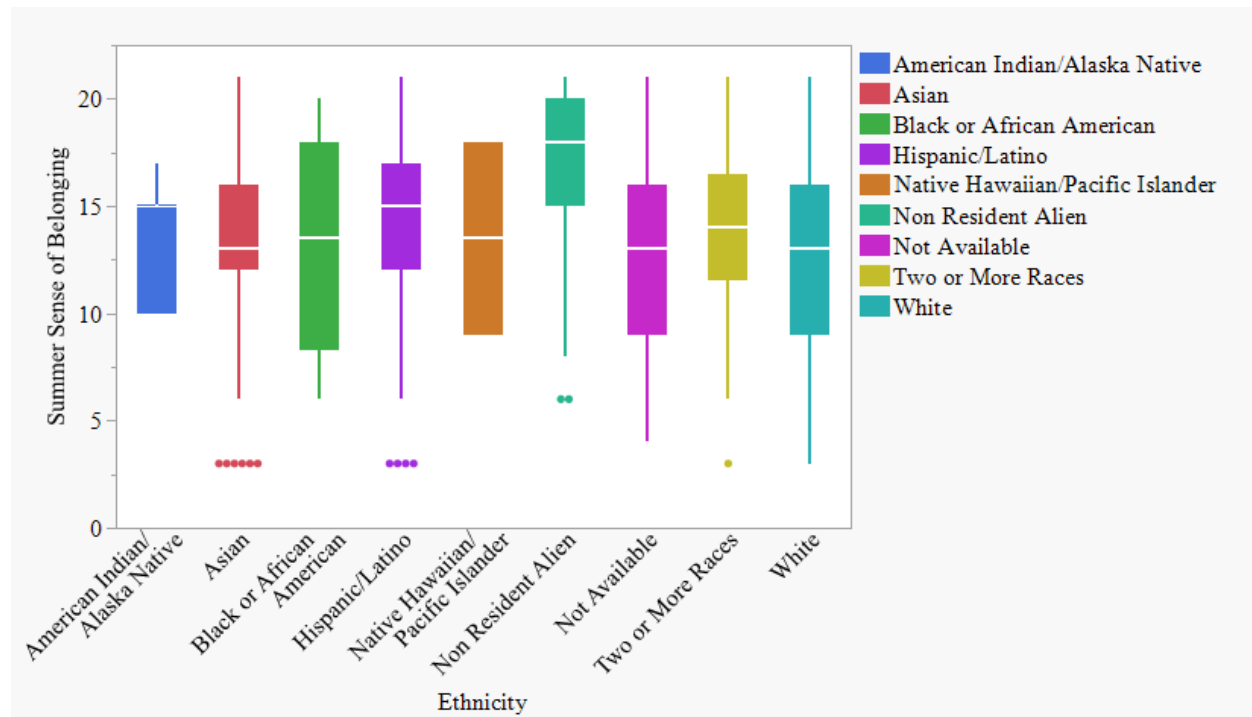


Fig. 2. Comparison of students' reported sense of belonging separated by ethnicity in the Fall 2021 cohort.

The remaining plots are in the appendix; each showing patterns like the above two charts. Each chart shows relatively small discrepancies in sense of belonging between categories, making it difficult to draw conclusions from the data despite the model's statistical significance.

The GPA and Sense of Belonging relationship was analyzed using a linear regression model, which was significant, $p > 0.05$. Despite its significance, the R-squared value for the model was 0.01 which means that there is a massive amount of variance in the Fall GPA variable not accounted for by the Sense of Belonging independent variable. This means that Sense of Belonging alone is a very poor predictor of a first-year student's Fall GPA.

To analyze the relationship between students' reported sense of belonging and next semester enrollment a logistic regression model was used to fit the data [18]. The resulting model was not significant, $p > 0.05$. The resulting chart of the model from JMP is shown in Fig. 3.

