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# Retrofitting Biophilic Design Elements into Office Site Sheds: Does 'Going Green' Enhance the Well-Being and Productivity of Workers?

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Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/intechopen.71890>

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## Abstract

The use of biophilic elements in industrial design has become more commonplace as the benefits of natural environments show stronger links to positive health benefits and mental well-being. This chapter discusses the rationale, process and results of a study which examined the effects and long term impacts of biophilic design for site office workers. The research investigated the impact of incorporating plants, natural sunlight, prospect, ventilation, open spaces and windows to an office environment through retrofitting the design of a site shed. To examine the impact on productivity, stress and general well-being, this longitudinal study spanning over 2 years tracked the concomitant cognitive, social, psychological and physical benefits for workers. Within the first 3 months, data indicated a strong positive effect from incorporating green space to amend stress, enhancing well-being, fostering a collaborative work environment and sustaining workplace productivity. Through the course of the study, data continued to support these findings by indicating a rise in engagement with the design components and repeated evidence of workplace collaboration. In exit interviews, transference of greening concepts and accessibility to transform the workspace was discussed.

**Keywords:** productivity, well-being, biophilic design, natural elements, site office, collaboration, stress

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## 1. Introduction

As we spend more and more time in traditionally designed office spaces, the need to address health, productivity and well-being in these spaces has grown [1]. Many modern companies are addressing an idea of 'going green' as it impacts their presence within the

industry, but recently there has been a shift into focusing addressing the benefits that may result from greening within the workplace environment. This chapter outlines the practical steps taken to retrofit a tiny site office shed into a bespoke open plan office and the subsequent response from workers on how they experienced the design. The office shed is designed as a temporary space, however, for many workers who may spend most of their careers moving between them, it becomes a more long-term working environment. Through this step-by-step guide, our vision was to provide a tool to transform site sheds across the nation into more comfortable, productive and attractive workspaces for their occupants. Davidson [2] discussed that the design of a workplace can have a negative effect on the desirability of a job: “a third of respondents said that an office layout would affect whether or not they wanted to work somewhere”. Through this vision, managers have the potential to heighten the quality of workplace environments. The effectiveness of this model was examined through four stages where person-plant interactions were tracked throughout the course of the study alongside the impressions and outcomes of those active in the workplace.

## 2. The research on nature within the built environment

Psychologists and environmental planners have been studying how people’s health is affected by the presence or absence of the natural world in their immediate surroundings for almost two decades. A plethora of research documents how nature, especially sunlight and plants, can have a causal link to human well-being [3–19]. Biophilic design intends to enhance human well-being by fostering connections between people and nature in the modern built environment [20–22]. Despite the empirical evidence we have been slow to react because governments and business still think of biophilia as something esoteric or whimsical.

Given the noticeable positive health and productivity benefits upon workers, companies around the world are now examining ways to ‘go green’ within the four walls of their office space [23]. By incorporating the presence of natural elements into their workspaces, Davidson [2] reports that “greenery and natural light can boost workplace productivity by 6 per cent and increase employee well-being and creativity by 15 per cent”. Views of nature outside the office or work area window have repeatedly shown that a natural view effects employees level of depression, frustration, and mood, with noticeable elevations in job satisfaction, patience, enthusiasm, and contentment [24–26]. Furthermore, the number of indoor plants proximal to a worker’s desk correlates to productivity [27, 28]. Despite these compelling metrics it is perplexing that most corporate employers do not offer these simple amenities. To this end, Davidson [2] reveals 47 per cent of office employees said they have no natural light at their workplaces, while 58 per cent have no plants in eyesight.

Human-nature contact possesses a myriad of benefits and over the past 3 decades a growing body of research has been generated to provide testimony to these claims. For instance, Berman et al. [29]; Cha [30]; Dannenberg et al. [6]; Lewis [31–33]; Relf [34]; Shanahan et al. [35];

Ulrich [36–38]; Ulrich & Parsons [39]; and Verderber [40] have identified the following gains: stress reduction, improved mental acuity, creativity, healing, attention restoration, development of perceptual and expressive skills.

Elings [7] postulates there is a dearth of information about the people-plant interactions or the mechanisms behind nature therapy. Additionally, previous studies have produced inferior evidence-based research due to the methodological limitations of their research design. Biophilic design incorporates such features as indoor-outdoor connections, natural ventilation and materials, plants, extensive natural lighting, views to the outdoors, restored landscapes, courtyards, natural landscaping, water features and interior designs that mimic shapes and forms found in nature [41, 42].

According to acclaimed Harvard biologist Wilson [43–45] we are biologically drawn to nature. In industrialized societies, we spend on average 90 per cent of our time indoors in built environments, often in cities [13, 41]. These artificial settings seldom offer contact with nature or design based on natural principles. Biophilic design intends to enhance human well-being by fostering connections between people and nature in the modern built environment.

