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Photo is describing a Lumen Prototype from an exhibition 2024 at Louisiana in Denmark called *The Living Structures*. The exhibition is the first in a new series 'Architecture Connecting', spotlighting the evolution of architecture in an era of climate crisis and the social, cultural and political challenges this reality poses.

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INVESTIGATING THE HOUSING CHALLENGES OF GRADUATE STUDENTS AND EXPLORING THE POTENTIAL OF ON-CAMPUS INFILL MICRO-HOUSING

AHMED K. ALI, ROHIT KUMAR, AND
PATRICIA NJIDEKA KIO

Abstract

University students' housing challenges have attracted global research attention over the past few decades as they are becoming a concern worldwide. In the United States, the situation is particularly unique, as the federal government does not offer specific housing programmes for students, unlike many other countries that provide targeted support in this area. This research explores the housing issues and homelessness among graduate and professional students at what is currently the largest university in the United States. In addition, this research introduces a novel on-campus infill micro-housing solution, and surveys and documents students' responses to both their housing challenges and their perception of the architectural designs proposed. To gather insights, an online survey was developed and administered. Approximately 1,500 respondents completed the survey, resulting in a response rate of 11 per cent. Findings from the data analysed indicated that 35 per cent of the respondents have experienced housing insecurity, whereas 13 per cent of the respondents have experienced homelessness. Forty-four per cent of the respondents expressed a willingness to live in the infill micro-housing solutions proposed. This article thus attempts to understand housing challenges faced by a relatively under-researched demographic and offers an innovative solution to the growing problem.

Keywords:
campus infill housing, micro-housing design, graduate students' housing, housing insecurity, college students' homelessness

Introduction

It has been reported that more than three-quarter of million Americans experienced homelessness on a given night in 2024, a problem which has worsened in the recent years (De Sousa et al., 2024). College students are among the various groups affected by homelessness, and a range of literature indicates that housing is directly linked to the ability to complete their higher education (Broton, 2017). Numerous studies have been conducted to understand the housing issues, namely the housing insecurity and homelessness experienced by college students in the United States to name a few (Crutchfield & Maguire, 2017; Goldrick-Rab et al., 2019; Goldrick-Rab et al., 2020; Goldrick-Rab et al., 2018; Hallett & Crutchfield, 2018; Ringer, 2015). A national governmental survey found that 8 per cent of undergraduate and 5 per cent of graduate students are homeless, amounting to an astonishing number of more than 1.5 million students (Cameron et al., 2021; Crutchfield & Maguire, 2017; Goldrick-Rab et al., 2019; Goldrick-Rab et al., 2020; Goldrick-Rab et al., 2018; Hallett & Crutchfield, 2018; Ringer, 2015).

The purpose of this research is to assess the housing issues confronted by an under-researched population of college students, namely, graduate students. It is known that the majority of graduate students in the U.S. are international and possibly married and/or have children. The research focusses on the graduate student population at what is currently the largest university in the U.S. and explores their perceptions of an innovative on-campus infill micro-housing concept. In this context, the term graduate students refers to students pursuing a master, PhD, professional degree, or a combination of these degrees. By shedding light on the unique housing challenges faced by graduate students and examining the potential of architectural interventions, this study aims to contribute to a broader understanding of housing insecurity and homelessness among college students, while exploring viable solutions to address their specific needs.

Research Questions, Significance, and Target Audience

The following set of questions guided this research:

- What is the current situation of housing issues, namely insecurity and homelessness, of graduate and professional students at the largest American university, and how does it compare to the situation at other universities in the United States?
- How do housing issues differ between domestic and international graduate students at the same university?
- What are the graduate students' perceptions of the infill micro-housing architectural solution proposed?

This study aims to contribute to the understanding of housing insecurity and homelessness among graduate-level college students, who have received limited attention in past research. By delving into their housing challenges, it is possible to generate insights that can inform policies as well as interventions tailored to the unique needs of graduate students. Moreover, by examining graduate students' perceptions of and attitudes towards the innovative micro-housing concept, the research can provide valuable insights into its feasibility, acceptability, and potential benefits. This information can be used to guide future design and development efforts, ensuring that architectural solutions are responsive to the specific needs and preferences of graduate students.

The other emphasis in this research is exploring an architectural solution to address college student housing issues. There is limited research on developing novel housing solutions that use innovative design approaches and technology. Although the significance of housing issues and their impact on students has been recognized, the solutions are limited (Broton & Goldrick-Rab, 2018; Goldrick-Rab et al., 2020). However, by leveraging new design approaches, these innovative solutions can be identified and assessed in order to evaluate whether they meet the students' needs.

Literature Review

University Level Students' Housing Options in the United States

In the United States, university students' housing options comprise on-campus and off-campus housing, the cost of both of which are typically borne by students and/or their sponsors, such as parents. On-campus housing includes dormitories (dorm rooms or hostels), student residence halls (similar to dormitories but with more amenities), and apartment-style accommodations. Off-campus housing options include renting an apartment or leasing an independent house. Students can obtain a renewable year-long lease for such a house and can look for roommates to share rent and utilities such as electricity, internet, and water. As of 2024, the average cost of a one-bedroom apartment in the study's geographical location (College Station, Texas) is $1,025 per month, which is considerably less than the national average (CoStar Group Inc., 2025).

Housing Challenges of University-Level Students Across the World

The housing challenges confronted by university students has been a topic of research around the world in the recent decades. Studies conducted by the National Union of Students in the United Kingdom revealed that university students are grappling with a housing crisis and facing increasing difficulty in finding affordable accommodation (Moss & Moss, 2024). A study in South Africa estimated a shortage of over half a

million beds for university students, which is thus regarded as a matter of grave concern (International Finance Corporation, 2020). The shortage of housing for students in India is leading to overcrowded, unsafe, and unsanitary conditions (Garg et al., 2014)

Housing Challenges Among University-Level Students in the United States

Housing insecurity includes a broader set of challenges such as the inability to pay rent or utilities or the need to move frequently (Goldrick-Rab, 2017). The term homelessness refers individuals or families who have "a primary nighttime residence that is a public or private place not meant for human habitation" (U.S. Department of Housing and Urban Development, 2019). Several studies describing the housing issues faced by university students have been published in the United States. Among them is the annual national survey of college students conducted by The Hope Center, in which thousands of students participate. The findings in the surveys conducted between 2015 and 2020 indicate that housing insecurity increased from 46 per cent to 60 per cent during this period, and that homelessness levels grew from 10 per cent to 20 per cent among university graduate students (Goldrick-Rab et al., 2020).

