Occupation Immersive

An innovative methodology to improve the spatial quality, well-being and understanding of contemporary office spaces and their users.

By

Ryuki Indiana Han

A thesis
submitted to the Victoria University of Wellington
in partial fulfillment of the requirements for the degree of
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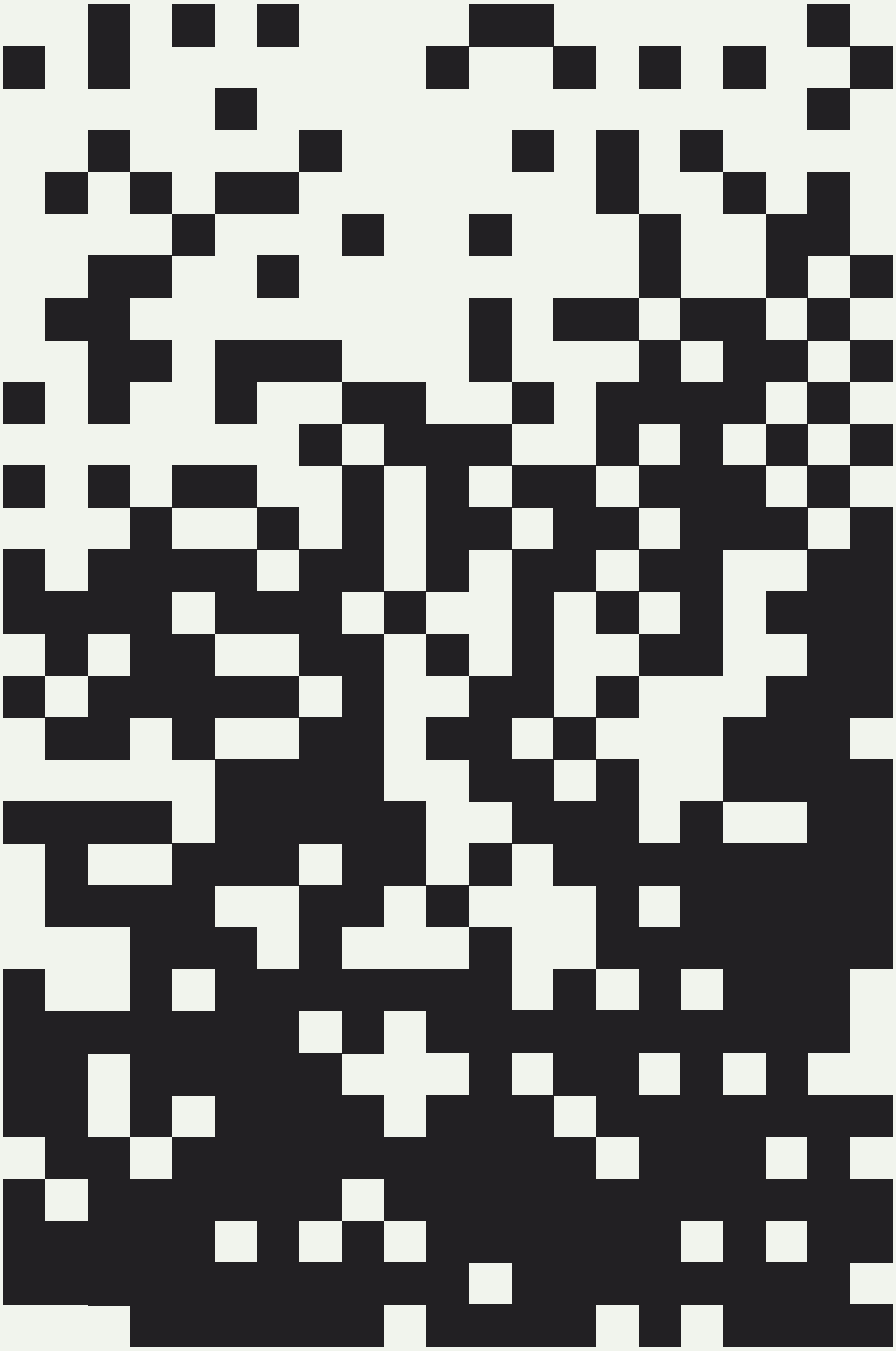
OCCUPATION IMMERSIVE



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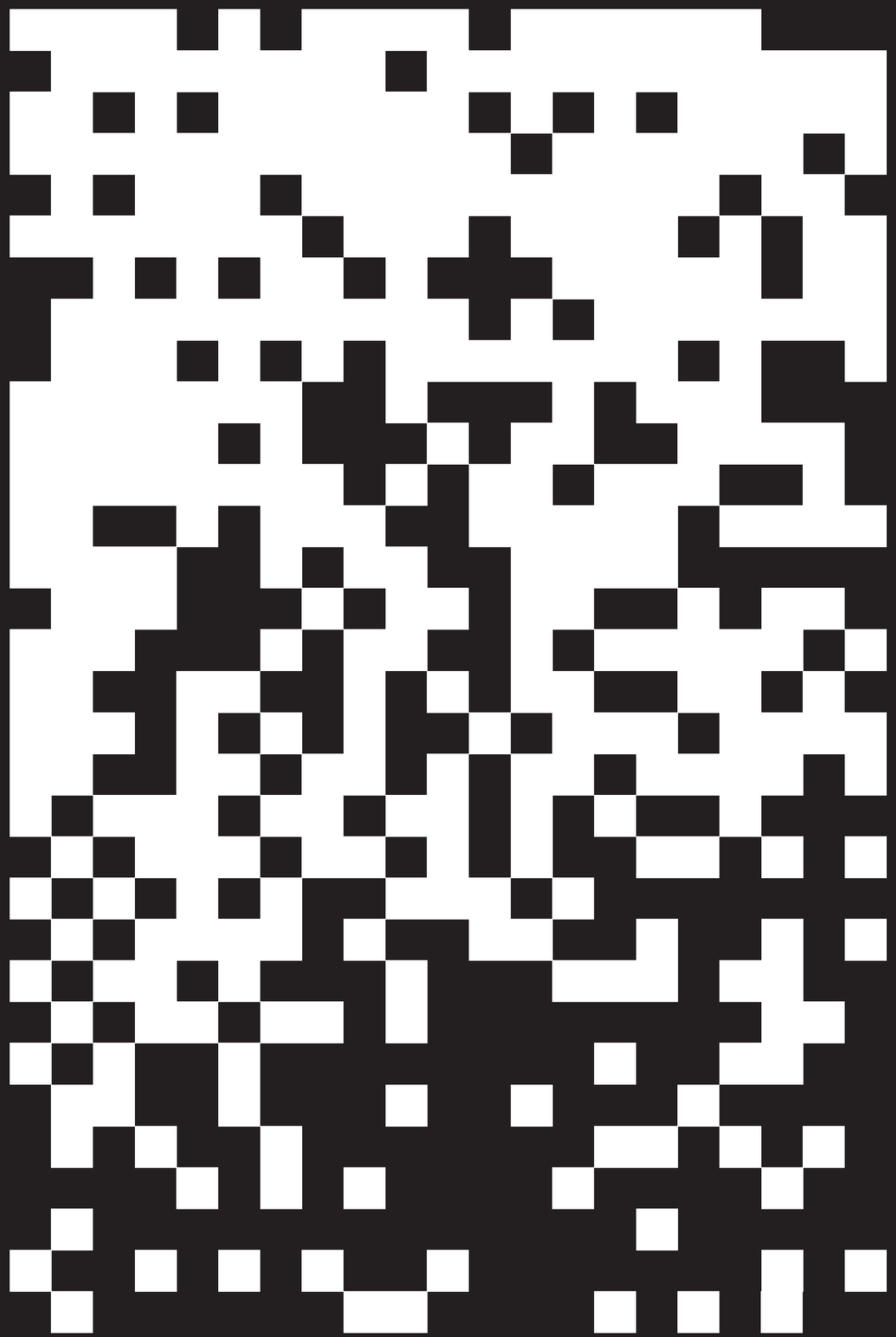

