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The Impact of Work Desk Shapes on the Utilisation of an Activity-Based-Working Environment

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Abstract: The design of Activity-Based Working (ABW) environments embraces workers' continuous mobility enabled by technology and the mindset of seeking work zones that best support the task at hand. This paper focuses on aspects of workspace selection within a facility designed to support ABW, focusing on the overall occupancy dynamics, temporal context, and information capturing less-explored details of the physical environment. This study analyses the active use of a workspace in relation to work desk shapes, rectangular and trapezial. Drawing from a longitudinal dataset spanning 12 months from an ABW facility, capturing the active workstation usage of 964 occupants through individual computer logins, this study employs descriptive statistics to analyse the active use of workspace relative to total work hours over the year. Inferential statistical techniques are utilised to compare active use measurements between and within specific workspace areas, revealing significant differences and highlighting the importance of temporal and spatial contexts in workspace utilisation patterns. The presented results demonstrate both tendencies and statistically significant differences, confirming the relevance of the studied variables in examining workspace utilisation. The results show significant usage variations throughout the day across different zones of the observed workspace, with peak activity between 11:00 and 13:00 h for both work desk shapes. This study's insights are relevant to improving the utilisation of facilities designed for ABW and contribute to a longstanding interest in designing and arranging workplaces to better fit the people who use them.

Keywords: activity-based working; building occupancy; workspace design; statistical analysis; occupancy dynamics; activity peaks

Citation: Stojanovic, D.; Vujovic, M.; Gocer, O.; Marzban, S.; Candido, C. The Impact of Work Desk Shapes on the Utilisation of an Activity-Based-Working Environment. *Buildings* **2024**, *14*, 1401. https://doi.org/10.3390/buildings14051401

Academic Editor: Chyi Lin Lee

Received: 11 April 2024
Revised: 3 May 2024
Accepted: 11 May 2024
Published: 14 May 2024

1. Introduction

Activity-Based Working (ABW) offers individuals the freedom to work in a way that suits them best and can lead to higher satisfaction levels [1–4]. This freedom empowers people to choose their work style, environment, and schedule and can enhance their productivity and well-being [1,5]. However, realising the full potential of this freedom relies on work zones that cater to different work tasks. Creating diverse and adaptable workspaces can ensure individuals have the appropriate environment for focused work, collaboration, or creativity [6,7]. While ABW enhances productivity and well-being, it necessitates an adequate physical environment. This includes spatial layout but also how offices are furnished and equipped. The literature suggests that the provision of adequate workstations, including a variety of desks, is an important aspect in facilitating workers' mobility and a range of work activities [8]. However, aspects such as that are less studied, while their impact on occupancy change over time could be highly relevant to supporting ABW [1].

ABW presents an opportunity to optimise space utilisation, particularly in the post-COVID era [9]. A comprehensive review of the literature on ABW from 2012 to 2022 has yielded valuable insights into the post-Covid workplace [3]. The findings of this review indicate that a partial adoption of ABW practices results in diminished occupant satisfaction, reduced productivity, and compromised well-being, while the implementation of ABW in a holistic manner, on the other side, increases the likelihood of achieving positive outcomes [3]. These outcomes can include organisations' capability to use their facilities more efficiently, optimise their workflows, and reduce their outgoings. However, a challenge arises as the planned utilisation of the space does not always align with the actual usage patterns and individual preferences [10]. A growing body of research suggests that this discrepancy can be mitigated through careful observation and analysis of how people utilise the space relying on different building occupancy measurement systems [11,12]. Moreover, research developing at the intersection of several disciplines explores how such data can provide insights to help adjust and improve the workspace to better cater to variable occupancy, employees' needs, and preferences [13].

Previous research has highlighted the significance of understanding employees' work patterns, tasks, and preferences to create a flexible and tailored workspace [8]. Leveraging data on workspace occupancy rates, frequency of space usage, and peak utilisation hours can provide valuable insights into how the workspace is utilised. By analysing such data, organisations can identify underutilised spaces, overcrowded areas, and patterns of workspace preferences [14]. Using data enables organisations to make evidence-based decisions in optimising the workspace [15,16]. Furthermore, continuous monitoring of utilisation data allows organisations to track the effectiveness of workspace changes over time and ensures that the workspace remains dynamic and adaptable to meet the evolving needs of the employees and the organisation [10,17].

The increasing volume of research is driven by the need to understand better how human behaviour and personal preferences, individual feelings, fatigues, and habits are impacting the timing of activities and how offices are utilised [18,19]. Scoping the research area for this study shows that the existing studies addressing ABW have not sufficiently explored the relevance of aspects that are perhaps obvious to designers and architects. These aspects include physical properties and finer nuances, such as desk shapes in the workspace. Some studies refer to the height and shape of the work surface and examine the ergonomic aspect [20]. Other related studies indicate the influence of the shape of the work desk on group work in educational settings [21,22]. While manufacturers and furniture suppliers provide various solutions, there is still a lack of analysis and evidence of their impact on the usage of workspaces supporting ABW.

Literature research leading up to this study shows that the change in active use across designated areas in the facilities designed for ABW needs to be examined further. We identify three aspects or topics for further inquiry: (1) the impact of workers' individual preferences, (2) better inclusion of the temporal context, and (3) a better understanding of the relationship between physical properties of space and building occupancy. Our literature research also recognises the complexity of workplace making, and we acknowledge that when any of the variables are observed in isolation, it may not provide adequate explanations. However, the research presented in this paper aims to contribute to the knowledge base and ways of studying by expanding the number of variables considered and including those less explored aspects.