FALL 2021 - REGRESSION MODEL OF SUMMER SENSE OF BELONGING VS STUDENTS ENROLLED BY COLLEGE CENSUS DATE

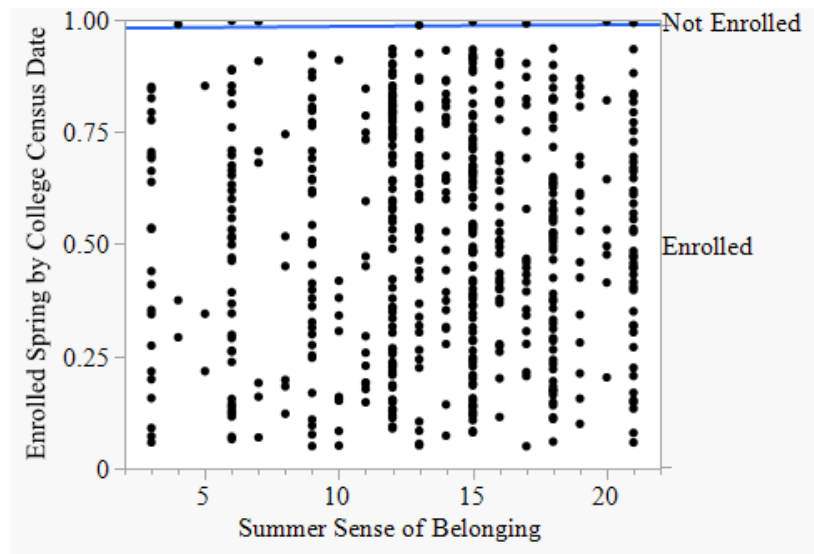


Fig. 3. Logistic regression model relating Summer Sense of Belonging and Enrollment by College Census Date

The poor fit of this model is more than likely explained by the very low number of students from our sample who did not enroll by the college census date. Only 8 of our 596 students were not enrolled. As such, any statistical model fit from this data set is unlikely to be accurate.

Discussion

Key Takeaways

Ethnicity, gender, and HW 0 completion were significant predictors of the aggregate Sense of Belonging outcome variable. Even so, the very large difference in sample sizes among factors and very high residual error make solid conclusions difficult to draw. This is a critical measurement for all students. However, a measurement of belonging is more relevant for the minoritized student populations as they can feel part of the college community while retaining a critical connection to home and family [19]. Indeed, the absence of belonging results in students feeling marginalized, isolated, and alone, and has been shown to lead to student departure. With the need for more individuals in STEM jobs, supporting more minoritized students towards degree completion is essential [8].

Sense of Belonging was a significant predictor of GPA for freshmen students but its R-squared value was quite low, R-squared = 0.01

Sense of Belonging did not have a significant relationship to students enrolling in spring by the college census date. This is likely due to almost all (588) of our sample enrolling prior to the college census date.

Conclusions

Implications

As a result of this work, we contribute to a use of additional types of formats for pre-college experiences beyond tradition residential or immersive BRIDE programs and high school STEM preparatory coursework [2].

Limitations

It is important to mention that the discussion and conclusions presented here are limited to populations like the sample considered in this study. Another limitation to consider is the fact that even when the number of students included in this study is considerable, it is still low to draw conclusive conclusions. Also, it is important to consider that the distribution between gender, ethnic groups, and majors is not balanced.