Occupation Immersive:
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Prologue

"Virtual Reality is a machine. But through this machine we become more compassionate, we become more empathic and we become more connected…Ultimately we become more human." – ***Chris Milk (2015)***

The Architects role in distinguishing the spatial requirements of an office have traditionally been that of a non-human centered design approach. This analogue method has always aimed to anatomize the workers needs without investigating the true spatial qualities needed to inhabit a space of well-being. Recent studies on virtual reality have shown, it is evident that a deeper understanding and empathy towards architectural space can be reached by implementing VR as an applied tool during the design process. This Thesis proposes an innovative technique that focuses on the use of digital mediums to pull out deeper understandings of our client's desires within contemporary office spaces, ultimately allowing us as designers to produce more compassionate connections with the end users of our built environments and their spaces of inhabitation.

Parallel to this switch from analogue to digital, within this Thesis the reader will find embedded QR codes which aim to dissolve the barrier between a traditional hardcover book and a digital version of it. By scanning these QR codes with your iPhone or smartphone you will be able to uncover further images, texts and details leading to a more fulfilled understanding of this research.

If you are unable to scan the QR codes, links are provided within the figure list of this research. These links will uncover the same images, texts and details as the embedded QR codes shown.

Acknowledgments

Occupation Immersive

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Abstract

In a working environment where employee poaching and regular staff turnovers are common, the culture of an office is at the core of company loyalty and organizational sustainability. This being said, many companies still lack the knowledge and understanding of their own work place, resulting in a disconnected understanding of what spatial qualities benefit employee well-being.

This Thesis proposes an innovated and unprecedented methodology in which a deeper understanding between office end user and work place are explored. Through the implementation of immersive virtual technologies such as 3D scanning and virtual reality, a deeper understanding of the worker and workplace can be facilitated. Explored through literature, the abilities of immersive virtual technologies allow for the potential of an alternative spatial environment in which users inhabit space. This methodology, tested through a pilot and case study, concur the potential of extracting connections between users and space at both an emotional and technical level. As such, the resulting data informs the design proposals, creating solutions that are cultured by the emotional connections extracted between user and office, as well as the spatial qualities needed to promote well-being.

The proposed research methodology fruitions the possibility to identify the intangible quality of office culture within existing work places, providing opportunities to improve the spatial quality and in turn enhance the well-being of the end users. Ultimately, providing a higher and more tangible understanding between architect, client and workplace.

Contents

1.0
Introduction

1.1 Problem Statement

The role of “the office” has played an integral part of the worlds working population ever since the early beginnings of office culture in the 1900’s (Duffy, 1997. With modern day office workers spending large portions of their time within set spatial configurations outside of home, it is clear to see the role we attribute to the office is indeed an extension of ourselves acting to some as “a second home” (Plunkett & Reid, 2014.

However, the preconceived office model - a spatial arrangement that varies from industry but nonetheless holds a similar vernacular internationally - is in need of change. Partly influenced by the global pandemic of 2020, Covid-19 has forced office based employees to leave the office environment and mandate working from home. This has ultimately granted the contemporary office obsolete and dissolved the barrier between home and workplace entirely, affecting the working population as a result.

This ability to work remotely has created a disconnect between architectural designers and the end users of these office spaces, as well as a disconnect between office workers and their own offices. The absence of understanding for this present day matter, in turn affects the ability to design new working environments that meet the needs of its inhabitants, thus taking away the sense of place from the end users of the office. The repercussions of this will dramatically change how we continue to work and impact the future of workplace design, slowly stripping away the comfortability and familiarity that was once present within our “second home”.

This impact is evident within New Zealand with some end users of office environments discovering post “lock-down” that remote working was preferential to them over the daily commute. This in itself is a clear signal that as we return to the office, the work place environment will need to adjust. The change in workplace preference / mentality, leaves the potential for the redesign of contemporary office spaces. This challenges the question, of what spatial qualities are key, in order to ensure the well-being of the office workers within their specific work places in a future working environment.

1.2 Research Question

What is the potential immersive virtual reality technologies have when designing to improve the spatial quality and well-being for the end users within New Zealand offices:

Using 3D scanning and virtual reality as an applied tool during the design process.

1.3 Aims

This research seeks to achieve a greater level of understanding between the end-users of contemporary office spaces and their work place. This proposition is to be achieved through the integration of 3D scanning technologies and immersive virtual reality (IVR). These tools will act as an alternative methodology in uncovering a higher level of understanding between a client's spatial and emotional needs within the office; an understanding that is currently not able to be discovered through conventional research methods.

Core to this research are the IVR and 3D scanning tools. These tools will allow the end-users to experience a virtual representation of the office they inhabit. This will create a familiar but simulated perspective on their work place and stimulate new outlooks on the spatial qualities of the interior composition – "a virtual office".

Throughout this research a pilot study and previous case studies will be used as a way to better develop the proposed methodology. This technique will then be implemented against office workers in Wellington. This target demographic will then give an insight of workers within New Zealand and as such, a new framework can be postulated, allowing for a concise and deeper understanding between spatial qualities of contemporary offices and the well-being of the end users.

1.4 Scope

From its early stages, virtual reality and architecture have always found themselves to be intertwined in some way or the other; with the possibilities of information transferable between the two to be seen as endless. However, even today, the application of this technology compared to the potential it has, can be seen as short-sited as virtual reality primarily still remains as a presentation tool within architectural practice. This being said, recent advancements in highly photo-realistic virtual environments have shown a greater potential between an architecture and virtual reality cross over. This can be seen in contemporary works by real estate companies, where VR has been used as a means to experience space and gauge spatial comfort before builds have been completed. This research aims to use an innovated methodology that changes the experiential medium of office inhabitance to allow a higher level of understanding for the spatial requirements and key factors needed for the well-being of the end users; the office workers. Subsequently the synthesized data collected from this methodology permit the learnings to be applied within the design process resulting in a pragmatic architecture to better fit individual contemporary office forms.

Due to constraints such as time, budget and participant sourcing, this research is limited on its ability to reach a wider scope of office environments and therefore only one New Zealand office was chosen as a case study. On the basis of previous research that had used similar methodologies to analyze ‘online shopping’ and ‘home’ (Mistry, 2018; Musson, 2019) a brief pilot study was introduced prior to the case study itself, aiming to further the understanding of this methodology and preparing the most refined method leading into the user study and design phase.