The Hope Center report indicated that 48 per cent of its student respondents have reportedly experienced housing insecurity and 14 per cent of its students have experienced homelessness (The Hope Center, 2021a). Nearly 18 per cent of respondents admitted their lack of confidence regarding being able to pay rent for the next month. Black and Indigenous students experienced nearly 20 per cent higher basic needs insecurity levels than white students. The Hope Center data was collected from fifty-four colleges and universities in twenty-six states, with a total 38,602 surveys completed. Another report on the basic needs (housing and food) insecurity faced by college and university students across the state of Texas was published in 2021 (The Hope Center, 2021b). The annual Hope Center survey was conducted in fourteen colleges and universities across the state of Texas in 2020. Results indicate that 55 per cent of respondents have experienced housing insecurity and 16 per cent have experienced homelessness. The State of Texas students reported 9 per cent-higher housing insecurity levels. Black, Indigenous, and Latinx students reported higher insecurity levels than any other race or ethnicity, while female students reported higher basic needs insecurity levels than male students. It is important to compare with the findings of this survey. As per Jones (2019), "a combination of factors, including rising tuition, financial aid packages that fail to keep up with the costs of food, gas and childcare, and an overall lack of affordable housing have fuelled the homelessness crisis among college students", which might partially explain the housing issues.

Negative Impact of Housing Issues on Academic Attainment

Unlike two decades ago, housing insecurity is today among the primary concerns of the leadership of universities in the United States (The Hope Center, 2021a). A survey conducted by the American Association of Collegiate Registrars and Admissions Officers (2020), 86 per cent of respondent institutions believe that housing and food insecurity adversely affect students' ability to pursue their degrees. This includes dropping out, lower grades, and slower degree completion. To address these issues, the majority of these institutions have conducted internally administered surveys to understand how their students feel about them. According to a report from Schoolhouse Washington (2018), the academic performance of students affected by homelessness is not as good as that of their housed peers (fig. 1). The graduation rates of homeless students were observed to be even lower than those of low-income students who were never homeless. The public-school students of Washington State who never experienced homelessness (housed students) showed an 81 per cent graduation rate, by contrast with a graduation rate of only 56 per cent for the students who experienced homelessness. With respect to attendance rates, the housed students showed the highest rate, at 86 per cent, but the homeless students showed a rate as low as 62 per cent. Between the two categories, the homeless students also exhibited the highest rate of suspension, at 10 per cent. The report also highlighted that the student homelessness rate has more than doubled in a decade. Studies have also been conducted in other countries where such housing problems are anticipated to affect academic attainment. The lack of student housing in South Africa is anticipated to lead to student homelessness and living in substandard housing that will undermine their academic attainment (The Institute for Justice and Reconciliation, 2025). A study in Sweden examined and found correlations between student mental health and their residential environment that affect their pursuit of higher education (Carlgren & Ohtonen, 2022).

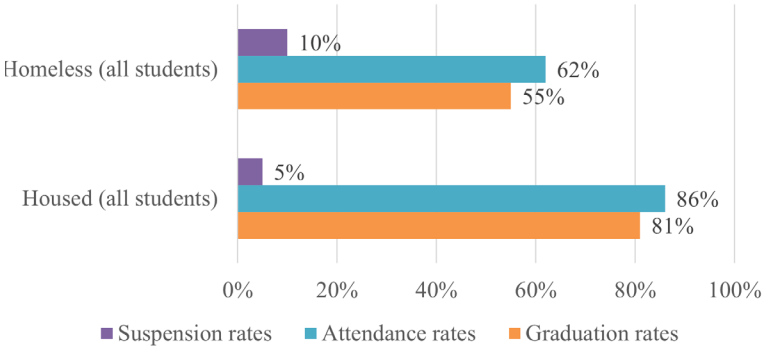

Figure 1
Academic performance of students affected by homelessness in Washington State (Schoolhouse Washington, 2018)

Government Housing Programmes for the Vulnerable in the United States

The U.S. Department of Housing and Urban Development (HUD) and other agencies offer housing assistance to vulnerable populations. Vulnerable groups include economically disadvantaged individuals, racial and ethnic minorities, the uninsured, low-income children, the elderly, the homeless, and those with chronic health conditions such as HIV or severe mental illness (Lansky et al., 2001). HUD offers several programmes to support vulnerable populations, including emergency vouchers for individuals facing homelessness or domestic violence. It also provides short-term housing and services for people with mental disabilities, families with children, and other at-risk groups. Additionally, HUD offers housing for the homeless and individuals with HIV/AIDS, and affordable housing for low-income families and seniors. It is reported that the government programmes such as these along with community programmes contributed to a 15 per cent decline in homelessness between 2007 and 2016 (Bailey et al., 2025). However, homelessness has risen in recent years, increasing by 18 per cent in 2023 compared with the previous year (U.S. Department of Housing and Urban Development, 2024). Despite the severity of U.S. student homelessness, the U.S. government neither recognizes graduate students as a vulnerable group, nor does it provide them housing assistance, and there are currently no federal laws addressing this issue. A few states such as California, however, have programmes like the Affordable Student Housing Program, which offer rent subsidies, build low-cost student housing, or partner with landlords to provide discounted rent for eligible university students.

Innovative Architectural Design as a Solution for Mitigating Housing Challenges

There are examples of architectural interventions which have attempted to mitigate housing issues such as homelessness. A study in Norway examined the architectural design of the Veiskillet housing project for homeless individuals (Hauge & Støa, 2009). The study found evidence that the project facilitated their inclusion in society and contributed to their well-being.

In the U.S., North Carolina State University (NCSU) led an initiative to address its student housing issues (North Carolina State University, 2019). The formation of the Food and Housing Security Initiative at the school in 2017 demonstrates a proactive approach to addressing food and housing insecurity among students. The involvement of faculty, staff, and students highlights the collaborative effort to tackle the issue on campus. A campus-wide student survey found that nearly 10 per cent of respondents had experienced homelessness in 2016. The Affordable + Supportive Student Housing for NCSU project is a direct outcome of the Food and Housing Security Initiative's findings and recommendations.

As part of the project, eleven NCSU students "conducted research on innovative university and multifamily housing, and designed demonstration projects for two university-owned campus sites, which included a range of unit types, community spaces, and supportive services" (fig. 2). Their research focused on exploring innovative models of university and multifamily housing to meet the specific needs of students facing housing insecurity. Based on their research, the students designed a number of hypothetical projects.

