

World Sustainability Series

Walter Leal Filho  
Fernanda Frankenberger  
Patricia Iglecias  
Roberta Consentino Kronka Mülfarth  
*Editors*

# Towards Green Campus Operations

Energy, Climate and Sustainable  
Development Initiatives at Universities

 Springer

# **World Sustainability Series**

## **Series editor**

Walter Leal Filho, HAW Hamburg, Hamburg, Germany

Due to its scope and nature, sustainable development is a matter which is very interdisciplinary, and draws from knowledge and inputs from the social sciences and environmental sciences on the one hand, but also from physical sciences and arts on the other. As such, there is a perceived need to foster integrative approaches, whereby the combination of inputs from various fields may contribute to a better understanding of what sustainability is, and means to people. But despite the need for and the relevance of integrative approaches towards sustainable development, there is a paucity of literature which address matters related to sustainability in an integrated way.

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# Preface

It is widely known that matters related to sustainable development, albeit global in nature, are best handled at the local level. This line of thinking is particularly true to the higher education context, where the design and implementation of sustainability initiatives on campuses can demonstrate how a given university translates the principles of sustainable development into practice, at the institutional level.

Yet, despite the perceived need to discuss approaches and methods to make university campuses more sustainable, there is a paucity of specific events where a dialogue among sustainability academics and practitioners concerned with (a) research, projects (b) teaching and (c) planning and infrastructure leading to campus greening takes place, so as to allow a transdisciplinary and cross-sectoral exchange of ideas and experiences on the issues, matters and problems at hand. It is against this background that the book **“Towards Green Campus Operations: Energy, Climate and Sustainable Development Initiatives at Universities”** has been prepared.

It is one of the outcomes of the **“First Symposium on Sustainability in University Campuses” (SSUC-2017)** organised by the University of São Paulo in Brazil, Manchester Metropolitan University in UK, the Research and Transfer Centre “Applications of Life Sciences” of the Hamburg University of Applied Sciences in Germany and the Inter-University Sustainable Development Research Programme (IUSDRP).

This book showcases examples of campus-based research and teaching projects, regenerative campus design, low-carbon and zero carbon buildings, waste prevention and resilient transport among others. It also demonstrates the role of campuses as platforms for transformative social learning and research and explores the means via which university campuses can be made more sustainable.

The aims of this publication are as follows:

- i. To provide universities all around the world with an opportunity to obtain information on campus greening and sustainable campus development initiatives from around the world;

- ii. To document and promote information, ideas and experiences acquired in the execution of research, teaching and projects on campus greening and design, especially successful initiatives and good practice;
- iii. To introduce methodological approaches and projects which aim to integrate the topic of sustainable development in campus design and operations.

This book entails contributions from researchers and practitioners in the field of campus greening and sustainable development in the widest sense, from business and economics to arts, administration and environment.

Thanks to its nature, this publication is expected to contribute to the further development of this fast-growing field. We thank the authors for sharing their knowledge and know-how, and the many reviewers who have assisted with the peer review of the papers. We hope this book will further support the development of more sustainable campuses around the world.

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Curitiba, Brazil  
São Paulo, Brazil  
São Paulo, Brazil  
Spring 2018

Walter Leal Filho  
Fernanda Frankenberger  
Patricia Iglecias  
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**Part I**  
**Concepts and Reflexions**  
**on Campus Greening**

# Space, Like Time, Is Money: Evaluating Space Utilisation in Saudi Arabian Universities



Naif Alghamdi

**Abstract** The demand for tertiary education in the Kingdom of Saudi Arabia has been increasing. As a result, the Kingdom is expanding its higher education sector, through which twenty public universities were established. The establishment of these institutions has led to the building of campuses in order to provide enough space for teaching, learning, training, and research. However, the United Nations long-term projections of the Kingdom forecast that there will be a sharp decline in the youth population. The consequences of these projections pose a problem to long-term strategic planning for space at university campuses. To ensure a match between supply and demand for space, this paper investigates the provision and utilisation of space in Saudi Arabian university campuses. Operating the physical plant sustainably by identifying and eliminating underutilised space not only saves energy and funds, but also improves the student and staff satisfaction by creating a good balance between space needs and space provision. The ultimate aim of this paper is to highlight how space use is measured, what the utilisation rate of existing premises is, and how space can be effectively and efficiently operated. Data was collected through two instruments: the first and predominant instrument was the examination of the space utilisation of five college buildings in five different universities; four buildings were from recently founded universities, while one building was from a well-established university. The second instrument employed was a questionnaire in which one thousand two hundred and ninety users including students, faculty members, and supporting staff were asked about their experience of space use. Findings show that almost all spaces in college buildings, in both new and old institutions, were not utilised as they should be. The paper ends with some recommendations to improve space planning and to optimise space use.