The enduring effects of plants and nature upon mood states of building occupants was examined in cutting-edge research undertaken by Burchett and colleagues [5]. Their groundbreaking research was the first empirical study to use universally validated psychological measures for evaluating the potential affordances of indoor plants. Worker productivity and the presence of plants correlates significantly [46] as well as lowering negative mood states and anxiety among building occupants [6]. Potted plants can improve indoor air quality for building occupants, but of particular interest, Burchett et al. [5] revealed that just one plant within the workspace can significantly enhance staff morale and simultaneously promote well-being and performance.

Furthermore, Burchett and colleagues' [5] seminal research investigated the benefits of indoor potted plants in reducing air pollution. A pivotal role was played by plants in minimizing volatile organic compound (VOCs) emanating from plastic or synthetic materials (such as furnishings, furniture, and equipment like computers, photocopiers), and CO<sub>2</sub> from occupants breathing. A causal relationship with enhanced cardiovascular health and mental acuity has also been found to be directly linked with air quality [47, 48]. The incorporation of green spaces in work sites is amassing extant research to support this area of inquiry and the 2-year collaborative project between Western Sydney University (Western) and Brookfield Multiplex (BM) was underpinned by these variables.

### 3. Methodology

A participatory action research design was adopted to ascertain the benefits of biophilic design within a site office upon workers. Data collection points in the 24 months of the study are displayed in **Figure 1**.

Phase 1:	Pre-implementation Interview with Sustainability Manager
Phase 2:	Qualitative data obtained from the recycling working bee post biophilic fit-out. Data was collected through interviews, observations and video analysis of site workers
Phase 3:	Qualitative data from in-depth interviews (n=12) following introduction of plants to office.
Phase 4:	Qualitative data from exit interviews at end of study

**Figure 1.** The qualitative data collection schedule.

### 3.1. Phase 1: preliminary interview for baseline data

In Phase 1, the study commenced with an interview with the Australasian Sustainability Manager for Brookfield Multiplex (BM), to gather detailed information about the rationale and raison d'être of the initiative. The questions were as follows:

- What was the impetus to get this innovative project off the ground?
- How important is the human capital in a work place?
- What support did you need from BM for this to happen?
- What is the sustainability message you want to impart at BM?

### 3.2. Phase 2: site office working bee: observations and interviews

Secondly, a Saturday working bee organized for site office workers, their partners, children and friends (See **Figure 2**). The primary intent of the exercise was to foster collaborative and group ownership of the project. Using elements of social capacity building and sustainable design, foremen were joined with apprentices and guided through innovative ways to up-cycle left-over materials freely found on their worksite which traditionally ends up as waste material. Workers witnessed first-hand how recycled office furniture and planter boxes can transform their site offices.

Qualitative interviews, observation and video footage were obtained during the working bee's proceedings.

### 3.3. Phase 3: site office interviews

Thirdly, 3 weeks after the working bee, researchers conducted onsite interviews with the workers (n = 12) to ascertain the initial impact of the biophilic design upon the workspace.

## OUR PILOT PROJECT

The photos in this guide came from a working day we did to test the concept.

We took a construction site shed and greened it in just half a day. It was a fun day for everyone involved and we finished with a BBQ lunch.



Figure 2. The working bee and collaborative ownership underway in the pilot project.

### Interview questions:

1. Demographics: (i) Gender and Age, (ii) Role or Position and (iii) Time spent in Site Office
2. Rate this office against previous offices you have worked in (score out of 10).
3. Do you think the design is beneficial in terms of health and well-being?
4. In terms of collaboration and co-operation, have there been any noticeable differences in the workspace?
5. Name three qualities that best describe "the vibe" of this workspace.

### 3.4. Phase 4: exit interviews after 24 months

Finally, 24 months following the introduction of plants to the office, researchers conducted exit interviews with four workers to investigate the lasting impact of the biophilic design in the workspace.

### Interview Follow-up Questions:

1. Demographics (i) Gender and Age (ii) Role or Position and (iii) Time spent in Site Office

2. Summative comments surrounding workers' impressions of the office environment
3. Rate this office against previous offices you have worked in (score out of 10).
4. Name three qualities that best describe "the vibe" of this workspace.
5. So what is the long lasting impact/s and what would most like to take with you to your next workspace?

## 4. Findings

The initial data collection that occurred in the first 3 months was previously documented in Gray and Birrell [1]. However, to acquaint the reader to the preliminary findings, a brief overview is provided (Phase 1–3 below).

### 4.1. Phase 1: pre-implementation interview with Sustainability Manager

#### 4.1.1. *What was the impetus to get this innovative project off the ground?*

BM is committed to delivering high performance buildings for our clients. By taking an evidence-based approach to building, we were seeing some great results in terms of productivity, health, staff attraction, retention, satisfaction comfort and so on. So I wanted to make sure we were doing it for our employees as well. With 80% of our staff in site offices, they were the most logical place to start.