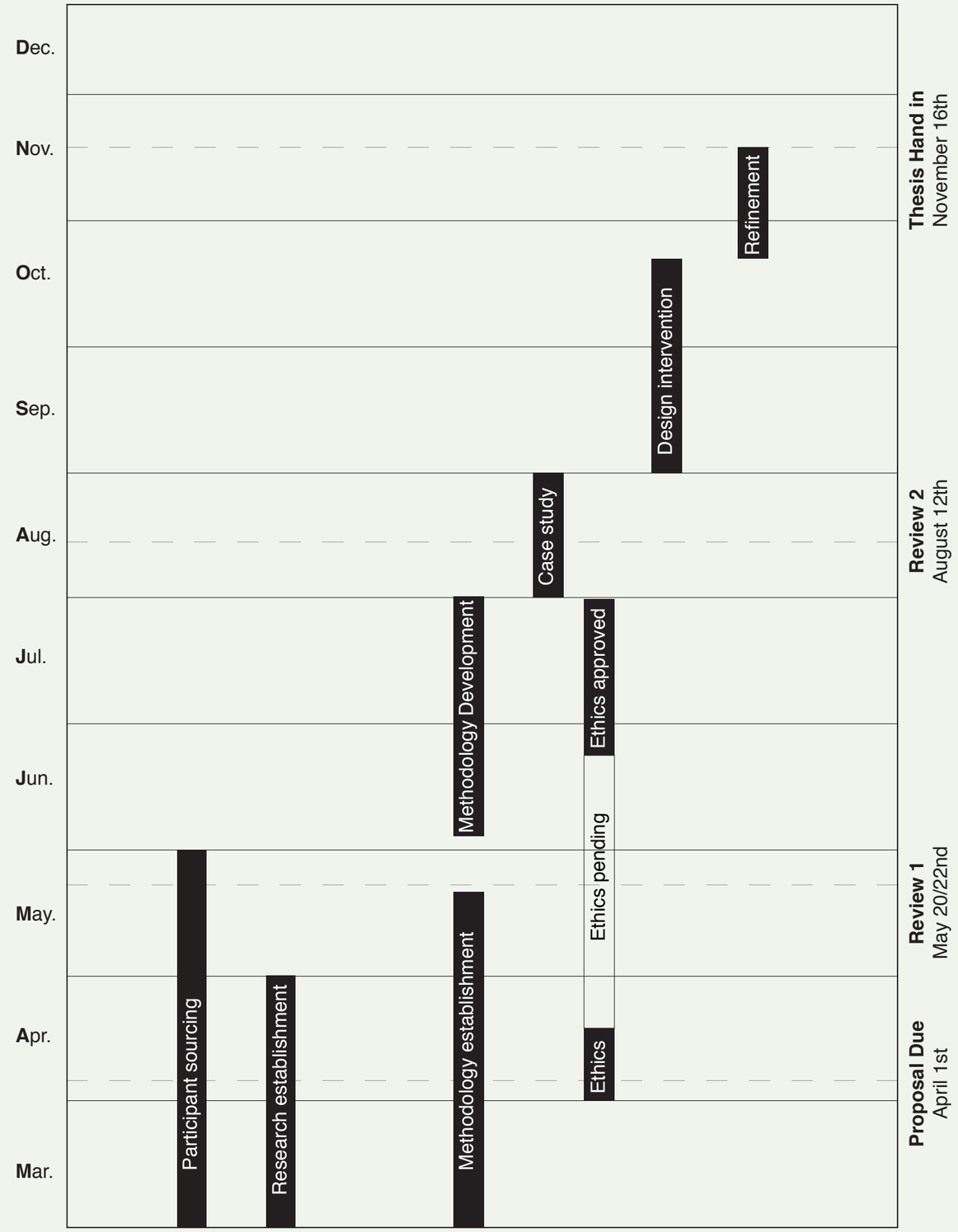
The chosen office for the case study - Victoria Universities Computational Media Innovation Centre (CMIC) – provided an opportunity to asses and criticize the initial methodology; a methodology that as previously stated was influenced and based upon previous successful case studies performed through Victoria University of Wellington.

From this case study the findings were then taken into a design process where the deeper understanding for each individuals’ relationship with their office space was synthesized and explored through design.

Although the previously mentioned limitations are apparent, a greater depth of understanding and analysis can be discovered for the chosen individual office. For this reason, there is no objective to reach a wider understanding of the spatial requirements and well-being needs for all types of office workers in all types of office environments, but rather place the focus on developing and implementing this methodology to meet the needs of specific individuals within a specific office environment.

As a continuation of the previous statement, it is eminent that the terms “office worker” and the “office” target a large demographic and encompass a wide range of specific individuals and professions. To narrow this scope, the focus of this research lies in creating architectural design that responds to a specific office context. The workers within the CMIC office have a unique relationship with their respective work place and thus making the study of this individual office especially intriguing.

1.5 Thesis Structure



Office 3D Scan - Underbelly

Point Cloud visualization

Informal Meeting Area + IVLAB

Office 3D Scan - Underbelly

Point Cloud visualization

Hallway + Office Work floor

2.0
Literature Review

2.1 Introduction

Two integral components of literature form the basis of this research - the psychological experience of well-being within office environments and the immersive virtual reality as a tool for experiencing space alongside 3D scanning as a tool to trigger specific response of users to the virtual experience.

Extensive research can be found within the field of well-being and architecture and thus the key interest within this section will be; the theoretical definition of well-being, the importance of well-being in the office space and what the current stance is on evaluating well-being within the office context. Subsequently this allows for an understanding for the emotional importance of well-being and a framework for evaluating the role of well-being in determining the spatial quality and lay out of a contemporary office plan.

Virtual reality possesses an innate quality that allows for new worlds and environments to co-exist with our everyday lives. This tool is used within the design process of this research and it is believed that by inhabiting these alternative existences one is able to track new understandings. It is believed that these co-existing virtual environments inform a deeper insight to what is needed to satisfy the desideratum of the end users within an office.

This section will aim to identify the different characteristics found in both the real world environment, as well as that of its virtual counterparts. Through analysis of these virtual reality types, immersive qualities and the potential of 3D scanning implementation, key insights can be evaluated. This understanding allows for the outputted information of these technological tools to showcase the potential they may have when applied to real world working environments. By using these applied technologies as the primary tools in which unique and individual participatory data is gathered, an understanding of specific office workers needs within their set offices can be generated.

Currently, the overlap between contemporary office well-being and applied virtual reality/3D scanning is scarce. Nevertheless, through previous research done at Victoria University of Wellington (VUW) it is clear a unique experiential quality can be found. This experience has indicated an unrealized potential for the use of this technology whilst evaluating the needs of contemporary offices and their workers.