The study presented in this paper focuses on finer details associated with workspace choice in an environment designed to support ABW, related to the floor plan layout and furniture specification. The observed physical characteristics of workspaces include trapezial or rectangular work desk shapes, which, along with the number of workstations, define layouts tailored to accommodate various activities within the workspace. This study also explores the temporal component and how such choices change at different times of the day. These choices are part of the broader set of aspects impacting occupancy. This study recognises the complexity of variables influencing the active use of the workspace, which has been identified in the literature and a growing body of research, demonstrating various occupancy data that can be utilised to improve the efficiency of space usage. However, it concentrates on the relevance of work desk shapes and the temporal context, as these are identified in the existing literature as relevant [18–22], and yet, they remain insufficiently explored in relation to ABW. Important aspects that are highly relevant to the utilisation of workspace, such as those related to distances from and to amenities and co-workers, daylighting, and other indoor environmental qualities, are not explicitly addressed in this study. These and many other variables impacting human behaviour were not included to allow testing and developing analysis focusing on specific datasets. This is realised to help establish a method that can be expanded to include more data and study correlations between different aspects in future undertakings.

This paper examines the relationship between workspace selection and utilisation within Activity-Based Working (ABW) environments, focusing on the influence of work desk shapes over time. By narrowing the scope to specific aspects, like desk shapes, this study aims to help find a way to expand the number of variables studied in relation to the active use of workspaces in future research. It fills gaps in the existing literature and contributes to establishing more comprehensive ways and methods for analysing workspace data, shedding light on the impact of architectural design choices on actual workspace utilisation.

The following Research Questions are formulated to help structure the study of the selected workspace: How are different working areas of ABW facilities used at different times of the day? How does the work desk shape affect the use of facilities designed to support ABW? And how can we use finer resolution data collected over time to study the utilisation of a workspace?

2. Materials and Methods

The research in this study comprises three steps that analyse the active usage of workstations within a workplace environment. First, the investigation is grounded on the primary data source of workstation activity, recorded in minutes over 12 months. Second, this dataset was systematically structured and normalised to facilitate a comprehensive understanding of workstation utilisation patterns. The data are organised into distinct groups and normalised to provide insights into the active usage of work zones. The studied data incorporate information on desk shapes. The active usage data are stratified based on two parameters: (1) the annual accumulation of minutes within each of the seven designated Work Zones and (2) 120 min intervals for each of the 93 Workstation Clusters observed during each workday over a year.

The test was performed with values reflecting active usage in two-hour slots for each Work Zone to establish if there is a statistically significant difference in active use across different times of the day.

The presented research utilises a longitudinal dataset to examine occupancy rates within the seven designated zones, each tailored to accommodate diverse work styles. Occupancy patterns are observed across the Workspace, which comprises multiple Work Zones. Each of the seven nominated Work Zones encompasses multiple clusters with a varied number of workstations, adding complexity to the tasks. This required the data to be standardised for comparative analysis. First, the annual sum of active minutes recorded for each Workstation Cluster is divided by the number of workstations within that cluster. Second, the resultant values are divided by 255, representing the total number of workdays per year. These values are then converted into fractions of the overall recorded usage. Finally, the active usage fraction for each Work Zone is computed as an average of all percentages calculated for clusters within that zone. This structured approach ensures a robust methodology for analysing and interpreting workstation activity within the workplace.

The available data are used for the analysis of Work Zone usage, and more specifically, for the analysis of Workstations taking different shapes of Work desks into account. Following the findings from the literature research, the emphasis is placed on the temporal context. This is accomplished by organising and normalising the available data to enable analysis aiming to answer the three posed research questions (Figure 1).

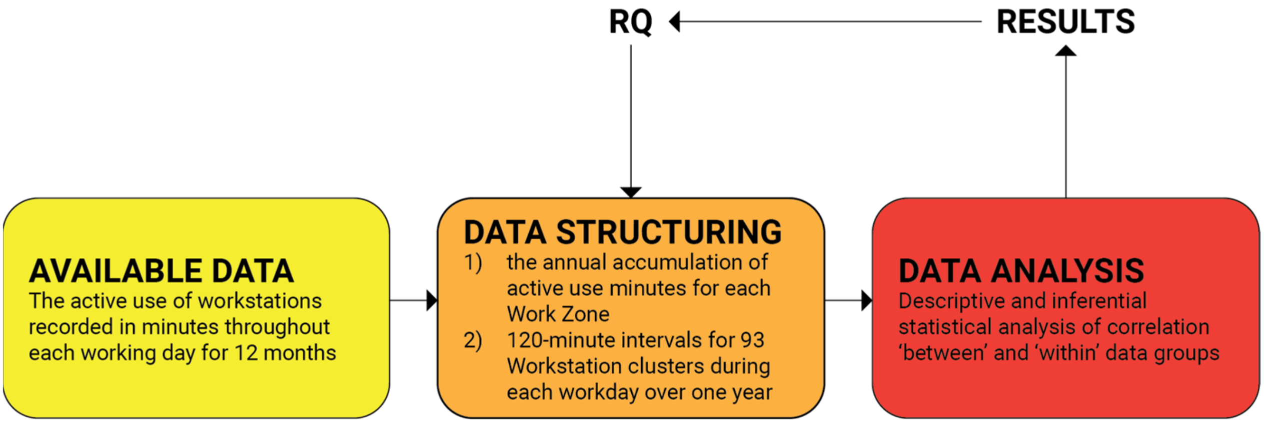

Figure 1. Summary of the research method.

This study differentiates between distinct spatial concepts signified by the following terms: (1) Workspace, (2) Work Zone, (3) Workstation Cluster, and (4) Workstation. These are presented schematically first (Figure 2). The four concepts are utilised in this study to help structure an inquiry into how work environments are designed and organised to support modern-day workflows, which is further elaborated in this section. These four concepts differ in size and are observed as 'layers' of spatial organisation relevant to architectural design and decision-making related to architectural layouts of modern office spaces. The 'workstation' is the smallest concept as it signifies an individual workplace, such as a space that includes a desk, a chair, and an area/room needed for one person to work. When identical workstations are grouped, they are acknowledged as a 'Workstation Cluster' in this study. The term 'Work Zone' in this study identifies a group of Workstation Clusters with identical desk shapes and united spatial layouts, as drawn in the architectural floorplan. It is essential to clarify that a Work Zone can comprise a single or multiple Workstation Clusters. Finally, the largest spatial concept, 'Workspace', denotes an indoor environment where people work, such as an open-plan office. Seven different Work Zones containing 93 Workstation Clusters are identified in the observed Workspace. The use of the Work Zone concept helps to organise available occupancy data for an observed Workspace to enable an inquiry into the impact of design decisions concerning the spatial layout, such as the choice of desks for individual Workstations and their positioning in reference to other Workstations with desks of the same shape. This study aims to structure occupancy data collected at the level of individual Workstations, to understand the usage of Work Zones and to discuss the relationship between physical properties and active use of a specific Workspace designed for ABW.