The housing options developed by the NCSU students were typical dormitory buildings and a variety of apartments with one or more bedrooms for the diverse needs and preferences of students. In addition to offering a variety of housing options, the Affordable + Supportive Student Housing for NCSU project also emphasizes the importance of creating social spaces, shared kitchens, common courtyards, and town-gown interfaces through retail and public spaces. This approach proposes a variety of new housing for its students on on-campus plots of land. However, it lacks information regarding the affordability of such housing for the students. On-campus dormitories at this university, like many others, have a higher rental cost compared with off-campus apartments. For NCSU, the rental cost of a double-occupancy dormitory room was $3,400 per semester (North Carolina State University, 2022b) whereas the rental cost of a room in an off-campus shared housing apartment was $2,500 per semester (North Carolina State University, 2022a). As per a recent report by LaSalvia et al. (2023), off-campus apartment rental costs have increased by 30 per cent in the last decade, making housing mostly unaffordable for students. These solutions may therefore not effectively address the housing issue if they do not prioritize affordability for students. Moreover, most of the NCSU proposals were envisioned as another big building on an empty plot, similar to any off-campus developer-model for student housing.

Figure 2
Proposed on-campus student housing at NCSU (North Carolina State University, 2019)

Methodology

This research utilized a two-stage methodology, whose workflow is shown in figure 3. First the infill housing proposal was conceptualized, designed, and modelled to be retrofitted onto a selected university campus building. Second, online survey research was designed and deployed in the fall of 2021 using a university-wide distribution method. The architectural proposal of infill housing was conceived because the authors have a background in architecture. The survey was conducted to determine whether such a housing proposal would be acceptable to the students and whether the responses would warrant the construction of the housing prototype.

The first stage of this research involved identifying a host building on a university campus where three sizes of infill architectural solution housing were conceptualized and designed, namely, small, medium, and large. The second stage of this research involved survey research conducted in 2021. The goal was to understand the housing issues and preferences of the graduate students at one of the largest public universities in the United States. The on-campus infill housing typology was presented to the survey participants to assess if an infill architectural solution is appealing to students.

The survey was administered to the graduate students via a university-wide email in the fall of 2021. The respondents were compensated

with a five-dollar Starbucks gift card at the end of the survey. As the survey was emailed to students it was assumed that they had the means to access it (smartphone or computer). The survey was designed to gather their perceptions of the proposed housing design on campus.

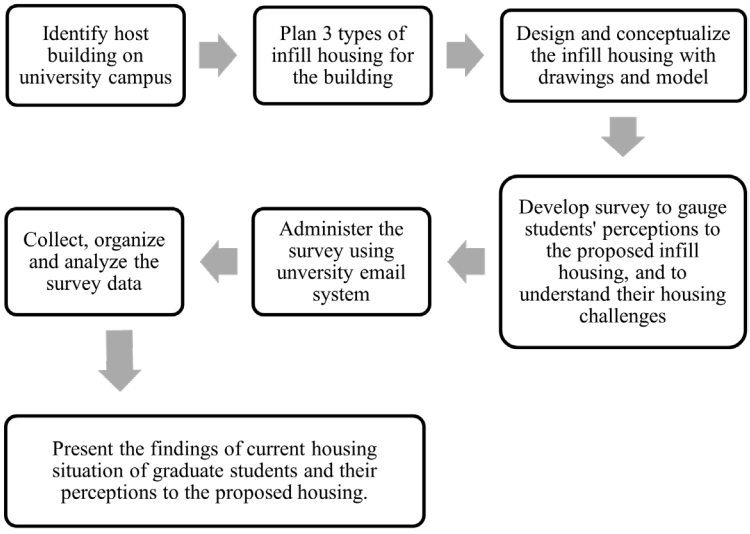

Figure 3
A workflow of methodology designed and executed for the survey research

Survey Description

A survey is a tried and tested approach to collecting data and producing statistics relating to a population by asking questions, usually, of a subset of those in the population (Fowler Jr., 2013). Survey research is suitable for this work because it allows for systematic data collection from a large and diverse student population, making the findings more representative and generalizable. The anonymous survey consisted of questions on the characteristics of students such as demographic information, socioeconomic status, current housing situation, experience of housing insecurity and homelessness, and their perceptions of the infill micro-housing proposed. The students demographic information component included questions on gender orientation, age, racial or ethnic background, whether they are full- or part-time students, domestic or international students, the specific college, the degree level being pursued, the number of years spent in college, the cumulative grade point average, relationship status, whether the respondent had children, and, if yes, the number of children and whether they lived with the respondent. The component on socioeconomic status included questions on their sources of income, whether they were employed at present, whether they were primarily employed on-campus or off-campus, the type of on-campus employment, estimated monthly household income, typical monthly household expenses, and household size. The questions on housing included whether the respondent resided in an on-campus or off-campus dwelling, whether it was rented or owned, the monthly rent

or mortgage, typical monthly utility costs, other details about their current residence (such as type, number of bedrooms, et cetera), and their reasons for choosing their current housing.

Housing issues were assessed using the questionnaire developed by the Hope Lab (Goldrick-Rab et al., 2019), which was adopted from the Adult Well-Being Module of the national Survey of Income and Program Participation (SIPP), which evaluates students' housing issues. Housing insecurity was identified by a set of nine questions sourced from the report by the Wisconsin Hope Lab (Goldrick-Rab et al., 2019). The questions included whether the respondent faced difficulties in paying rent, a mortgage, or utilities as a student, whether the respondent had to move because they could not afford a hike in rent or reasons such as lack of safety or overcrowding. Questions on homelessness were also sourced from the Hope Center report (Goldrick-Rab et al., 2019) and asked the respondents whether they had experienced homelessness (self-reporting) and whether they had lived in any place not intended for human habitation due to their inability to afford shelter, and not for recreation. In the final section of the survey, a short video describing the proposed on-campus infill housing was played. The details of small, medium, and large size infill housing at an on-campus building were addressed. The students were asked to indicate the housing option that appealed to them, to rate how likely they were to live in this type of housing in exchange for on-campus employment, and how they perceived the advantages and problems of such housing.