A Brief History of the Office

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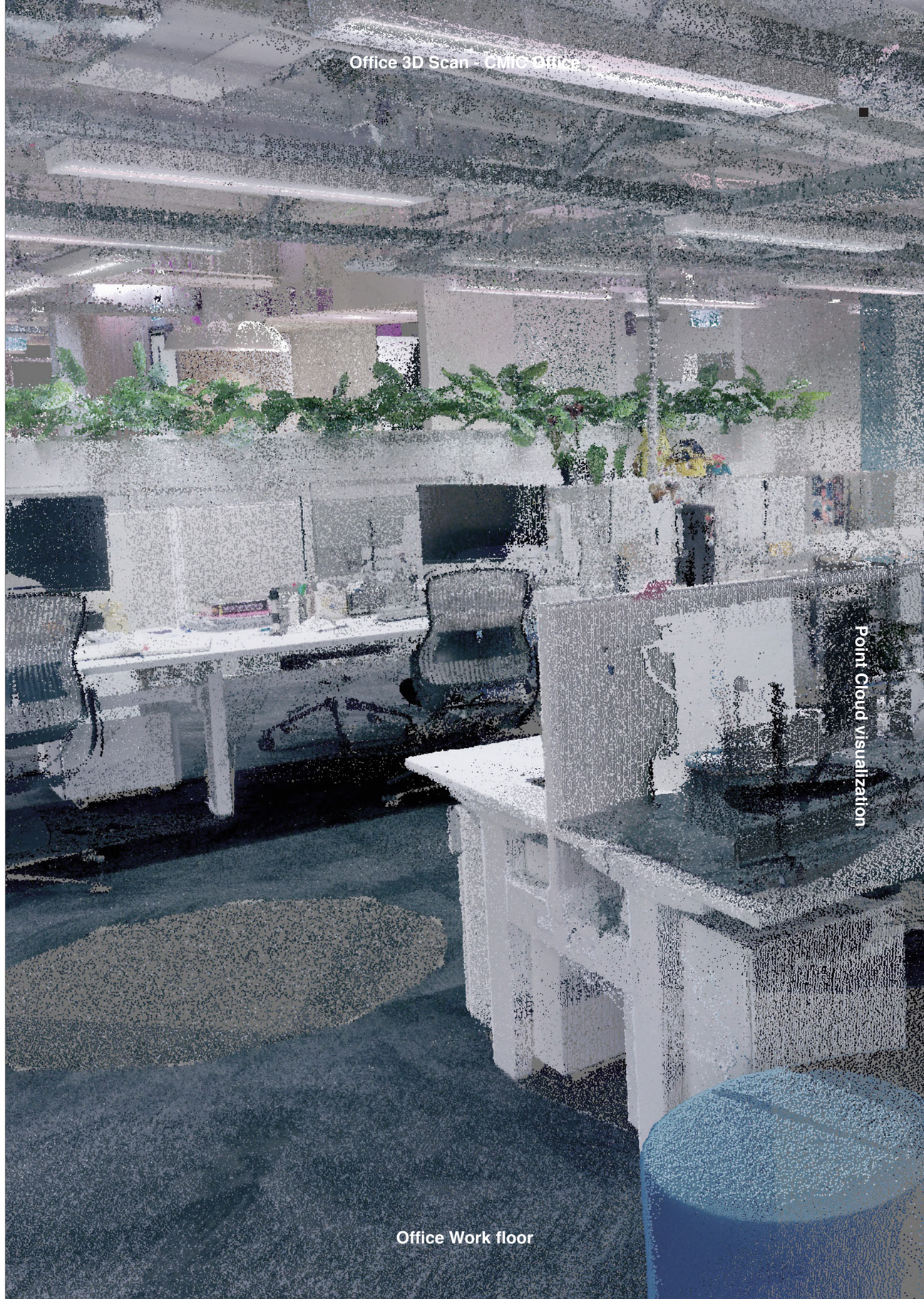
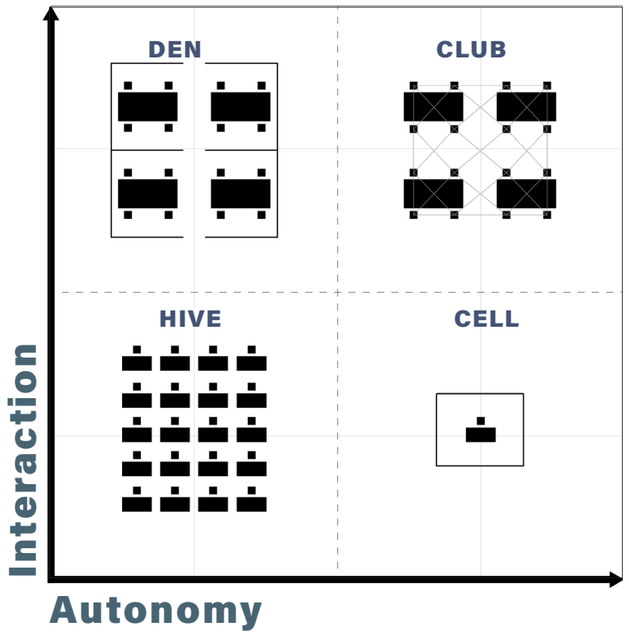


The Office

2.2



Duffy Adaptation
Figure 1

Introduction

This section aims to correlate the known spatial design of different office structures and how that effects the working behaviors of the end users of the office space. This literature theme of the office will discuss the current understanding of office design and office usage, the type of work of the end users within these designs and how this knowledge can be applied to improve the future office design for end users, in turn speaking to the following literature theme; the well-being within the office.

Office Models

Architect and author Francis Duffy holds a strong stance on the architectural model of 'the office' and has categorized traditional office working environments within four categories that satisfy the 'new way of working' post 1997.

These categories can be mapped out tracking the social interaction of workers against the autonomy of the work being conducted and Duffy believes the core of modern office structures can be categorized into one of following office models (see Fig. 1) with some newer technology based companies falling into a hybrid category but none the less measurable on the scale created.

As shown in the previous figure *Dens* primarily act as complex and or continuous spaces that merge work and meetings areas which focus on project or group work, balancing interdependent skills and therefor a higher rate of social interaction. The overall occupancy within the actual office space is typically that of a conventional 9-5pm working day and the use of technology can consist of shared computers and specialized equipment (Duffy, 1997, p. 66).

Clubs work as diverse and flexible layouts and consist of high level work usually of both individual and collaborative manners.

The overall occupancy within the office space for *Clubs* can be seen as highly intermittent and patterns of high occupancy are usually based around individual arrangements and what tasks need to be done within certain time frames (Duffy, 1997, p. 66).

Hives work in smaller components and staff usually carry out specific individual tasks that contribute to the entirety of a job. The typical spatial layout can be seen as imposed desk arrangements that offer little partitions but maximize open space. Conventionally these *Hives* are occupied during a 9-5pm working day but labor tends toward shift work, therefore, low interaction and autonomy can be seen. *Hives* can be seen as the predecessors to the open plan layout and encompasses industry work such as airline operation centers, trading companies and many creative offices (Duffy, 1997, p. 110).

Lastly *Cells* consist of a typical pattern of high level work completed by skilled individuals. The typical spatial layout can be seen as cellular enclosed spaces usually partied with individually occupied workstations with a variety of computers, laptops and or specialized equipment. The occupancy time within these offices are increasingly ranged depending on the individuals arrangements (Duffy, 1997, p. 66).

From these four categories, it can be seen that *Hives*, *Cells* and an adaptation of the two, have become the basis of the office model development. With Duffy predicting the direction of future office heading towards a majority of Hive based work, Cells can be seen to resemble the dissolving barrier between home and office as the nature of the space can be translated to the concept of remote working or home working (Duffy, 1997, pp. 61, 67).

From the development of the four categories coined by Duffy, newer stances have been found on contemporary office spaces such as co-working,agile workspaces and telecommuting or telework. These office models showcase flexible programmatic functions that contrast the traditional Hive or Cellular composition of floor space and in some cases introduce multiple locations acting as remote offices. It is agreed by other researchers that these newer office models some of which are composed of breakout spaces, collaborative spaces, unassigned desks and informal meeting areas evolved from Duffy's *Dens*, *Clubs*, *Hives* and *Cells* (Keeling et al., 2015, p. 881).