Statistical analysis is employed to determine if a statistically significant difference exists between and within data groups on the active use of specific (1) Work Zones and (2) Workstations.

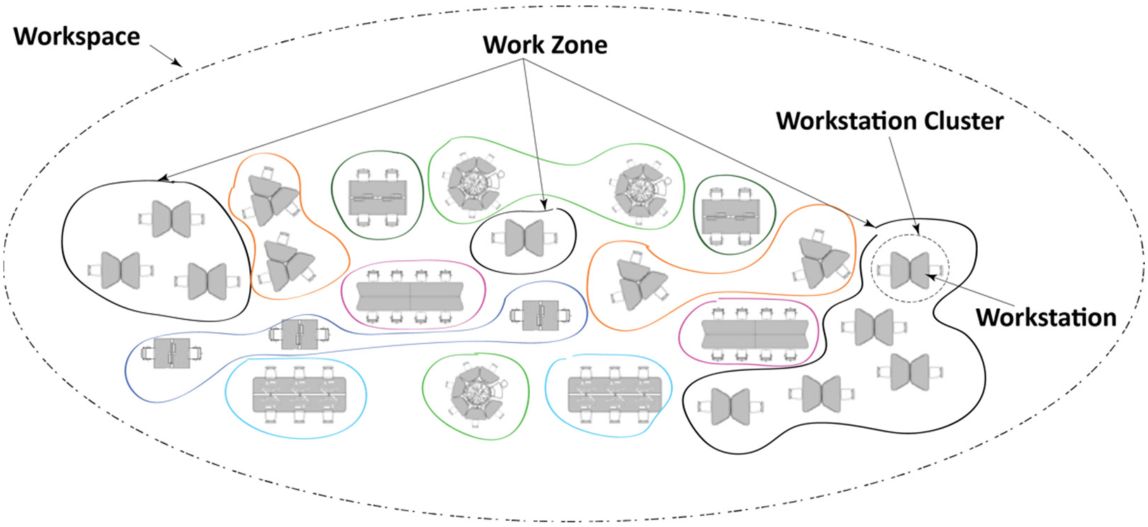

Figure 2. Schematic illustration of spatial concepts that are relevant to this study.

2.1. Setting

The observed office is designed to support ABW, enabling occupants to choose different workstyles and mobility. This study examined a Workspace occupying a single floor of a large building for which occupancy data were made available to researchers and focused on Work Zones as groups of identical Workstation Clusters designed to accommodate different work activities. The seven types of Workstation Clusters are identified (Table 1), and, accordingly, seven Work Zones are established. All Clusters are composed of Workstations with identical desks. The number of Workstations per Cluster varies from two to eight across different clusters. The work desk shape, the observed physical characteristics of the Workplaces, is either trapezial or rectangular. These two parameters, the shape of the work desk and the number of Workstations, are characteristics of different layouts planned for various activities unfolding within the Workspaces. In an architectural project, during the building planning phase, the choice of Workstations and layout of Workstation Clusters is often considered relevant to the interaction between co-workers and for accommodating a balance between individual and group work. For example, Clusters 2T, 2L, and 3L are designed for individual work and as little disturbance as possible. Clusters 4L, 6L, and 6C may be more suitable for casual interaction between co-workers and collaborative activities without booking requirements. Cluster 8L could be best suited for a formal meeting and group teleconferencing with booking requirements. Ways of working and interior design support workers moving between these layouts throughout the day, depending on their preferences. The resulting occupancy pattern reflects active workplace usage.

Table 1. Overview of Workstation Clusters and Work Zones.

Workstation Cluster Code:	**2T**	**2L**	**3T**	**4L**	**6L**	**6C**	**8L**
Work Desk shape: T—Trapezial; L—Rectangular; and C—Circular	T	L	T	L	L	C	L
Number of Workstations per cluster	2	2	3	4	6	6	8
Total number of clusters within the Work Zone	8	2	17	24	29	3	10
Total number of Workstations per Work Zone	16	4	51	96	174	18	80

2.2. Available Data and Data Structuring

The primary data available for this study are the active usage of workstations recorded in minutes throughout 12 months. That data are structured into data groups and normalised to allow insight into the active use of Work Zones as groups of Workstation Clusters.

The active use data are structured according to (1) the annual accumulation of minutes for each of the seven Work Zones and (2) 120 min intervals for each of 93 Workstation Clusters during each workday over one year. A presence-based, longitudinal dataset is used to examine occupancy rates in the seven zones designed for different workstyles and investigate occupancy patterns across the observed Workspace. Each of the seven nominated Work Zones comprises multiple Clusters and a different count of Workstations distributed across the observed Workplace.

2.3. Data Analysis

This study employs descriptive and inferential statistical analysis, commonly used in building occupancy studies and research on workspaces [23]. The posed research questions required a combination of the two methods, descriptive and inferential. Data normalisation is undertaken to improve integrity in comparison between Work Zones, as groups of identical Workstation Clusters with a varied number of Workstations. Descriptive statistics are employed to analyse active use for each Work Zone individually in reference to the total number of work hours for one year and to provide a broader overview of the data acquired through measuring. Inferential statistics, on the other hand, have helped reach conclusions through extrapolations of those data. Work Zones with an inadequate data sample were excluded from the statistical analysis because of the small number of Clusters and Workstations. The employed inferential statistics Kruskal–Wallis test was used to identify patterns within the collected data. The analysis of variance (ANOVA), a statistical analysis technique, compares data groups to establish if active use measurements between and within Work Zones are significantly different.