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Appendix

FALL 2021 - STUDENTS SUMMER SENSE OF BELONGING VS ETHNICITY & HW0 COMPLETION DURING SUMMER

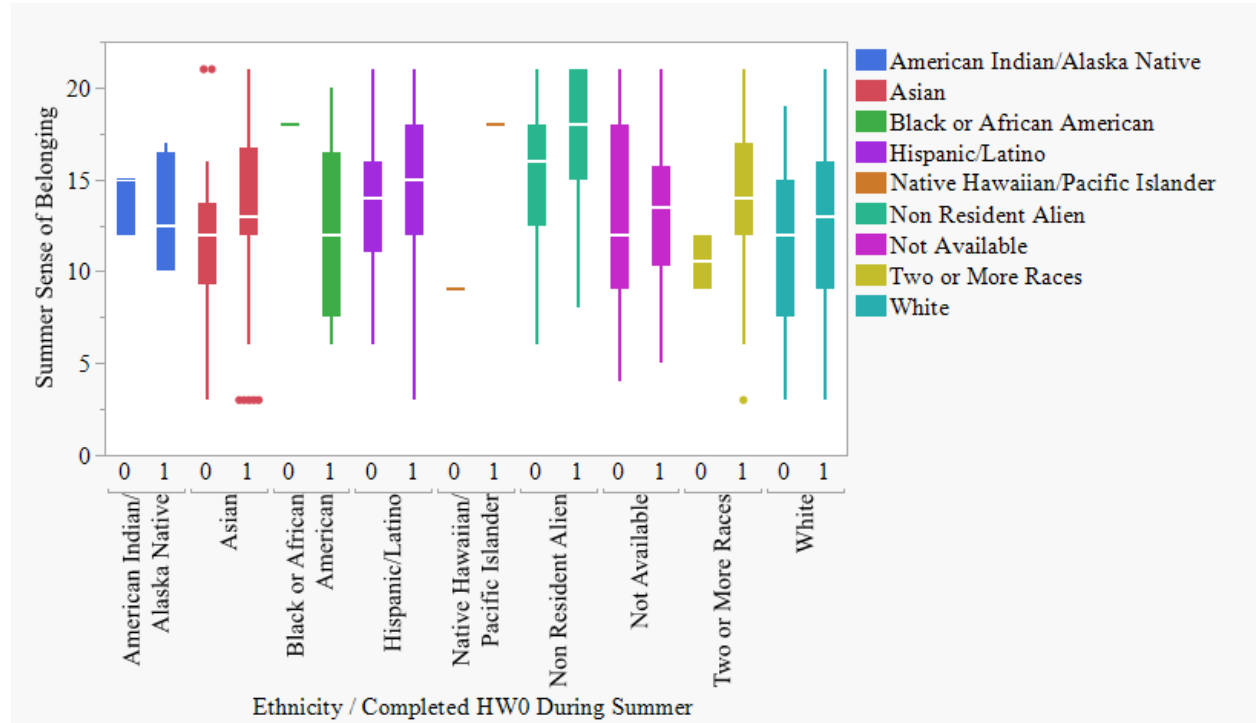


Fig. 4. Comparison of students' reported sense of belonging separated by ethnicity and HW 0 completion in the Fall 2021 cohort.