**Keywords** Space utilisation · University campus · Space planning  
Facility management · Saudi Arabia

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## 1 Introduction

The institution's physical structure is 'one of its most valuable assets' (HEFCE 2000, 01). The real estate owned by universities can be described as the most expensive asset (Abdullah et al. 2012). It is widely observed that higher education institution buildings 'are becoming an under-utilised asset' (Shabha 2004, 81). A poor ratio of utilising space dictates the costs of cleaning, maintaining, cooling, heating, and so on (Williams and Worthington 1986). They added that '[a] large number of buildings seem to be designed for the benefit of the passerby, the investor, the builder—anyone but the occupier, the user of space' (Williams and Worthington 1986, 07). This indicates the significance of space planning in general and in university campuses in particular.

Identifying and eliminating vacant spaces can save money and energy. The significance of operating space efficiently is certainly not new. Knapp et al. (2009) believe that what is less widely understood is how difficult it can be to precisely measure space utilisation. They highlight the fact that '[there] is often a significant difference between how much vacancy real estate executives think they have and how much they actually have in their portfolios' (Knapp et al. 2009, 238). The way in which space is utilised will have a major influence on efficiency and cost (Williams and Harris 1988). This shows the importance of understanding how space can be measured and how it can be managed. The UK National Audit Office (NAO 1996, 01) succinctly stated that:

Space, like time, is money. If your institution is typical, the provision, servicing and maintenance of accommodation is the second largest cost it has to bear. Without efficient space management, the resources tied up in your institution's estate are not used to best effect. Reducing estates costs by using space more efficiently can release funds for other important activities.

The amount of resources needed to provide and operate space in higher education has drawn attention to both space provision and space utilisation. As a developing country, Saudi Arabia is spending massively in education, health, infrastructure, among others. Special focus is given to its higher education sector, through which new universities have been recently established. A considerable investment in university campuses is intended to meet accommodation demands for ever increasing student population. Space provision has become a necessity in the majority of public universities in Saudi Arabia. Space planning and space management are vitally important in order to achieve a balance between the supply and demand. 'What we need versus what we have determines the mismatch between current supply and current demand, [while] what we might need in the future versus what we have now determine the mismatch between future demand and current supply' (De Jonge et al. 2009, 36). Building new university campuses in the Kingdom is undertaken in phases. Nonetheless, the scale, size, and speed of constructing new college buildings in the country raise concerns about not only the utilisation of the existing stock of premises, but also the feasibility of the newer ones.

There is an urgent need to address the issues of space planning and space management in Saudi Arabia in order for university campuses to be more environmentally, economically, and socially sustainable. Therefore, the purpose of this paper is to explore the provision and utilisation of space in Saudi Arabian university campuses. The ultimate aims of this research are to highlight how space use is measured, show the utilisation rates of existing premises, and underline how space can be operated effectively and efficiently.

Surprisingly, little attention has been paid to space utilisation in the literature. Conducting a space utilisation study was described as ‘difficult due to the lack of research in this area’ (Abdullah et al. 2012, 932). The central reason for this difficulty is that utilisation surveys are expensive. They require considerable resources, given the number of staff involved, the number of rooms surveyed, and the length of observation time (NAO 1996). Another reason is that ‘some have argued that the amount of space per student or per member of staff is a more useful space management performance indicator than space utilisation rates’ (SMG 2006, 06). Having said that, there has been no single study that explores space utilisation in Saudi Arabian campuses. As a result, this research makes a major scientific contribution to research on space utilisation by providing data on how space is being utilised and hence helping to inform policy- and decision-makers about the type and amount of space required.