Agile Office – The New Office Model

The growth of the agile open plan office model was predicted by software company Intuit, who said that by 2020 free lancers/remote workers would constitute 40 percent of the entire workforce (Saval, 2014, p. 310). This resonates with Keeling's earlier statement, that the fastest growing contemporary office model is that of the agile work place, spaces that encourage remote working and collaborative activity (Keeling et al., 2015). Various sources imply different increases in remote working but they all hold the same narrative that the scale in which traditional fixed spaces - like that of Duffy's analyses - and work are rapidly detaching from one another (Felstead & Henseke, 2017). This detachment from specified working environments are especially high in the case of white collared workers, management and professionals, as it is believed paid employment for these workers are no longer confined to what was once a designated work space (Felstead & Henseke, 2017, p. 196).

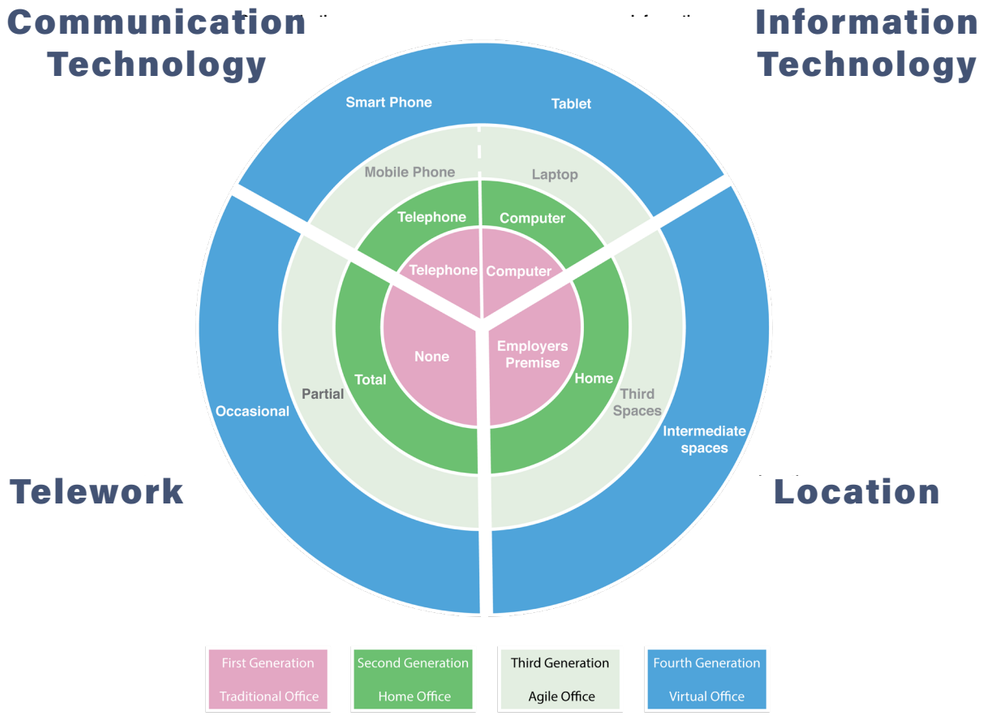
The growth and success of the increased ability to be a remote worker has been critiqued by large companies such as Yahoo, who have in fact been promoting and implementing the idea of home working since the 1980s under the term telework or telecommuting (Nilles, 1988).

Telework or Telecommuting is the arrangement in which employees are not bound to commute to a central office or workplace but rather spend paid hours working remotely, either partially or entirely away from the employers premises. As illustrated in Messenger & Gschwinds 2016 research, , in 2013 former CEO Marissa Meyer of Yahoo abandoned the working from home policy as she found the need to communicate and coordinate with home workers caused drag and ultimately wanted workers to return to the office (Messenger & Gschwind, 2016, p. 195).This can be seen as a perspective of a management role whilst another critic on these agile work environments are on the composition of space itself and the effect this has on the perspective of the mobile worker's role. The previously mentioned terms such as 'breakout spaces' and 'informal meeting areas' are known to be ever present in the contemporary office context which can be partly accredited to Duffy's research. Although these terms are ingrained in modern architectural thought Duffy's foundational office predictions have been criticized by some who claim the development of these informal spaces have created architectural concern (Klonk, 2016, p. 122).

Klonk's research states that the over-saturation of these new unassigned spaces within agile offices hold no real function and that the spatial layouts create unnecessary areas that lack relevance (Klonk, 2016, p. 122). Klonk's analysis of contemporary office space possibly correlates with the later ideas of Keeling. Keeling suggests that Duffy's prediction of the future office model moving to a more open plan layout as a development from the Hive, inevitably equates to less assignable areas causing issues for dense crowds and lack of privacy.

Briefly touching on the next literature theme of well-being, contemporary agile workspaces may need to pay close attention to the "improvement of privacy in the office" in order to improve the well-being of workers as with the development of this work style comes the increased "trade-off between interaction and privacy" (Keeling et al., 2015, p. 896).

This being said remote working and privacy is not necessarily fixed to a space that inhabits a dense crowd of free lancers, but rather gives the flexibility of work being able to be conducted from any space even that of one's home. As introduced in the previous section "a brief history of the office", potential for technological and communicational tools to dictate the spatial arrangements of offices is seen again as a recurring phenomenon. In 2016 Messenger and Gschwind suggest that the growth of *Information and Communications Technology or ICTs* have furthered the development of various location independent work styles and a movement from home office / agile workspaces to 'virtual office' can be seen. This 'virtual office' being accessed by cloud networks at any location on hand held devices allowing for a continuous link with 'the office'. This growth is stated to be a further development of ones interconnection between work life and personal life and once again supports the previous statements and predictions of remote working (Messenger & Gschwind, 2016, p. 195). When juxtaposing Meyers and Keelings criticism on agile work spaces with the ideas of Saval, Felstead & Henseke a clear ambiguity within 'the new office model' can be seen. This not only shows uncertainty in the final outcome of what should constitute the new office model but clearly showcases the rapidly changing multifaceted phenomenon that is 'the office'.



Evolution of Office

Figure 2

Virtual Office

Although remote working is still limited on research the majority of literature suggest that it is in fact rapidly growing and even developing further than that of set agile office environments previously mentioned. Mobile or remote working allows for work to be completed at one's home, employer's premises or any location in between and owes its recognition to the advancements in ICT. The agile workplace can be seen to be a product of the development in technology as increased mobility can be directly aligned to the ability to carry information in smaller physical forms (Messenger & Gschwind, 2016).

This ability to transfer and transport information efficiently has advanced to what we now have today as cloud storage. Makimoto & Manners, 1997 predicted this type of "network accessed" information system in their theory of future work and concept that office space is neither "here nor there, but constantly shifting in motion" (Makimoto & Manners, 1997).

This constant shift in motion and working "on the move" is evident through the ability to write emails, conduct trades and coordinate with team members through a single handheld device; the mobile phone or now smartphone (Messenger & Gschwind, 2016, p. 200). The ability to "work on the go" is an extension of the previously stated telework and can be seen as the most advanced model of remote working to date. Ultimately, the development from Duffy's categorization of traditional work environments to the in-dependency of virtual office work can be diagrammed, showcasing the evolution from employer premises' office models to the new intermediate locations and how the influence of ICTs has affected this growth of the office in generations (see Fig 2).