Infill Housing Within Existing Campus Buildings

Literatures suggest that the term "infill" was introduced by Habraken (1961), who proposed the idea of "support and infill" in the book titled *Supports: An Alternative to Mass Housing*. The concept was introduced in the 1960s "as a means of improving building performance and enabling user participation" (Carp, 1986). The framework advocated an approach to housing development that involves the active participation of the occupants. Habraken (1961) envisioned that such housing should have scope for expansion, which the occupants could later add as "infill". These ideas inspired a group of architects from The Netherlands to establish the Foundation for Architectural Research (SAR), which developed several housing projects in the country (Carp, 1986). In the field of urban planning, infill or infill development refers to the process of repurposing or redeveloping vacant or underutilized land within an existing urban environment (Alfirević & Simonović-Alfirević, 2015). The concept of infill in the context of urban planning can be dated back to 1940s (Landis et al., 2006).

In the context of this study, infill micro-housing refers to the reclamation of underutilized outdoor adjacent spaces within or between selected

campus buildings to provide housing options for students. Instead of constructing new buildings or expanding the campus footprint, infill micro-housing focusses on the addition of light structures to existing buildings to accommodate student living spaces. This approach is distinct from adaptive reuse or the redevelopment of existing buildings, as it involves new construction that is carefully integrated with an existing building. In this study, however, the proposal has a specific application. Although it is an innovative design idea, it is applicable to only one specific campus building and is not applicable to others. The host building for which the infill micro-housing proposal was developed is described below.

Proposed Design of Infill Micro-Housing

In this research project, an architectural solution was first developed and proposed as a possible solution to the housing problems faced by graduate students (fig. 4). The proposed housing design was tailored to the unique characteristics of the host campus building and adhered to campus design guidelines. Each housing unit was designed to complement the architectural style of the host building. The housing incorporates innovative construction systems such as Cross Laminated Timber (CLT) which has been used widely in most Scandinavian countries, but has recently experienced an increase in interest in the U.S. Each unit will have its own private toilet, while utilizing the existing host building's infrastructure, including water supply, sewerage, and electricity. This serves as a temporary solution that attempts to address the students' immediate housing needs. The university will provide such housing to graduate students in exchange for assistantship services such as teaching or research assistance.

For this project, the Langford Architecture Building A on the Texas A&M University campus was selected as the host building for the infill housing. The Langford Architecture Building A is a precast concrete Brutalist structure with distinctive louvres or coffers in one of its external walls. The louvres, facing north, were designed to serve as a device for shading the building. The building today is, however, fully artificially lit and centrally air-conditioned, and the uses of the coffers have thus been diminished. The building was designed by HKS Dallas, and was erected in 1977. The proposed housing units will be situated within these coffers, resembling drawers in a desk, thus making minimal modifications to the existing building necessary. The proposal seeks to make use of the underutilized external spaces of the host building with minimal modifications.

Three types of houses are proposed based on their floor area, namely, small, medium, and large, with respective sizes of 29, 65, and 130 square metres (fig. 5). The small house (29 square metres) is designed for a single student. Areas in the house include a kitchen and entrance area (5 square

Figure 4
Langford Architecture Center A, north facade, showing the louvres or wall coffers to host the infill micro-housing

metres), bathroom (0.7 square metres), study (2 square metres), bedroom (6 square metres), and stairs (1.5 square metres). The medium-size house covers 65 square metres and is designed for a married student with one child. The medium-size house comprises an entrance (5 square metres), kitchen (7 square metres), bathroom (1.8 square metres), living room (8 square metres), bedroom 1 (5 square metres), bedroom 2 (3.3 square metres), and platform (27 square metres). The large-size house, of 130 square metres, is designed for a married student with two kids. It consists of two medium-sized houses joined together. Areas include a kitchen (7.4 square metres), dining room (7 square metres), bathroom (1.8 square metres), living room (18 square metres), bedroom 1 (5 square metres), bedroom 2 (3.3 square metres), corridor (27 square metres), spare room 1 (7.4 square metres), spare room 2 (8 square metres).

Figure 5
Exterior views of the proposed infill micro-housing in the existing coffers

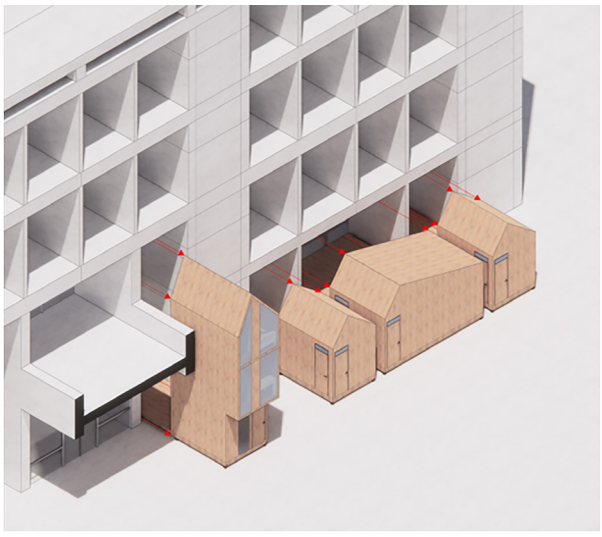

Figure 6
Floor plans of the small (a), medium (b) and large (c) micro units proposed

Results

Results of the Survey on Housing Issues

During the fall of 2021, 67,133 students were enrolled at the College Station campus, of which 54,595 (83 per cent) students were undergraduate students and 13,257 (19.7 per cent) graduate students (Texas A&M University Accountability Office, 2022). The number of graduate students living on-campus or off-campus was not available. A total of 3,360 students started the survey, and over 1,500 respondents completed the survey, resulting in a response rate of over 11 per cent. To answer the first research question: What is the housing issue situation among the graduate and professional students at a large public university? The overall results indicated that 35 per cent of respondents have experienced housing insecurity and 13 per cent have experienced homelessness. In terms of gender, 79 per cent and 53 per cent of nonbinary respondents have experienced housing insecurity and homelessness respectively, the highest among all gender categories. By race, Black respondents reported the highest levels of homelessness, while Native Americans reported the highest levels of housing insecurity. Respondents from the different units within the university such as the colleges of the interdisciplinary degree programme, Architecture, Liberal Arts, and Public Health reported the highest levels of housing insecurity. When the proposed infill housing was presented during the survey, more than half of the respondents opted for the medium-size housing proposal of 65 square metres in area. This survey highlights the housing vulnerability of the graduate students by categories such as gender and race, which necessitates further investigation and an architectural solution as a response to the problem.