This research paper has some limitations. Although Saudi Arabia has 28 public universities, this research project selected only five university campuses as case studies. This choice was purely based on the availability of information and also permission to access these premises. The research is unable to include all college buildings in the five selected university campuses. Instead, only five buildings were chosen. Yet, in every college building, not all rooms were included in the survey. Only 30 rooms were surveyed in each building. These rooms, according to the scheduled activities and the planned group sizes, were the busiest rooms in the building. Therefore, the result of this research cannot be used for generalisation. However, what matters is that this research provides in-depth analysis to better understand the issues of space utilisation and planning in Saudi Arabian campuses. Flyvbjerg (2006, 227) ‘[a] purely descriptive, phenomenological case study without any attempt to generalise can certainly be of value in this process and has often helped cut a path toward scientific innovation.’ Another limitation is that it is beyond the scope of this study to examine all types of space in college buildings. The main focus was on the teaching rooms, which include classrooms, science laboratories, studios, and computer rooms, given that most higher education institutions collect data mainly for teaching space (SMG 2006, 07). Rooms that are excluded from the survey include technology laboratories, libraries, offices, meeting rooms, exhibition areas, conference rooms, theatres/auditoriums, staff rooms, and leisure rooms.

The overall structure of this paper takes the form of six sections. The first part, the introduction, begins by underlining the importance of space utilisation study, presenting background information about the use of space and its implications. It also emphasises the societal and scientific problems of the research. Section two

gives a brief overview of the higher education system in Saudi Arabia, some recent developments of university campuses, and the projection of youth population in the Kingdom. Section three analyses space utilisation literature through which definitions and measurements are presented. Section four reports the research methodology in which data collection techniques are explained. Section five comprises of discussion of the results of the survey. The last section presents the findings of the research and some recommendations.

## **2 Higher Education in Saudi Arabia**

### ***2.1 Higher Education System in Saudi Arabia***

The Kingdom of Saudi Arabia has adopted a long-term strategic plan for its Higher Education (Ministry of Education 2011). The strategic plan, the so-called 'The Horizon', aims to build a knowledge society by investing in human resources through both general education and higher education. Additionally, it aims to be a major driver for transforming the Saudi Arabian economy from dependency on oil revenues to diverse resources and manufacturing. The plan's three strategic dimensions are quality, expansion, and diversity. It is believed that through these dimensions, higher education can advance the country efforts in achieving a 'knowledge society'. The plan identifies eight main areas to focus on, one of which is the infrastructure. The physical settings, such as buildings and other facilities, include both the planning for the transformation of existing university campuses as well as the construction of new campuses in both public and private higher education institutions.

To implement the abovementioned strategic plan, the government of Saudi Arabia is currently investing heavily in the education sector with a special focus on the higher education sector. In 2016, almost a quarter of the national budget was spent on education and training sector.

Furthermore, when comparing higher education in Saudi Arabia with other nations, the Kingdom's system is relatively young. Only four universities are over 50 years old. For almost four decades (1960–2000), the Kingdom was known to have just eight universities, established between 1957 and 1998. Today, however, it has 28 public universities, in which the majority of universities were established between 2003 and 2014. The recently founded universities were in fact satellite or branch campuses of those eight well-established Saudi universities, which in recent years became independent universities. This in turn means that 70% of public universities have been established in the last decade. These 28 public universities are funded directly by the Saudi Ministry of Education. These public universities tend to be comprehensive; providing a wide range of disciplines. These universities serve 1,323,692 students (Ministry of Education 2015). Furthermore, there are other higher education institutions that are managed and funded by other

ministries and government agencies. These institutions focus on some technical, industrial, medical, and administrative aspects, offering higher education to 125,279 students in the country.

Moreover, private higher education in the Kingdom is expanding rapidly. Currently, the country has 11 private universities and 18 private colleges, covering a whole range of areas including medical, administrative, scientific, and technological subjects. There are over 78,798 students in private universities and colleges in Saudi Arabia (Ministry of Education 2015).

According to the Ministry's Statistic Centre, there were in total 1,527,769 students, 76,985 faculty members, and 77,130 administrative and technical staff in higher education institutions, both public and private (Ministry of Education 2015).

Other characteristics of the higher education system in the Kingdom are: centralised system of control, gender segregation, funded by the state, free for all citizens at all levels, so citizens do not pay to study, instead they are paid (Smith and Aboummoh 2013).