Figure 2.0 demonstrates the evolution of office typology and creates a framework in which the most recent developments in office structure and spatial use of these office models can be identified.

The diagram is split into four generations, each representing a model of ‘the office’ as stated in the relevant literature across the years of office based work. Each generation depicts the location and organizational telework of the ‘office’ and what ICTs were the back bones to those models.

The first generation constitutes Duffy’s exploration into office models and the ‘traditional office’ can be seen to be in the location of the employer’s premises. ‘Total’, in this case, refers to the total working hours spent working remotely compared to at the location of the organization, there is no telework at play. The first generation, in the 1950s where primal computers and non mobile telephones were used as ICTs, computing was at a fraction of what is possible today, resulting in the traditional 9-5pm working hours and a stationary centralized work location for employees. This generation falls within Duffy’s categories of the Hive,Den,Cell and Clubs (Duffy, 1997).

The second generation is where the concept of Nilles telework is introduced (Nilles,1988). Similar to that of the traditional office, the home office constituted of stationary ICTs and a total working hours spent at home. By translating the total hours working from the employer’s premises to home, a ‘total’ amount of paid work can be seen as being remote and there for the first signs of telework.

The third generation begins to introduce a more mobile worker and the model of the office begins to dissolve from home and set space. This ‘partial’ telework means that a portion of the time spent working could be in these agile workspaces or agile offices whilst the remaining paid hours would be at that of the organizations office. During this generation old ICTs were still in use and the early mobile phones and laptops of the era allowed for flexibility in both location and hours, for example working more at night rather than the traditional 9-5pm working day (Keeling et al., 2015).

The fourth generation showcases where the most current form of office work stands, the model of the virtual office. Similar to that of the third generation the growth of ICTs in this current time period allows for extreme mobility and freedom of choice when it comes to remote working.

It is important to understand that intermediate spaces refer to any location imaginable as the ICTs of now provide the informational and communicational accessibility to essentially work from anywhere. Third spaces on the other hand refer to spaces only in-between home and office such as libraries, airports or cafes (Messenger & Gschwind, 2016).

Today we can see a combination of multiple ICTs from multiple generations being used. It is common to encompass a hybrid of technologies and locations during paid working hours and whilst the traditional office from the first generation still exists and is widely used, it is important to note that the integration of the ‘third place’ and ‘intermediate spaces’ are inevitably growing and no longer are the clear office models separated by a defined lining. This can be seen as smartphones, advanced tablets and laptops are all used for remote working in motion, whilst the stationary computer is also utilized either at home or set office location when occasionally needed (Messenger & Gschwind, 2016, p. 204).

Covid -19

The economic and social shock when faced with a worldwide pandemic has made organizations have to rethink the way they do business. The fluidity needed for employees to move from a physical location to online has impacted the ‘office space’. Setting home offices and remote working, essential for continuous growth of the business (Kramer & Kramer, 2020).

In previous economic crisis’, we have also seen shifts in the work culture and office life, for example the 2000 dotcom bubble. A significant effect that impacted the engineering, science and technology departments whilst other sectors and industries faced minor negative results (Kramer & Kramer, 2020). Nevertheless, the effects of Covid-19 on office structures and working styles is unlike anything seen in recent years. Having a drastic effect on all working sectors, the nature of this virus meant that the majority of the working sector was forced to participate in the unplanned ‘working from home’ experiment (Kramer & Kramer, 2020, p.2).

Well-Being

2.3

Introduction

This section aims to correlate the previously discovered spatial design and differences in office structure with the affects these working spaces have on the well-being of the end users of the office space. This literature theme will also discuss the current understanding of well-being in an architectural context, the well-being of the end users within designed office models and how this knowledge can be applied to improve the future office design for end users in turn speaking to the following literature theme; Virtual Reality.

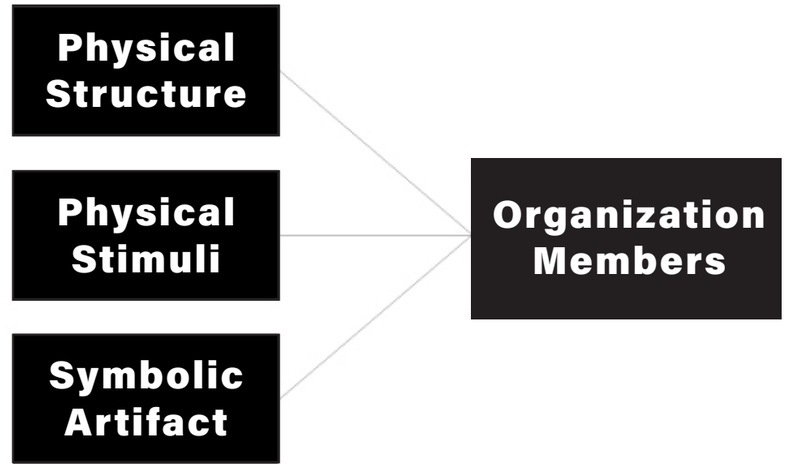
Well-being

Well-being is undoubtedly interlinked with several health factors such as the physical, mental and social state of a person. This is mentioned by the World Health Organization who state “Health is a state of complete physical, mental and social well-being”(WHO, 2006).The investigation into well-being can be seen as a relatively new venture with some scholars such as Steemers, 2015 defining the concept of well-being as a factor of two components, “feeling good and functioning well” (Steemers, 2015, p. 1). This definition of well-being alongside the definition supplied by the World Health Organization show cases that health is now increasingly more complex than just access to medical treatment with Steemers later suggesting that the built environment also plays a large role on the well-being of people (Steemers, 2015). This connectivity between space and health can be dated back to the early days of survival as the built form not only provided safety parameters but also provided comfort for its occupants and therefor resulting in an aspect of supported well-being (Stoneham & Smith, n.d.). With these understandings in mind, well-being within the architectural context of an office can then be defined as “a workplace that at least does not harm employees’ well-being, and ideally actively supports it”(Colenberg et al., 2020, p. 1).

Parallel to this, ongoing debates have speculated the negative health impacts and concern for the contemporary office layouts. Alongside Klonk’s previously mentioned criticism of open plan, others have found business goal for their company have suffered because of the spatial configuration. This has not only challenged designers to conceptualize aesthetics but also take into account the impact space has on the strategic business approach on staff as this directly affects organization (Colenberg et al., 2020).

Framework for Well-being

As concluded in the previous literature theme the progression of ‘the office’ can be seen to be a future development of the Hive, ICTs and intermediate spaces. Therefore it is relevant to correlate the performance within these open plan layouts and the well-being of end users as the open floor configuration represents the most recent evolution of the Hive and follows the predicted growth of organizational office models as a whole (Duffy, 1997; Kamarulzaman et al., 2011). The open plan layout acts as fundamental aspect that directly impacts the behavioral patterns of end users within an office (Kamarulzaman et al., 2011, p. 263). These behavioral patterns are influenced by environmental factors brought by the spatial configuration of the office and when acting in a negative way are called ‘environmental stressors’ and can be used within a framework in determining the factors that are directly related to the employees well-being in an office context (Evans & Johnson, 2000). In saying this, it is important to take a holistic stand as there are simultaneous environmental influences that are functioning together and the varying disciplines of ‘offices’ make it difficult to assess all environmental influences accordingly (Bodin Danielsson et al., 2010).