There are several ways to resolve housing issues among graduate students. A "Host-Homes Programme" can be set up by the university, in which members of this community shelter vulnerable students in their houses. The university administration can establish emergency housing to serve as an immediate solution for students who need housing urgently. The university leadership can consider "future building ideas" to envision types of university housing for students experiencing homelessness or housing insecurity. This study explores the third solution, in which an architectural solution is proposed.

The second research question was: How does the graduate student housing situation compare to that at other universities in the United States? According to the U.S. Department of Housing and Urban Development (2019), "affordable housing is generally defined as housing on which the occupant is paying no more than 30 percent of gross income for housing costs, including utilities". Paying above 30 per cent is an accepted metric for identifying housing unaffordability that qualifies people for government assistance. In contrast, a survey conducted by The Hope Center (2021b) across fourteen colleges in Texas found that 55 per cent of respondents have experienced housing insecurity and that 16 per cent have experienced homelessness (fig. 7). Across United States, students have experienced 48 per cent and 14 per cent of housing insecurity and homelessness respectively (The Hope Center, 2021a). These surveys were, however, conducted among students enrolled in two-year and four-year colleges and do not specify whether graduate students were included.

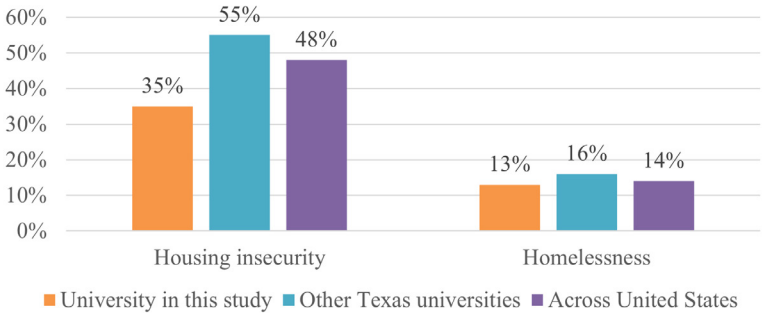

Figure 7
Comparison (per cent) of housing issues of the graduate students at the university and of students at other universities in the United States (The Hope Center, 2021a; 2021b).

Figure 8 shows the indicators for identifying housing insecurity among the graduate students. The majority (23 per cent) of the respondents experiencing housing insecurity indicated a "rent or mortgage increase that made it difficult to pay". This was followed by "lived with others beyond the expected capacity of the housing" at 11.1 per cent. Of the respondents, 10.7 per cent experiencing housing insecurity moved in with others due to financial difficulties.

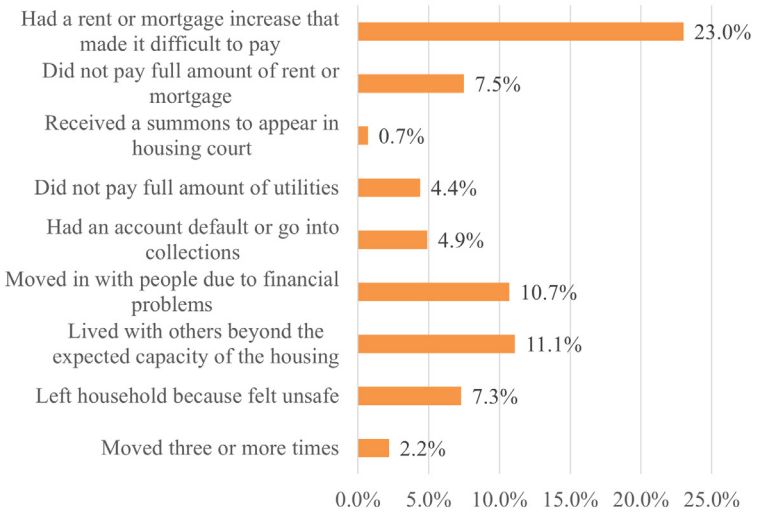

Figure 8
Housing insecurity breakdown among the graduate students of the university

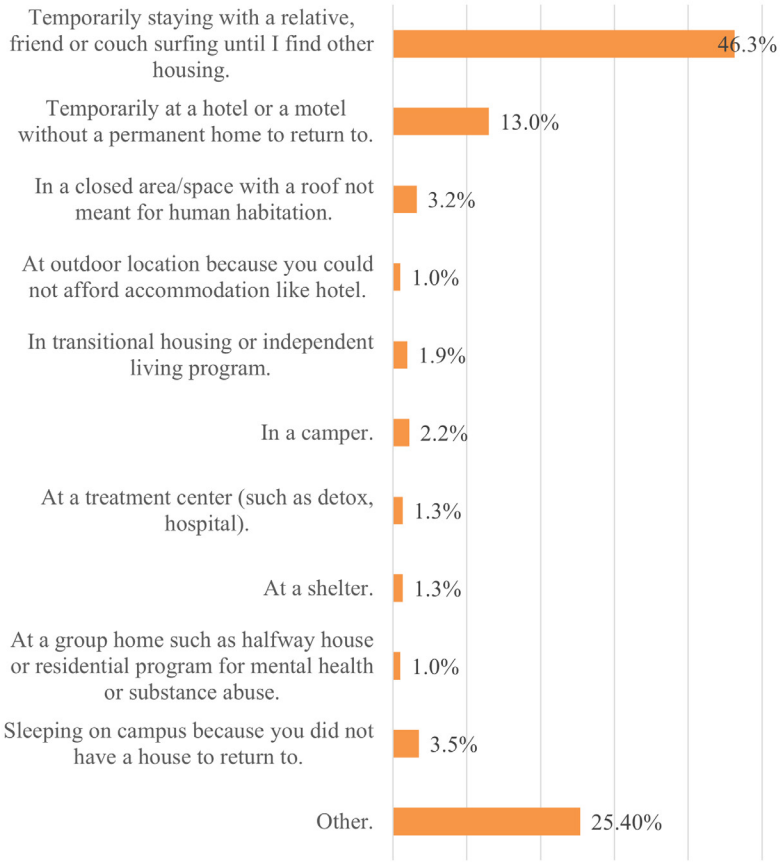

Figure 9
Homelessness reported by the graduate students of the university

Figure 9 shows the indicators for homelessness and the response to the indicators. Of the respondents, 46.3 per cent who experienced homelessness temporarily stayed with a relative or friend or couch surfed until they found their own place. This was the majority of the respondents who experienced homelessness, followed by 13 per cent of the respond-

ents who stayed at a hotel or motel temporarily because they did not have permanent housing to return to. Of these respondents, 25.4 per cent marked "other", where they were compelled to stay somewhere other than a permanent residence.