FALL 2021 - STUDENTS SUMMER SENSE OF BELONGING VS HW0 COMPLETION DURING SUMMER

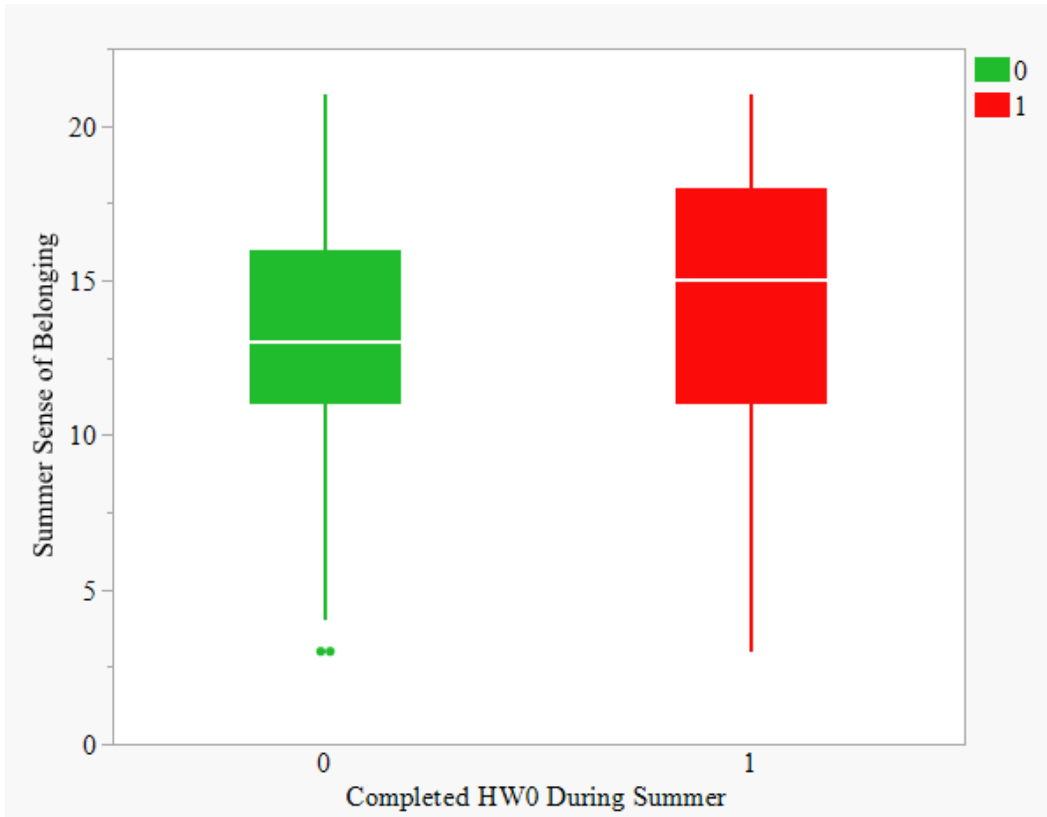


Fig. 5. Comparison of students' reported sense of belonging separated by HW 0 completion in the Fall 2021 cohort.

FALL 2021 - STUDENTS SUMMER SENSE OF BELONGING VS GENDER & HW0 COMPLETION DURING SUMMER

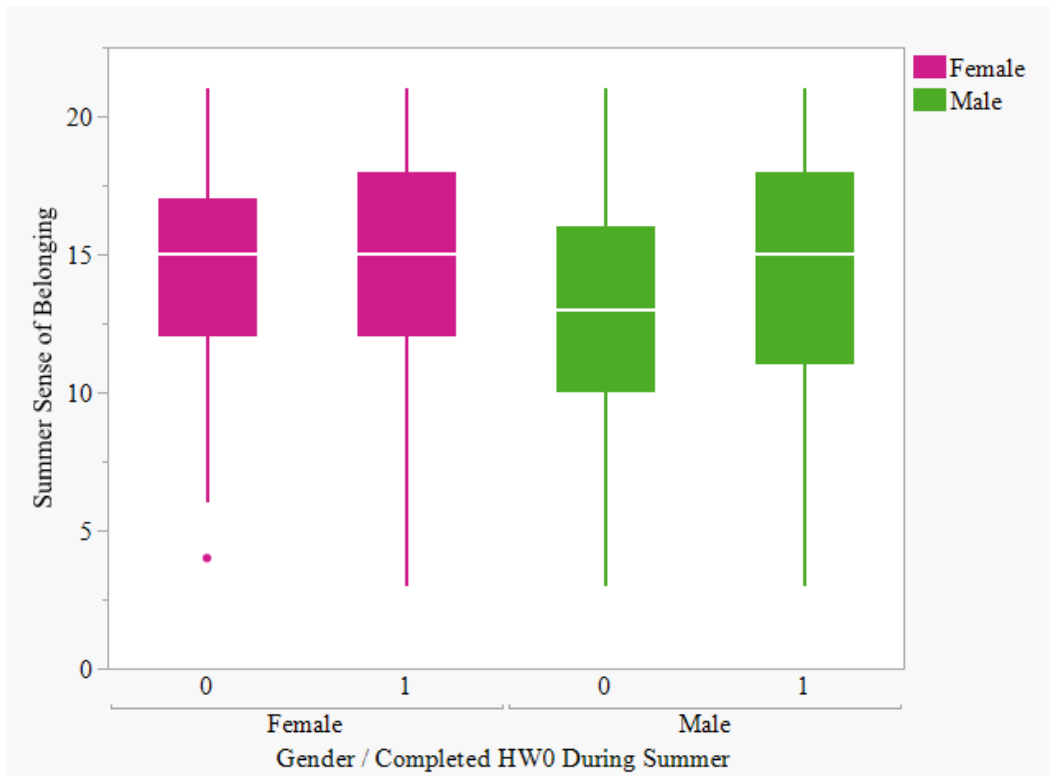


Fig. 6. Comparison of students' reported sense of belonging separated by gender and HW 0 completion in the Fall 2021 cohort.