## ***2.2 University Campuses in Saudi Arabia: A General Overview***

With this in mind, the boom has led to the construction of 20 new campuses in different parts of the kingdom. Phase one—which includes constructing community colleges, science colleges, medical colleges, engineering colleges, and some housing units for both students and academic staff—is expected to be completed by 2017. These campuses are located in cities that have had no prior history of hosting such institutions. Thus, their impact can be clearly ascertained, to the extent that it is safe to conclude that their construction has added value to these cities and even to the wider province. The new universities cost more than €16 billion in total. The capacity of new campuses ranges between 10,000 and 90,000 students each. According to the Saudi Ministry of Education (2015), the enrolled students in 2015 were 1,323,692 students; 1,252,634 Saudis (94%) and only 71,058 non-Saudis (6%). Around 350,000 new students (freshmen) are expected to be enrolled in public universities each year. The total capacity of the 20 new campuses will be more than 800,000 students, increasing accessibility of higher education learning to a total of almost two million students once these new campuses are fully operational. The total area of campus land is more than 112 million square meters (11 thousand hectares). This massive city-like area allows for flexibility and future expansions. It has to be said that the majority of the 20 new universities have male campus and female campus within the university campus boundaries. These campuses also include medical cities, research cities, sport cities, housing for students and staff, investment areas (endowments), future expansion zones, and other service areas. Such rapid expansion has the propensity to hinder a more sustainable future.

### 2.3 Saudi Arabia's Youth Population

Figure 1 shows that the projections of the youth population in Saudi Arabia aged between 15 and 24. The data is based on the United Nations (2015) projections of the Saudi youth population. It should be highlighted that the important segment for this study is the group aged between 19 and 24, where youth are expected to be at the university having completed their high school. The graph displays that in the short-term, there will be an increase of the youth population. It is also projected that this particular segment of the Saudi society will continue to increase and reach its peak in 2035. In the long-term, however, a sharp continuous declining of the youth population can be clearly noticed. This raises a concern about the long-term planning for space management and the feasibility of such large university campuses.

Looking closely at this graph, especially at the statistics of the year 2015, it can be said that of the 4.5 million youth population, 1.5 million were studying in higher education institutions in Saudi Arabia. This means that around one-third of the youth population was enrolled in the Kingdom's colleges and universities. Moving forward, it can be seen that there will be a sharp increase until the year 2035 with the peak reaching about 5.7 million. If one-third attends universities, then the expected number would be around 1.9 million students in the years 2030–2035. This should not automatically mean an increase in the space provision at university campuses. That is because there will be a huge drop in the youth population from its peak of 5.7 million to 5 and then 4 million in 2040 and 2045, respectively. The projection indicates that the youth population might remain flat at around 4 million, which means about 1.3 million students in higher education system if the admission's level stays as it is now. This data should be taken into account when planning for physical space in university campuses. In order to avoid over-provision of space, there is a need to audit space at the national level, given that the latter does not exist yet in the Kingdom of Saudi Arabia. The drop in the number of students is a major issue facing many countries around the world, including Japan (TJTN 2016), Russia (UWN 2015), and the United States of America (IHED 2015). The only reservation about the United Nations (2015) projections for the Saudi youth

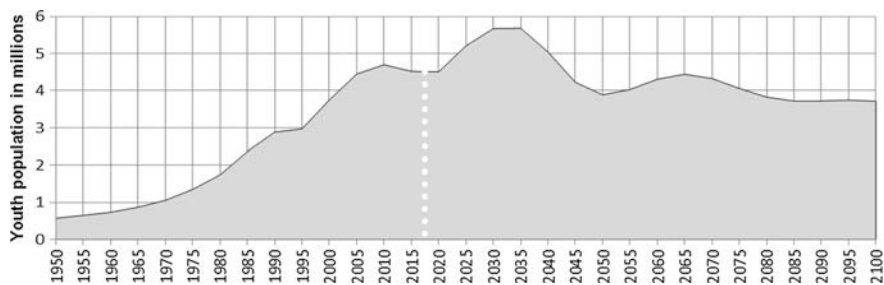


Fig. 1 Saudi Arabia's youth population in millions

population is that it is merely a prediction. With this in mind, planners should make scenarios in which youth population might be far less or maybe far more than projected and build upon these scenarios by taking into consideration other alternatives.

### **3 Space Utilisation: An Analytical Review**

This section aims to systematically review the concept of space utilisation by providing some key definitions as well as outlining some theories and practice in order to understand the idea behind space utilisation.