3. Results

3.1. The Active Use of the Observed Workspace at the Annual Level

The active use fraction for each Work Zone is calculated as an average of all percentages calculated for clusters in that zone (Figure 3).

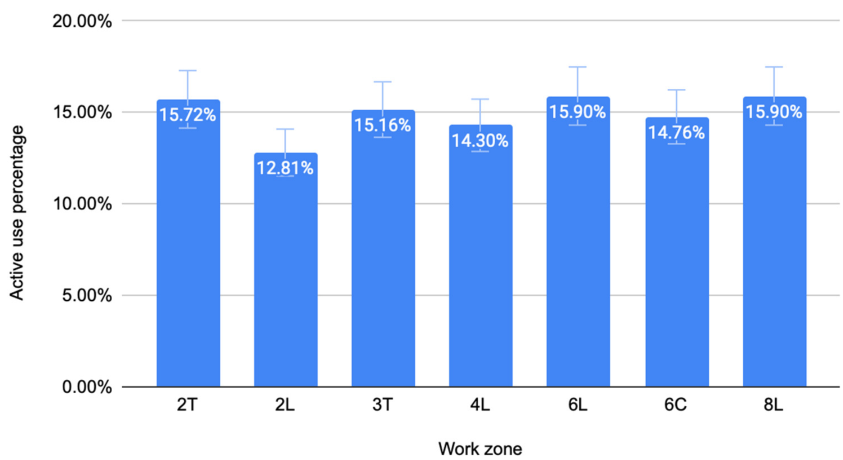

Figure 3. Overview of active use per Work Zone as a fraction of overall active use at the annual level.

The graph shows that Work Zones composed of clusters 6L and 8L have the highest active usage, and the Work Zone composed of clusters 2L has the lowest active usage. The statistical analysis examines differences between groups, showing the difference between the active use of Work Zones at the annual level. Analysis of variance (ANOVA) for Work Zones composed of clusters 2T, 3T, 4L, 6L, and 8L was conducted for the normalised data for active usage during work hours over one year or 255 working days. Work Zones composed of clusters 2L and 6C were excluded from the analysis because of the small data sample. Results (p = 0.871095) show no statistically significant active usage difference between Work Zones.

3.2. The Active Use of the Observed Workspace throughout the Day

Figure 4 and Table 2 show the values of average annual occupancy for five Work Zones according to two-hour slots. Work Zones composed of clusters 2L and 6C were excluded from the analysis because of the small data sample.

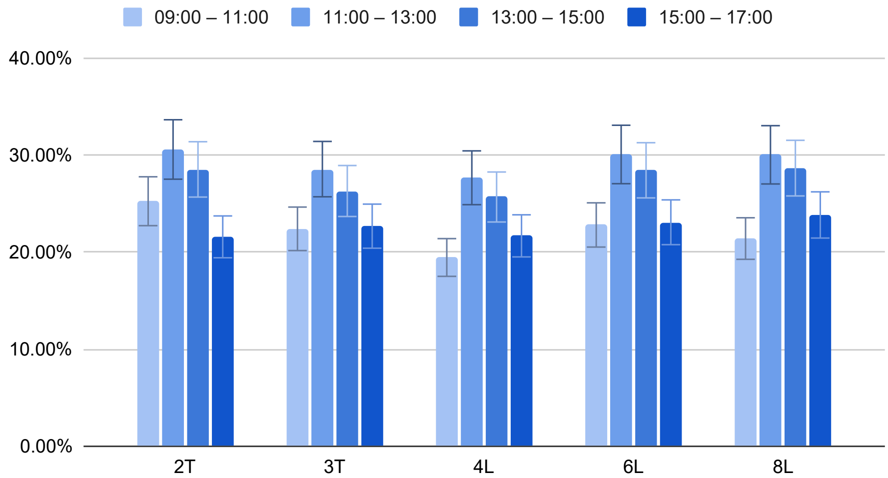

Figure 4. The active use of the Work Zones at two-hour intervals throughout the workday.

Table 2. Percentages of the active use of the Work Zones at two-hour intervals throughout the workday.

	2T	3T	4L	6L	8L
09:00–11:00	25.25%	22.41%	19.45%	22.81%	21.40%
11:00–13:00	30.58%	28.55%	27.66%	30.06%	30.03%
13:00–15:00	28.52%	26.30%	25.68%	28.43%	28.66%
15:00–17:00	21.58%	22.68%	21.67%	23.08%	23.83%

The presented results show no statistically significant differences between the five data groups. Therefore, the conducted statistical analysis is concerned with the correlation within data groups. Results ($p < 0.00001$ for 4L and $p = 0.000126$ for 6L) show that the difference in active usage of Work zones composed of clusters 4L and 6L from 11:00 to 13:00 and from 13:00 to 15:00 is statistically significant compared to active use from 9:00 to 11:00 and from 15:00 to 17:00 (Table 3). This shows that usage of Work Zones composed of Clusters 4L and 6L is higher in the middle of the day than at the beginning or end of the working day. ANOVA results for Work Zones composed of clusters 4L and 6L are presented in Tables 4–7.

Table 3. ANOVA results (within groups) for active use according to two-hour periods per Work Zone.

Type	*p*-Value
2T	0.2718
2L	low sample size
3T	0.1888
4L	<0.00001
6L	0.000126
6C	low sample size
8L	0.1652

Table 4. ANOVA results for Work zones composed of cluster 4L.

Result Details				
Source	***SS***	***df***	***MS***	
Between-treatments	8,070,952,542	4	2,017,738,136	*F* = 16.07923
Within-treatments	14,431,033,447	115	125,487,247.4	
Total	22,501,985,990	119		

The f-ratio value is 16.07923. The p-value is <0.00001. The result is significant at $p < 0.05$.

Table 5. Pairwise comparison of active use between periods for Work Zones composed of clusters 4L.