Davis Framework
Figure 3

Davis Framework

The Davis framework looks to address categories that impact the well-being of organizational members within the office context. The first category describes how Davis’ framework directly showcases architecture influencing the behavioral patterns of office end. This describes how architectural components influence workers which in turn result in the organizations performance and directly the workers performance (Davis, 1984). Figure 3 breaks up the architectural environment into three sections; physical structure, physical stimuli and symbolic artifacts. Each section directly correlating with staff members perceived well-being and the office in which they inhabit.

Physical structure within the context of Davis’ framework represents the architectural design of the office itself. As well as the configuration of interior furnishings within the space. Davis specifies that physical structure or the architectural design both exterior and interior, directly impact the end users behavioral patterns such as privacy, communication and inter worker social interactions (Davis, 1984).

Physical Stimulus refers to the external factors that may directly impact the office worker’s behavioral patterns such as concentration. These factors are described as aspects of the architectural environment that can either positively or negatively impact the performance / well-being of an individual. For example, constant surveillance by management resulting in unwanted stress, multiple phones ringing and/or conversations causing lack in concentration. Collaboration and communication between staff can also be heightened through these physical stimuli with social interactions increasing staff connections and comfort within a work environment (Davis, 1984).

Symbolic artifacts in this case represent elements that subconsciously influence social status and organizational cues within an office context. Examples could be the interior decor, individuals displayed photographs, carpet or lack of, wall paper/color etc. These artifacts or objects differ within each office but Davis believes that the individual interpretation of these objects lead to unsaid organizational cues and office culture. These artifacts play an importance in the architecture of the office as more often than not a parallel exists between the hierarchical structure of an office and the workplace design (Davis, 1984). This physiological factor may directly impact the employee’s emotional fulfillment within the working environment and has been stated that these symbols and artifacts used by organizations should represent non conflicting messages in order to satisfy the needs of both employee and client comfort and privacy (Becker, 1991).

Other architectural factors that influence the well-being of occupants include ambient features such a noise, temperature, lighting and colors. These when affecting staff members negatively can be stated as environmental stressors. One of the most important factors that influence job satisfaction can be seen as noise.

Noise plays a huge role in the overall office environment and is stated to be the number one complaint in open plan offices which directly correlates with employee well-being (Nemecek & Grandjean, 1973; Sundstrom & Sundstrom, 1986). This being said, some noise is stated to be helpful in working environments and lead to stimulation, unity and feelings of non-isolation (Bodin Danielsson et al., 2010). The loudest noises are also stated to not necessarily cause the most annoyance within the open plan layout but rather that of ringing phones and employee conversations (Sundstrom & Sundstrom, 1986) which supports the framework of physical stimuli mentioned previously (Davis, 1984).

Temperature also plays a role in job satisfaction with the BOSTI study of employees stating that inconsistent temperature within office environments can be associated with employee job dissatisfaction (BOSTI,1981). Although this is an important factor, not much variance can be made with temperature as individuals react to climates. This being said it has been found that 21 degrees Celsius is the optimal office environment temperature with woman finding a slightly higher degree in temperature to be optimal (Hedge, 1982). Lighting plays a significant influence on employee well-being as both stress and anxiety have been found to be significantly reduced through close proximity to natural daylight (Lehrner et al., 2005). Workers who are exposed to very little light in an office context have been found to show traits of sadness, fatigue and depression as well as lack in concentration. This ultimately leads to less social ability within the office context and results in a damaged employee well-being (Bodin Danielsson et al., 2010; Lehrner et al., 2005; Sundstrom & Sundstrom, 1986). This being stated literature comparing the benefits of artificial light compared to natural daylight have not shown evident research suggesting one is superior than the other (Mitchell McCoy & Evans, 2005).

It can be suggested that well-being comparing natural and artificial light may be dependent on the amount of time spent and the function of the space time is spent in rather than the absence of windows.

Finally colors also have a part to play in the behavioral influence of office workers. Colors work respectively with the previously mentioned lighting of the room and can enhance office environments both negatively and positively (Riley, 1996). Something that is common in architecture is the correlation between color, material and structure. All components which hold intangible qualities within themselves that are enhanced through light. Resulting in darker colors grounding space and lighter colors expanding space(Riley, 1996; Sundstrom & Sundstrom, 1986). Within the office context research has shown bright colors are preferred by employees (Hedge, 1982) and are often associated with the organizations status cue or culture. Again, relating to Davis' framework of symbolic artifacts as the color within office context usually hold symbolic effects of workers subconsciously noticed (Davis, 1984).

The previously mentioned architectural impact on well-being can be classified under a larger category of 'environmental factors' which directly affect the well-being of office workers and can be the physiological factor. Literature has shown that there are two key physiological factors that influence the well-being of an employee within the office context – personal control and privacy (Averill, 1973; Rothbaum et al., 1982; Stokols, 1976; Sundstrom & Sundstrom, 1986).

Personal control can be seen as a critical component that can directly influence the well-being of workers. When control of one's surroundings is something immediately there it has been shown that good mental health and well-being to also be present. On the other hand when control is not present it can be detrimental to ones well-being (G. W. Evans & Johnson, 2000). (G. W. Evans & Johnson, 2000). Key literature have stated that there are three main types of personal control – behavioral, cognitive and decisional – which can dictate the mental health and well-being within the office environment (Averill, 1973; Bodin Danielsson et al., 2010; G. W. Evans & Johnson, 2000).

This statement in office context can be supported through Averills three psychological sectors of personal control (Averill, 1973). Behaviorally, it may come through employee confidence and ability to perform work with a degree of autonomy, cognitively, it can be seen through worker motivation and decisionally, through the ability to embrace work changes through choice. Personal control is also dictated by architecture and can relate to Davis' framework as the form, location, materials and size of rooms can directly influence the employee's ability to control their environments to a certain degree. A heightening experience of control may come from architectural features such as open meeting spaces giving workers have the ability to dictate the space in accordance to the work needed to be conducted. The opposite of this may be spaces that exaggerated surveillance leading to workers feeling overly watched and lead to territorial emotions of dictatorship as seen in 'Taylorism' (Bodin Danielsson et al., 2010; Saval, 2014). The desire to have personal control of a space that is in direct influence of one self has been stated as an innate human characteristic (Rothbaum et al., 1982). When further translated into the office environment it is important to allow for participation in the design process of personal assigned areas such as desks. The lack of this may be an issue that correlates with the lack of job satisfaction found in Keeling's research of agile work spaces as 'hot desks' restrict personalization of work stations (Keeling et al., 2015). The importance of personal control also directly relates with Keeling's work in terms of privacy as a direct influence can be found between the individually chosen aspects of a work station and the privacy / crowding. These together create the two main components leading to affective employee job satisfaction and well-being (Bodin Danielsson et al., 2010).