#### ***3.1 Key Definitions***

In one of its early reports, Space Management Group in the United Kingdom (SMG 2006, 03) has concisely defined space utilisation key terms as:

- Space utilisation is ‘a measure of whether and how space is being used’.
- Frequency rate ‘measures the proportion of time that space is used compared to its availability’.
- Occupancy rate ‘measures how full the space is compared to its capacity’.
- Space utilisation rate is ‘a function of a frequency rate and an occupancy rate’.

#### ***3.2 The Importance of Space Utilisation Studies***

The SMG (2006, 11) emphasises that the survey of UK Higher Education Space Management Project ‘found that utilisation rates were the most frequently cited indicator’ for measuring the performance of managing space.

Additionally, there are a number of benefits results from conducting space utilisation studies. Russell and Doi (1957, 02) pointed out that there are two compelling reasons why universities should make space utilisation studies:

- Knowledge of the degree and kind of use made of the physical plant is a condition of good management. The physical plant of a typical college or university represents a large investment of financial resources. It is costly to build, costly to maintain in good repair, and costly to heat, light, clean, and attend to. Thus, any addition to the physical plant should be made only after careful study.
- A second compelling reason for plant utilisation studies is the prospect of large enrolment increases, dramatized by the now familiar phrase “the impending tidal

wave of students.” The plant facilities hosting greater student numbers will have to provide more efficient utilisation of space.

The strategic role of space utilisation studies was highlighted by the SMG (2006, 03) indicating that these studies assist universities to ‘assess what size of estate is affordable’ by providing ‘information on how space is being used and help to inform decisions about the type and scale of facilities needed.’ Such information can be directly used to reduce the energy consumption of building systems such as lighting, HVAC, IT, and other plugged-in devices including computers, printers, desk lamps, coffee makers...etc. (Garg and Bansal 2000). For example, good occupancy detection and control for lighting systems and for HVAC result in energy savings of 50% (Harle and Hopper 2008) and 20% (Erickson and Cerpa 2010), respectively.

The technical role of such studies was summarised by the National Audit Office in the United Kingdom (NAO 1996, 01) as:

- Measure how intensively accommodation is being used, both in terms of levels of occupancy and frequency of use.
- Reveal whether scheduled activities are actually taking place.
- Track changes in demand over a period of years.
- Identify surplus and shortfalls and areas of poor performance, which could be remodelled or disposed of.
- Provide data for reviewing space management policies.

### ***3.3 Historical Development of Space Utilisation Studies***

Historically, the first work on space utilisation in higher education institutions was initiated in the United States by the University of Iowa in 1916 (Sharma 1991). In 1957, Russell and Doi have published a comprehensive document titled ‘Manual for studies of space utilization in colleges and universities’, which was seen by many as the first extensive research on how space in universities can be measured (Tjomsland 1959).

Kenny (1977) believes that space utilisation studies began to gain momentum in the United Kingdom in the late 1960s, when higher education institutions came under huge pressure to take in more students. The National Audit Office (NAO) was established in 1996 to manage the space provision and utilisation in British colleges and universities.

In Australia, Sharma (1982) is believed to be the first to undertake space utilisation survey in the Australian higher education institutions. Since 1978, the then Tertiary Education Commission began a yearly gathering of space utilisation data from the Australian Colleges (Sharma 1991). Another early attempt to advance space utilisation studies in Australia was carried out by Lagunzad (1990) in which it

was indicated that a great effort is needed to institutionalise such studies in higher education institutions.

Scanning the literature of space utilisation shows that there are a number of publications coming from Malaysia. Authors such as Abdullah et al. (2012), Kasim et al. (2012), and Abdullah et al. (2012), have all provided some insightful practice and performance of space utilisation in Malaysia.

### ***3.4 The Challenges in Optimising Space Utilisation***

There are a number of factors influencing the optimal use of space. The SMG (2006, 13) sums them up in eight factors:

- Poor condition and functional suitability.
- Poor environmental quality.
- Split sites.
- Specialist spaces and equipment that have a limited range of uses.
- Accessibility and health and safety restrictions on space.
- Availability of audio-visual equipment and the layout of rooms.
- The difference between predicted and surveyed rates of utilisation.
- Other factors include teaching and learning trends, whether or not detailed information is available on what space is needed, and the nature of the estate in terms of its fitness for purpose and versatility.