Pairwise Comparisons		
09:00–11:00 and 11:00–13:00	M1 = 23,811.13 M2 = 33,857.00	Q = 4.39 (p = 0.01980)
09:00–11:00 and 13:00–15:00	M1 = 23,811.13 M3 = 31,433.63	Q = 3.33 (p = 0.13481)
09:00–11:00 and 15:00–17:00	M1 = 23,811.13 M4 = 26,529.33	Q = 1.19 (p = 0.91736)
11:00–13:00 and 13:00–15:00	M2 = 33,857.00 M3 = 31,433.63	Q = 1.06 (p = 0.94421)
11:00–13:00 and 15:00–17:00	M2 = 33,857.00 M4 = 26,529.33	Q = 3.20 (p = 0.16361)
13:00–15:00 and 15:00–17:00	M3 = 31,433.63 M4 = 26,529.33	Q = 2.14 (p = 0.55391)

Table 6. ANOVA results for Work Zones composed of cluster 6L.

Result Details				
Source	***SS***	***df***	***MS***	
Between-treatments	4,018,491,388	3	1,339,497,129	*F* = 7.51026
Within-treatments	19,975,828,201	112	178,355,608.9	
Total	23,994,319,589	115		

The f-ratio value is 7.51026. The p-value is 0.000126. The result is significant at $p < 0.05$.

The presented results show tendencies and statistically significant differences between the active use of the workspace at different times of the day. These results corroborate that active use for all Work Zones peaks in the middle of the working day, as indicated by descriptive statistics results.

Further analyses were conducted for the two Work Zones with the most significant number of Workstations, providing a larger research sample with a more substantial data quantity. The following graphs show active use for each Workstation Cluster in the same Work Zone, according to two-hour intervals calculated at the annual level (Figures 5 and 6). The two graphs show that active usage varies across all Workstation Clusters of the same Work Zone. Both graphs show that all clusters are most active between 11:00 and 13:00 h.

Table 7. Pairwise comparison of active use between periods for Work Zones composed of cluster 6L.

Pairwise Comparisons		
09:00–11:00 and 11:00–13:00	M1 = 41,870.00 M2 = 55,191.86	Q = 5.37 (p = 0.00134)
09:00–11:00 and 13:00–15:00	M1 = 41,870.00 M3 = 52,206.21	Q = 4.17 (p = 0.02010)
09:00–11:00 and 15:00–17:00	M1 = 41,870.00 M4 = 42,377.90	Q = 0.20 (p = 0.99891)
11:00–13:00 and 13:00–15:00	M2 = 55,191.86 M3 = 52,206.21	Q = 1.20 (p = 0.82970)
11:00–13:00 and 15:00–17:00	M2 = 55,191.86 M4 = 42,377.90	Q = 5.17 (p = 0.00221)
13:00–15:00 and 15:00–17:00	M3 = 52,206.21 M4 = 42,377.90	Q = 3.96 (p = 0.03004)

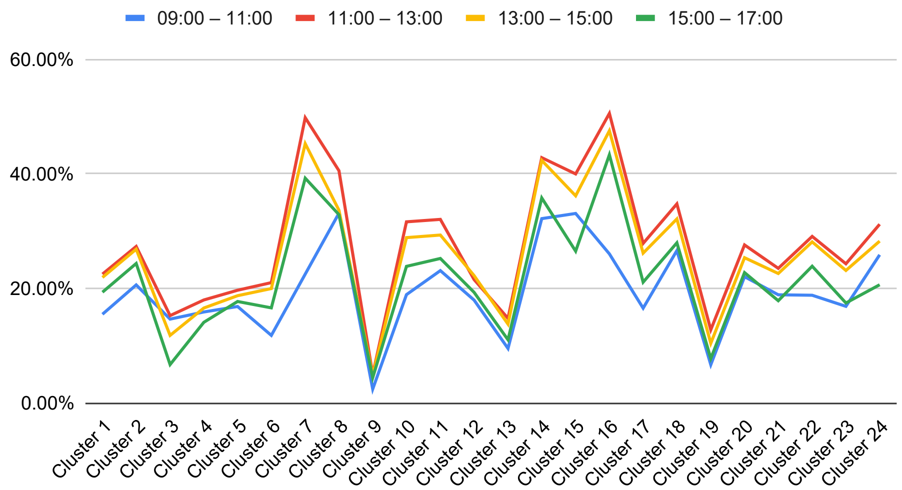

Figure 5. Annual active use of 4L Workstation Clusters per two-hour intervals throughout the workday.

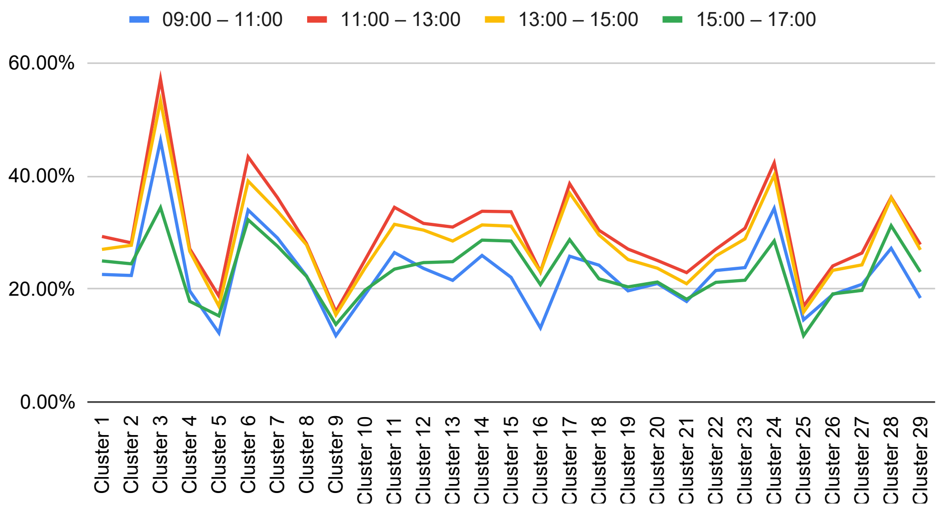

Figure 6. Annual active use of the 6L Workstation Clusters at two-hour intervals throughout the workday.