By Nationality

The third research question was: What is the difference in housing issues between the domestic and international students at a large public university? During the Fall 2021 term, 3,091 international students were enrolled in the graduate and professional degree programmes out of a total of 11,456 graduate and professional students. The international students thus constitute nearly one-fourth of the total graduate student population. Figures 10 and 11 show the difference between domestic and international graduate students in housing insecurity and homelessness respectively. The domestic students reported higher levels of housing insecurity (73 per cent), whereas the international students reported higher levels of homelessness (63.2 per cent). Twenty-one per cent of the domestic and 23 per cent of the international respondents experiencing housing insecurity indicated a "rent or mortgage increase that made it difficult to pay" (fig. 9). This was the largest reported indicator among all the indicators for housing insecurity. This was followed by "lived beyond the expected capacity of the housing", indicated by 10 per cent and 15 per cent of the domestic and international students respectively. Eleven per cent of domestic students and 12 per cent of international students who experienced housing insecurity indicated they that they "moved in with people due to financial problems".

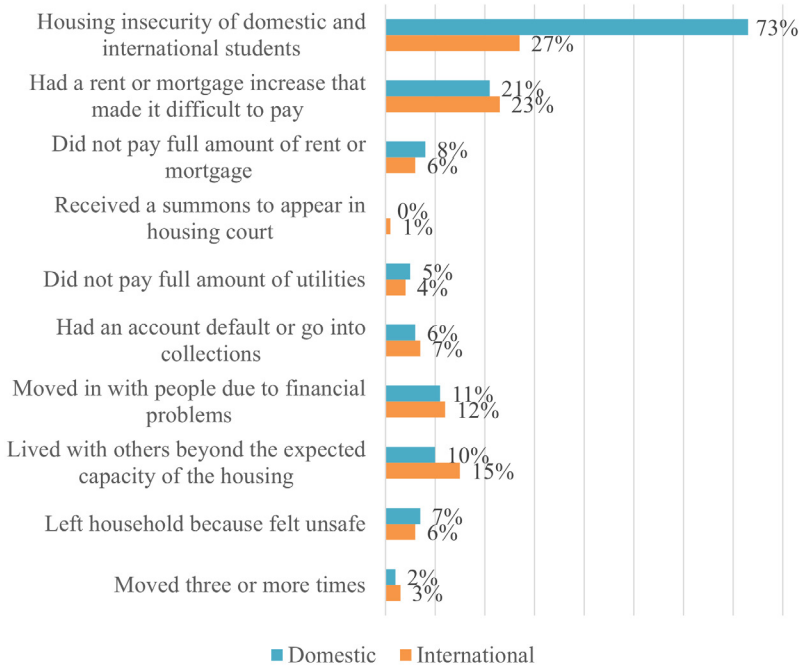

Figure 10
Housing insecurity levels (per cent) indicated by the graduate students by nationality

Among the respondents, 2 per cent of the graduate students and 2 per cent of the international students reported themselves as being self-identified homeless (fig. 11). "Temporarily staying with a relative, friend or couch surfing" was the most reported identifier for homelessness, indicated by 46.5 per cent of international students and 50.8 per cent of domestic students. This was followed by "temporarily staying at a hotel or a motel without a permanent home to return to", indicated by 13.1 per cent of the international students and 12.6 per cent of the graduate students.

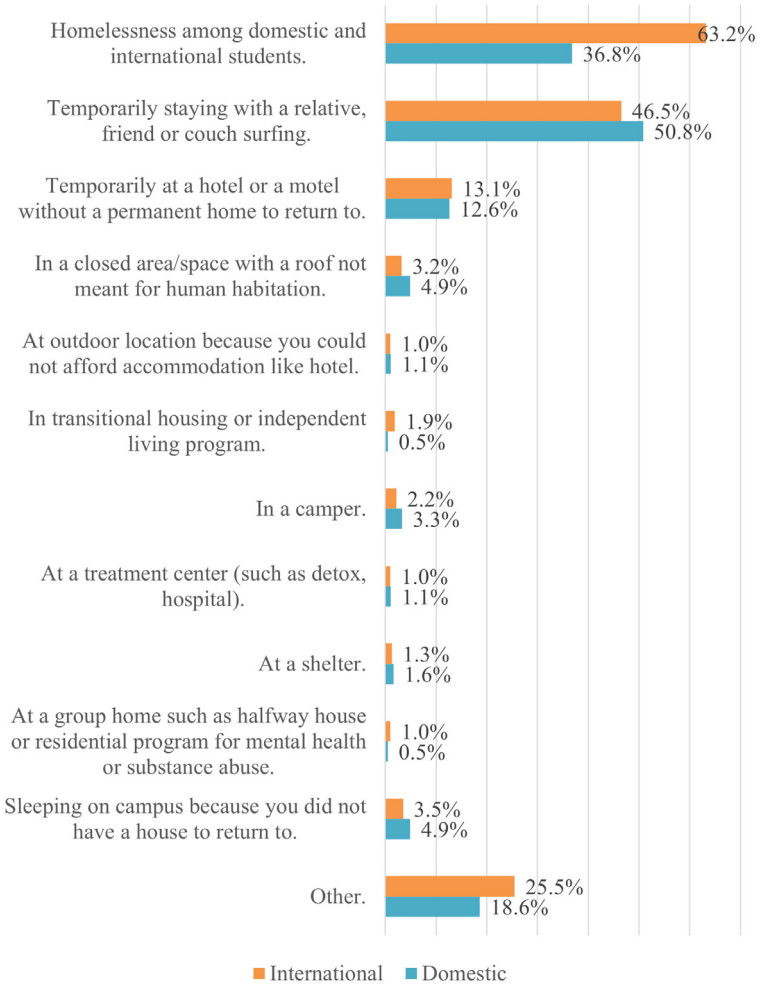

Figure 11
Homelessness (per cent) levels indicated by the domestic and international students in the survey

Table 1 shows the housing issues by nationality in this study. Brazilian, Iranian, and Japanese respondents have reportedly experienced the highest housing insecurity (100 per cent). 80 per cent of Turkish respondents have experienced homelessness, followed by Japan (67 per cent), and Nigeria (50 per cent), which represent the highest levels of homelessness experienced.