### ***3.5 How to Measure Space Utilisation Level***

There are a number of aspects to bear in mind when conducting data collection for space utilisation rate. There are two methods of calculating the utilisation rate:

- First is by calculating the planned utilisation which is based on the assumption of how the space will be used. For example, using data from the timetables in existing buildings or the projected level of use in new buildings.
- Second is by calculating how the space is actually being used. For instance, using data based on observation (manually counting).

Some colleges and universities collect data using both methods: planned and actual use of space. There is, however, a difference between predicted and surveyed rates. The predicted or timetabled rates tend to be higher than the actual use of space with about 15% (SMG 2006, 10).

Furthermore, some institutions have used other ways to collect space utilisation data. Swipe card and webcams are cases in point. Yet, these tools have pros and cons. The main advantage is that it reduces the time required to collect data.



However, the swipe card does not provide reliable data about how many people are actually using the space. In both cases (Swipe card and webcams) ‘data obtained would still need to be entered into the analysis software’ (SMG 2006, 23). More advanced technologies are being used to monitor the utilisation of space in university campuses worldwide. Examples of such as technologies include Bluetooth, Wi-Fi, Passive Infrared and Ultrasonic Motion Sensors, and PC Login (Von Neida et al. 2001; Dodier et al. 2006; Melfi et al. 2011; Christensen et al. 2014). Valks et al. (2016) have investigated using such technologies in 14 Dutch public universities and concluded that using Wi-Fi to measure utilisation in university campuses is the most suitable tool, given that it uses already existing IT infrastructure and hence cheaper compared with other technologies. It is also flexible and hence easy to change, and it is applicable for many users on campus.

Higher education institutions focus more on the teaching rooms, given that ‘the general purpose teaching space is the most common type of space to be surveyed’ (SMG 2006, 07). Other rooms that are less surveyed include science and technology laboratories, libraries, offices for both academic and staff, meeting rooms, exhibition areas, conference rooms, theatres/auditoriums, staff rooms, and leisure rooms.

According to the SMG (2006, 07), comparing results of utilisation between institutions is difficult. This is because there are many issues to take into account including ‘the types of rooms surveyed, the hours covered, the basis on which capacities are calculated, and whether reports are provided on the basis of a planned use of space or observations of how space is being used.’

The NAO (1996, 20) indicates that ‘[the] survey represents a snap shot view of the use of the estate at a particular time. The standard calculation of utilisation is

$$\frac{\% \text{ frequency} \times \% \text{ occupancy}}{100} = \text{space utilisation rate}$$

- Frequency is the number of hours a room is in use as a proportion of total availability (the timetabled week).
- Occupancy is the average group size as a proportion of total capacity for the hours the room is in use.

It is important to highlight that some higher education institutions do not collect data on occupancy rates; instead they focus on merely the frequency levels. The SMG (2006, 08) shows that this is ‘often on the grounds that they have much greater control over the frequency with which rooms are used, whereas occupancy rates are highly dependent on whether students and other users choose to attend.’

Timing is crucial when collecting data for the utilisation study. The utilisation rate will be greatly influenced by the chosen timeslots. ‘Results will differ if average utilisation levels are calculated over a 9.00 am–5.00 pm period or between 8.00 am to 8.00 pm’ (NAO 1996, 21). Undertaking the survey over a period of time may

result in a better overview of the utilisation level. ‘One Welsh institution carried out a survey over five weeks taking a different day each week in order to minimise the possibility that staff would argue that the selected week was not typical’ (NAO 1996, 21). The main objective should be to:

- assess the space at ‘a time of peak load’,
- assess ‘four to six weeks’ after the semester starts, and
- ‘avoid seasonal factors such as reading weeks, examination weeks, or field trips’ (NAO 1996, 21).

### ***3.6 The Targeted Rate of Space Utilisation***

The Polytechnics and Colleges Funding Council (PCFC) in the UK suggests a figure of 64% (80% frequency and 80% occupancy), which many believed to be significantly higher than any figure in practice (NAO 1996, 21). They added that ‘[even] 50% (70% frequency and 70% occupancy) may prove very challenging. The Higher Education Funding Council for England (HEFCE 2000, 37) grades space utilisation levels ‘as follows:

- Good is equal to or greater than 35% utilisation rate.
- Fair is 25–35% utilisation rate.
- Poor is equal to or less than 25% utilisation rate’.

Regardless, all higher education institutions ‘must set their own target rate in relation to their individual problems of bad fit. The target rate should improve each year’ (NAO 1996, 21).