3.3. The Impact of the Desk Shape on the Active Use of the Workspace

Further analysis investigates the correlation between desk shape and active usage. Several studies identified in the Introduction section of this paper have already shown the validity and relevance of this relationship. The longstanding interest in ergonomics and designing and arranging workplaces to better fit the people who use them also suggests the relevance of this line of inquiry.

The average annual active use for all trapezoidal desks in the observed Workspace is calculated first (Figure 7), and the average annual active use for all rectangular desks is calculated second (Figure 8).

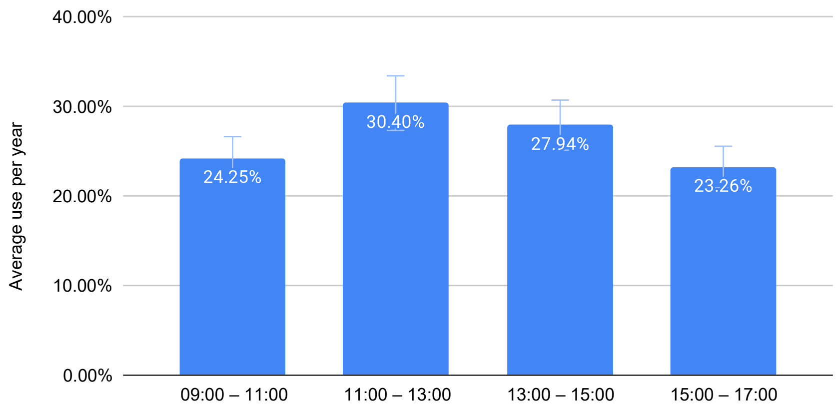

Figure 7. Annual active use of Work Zones composed of Workstation clusters (2T and 3T) with trapezoidal tables only, per two-hour intervals throughout the workday.

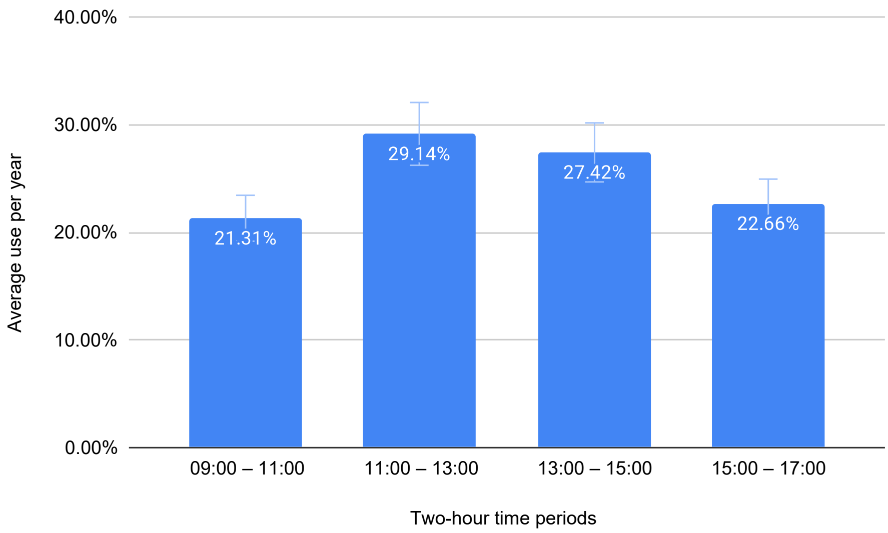

Figure 8. Annual active use of Work Zones composed of Workstation clusters (4L, 6L, and 8L) with rectangular tables only, per two-hour intervals throughout the workday.

The graphs show active usage peaks between 11:00 and 13:00 h for both desk shapes. It is almost identical, calculated at 30.40% for trapezoidal and 29.14% for rectangular, at the annual level. For trapezoidal desks, the least used time slot is 15:00–17:00 h, with active use calculated at 23.26%, and in the morning time slot 09:00–11:00 h, calculated at 24.25%. For rectangular desks, the least used time slot is 09:00–11:00 h, with active use calculated at 21.31%, followed by the afternoon time slot 15:00–17:00 h, calculated at 22.66%.

An ANOVA was conducted to examine differences between active use during various time periods. It shows no significant difference in active use between the two different desk shapes, rectangular and trapezoidal. However, the analysis within data groups, reflecting the active use of Work Zones with rectangular tables in two-hour intervals throughout the workday, shows statistically significant differences (Tables 8 and 9). Results ($p < 0.00001$) show that rectangular tables are used more between 11:00 and 15:00 h.

Table 8. ANOVA results for periods for Work Zones composed of clusters with rectangular tables.

Results		
SS	*df*	*MS*
68,903.3481	3	22,967.7827
501,989.4354	248	2024.1509
570,892.7835	251	

The f-ratio value is 11.34687. The *p*-value is <0.00001. The result is significant at $p < 0.05$.

Table 9. Pairwise comparison of active use between periods.

Pairwise Comparisons		
09:00–11:00 and 11:00–13:00	M1 = 108.66 M2 = 148.62	Q = 7.05 ($p = 0.00001$)
09:00–11:00 and 13:00–15:00	M1 = 108.66 M3 = 139.85	Q = 5.50 ($p = 0.00074$)
09:00–11:00 and 15:00–17:00	M1 = 108.66 M4 = 115.59	Q = 1.22 ($p = 0.82328$)
11:00–13:00 and 13:00–15:00	M2 = 148.62 M3 = 139.85	Q = 1.55 ($p = 0.69342$)
11:00–13:00 and 15:00–17:00	M2 = 148.62 M4 = 115.59	Q = 5.83 ($p = 0.00030$)
13:00–15:00 and 15:00–17:00	M3 = 139.85 M4 = 115.59	Q = 4.28 ($p = 0.01443$)

The available longitudinal data also provide an overview of the active usage of all rectangular tables across the observed Workspace at the annual level. The graph below shows that active use of rectangular tables, comprising Work Zones 4L, 6L, and 8L, varies and peaks between 11:00 and 13:00 h (Figure 9). Work Zone 2L is excluded from statistical analysis because of the small sample size, which is consistent with the previous analysis.