#### 4.1.2. *How important is the human capital in a work place?*

Very! Most of a company's spend is on their people and they are usually one of the most important assets as well.

#### 4.1.3. *What support did you need from BM for this to happen?*

It just made business sense to invest in our people. So I got a lot of support both from upper management and the executive team, and more importantly, from the employees themselves.

#### 4.1.4. *What is the sustainability message you want to impart at BM?*

If I can improve the workplaces of our people and help them be happier, less stressed or more productive in even just a little way, I think that makes the high performance site office worthwhile.

### 4.2. Phase 2: working bee findings

The use of the apprenticeship relationship reinforced team building and increased social engagement. Once up-skilled by the foreman, the apprentices were responsible for the construction of their personalized recycled planter box, choice of greenery and general maintenance for their plants. This process is outlined in **Figures 3** and **4** outlining the step-by-step stages.

One unexpected finding of the working bee was the hidden benefit of intergenerational influence. Although unforeseeable at the commencement of the study, the children were both receptive and fully engaged in the activities on the day. The experience (see **Figure 5**) afforded many “teachable moments” for the young children to interact with adults. From the researcher’s and parent’s perspective, the intergenerational influence was a pleasant side benefit.



Figure 3. Steps involved in the working bee day.



Figure 4. Steps involved in constructing a planter box from recycled materials.

### 4.3. Phase 3: site office interviews

A breakdown of the demographics of the 12 participants and their workplace information is provided in **Table 1**.

Individuals were asked during interview Question 2 to rate (score out of 10), previous offices they had worked in against the biophilic office (see **Table 2**).

Data collected from interview questions 2–5 identified several emerging themes: the unique nature of this site shed (compared to other site sheds), sustainable workplaces and the transfer of learning (sustainable practices and ownership) from workplace to home, high performance workplaces, impact of external surroundings of working site shed, and the role and impact of ‘green space’ (specific plants) in workplace.

### 4.4. Phase 4: exit interviews 24 months later

Data collected from the exit interviews identified repeated themes from phase three: the unique nature of the site shed (compared to other site sheds), high performance workplaces, and the role and impact of ‘green space’ in the workplace. In addition to these themes, interviewees spoke about the lasting impacts of the biophilic design (transferability and how it