## **4 Research Methodology**

This section explains the approach used in this research through highlighting (i) how the data was collected, (ii) what type of space surveyed, (iii) how the space rate is calculated, and (iv) when the survey was carried out.

Two techniques were employed in order to collect data to explore the utilisation level in public university campuses in Saudi Arabia. The primary technique was the examination of the space usage of five college buildings in five different universities. The second instrument employed was a questionnaire in which almost 2000 users including students, faculty members, and supporting staff were asked about their experience of space use in their college buildings.

Given that the majority of higher education institutions tend to focus on the general purpose teaching space, this research has followed suit. Therefore, this paper concentrates on general teaching rooms which include mainly classrooms,

few teaching laboratories, studios, and computer rooms. Other rooms such as specialist teaching space (theatres/auditoriums), research areas (research laboratories), offices (for both academic and staff), and support space (libraries, meeting rooms, exhibition areas, conference rooms, staff rooms, and leisure rooms) are not included in this study.

As for how space utilisation rate is calculated, this research uses the scheduled activities and the planned group sizes to calculate the predicted utilisation rates. This means that this study uses data from the timetables of the five existing college buildings in order to assume how teaching space is used. Digital copies of the timetables have been requested from the Registration Departments at each college. Microsoft Excel program was used for data entry and analysis.






The research collected its data during the second semester of the academic year 2015–2016 and hence the results of this research represent the utilisation rates of this period. This research uses the standard working hours of 40 per week for its analysis (eight hours a day; 09:00–17:00). However, since universities in Saudi Arabia have different timetables, and hence no ‘typical day’, a comparison between different working hours per day and their impact on the utilisation rates has been carried out to identify the utilisation levels in every case. Note that the working week in Saudi Arabia starts on Sunday and ends on Thursday.

Therefore, the sample in this research consists of five college buildings from five different universities; four buildings were from recently founded universities, while one building was from a well-established university. Table 1 illustrates the five cases and some basic information for each case. The choice of these five cases was purely based on the availability of information and also permission to access these premises. These cases are:

- 1st Case** College of Languages and Translation at King Saud University (KSU) that founded in 1957, and is in the centre of the country (Note 1).
- 2nd Case** College of Science at University of Hail (UofH) that founded in 2005, and is in the north of the country (Note 2).
- 3rd Case** College of Engineering at University of Najran (UofN) that founded in 2006 and is in the south of the country (Note 3).
- 4th Case** College of Science and Humanities at Prince Sattam bin Abdulaziz University (PSAU) that founded in 2006, and is in the centre of the country (Note 4).
- 5th Case** Community College at University of Hafr Albatin (UHB) that founded in 2006 and is in the east of the country (Note 5).  
\* More information about these college buildings can be found in Note 6.

In order to assess the space at ‘a time of peak load’, 30 of the busiest rooms were selected in each college building. These rooms were selected based on their high frequency and occupancy rates. The total number of rooms analysed in this research were 150 rooms.

**Table 1** The research sample

| 1st case  | 2nd case  | 3rd case  | 4th case  | 5th case  |
|---|---|---|---|---|
|  |  |  |  |  |
| College of Languages and Translation<br>King Saud University                        | College of Science<br>University of Hail  | College of Engineering<br>University of Najran                                    | College of Science and Humanities<br>Prince Sattam bin Abdulaziz University       | Community College<br>University of Hafr Albatin                                   |
| (KSU)   | (UofH)  | (UofN)  | (PSAU)  | (UHB)   |
| City of Riyadh  | City of Hail  | City of Najran  | City of Alkhaij   | City of Hafr Albatin  |
| Central part of Saudi Arabia  | North part of Saudi Arabia  | South part of Saudi Arabia  | Central part of Saudi Arabia  | East part of Saudi Arabia   |

## 5 Results and Discussion

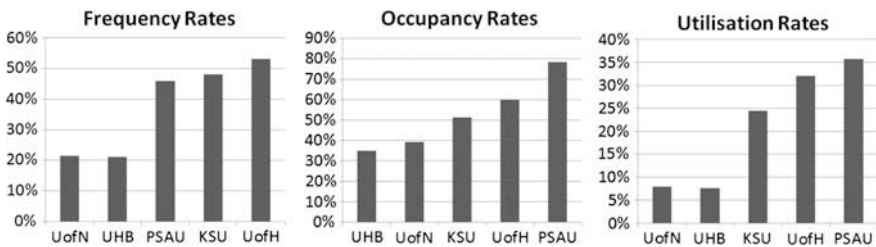
This section presents and describes the results of the analysis of exploring space utilisation of five college buildings from different universities in Saudi Arabia. It shows the rates of utilisation, frequency, and occupancy of 150 rooms. It highlights the frequency rates per timeslot, the occupancy rates per timeslot, and the room requirement. Finally, this section gives an overview of space utilisation and user satisfaction (students, academics, and supporting staff) and how flexible are users with working hours.