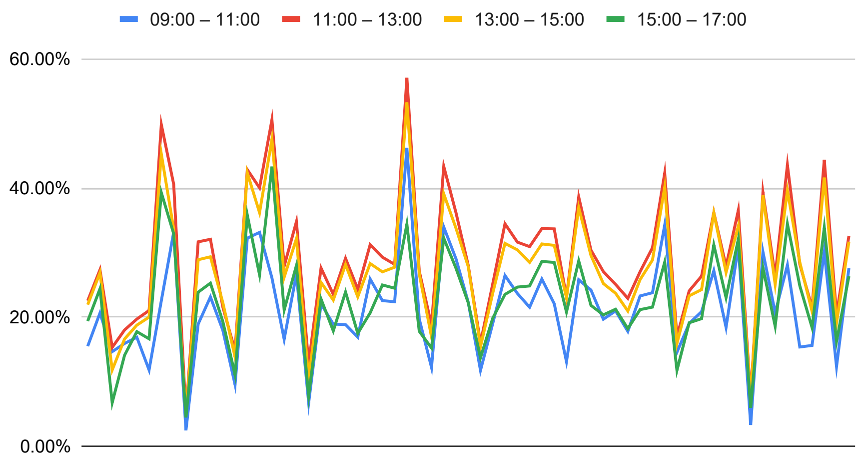

Figure 9. Annual active use of rectangular tables (comprising Work Zones 4L, 6L, and 8L) per two-hour intervals throughout the workday.

4. Discussion

This study provides new knowledge and insights into the active use of the workspace at different times of the day in relation to the work desk shapes. The impact of desk shapes has been studied in different settings [21,22]. However, to our knowledge, the impact of desk shapes has not been studied in ABW workspaces. This study contributes to a better understanding of environment design for ABW and a growing body of research on human behaviour and personal preferences, driven by individual feelings, fatigues, and habits that impact the timing of activities and how offices are utilised [8,18,19]. This study recognises the complexity of variables influencing the active use of the workspace [24]. However, it concentrates on the relevance of work desk shapes within a temporal context to track changes or active usage over time to address the impact of finer details and fewer aspects of the physical environment, such as desk shapes, on workspace choices.

This study's findings align with the literature's emphasis on understanding workspace dynamics within ABW environments. As highlighted in previous research [1–4], ABW offers individuals flexibility in choosing their work style, environment, and schedule, potentially leading to higher satisfaction levels and increased productivity. This study's identification of peak usage periods between 11:00 and 13:00 h resonates with the existing literature's recognition of ABW's ability to empower individuals to shape their workday according to their preferences [5] Furthermore, this study's focus on workspace utilisation patterns, considering desk shape choices across the workday, aligns with the literature's call for more detailed investigations into factors influencing occupancy and workspace choice within ABW environments [6,7].

Moreover, the findings underscore the importance of aligning workspace design with actual usage patterns and individual preferences, as emphasised in the existing literature [10–12]. This study's identification of statistically significant differences in usage patterns between trapezoidal and rectangular desks during specific time intervals echoes the literature's recognition of the need for careful observation and analysis of workspace dynamics to mitigate discrepancies between planned and actual utilisation [10]. Additionally, this study's exploration of utilisation trends throughout the workday contributes to the growing body of research aimed at optimising workspace design and usage within ABW environments [18–22]. By providing insights into the impact of desk shapes in the temporal context of workspace utilisation, this study contributes to advancing our understanding of ABW and informs evidence-based decision making in workspace design and optimisation efforts, as advocated in the literature [15,16].

The presented research contributes to studying temporal dynamics and specific work zone compositions when designing and managing flexible workspaces. It shows a capability to identify peak activity periods and to understand the preferences of employees for different zones, which, in future research on ABW, can be used to inform decisions on space allocation, amenities, and optimisation strategies, ultimately enhancing employee satisfaction, productivity, and well-being.

5. Conclusions

This study contributes to the future development of new methods for studying environments designed for ABW. It explores workspace selection within a facility designed to support ABW, focusing on the overall occupancy dynamics, temporal context, and information capturing less studied details of the physical environment, such as the shape of work desks. This can be valuable to future undertakings by researchers and designers looking to expand the number of variables considered in planning and examining workspaces. Building on this study, future interdisciplinary explorations can include collaboration with neuroscience, in studying circadian rhythms, workspace activity, and well-being. The findings of this study show trends and statistically significant differences in the data groups, capturing the impact of specific time intervals and work desk shapes and work desk configurations on the active use of the workspace.

This study is structured around three research questions: How are different working areas of ABW facilities used at different times of the day? How does the work desk shape affect the use of facilities designed to support ABW? And how can we use finer resolution data collected over time to study the utilisation of a workspace? It has examined the active use of different Work Zones, Workstation Clusters, and Workstations as different organisational layers of the modern Workspace. It contributes to developing techniques for structuring evidence needed to generate insights into actual rather than planned utilisation of the workspace, which can support improvements in the design and management processes. The innovation and future development of the ABW, an organisational model that requires adequate physical conditions, may hold the potential to improve the productivity, comfort, and well-being of workspaces. Insights from this study are relevant to the future collecting of evidence and developing techniques and methods of studying the correlation between the physical properties of space, determined by architectural design decision making, and its active use.