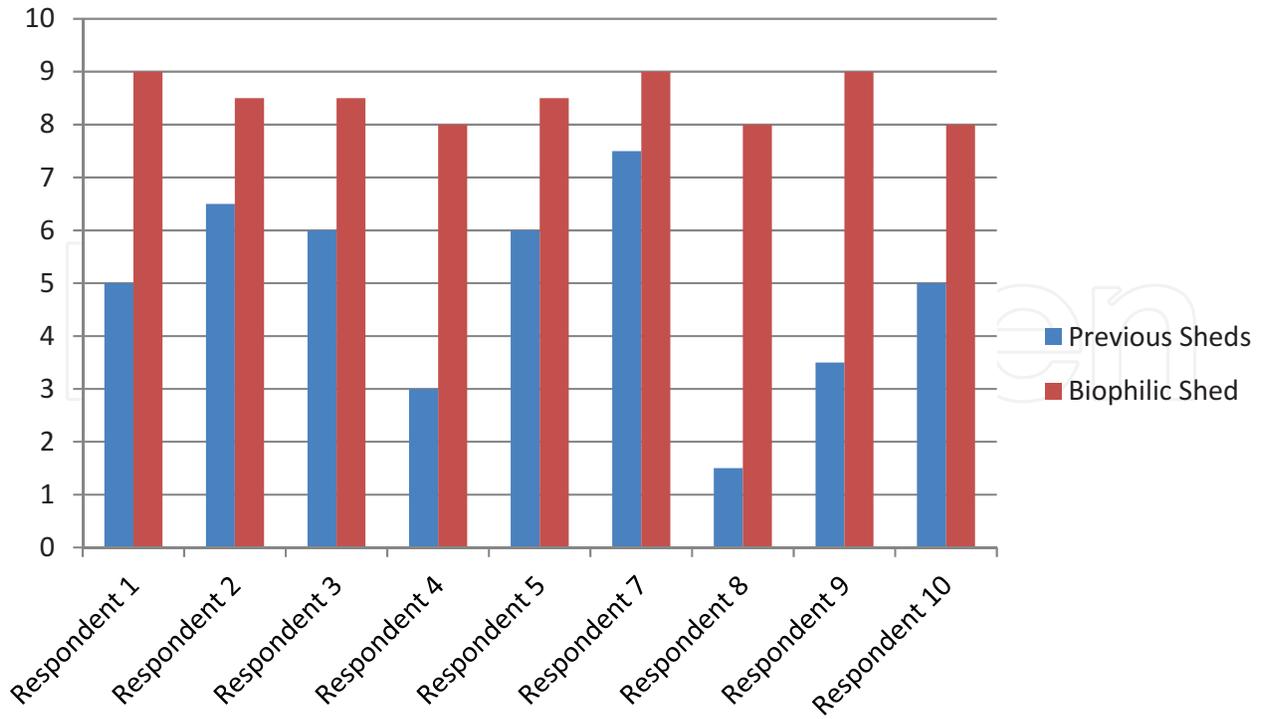


**Figure 5.** Success of the working bee including intergenerational impact with children learning how to pot plants.

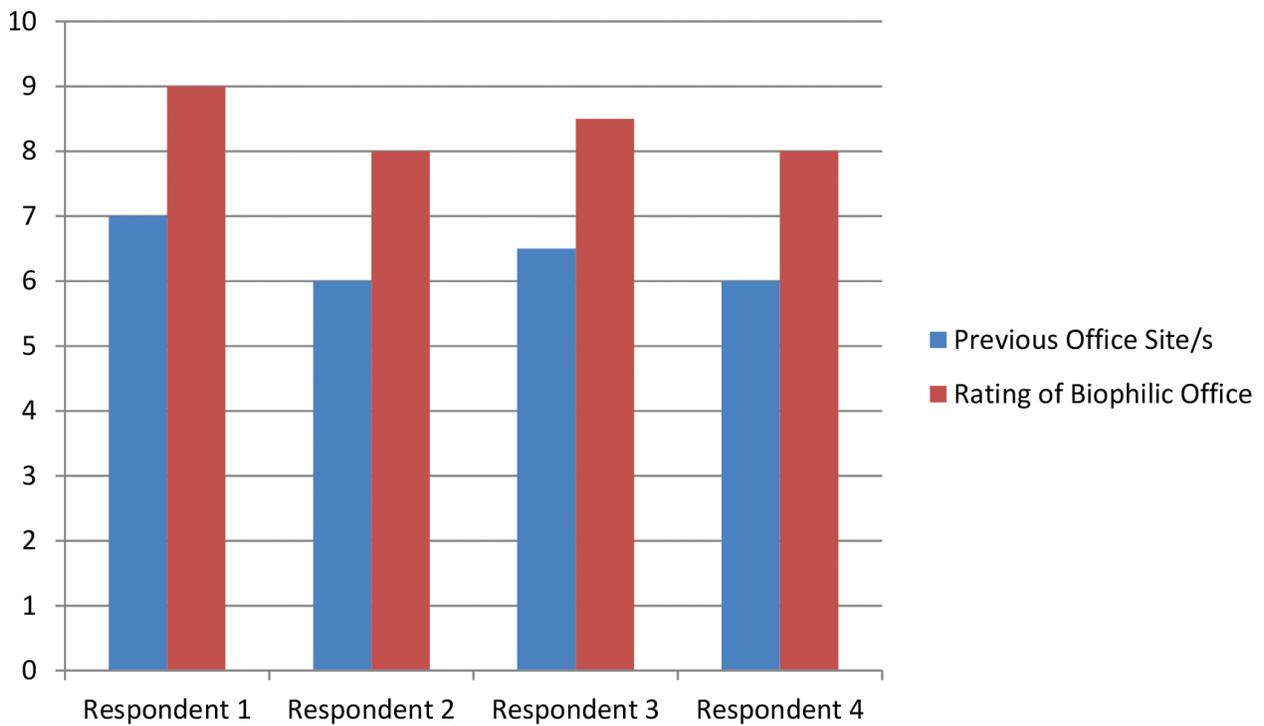
Gender	Age	Role/position	Time spent in office
Female	25 years	Site Engineer	70%
Male	29 years	Services Manager	80%
Male	32 years	Project Manager	60%
Male	27 years	Site Engineer	40–50%
Male	32 years	Senior Site Supervisor	20–30%
Male	41 years	Site Manager	50%
Male	27 years	Foreman	20%
Male	22 years	Cadet	90%
Male	35 years	Contracts Manager	99%
Female	25 years	Site Secretary	100%
Male	31 years	Design Manager	95%
Male	31 years	Contract Administrator	90%

**Table 1.** Snapshot of the demographics of respondents.

affected productivity). As in Phase 3, the respondents were invited to rate the current office against their previous site offices (see **Table 3**) to ascertain the sustained impact of a biophilic office over 24 months.



**Table 2.** Rating the biophilic office shed against previous offices worked in (score out of 10, 1 = poor, 10 = excellent) NB respondent 6 was a new team member (midway through project) so their data was excluded.



**Table 3.** The sustained impact and rating the office space against previous offices worked in, after spending 24 months in biophilic site shed.

## 5. Emergent themes

Emergent themes are inductive approaches to qualitative research and are obtained from research on participants through the process of thematic coding. For the purposes of this chapter, three emergent themes will be addressed: high performance workplaces, the impact of plants and biophilic design in the workplace, and social dynamics in the workplace.