Table 1
Housing issues by country as reported by the respondents in this survey

Country	Housing insecurity	Homelessness
Brazil	100 %	20 %
Canada	43 %	0 %
China	62 %	19 %
India	63 %	21 %
Iran	100 %	27 %
Japan	100 %	67 %
Mexico	78 %	11 %
Nigeria	67 %	50 %
Turkey	80 %	80 %
United Kingdom	0 %	20 %
United States	61 %	10 %

By Race

Figure 12 shows the housing vulnerability by race in this survey. Among the respondents in this survey, 71 per cent of Black respondents have experienced housing insecurity and 27 per cent of them have experienced homelessness, which is the highest among all the respondents. This corresponds with the findings of The Hope Centre survey, in which Black, Indigenous, and Latinx students reported higher insecurity levels than other races. Eighty-nine per cent of native American respondents have experienced housing insecurity, which is the highest among all the races in this survey. Among the Asian students, 63 per cent reported having experienced housing insecurity and 17 per cent having experienced homelessness. Sixty-three per cent of Hispanic students have experienced housing insecurity and 16 per cent have experienced homelessness. Among the white student respondents, 62 per cent have experienced housing insecurity and 9 per cent have experienced homelessness.

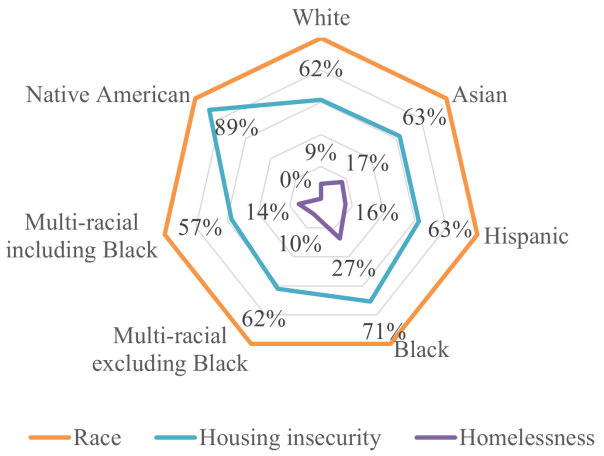

Figure 12
Survey results for housing insecurity and homelessness by race

By Gender

Female students formed the largest gender category of respondents who participated in this survey. Fifty-eight per cent of the respondents identified themselves as female, 41 per cent as male, and 1 per cent as nonbinary. Figure 13 shows the housing issues among these genders as reported by the survey participants. Seventy-nine per cent and 53 per cent of the nonbinary gender respondents have experienced housing insecurity and homelessness respectively, the highest among all three categories. Among respondents who identify as male and female, males reported higher levels of homelessness by comparison with females (15 per cent in contrast to 12 per cent). Females reported higher housing insecurity values (64 per cent as opposed to 59 per cent) similar to the results from The Hope Centre report (2021b), in which female students reported higher basic needs insecurity levels than male students. It can be speculated that perhaps the nonbinary students have difficulty in finding roommates, which might contribute to their housing issues.

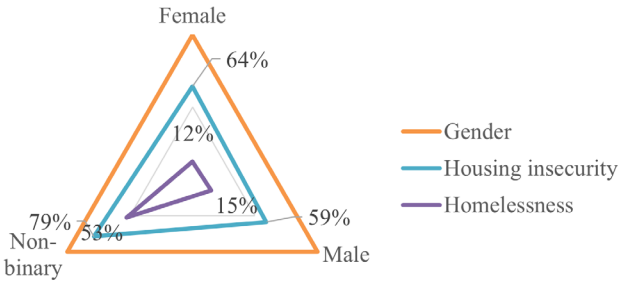

Figure 13
Survey results for housing insecurity and homelessness by gender

By Employment Type

Figure 14 shows the housing issues by employment type in this survey. Full-time graduate and professional students have reportedly experienced higher levels of housing insecurity (63 per cent) and homelessness (13 per cent) by contrast with their part-time counterparts. Fifty-six per cent of part-time graduate and professional students have experienced housing insecurity and 10 per cent have experienced homelessness. The survey findings indicate that the average rent or mortgage of the respondent is $952, and the average utilities costs $198.

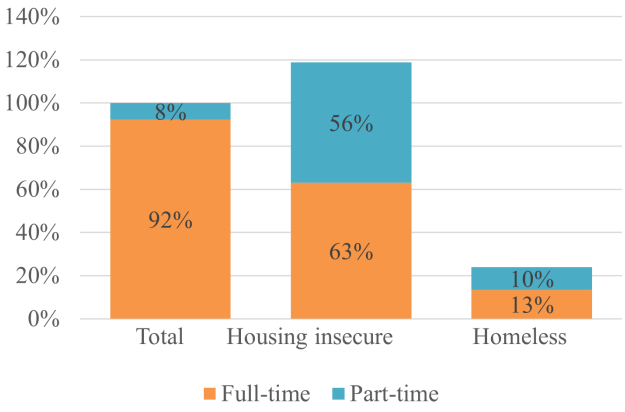

Figure 14
Survey results for housing issues by employment type

Response to the Infill Housing Proposed

During the survey, the respondents were shown a video describing the proposed infill housing and were asked to indicate their preferred housing type from among the three choices (fig. 15). Nearly three-fourths of the respondents chose the small- and medium-size houses. The majority (51 per cent) of the respondents indicated a preference for the medium-size house, with an area of 65 square metres. This was followed by the small-size house, with 29 square metres, which 30 per cent of the respondents indicated as their preference. The large-size house, with 130 square metres, was the least preferred housing type, and was chosen by 19 per cent of the respondents.

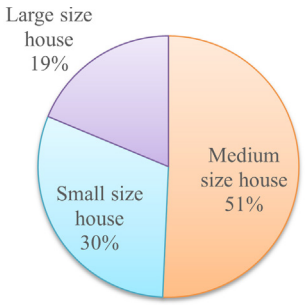

Figure 15
Preference for the proposed infill micro-housing as indicated by the survey respondents

Figure 16 shows the respondents' levels of likelihood to live in the proposed infill housing in exchange for work. Nearly half (44 per cent) of the respondents indicated their willingness to live in the proposed housing. However, this survey should also be conducted with graduate students in other contexts such as larger cities, where housing is more expensive. This would make it possible to obtain a better understanding of the graduate students' response to the concept of infill housing.