### 5.1 Frequency, Occupancy, and Utilisation Rates

Figure 2 displays the frequency, occupancy, and utilisation rates of the five college buildings. The figure shows each college individually, in which there were two colleges with very poor utilisation rates (UofN 7% and UHB 7%), two colleges with fair level of utilisation (KSU 25% and UofH 32%), and one college with good rate of utilisation (PSAU 36%). The poor utilisation rates are caused by very low frequency and occupancy rates. It has to be highlighted though that these rates represent the 30 busiest rooms in each college building. Therefore, this indicates a serious utilisation issue, given that the predicted or timetabled rates tend to be higher than the actual use of space.

This paper uses the standard working hours of 40 per week for its main analysis (eight hours a day; 09:00–17:00). Table 2 shows the frequency, occupancy, and space utilisation rates of all college buildings combined when working hours are between 09:00 and 17:00 (8 h per day–40 h per week). It illustrates that the average rate of utilisation of all college buildings is poor (22%).

However, given that every institution has different timetables (no fixed working hours per day), a comparison between different working hours per day and their impact on the utilisation rates was carried out to identify the utilisation levels in every case. Tables 3 and 4 present the frequency, occupancy, and space utilisation rates of all college buildings combined when working hours are between 08:00 and



**Fig. 2** Frequency, occupancy, and utilisation rates of the five college buildings

**Table 2** Frequency, occupancy, and space utilisation rates of all college buildings combined when working hours are between 09:00 and 17:00 (8 h per day–40 h per week)

|  | Frequency (%) | Occupancy (%) | Utilisation (%) |
|--|---------------|---------------|-----------------|
| Average rates of recently founded colleges | 35            | 53            | 21              |
| Average rates of old college               | 48            | 51            | 24              |
| Average rates of all                       | 38            | 53            | 22              |

**Table 3** Frequency, occupancy, and space utilisation rates of all college buildings combined when working hours are between 08:00 and 17:00 (9 h per day–45 h per week)

|  | Frequency (%) | Occupancy (%) | Utilisation (%) |
|--|---------------|---------------|-----------------|
| Average rates of recently founded colleges | 37            | 53            | 22              |
| Average rates of old college               | 50            | 53            | 27              |
| Average rates of all                       | 39            | 53            | 23              |

**Table 4** Frequency, occupancy, and space utilisation rates of all college buildings combined when working hours are between 08:00 and 20:00 (12 h per day–60 h per week)

|  | Frequency (%) | Occupancy (%) | Utilisation (%) |
|--|---------------|---------------|-----------------|
| Average rates of recently founded colleges | 26            | 52            | 15              |
| Average rates of old college               | 35            | 53            | 19              |
| Average rates of all                       | 28            | 52            | 16              |

17:00 (9 h per day–45 h per week) and when working hours are between 08:00 and 20:00 (12 h per day–60 h per week). In all seniors, the utilisation rates are very low, except in the old college where working hours are 45 per week. These poor utilisation rates are alarmingly low, since the analysed rooms were supposed to be the busiest in each building.

Another serious issue is the space area per an equivalent full-time student unit (EFTSU). The analysis of space per user in the five college buildings (see Notes 1, 2, 3, 4, and 5) shows that the average area per student is 1.8 m<sup>2</sup> per student. This excludes specialised teaching rooms such as science laboratories, computer rooms, and studios, which all have different size requirements. The standard for general teaching room suggests 1.0 m<sup>2</sup> per workplace (UGC 1987). Therefore, space planning has to be addressed, given that the average area of teaching space in Saudi Arabia tends to be higher than the norm.

The space planning issue, abovementioned, has led to a mismatch between the planned capacity and the scheduled capacity. The planned capacity is what the designers/architects have suggested for each space, whereas the scheduled capacity is what the college registrars have actually scheduled in each space (the scheduled