### 5.1. High performance workplaces

The site office, although deemed to be by its very nature transitory and temporary, is in fact the type of workplace setting that workers and managers inhabit serially over their working lives; although the site may be temporary, the workers are permanently in similar structures. Most respondents noted an overwhelming positive difference between previous site sheds and the present one.

Notably, the qualitative data uncovered the following comments:

*"It's an 8 or a 9 [rating out of 10] definitely the best office that I've ever worked in"*

*"...my last site is at say a six or a seven...this one at an eight or a nine."*

Comments such as 'aggressive', 'stark surroundings', 'sterile environment' and 'stale kind of environment' typified the responses associated with previous site offices. Many comments related to a changing 'vibe' within the office:

*... most site offices, they're fairly cold, harsh, walled sort of environments, and that's not the sort of environment that's conducive to really collaborating well and creating an relaxed atmosphere.*

*"My last job, no one really went to the office. There wasn't a good vibe in the office."*

In contrast, many viewed the biophilic site shed as increasing social capability. Several workers referred to the 'gentler feel' of the place, and one also highlighted the 'softening of social interactions' in the site shed. These included more communication between younger and older workers, as well as between the more and the less experienced members of the team:

*If you're in an open area you feel as though everyone's on the same level, where you can walk past and just have a conversation and ask questions.... I come back to the office and you know, I'm looking for an answer first from someone. And I find that this office gives me an opportunity to speak to different people. I'll just walk past someone, and I'll think to myself, maybe I can ask this person. Because you get an opportunity to see people in their open area and you're not, in an office, or kind of restricted.*

The newly designed open plan arrangement suited this type of increased social interaction, as well as the range of smaller meeting places:

*I came from a previous site where our site shed was quite limited, and there wasn't really a lot of room to kind of set up and have an area to work. There was more room – that was definitely a bonus.. It was, yeah, very different. We also didn't have a lot of meeting rooms, so a lot of the conversations where we didn't want to make a lot of noise, we would walk outside and talk on the phone.*

The open design and accessibility to co-workers was reported as a factor of enjoyment for those coming to work. Friendships and teamwork were repeated long-term themes from those experiencing the open plan design:

*I think it definitely made it a more enjoyable place to be compared to other offices I have been in and worked in. I have definitely been in offices where I avoid going there. Here, it's a good environment here. Everyone gets along. [W]e've got good people here and the office, the way it's set up, it allows you to communicate.*

A repeated theme for workers involved the utility of the open concept design and its ability to ignite an organic space for collaboration. A change in the workplace atmosphere along with improved collegiality was evidenced in the interviewees comments. Many noted spontaneous collaborations occurring on a frequent basis which was noticeably absent in other sites. These productive collaborations expedited problem solving across teams:

*There are opportunities here in the office where they can grab someone, ask a question... the problem can be solved in five minutes rather than let the problem be ongoing for a couple of days before they bring it to the attention of the design team.*

Workers remarked on the barriers created by walled offices and closed doors and how these obstructions were minimized by the open concept design:

*It's been good for me personally because you get more involved in conversations. Where I was sitting, as a general foreman you've got the site manager and then there was a foreman, there was a grad, there was an engineer. Just so many different people... Everyone starts collaborating a lot better which I think has been great. I would recommend this office now to anyone.*

Some participants found those increased interactions distracting, but these reactions were in a minority:

*Personally, I haven't got the best attention span anyway, so with everyone talking, especially, I'm in the design hub so there's a constant flow of people coming in and asking questions. ... A lot of what I do is reading reports and trying to knuckle down and get design done... I can't focus because there's seven different conversations, and everyone asks you, because you're sitting there and its so open plan...*

The mutually beneficial nature of the space was also recognized by the same person:

*I think collaboration in this job has been good, and a lot of that's been because of the way the office is set up. ... we review something in the meeting room and get the screen up, or we do at design art, so that's been good. Yeah, I think it has been good, quite a good collaboration.*

Ease of communication was also a benefit for this worker and the layout was described as both efficient and effective:

*Reason being the design is an open plan so people can hear other people talk. You know what's happening around the site, and then you just bounce off ideas off each other.*

When revisited during the exit interview, one participant highlighted the efficiency he felt that had resulted from the previously mentioned collaborative workplace design:

*The way it's set up. You have the design manager sitting with the project engineers. They always work together which is good...the layout is efficient...it's just an open plan.*

In addition, during the exit interviews, one worker spoke about how implementing a biophilic workspace made a statement for the economics of the situation and what kind of impact it made to have the company invest in the workers:

*I think what it probably did was break the culture somewhat in the company for wanting to spend the smallest amount possible on an office space. I think maybe it's opened a few people's eyes. They're saying it's probably worth spending a relatively small amount of money – in the context of a 150 million project – to spend a bit of extra money on making the office a good place to work in. I think it's been money well spent whereas traditionally you wanted to spend as little amount of money as possible because it was considered 'dead money'*

Another worker echoed feeling a similar impact:

*The company invests in us all really well. That's why everyone does their job so well and completes it on time. It's good to look after your clients but very important to look after your employees because they are the ones doing all the work.*

Individuals spoke of the site shed as a 'happy environment': One worker commented on their observations of the interpersonal dynamics:

*I think it's a happy project team, it's a productive team. Everyone works well together. Everyone likes coming in to work. Again, lot of different factors for that but having a big nice office that's roomy enough for everyone and comfortable to be in doesn't hurt.*

One worker continued to express the positive differences that they experienced in this site shed as compared to previous sites:

*The team there was different. We went through a lot of people. The turnover was quite high but here, I don't know, I've just enjoyed it more.*

From natural lighting, furniture made with natural materials, white painted walls and carpet, to open windows and hearing bird sounds, all of the interviewees pointed to different positive attributes of the unusual biophilic workspace. Accounts from the qualitative interviews also suggest that this space increases social capacity and collaboration, and may lead to gains in productivity.

## 5.2. The impact of green spaces and biophilic design in workplaces

One of the primary goals of the study was to better understand the impact of natural elements upon workers. In particular, the researchers wanted to gauge the perceived benefits of biophilic design elements in the workspace. The dominant effects seemed to fall into two categories: esthetic appeal of the green office space and emotional bonding with nature

The esthetic appeal of the green office was described with words such as: 'positive vibe' 'relaxing' 'calming' and 'natural'. When asked about impressions of the office, many users described a dominant feeling rather than a physical description:

*Immediately you notice something different because it's got that 'vibe' ... kind of secluded away. \ you don't really know what to expect, and then you walk in, .. it is modern and relaxing. I'm not sure what words to use, but it's different in a very positive way.*

In terms of the 'greenness' of the site office, this interviewee does speak specifically about these qualities, however, the plants are mentioned overtly:

*Yeah, ... you see plants, and you're just, you know, it's different. You don't feel as though you're indoors the whole day, if that makes sense.*

Interestingly, the disbeliever acknowledges the greenness in some way may contribute to the transformed working environment:

*Look, I'm a bit of a skeptic to be honest with you, ... But I was actually surprised when we did all the plants, because it actually, it is good. And it does make, it does create a better vibe within the office.*

When prompted further about the impact of the 'vibe,' he explained:

*I'd say 'energetic' would be one word: relaxed, calm, enjoyable.*

All interviewees were overwhelmingly positive about the plants and how they were impacting on the work site:

*You know, our subbies [subcontractors] come in and have a meeting with us, and they go, geez, where did you get all the plants? I don't think it's going to have a negative impact on anyone who works here, that's for sure.*

In the same vein, another articulates:

*Look, it reduces stress and fatigue and stuff like that, but I think not knowing, it probably does. ... I may not directly know that it's making me feel a lot better, but you walk in and it doesn't feel like your standard office.*

Based on the previous evidence, it is clear that workplaces matter to workers who inhabit them, perhaps more so to those who inhabit temporary spaces such as site offices. Despite issues of who waters the plants (which appears to be a gendered issue!), the plants themselves contributed to a transformed working environment:

*I suppose it kind of reminds you we are in a living environment... We're working long hours though; I'm sure it does help though, just not being such a stale kind of environment... Anything that's natural, anything natural that's I suppose growing and changing every day.*

During the exit interviews, workers reflected on the lasting impacts of the biophilic design:

*"The deck has been good, having the space out the front, the big lunch area. The greenery has been good."*

*"[A] more happy environment, very green."*

*"The well-being of the office seems really good."*

One participant reflects on the lowered stress levels they experienced during their time in the site shed:

*I've enjoyed work, I really, really have. Even my wife said it to me. My last job I was very, very stressed out at this stage in the job and she said: "Here you're not".*

Another reflected on the significance of the biophilic design:

*I think it definitely made it a more enjoyable place to be compared to other offices I have been in and worked in. I have definitely been in offices where I avoid going there.*

Many of the onsite workers initially experienced individual attachment to plants on site. Stories of plants being personified with names and characteristics were shared during the interviews, as well as a sense of ownership and comradeship toward each worker's individual "desk buddy":

*Mine was a bit of a struggler. It was a battle of mine. It went to the big nursery in the sky but it will be remembered.*

Others commented on high stress levels in their previous job, and made reference to the site office plants in a favorable context:

*But I do enjoy having them [the plants] now; I think it's really nice. I'm not super-stressed at the moment. I'm in one of my calmer cycles, so I don't know if that's down to the plants, or whether that's down to just where the job's at. I like them.*

By the exit interviews, however, individual relationships were mentioned less often by interviewees. The lasting impacts from the emotional bonds were related more to the overall feeling and environment that the plants set up in the office, speaking about the overall green environment and the office having a 'vibe'. Accounts from the qualitative interviews report lower stress levels and positive well-being.