Author Contributions: Conceptualization, D.S., M.V., O.G., S.M. and C.C.; methodology, D.S. and M.V.; validation, D.S. and M.V.; investigation, D.S., M.V., O.G., S.M. and C.C.; data curation, O.G. and M.V.; writing—original draft preparation D.S. and M.V.; supervision C.C.; All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Australian Government through the Australian Research Council's Discovery Projects funding scheme (project DP190100705). The authors express their gratitude to AETMOS for their support of this research.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Engelen, L.; Chau, J.; Young, S.; Mackey, M.; Jeyapalan, D.; Bauman, A. Is activity-based working impacting health, work performance and perceptions? A systematic review. *Build. Res. Inf.* **2018**, *47*, 468–479. [CrossRef]
2. Candido, C.; Gocer, O.; Marzban, S.; Gocer, K.; Thomas, L.; Zhang, F.; Gou, Z.; Mackey, M.; Engelen, L.; Tjondronegoro, D. Occupants' satisfaction and perceived productivity in open-plan offices designed to support activity-based working: Findings from different industry sectors. *J. Corp. Real Estate* **2021**, *23*, 106–129. [CrossRef]
3. Marzban, S.; Candido, C.; Mackey, M.; Engelen, L.; Zhang, F.; Tjondronegoro, D. A review of research in activity-based working over the last ten years: Lessons for the post-COVID workplace. *J. Facil. Manag.* **2022**, *21*, 313–333. [CrossRef]
4. Babapour Chafi, M.; Rolfö, L. Policies in activity-based flexible offices—I am sloppy with clean-desking. We don't really know the rules. *Ergonomics* **2019**, *62*, 1–20. [CrossRef] [PubMed]
5. Arundell, L.; Sudholz, B.; Teychenne, M.; Salmon, J.; Hayward, B.; Healy, G.N.; Timperio, A. The impact of activity based working (ABW) on workplace activity, eating behaviours, productivity, and satisfaction. *Int. J. Environ. Res. Public Health* **2018**, *15*, 1005. [CrossRef] [PubMed]
6. Wohlers, C.; Hartner-Tiefenthaler, M.; Hertel, G. The relation between activity-based work environments and office workers' job attitudes and vitality. *Environ. Behav.* **2017**, *51*, 167–198. [CrossRef]
7. Zamani, Z.; Gum, D. Activity-based Flexible Office. *J. Corp. Real Estate*, 2019; *Ahead-of-print*.
8. Skogland, M.A.C. The Mindset of Activity-Based Working. *J. Facil. Manag.* **2017**, *15*, 62–75. [CrossRef]
9. Tokumura, T.; Akiyama, Y.; Takahashi, H.; Kuwayama, K.; Wada, K.; Kuroki, T.; Takahashi, M.; Takahashi, S.; Shinoda, J.; Nakagawa, J.; et al. Impacts of implementing activity-based working on environmental satisfaction and workplace productivity during renovation of Research Facilities. *Japan Archit. Rev.* **2021**, *6*, 189–198.
10. Motuzienė, V.; Bielskus, J.; Lapinskienė, V.; Rynkun, G.; Bernatavičienė, J. Office buildings occupancy analysis and prediction associated with the impact of the COVID-19 pandemic. *Sustain. Cities Soc.* **2022**, *77*, 103557. [CrossRef]
11. Sun, K.; Zhao, Q.; Zou, J. A review of Building Occupancy Measurement Systems. *Energy Build.* **2020**, *216*, 109965. [CrossRef]
12. Liang, X.; Hong, T.; Shen, G.Q. Occupancy data analytics and prediction: A case study. *Build. Environ.* **2016**, *102*, 179–192. [CrossRef]
13. Ouf, M.M.; O'Brien, W.; Gunay, B. On Quantifying Building Performance Adaptability to Variable Occupancy. *Build. Environ.* **2020**, *155*, 257–267. [CrossRef]
14. Hoendervanger, J.G.; De Been, I.; Van Yperen, N.W.; Mobach, M.P.; Albers, C.J. Flexibility in use. *J. Corp. Real Estate* **2016**, *18*, 48–62. [CrossRef]
15. Colenberg, S.; Jylhä, T.; Arkesteijn, M. The relationship between interior office space and employee health and well-being—A literature review. *Build. Res. Inf.* **2020**, *49*, 352–366. [CrossRef]

16. James, O.; Delfabbro, P.; King, D.L. A comparison of psychological and work outcomes in open-plan and Cellular Office Designs: A Systematic Review. *SAGE Open* **2020**, *11*, 215824402098886. [CrossRef]
17. Wei, Y.; Xia, L.; Pan, S.; Wu, J.; Zhang, X.; Han, M.; Zhang, W.; Xie, J.; Li, Q. Prediction of occupancy level and energy consumption in office building using Blind System Identification and Neural Networks. *Appl. Energy* **2019**, *240*, 276–294. [CrossRef]
18. Molzof, H.E.; Prapanjaroensin, A.; Patel, V.H.; Mokashi, M.V.; Gamble, K.L.; Patrician, P.A. Misaligned core body temperature rhythms impact cognitive performance of hospital shift work nurses. *Neurobiol. Learn. Mem.* **2019**, *160*, 151–159. [CrossRef]
19. Hasegawa, S.; Fukushima, H.; Hosoda, H.; Serita, T.; Ishikawa, R.; Rokukawa, T.; Kida, S. Hippocampal clock regulates memory retrieval via Dopamine and PKA-induced GluA1 phosphorylation. *Nat. Commun.* **2019**, *10*, 5766. [CrossRef] [PubMed]
20. Lee, I.; Choi, J.; Kang, S.H.; Jin, S. Alternative to reduced stresses on the upper extremity in a standing workstation. *Hum. Factors* **2021**, *65*, 1641–1654. [CrossRef]
21. Vujovic, M.; Hernández-Leo, D.; Tassani, S.; Spikol, D. Round or rectangular tables for collaborative problem solving? A multimodal learning analytics study. *Br. J. Educ. Technol.* **2020**, *51*, 1597–1614. [CrossRef]
22. Higgins, S.E.; Mercier, E.; Burd, E.; Hatch, A. Multi-touch tables and the relationship with collaborative classroom pedagogies: A synthetic review. *Int. J. Comput.-Support. Collab. Learn.* **2011**, *6*, 515–538. [CrossRef]
23. Bodin, D.C.; Theorell, T. Office Employees' Perception of Workspace Contribution: A Gender and Office Design Perspective. *Environ. Behav.* **2019**, *51*, 995–1026. [CrossRef]
24. Gocer, O.; Candido, C.; Gocer, K.; Brambilla, A.; Thomas, L.; Billoria, N.; Mackey, M.; Alizadeh, T.; Sarkar, S. Overlaps in Space Utilisation Patterns and IEQ Conditions Observed in Activity-Based Working Supportive Office. *Build. Environ.* **2022**, *220*, 109273. [CrossRef]