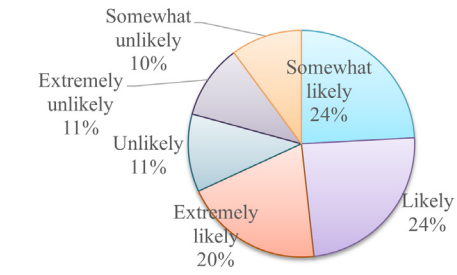

Figure 16
Likelihood of living in the proposed infill housing as indicated by the survey respondents

The responses regarding the likelihood of living in the proposed housing were categorized into students who have experienced housing insecurity and those who have not (fig. 17). Three-fourths of the respondents who admitted having experienced housing insecurity indicated they would be likely to live in the proposed infill housing. In comparison, only one-fourth of the students who indicated never having experienced housing insecurity would be likely to live in the proposed infill housing.

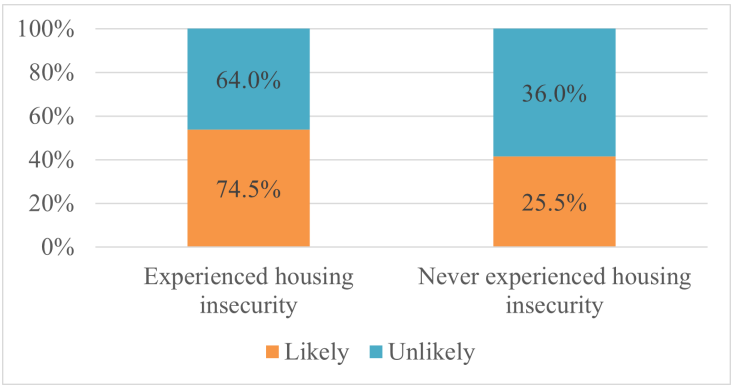

Figure 17
Response of the students who have experienced housing insecurity versus those who have not regarding the likelihood of living in the proposed infill micro-housing

The question that therefore arises is whether the difference observed is statistically significant. This question examines whether graduate students who have experienced housing insecurity will indicate whether they are more likely to live in the proposed housing than those who have not. A chi-square test was run to determine whether the difference is significant. The null hypothesis (H_0) states there is no difference in the response regarding the likelihood of living in the proposed housing between the graduate students who have experienced housing insecurity and those who have not. The alternative hypothesis states that students who have experienced housing insecurity are more likely to indicate a likelihood of living in the proposed housing. This is a one-tailed directional test, in which the significance level was set at 0.05. The chi-square statistic was computed to be 0.00021, which is lower than the significance level. We therefore reject the null hypothesis. This means that graduate students who have experienced housing insecurity will indicate they are likely to live in the proposed housing.

Discussion

There is limited literature on the housing challenges of university students who pursue graduate degrees. This research thus attempts to address this gap. The study also proposes an architectural solution by means of housing retrofitted onto a selected campus building. The research utilized a survey designed to obtain a better understanding of the housing issues.

The first and second questions in this survey focussed on the housing challenges encountered by graduate students at Texas A&M University, and how they compare with other universities. The findings indicated that approximately 35 per cent of survey respondents indicated having experienced housing insecurity, and 13 per cent having experienced homelessness. The figures are lower than the survey conducted across other universities in the state. This therefore needs to be investigated further in order to determine the explanation behind the findings and find out whether the difference is significant.

With respect to gender, the findings suggest that nonbinary respondents indicated a higher level of housing issues and homelessness than the male and female respondents. There is an opportunity to investigate the reasoning behind this. Seventy-nine per cent and 53 per cent of nonbinary respondents reportedly experienced housing insecurity and homelessness respectively. These respondents indicated a higher degree of housing issues and homelessness than the male and female respondents. In this survey, the nonbinary respondents constituted only 1 per cent of the total respondents. Their housing challenges therefore need to be investigated to determine whether they face more difficulties than other genders and find the explanation for this result.

The third research question sought to gather the respondents' opinions on the architectural solution of the infill housing proposal. Nearly half of the respondents indicated their willingness to reside in the proposed housing. However, this solution was proposed for a university where the students primarily reside in the college town and its adjacent sister city, with a combined population of less than 300,000 people (U.S. Census Bureau, 2023). To fully assess the response to the proposed infill architectural solution, perceptions from university students in different contexts, such as those located in larger cities, should be compiled. Additionally, the micro-housing solution proposed in this study is specifically tailored to the Langford Architecture Building A, which features exterior wall louvres (coffers), making it a unique case. Infill housing solutions for other types of buildings need to be planned and designed according to their specific characteristics. Therefore, further exploration and planning are necessary in this regard so as to develop similar infill housing solutions for different building types.

Conclusion

This research bridges the gap between architectural design innovation and social science by proposing an infill micro-housing model that reclaims underutilized spaces on campus and is tailored to the needs of graduate students, many of whom face housing difficulties. It attempts to determine the acceptability of a micro-housing proposal as a viable campus housing strategy, while contributing empirical evidence on the extent of housing insecurity among an overlooked student demographic. Graduate students pursuing master, professional, and PhD degrees are a different demographic than those pursuing an undergraduate degree and their needs are unique. This article focussed on their housing issues and attempted to provide an innovative architectural solution. As individuals with a higher education contribute substantially to a nation's development, it is imperative to address the needs of such students. Findings reveal that more than one-third of this population have experienced housing insecurity and nearly half of the total survey respondents spend more than 30 per cent of their income on housing. Differences were also observed in terms of aspects such as the nationality, race, and gender of the students and the college in which they were enrolled. In response to the proposed infill micro-housing, close to half of the respondents expressed a willingness to live in the proposed models. Notably, a statistically significant difference was observed between the graduate students who have experienced housing insecurity and indicated they are likely to live in the proposed housing and those who have not experienced housing insecurity.

The infill micro-housing proposal was, however, only designed for a specific on-campus building, a Brutalist concrete structure with its unique form, and is not applicable to other buildings. It was developed without mass adoption in mind, and was instead conceived to serve as temporary housing for graduate students in exchange for assistantship services provided to the university. At this stage, the housing remains a proposal, with future work focussing on developing a real-life prototype to assess its feasibility and practicality.

This work aims to inform university administrators and government officials of the housing challenges of their graduate student population, with the goal of aiding them in developing policies and implementing actions to address the housing issues. The insights gained from this work will therefore hopefully contribute towards mitigating the housing problems faced by graduate students.

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Declaration of interest statement

The authors report that there are no competing interests to declare.

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