## 6. Discussion

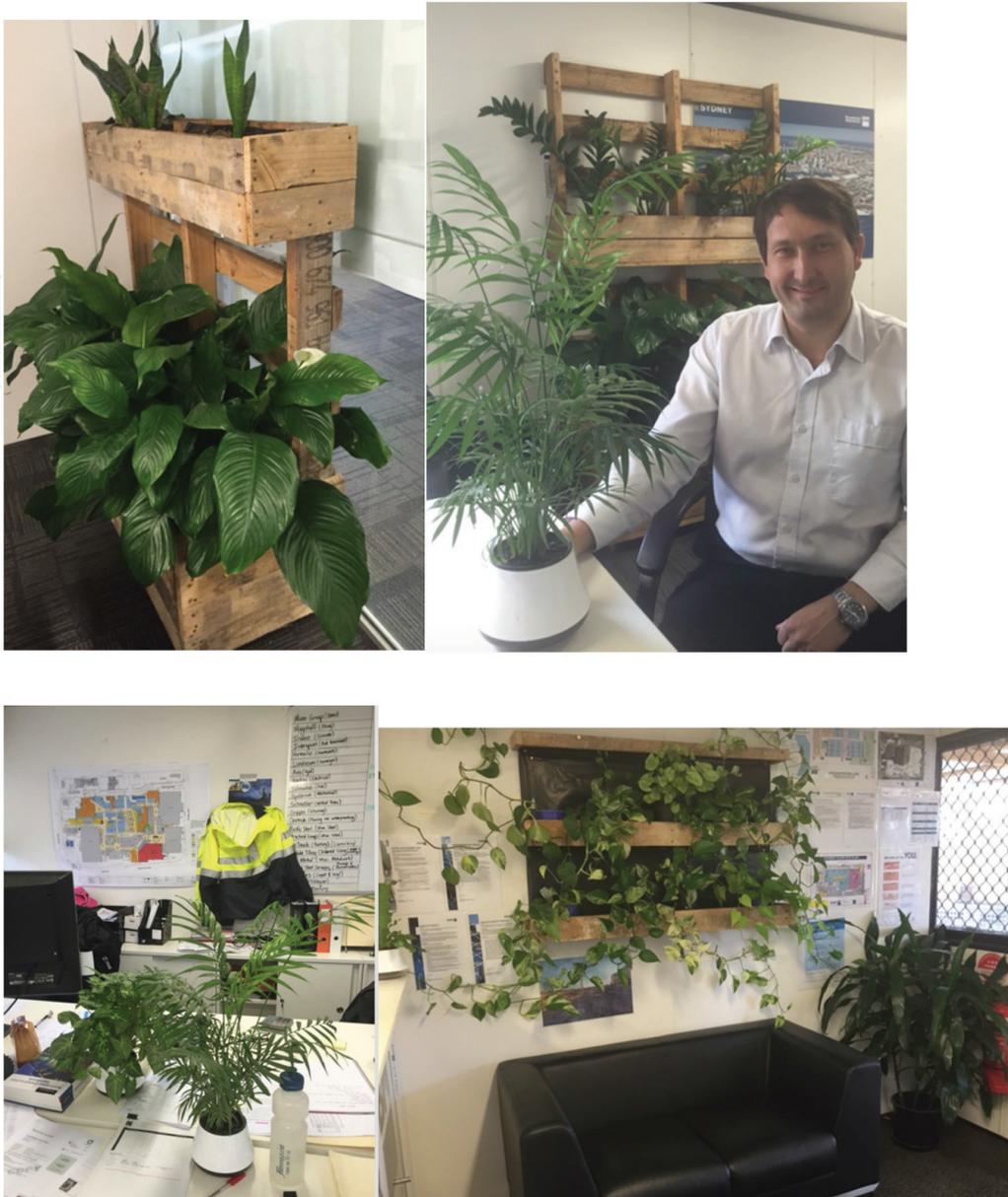
### 6.1. High performance workplaces

One intended goal of this study was to investigate the effect of biophilic design on worker productivity. Through gathering data over the course of 24 months, the researcher can report the biophilic design contributed to a site of productivity for workers at the site shed (see **Figure 6**) where the lingering benefits still remained. The biophilic elements of this retrofitted site shed that showed up the most in data were the desk buddies themselves and the open concept design.

### 6.2. Greenery

Lohr et al. [45] state the presence of plants having positive correlations with worker productivity. Interaction with nature has been shown to boost mental productivity [29] and provide increased venues for attention span as well as lower stress levels. Participants acknowledged the green additions to the workplace as accompanying factors to inspiring creativity. One participant commented on previous offices emitting a "sterile environment" while this retrofitted shed felt more "alive" and "energetic" in comparison. These parallels between an "alive" and "energetic" environment were supported through a rise of engagement with the biophilic elements in the office.

The use of natural spaces softening an environment was reinforced in the way workers reported largely on the open concept format creating different 'vibes' within the workplace. Many reflected on improved mood states and heightened desire to work and be engaged with those in their workplace as compared to previous site sheds. Interviews at the summation of the study



**Figure 6.** The site office site transformed by biophilic design.

indicated repeated incidents of workplace collaboration occurring at the site shed. Participants reported that these instances of collaboration were unique to the design shed and space.

Notable enduring impacts reflected upon in the exit interviews were the open space concept providing a viable space for collaboration and team building within the workplace. Dannenberg et al. [6] reported large reductions in negative mood states and levels of stress among building occupants. The biophilic design evokes use of space and an open concept method that intentionally strives to foster human-nature relationships in a built environment. These softer environments allowed workers to thrive and experience the mental benefits of a relaxed vibe within a workspace.

As a result of the renovated space, employees were able to deconstruct barriers that previously existed in both formal and informal hierarchies of office members. An increase in neutral spaces provided a setting for what participants described as “spontaneous collaboration”. The step-by-step workshops designed for the creation of desk buddies allowed participants to contribute to the space and fostered a sense of accountability in the outcome.

### **6.3. The impact of green spaces and biophilic design on well-being**

Biophilic design exemplifies the interaction between people and natural elements, not limited to and including use of space, greenery and access to natural light. The benefits of nature on well-being are highlighted in the literature. Retrofitting the office space with biophilic elements provided access to natural elements for office workers.

By the end of the longitudinal study, the ‘desk buddies’ introduced were reported to be 80 per cent still flourishing in the workplace although looked after largely by the caretakers and less by the workers. The desk buddies had initial interest and high attention by workers before absolving into the general green space of the office by the end of the project. From the initial introduction of plants, to the time the temporary workers disbanded, there was a shift in focus to the ambiance and environment rather than specific plant relationships. As specific plant relationships were absolved into the overall greenery in the office, the foreignness of greenery in a work environment lessened and workers were engrossed more in the overall ambiance and comfort of the space. This ambiance produced a softer environment for workers as a contrast to the harsh and sterile environments of previous sheds.

Many workers highlighted the simplicity in the approach and design, and commented on the biophilic workspace as a feasible concept to transfer to other site sheds they were being assigned to. The step-by-step model was an asset for transforming the site shed into a more energetic and productive space for the workers and also facilitated accountability and a relational aspect for those who had worked on the design. Workers in the site shed felt that having a hands-on element to the retrofit made it more genuine.

## **7. Conclusion**

This study provided a long term investigation of the effects of biophilic design on worker productivity and well-being. The ongoing qualitative interviews offered an insight into the study at different stages of development. Historically, site workers have been assigned ‘temporary, match-box’ sized offices for the duration of construction projects [48]. In this landmark study, aspects of open plan design and green interior spaces were purposely infused into the newly devised bespoke office site. Within the literature, there has been little documentation of a longitudinal study and its long term effects on workers. Occupants clearly support the newly introduced biophilic design elements to enhance collaboration among workers, improve morale and mitigate against stress. Early data trends from this study suggested resounding approval by

office workers for the newly introduced biophilic site office and were supported by the follow up and exit interviews highlighting lasting effects for those workers. We can confidently report that biophilic-designed site offices are linked to social benefits, including cooperation and mentoring, and to positive psychological effects, such as improved work satisfaction and higher morale. Not only were workers viewing the site shed as a place where work needs could be met, they actively thrived in the environment that was created through the unique design.

Applications for this study include the transferability of these flexible, multi-use spaces and their role in increasing productivity and collaboration. This was recognized in the opportunities for spontaneous collaboration and transcending levels of authority in the neutrally presented space.

The enduring impacts of this study recognize the trends of the multi-faceted human-environment relationships. This study enhanced worker well-being, productivity and performance by establishing long term exposure to a more biophilic workplace. The 2020 model provides a step-by-step model for which to outfit workplace environments with biophilic design. An unexpected positive outcome of this study was the opportunity to increase the skill level of workers to accomplish similar greening outcomes in their own backyards, homes or future workspaces. The outcomes of this focus group illustrate potential for accessible biophilic workspaces that can be self-designed by workers and contribute to the ongoing well-being of staff. This was a focus group study – the first to be initiated, and more confirmatory studies are needed in various contexts. However, given the consistency of positive results among the workers surveyed, it would be advantageous to recommend indoor plants should be a standard fixture in temporary (and permanent!) workplaces.

## Acknowledgements

The author would like to acknowledge the School of Education Western Sydney University kindly funded this publication.

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