Privacy can be defined in multiple ways. In the context of office design, a key definition can be that of Sundstrom and Sundstrom who categorize privacy as both a matter of acoustics and visualization (Sundstrom & Sundstrom, 1986).In the context of an office, the acoustic component relates to isolation from unwanted noise and seclusion of speech. Visualization, on the other hand describes the ability to stray from unwanted visualizations and or stimuli relating to Davis framework as physical stimuli and artifacts can directly affect employee's visual privacy (Davis, 1984; Sundstrom & Sundstrom, 1986). An example of improving the visual privacy for workers could be architectural components blocking unnecessary view of surprise visitors entering the office. Sundstrom and Sundstrom describe in their 1986 research, three important features of privacy - retreat from people, control over information and control over interaction (Sundstrom & Sundstrom, 1986). The need for social interaction within the office environment can be seen, as too little interaction and isolation may occur leading to loneliness, while too much interaction may lead to the sense of overcrowding (Stokols, 1976). It has been stated that the best balance of the three features of privacy mentioned is the office model of the Cell (Bodin Danielsson et al., 2010, p. 34). The key acoustic privacy and visual privacy components of this model however cannot be directly translated to the most common working environment of the open plan but can be achieved through other means such as acoustic panels and partition walls.

Well-being and Remote working

The three aspects of privacy defined by Sundstrom & Sundstrom cross over with the research into well-being of agile workspace workers. Keeling's 2015 research found that mobile workers who were not fixated to an assigned desk find a higher need for privacy compared to that of their fixed desk counterparts (Keeling et al., 2015, p. 894). This was the result of mobile workers facing little control over interaction and retreat from people leading to a feeling of crowding and increased density. It was also found that the new model of agile work spaces scored similarly to that of other models such as the cellular office design in terms of information control. It was found that open plan layouts and especially that of agile work stations allowed for confidential conversations similar to that of the cell (Keeling et al., 2015, p. 879). A positive result was also found in interaction with work colleagues which resonant similar results with Ilozors 1999 studies on open plan layouts.

In 1999, Ilozor & Oluwoye investigated the impact of open plan office layouts have on the effectiveness of facilities and space management, exploring the productivity of end-users within 102 Australian open plan offices.

Productivity in the work place can be directly linked to well-being as research has shown that the external environmental factors of an office can ultimately result in the mental health and performance of staff (Kamarulzaman et al., 2011). Ilozors et al. (2002) backed this notion as they concluded that there is a correlation between spatial configurations of open plan layouts and the productivity of the end users of the office and concluded that by fostering staff interaction the productivity of staff can be seen to increase. The exact spatial configuration factors that influenced the well-being of end users were not stated in Ilozors et al's studies but from other sources it can be seen that various ambient factors such as light, temperature, noise may be related to the spatial configuration explored within Ilozors et al's work which can be categorized as environmental stressors (G. W. Evans & Johnson, 2000; Leaman, 1995). Continuous to the findings of Ilozor's open plan layout work and Keeling's agile spaces, other authors have also concluded the 'open' nature of modern office layouts positively increased staff communication, sociability and well-being and by allowing having an open spatial configuration it immediately effects staff in a positive manner (Brennan et al., 2002; Kamarulzaman et al., 2011).

This being said others have stated negative views with open plan design. Stated previously, Keeling et al. (2015) findings on agile spaces allude to end users facing privacy issues within more open plan designs (Keeling et al., 2015, p. 896). This is supported through G. W. Evans and Johnson's work stating that from the perspective of the workers, open plan layouts lead to a lot of excess noise, unwanted interactions and privacy issues which in turn reduce the productivity and impact the well-being of workers (G. W. Evans & Johnson, 2000). This is plausible as the dense spatial configuration of personal spaces imposed with others personal work spaces can be seen to cause crowdedness and discomfort levels among employees in an open plan setting.

However, complete mobile working and the detachment of employee and set employer premises cannot be concluded to have definite benefits or draw backs on employee well-being (Felstead & Henseke, 2017).

Although this being said, through previously mentioned work done by Felstead, it is clear that the movement towards remote working is resulting in a positive well-being for both employer and employee. On a whole it can be seen as advantageous and can be further merited after the face of Covid-19 and enforced 'work from home policies' (Felstead & Henseke, 2017; Kramer & Kramer, 2020).

Office 3D Scan - CMIC Office

Virtual Reality

2.4

Introduction

This literature theme will discuss the current understanding of virtual reality (VR) / immersive virtual reality (IVR) and virtual environments (VE), the importance of presence within these alternative spaces and how this knowledge can be applied to existing technologies that will be used within the methodology stage of this research. This section will aim to correlate what is known within the previous literature reviews and ultimately conclude all findings and grasp the current understanding of the future office design for end users, well-being and integration with virtual reality and 3D scanning tools.

Virtual reality within architecture has developed significantly over the past decade. With early researchers critiquing the use of virtual reality technologies within architecture, believing the tools were limited to capabilities such as 'virtual walkthroughs' (Campbell & Wells, 1994). To contemporary literature, believing that VR tools hold extensive capabilities such as virtual reality aided design, construction, collaborative decision making and real time project communication (Fuchs et al., 2011; Milovanovic et al., 2017). This being said, there is still a lack of understanding within VR and the use it has on understanding psychological implications within architectural space; namely office design and the impact it has on the end-users. This lack of literature results in the potential to the further wide spread usage of VR and use it as an applied tool in order to understand emotional connections people have within the built environment - relating to the previous theme of directly connecting the well-being of office users to the architecture of the office. This literature theme thus explores the potential of a more physiological and creative usage of immersive virtual reality as a clear potential for connecting the IVR of users and their emotional response to these spaces can be seen.

Virtual Reality Environments

The realm of virtual reality consists of creating alternative environments which are able to be inhabited by users through the current technology of head mounted display sets or immersive rooms (Milovanovic et al., 2017). These alternative environments are named virtual environments or VEs and describes the interaction between participant and a three dimensional space with aided computer audio and digitally simulated visual components (Korićanin et al., 2014, p. 52). These experiences within VEs can then be categorized into a framework which assesses the total immersive qualities of the experience. This framework includes terminologies such as totally-immersive VE, semi-immersive VE, or non-immersive VE (Korićanin et al., 2014, p. 52).

Nanyang technological university professor Kwan Min Lee believes that the ability to connect a pre-experienced objects/space with those seen in virtual reality defines the authenticity of those virtual objects within VEs. Categorizing the experienced objects as either authentic objects, artificial objects or para-authentic objects (Lee, 2004).

4

5

6

These terms for objects are explained through the relation entities seen within virtual environments have with the real world environment. Authentic objects represent objects that are experienced within real life and are tangible in the real environment (See Fig 4).

Artificial objects represent entities within VEs that have no correlation with the real world and therefore lack any connection with authentic objects (See Fig 5).

Para-authentic objects represent entities that do have direct connections with authentic objects and have been digitally transposed into a virtual environment (See Fig 6.).

In saying this, Lee mentions it is important to understand that the prior cognitive relation an individual has with an object determines the measure of authenticity an entity has within the virtual environment. Therefore resulting in the validity of objects being completely subjective to the experiencer (Lee, 2004, p. 34). An extension of this statement would be if a participant within a virtual environment was to view the Statue of Liberty without any prior knowledge of its existence it would then be categorized for that individual as an artificial object but to a viewer with prior knowledge of the object it would constitute as a para-authentic object.

Through Lee's 2004 explanation of virtual objects and scale of immersion explained by Korićanin's 2014 paper, we can understand that in order to have a fully immersive experience within virtual reality one must feel no presence of the outside world but rather be isolated within the virtual space viewing virtual objects either of para-authentic or artificial nature. The key factor to this experience being presence.

Virtual Objects
Figures 4,5, 6

Presence

As previously mentioned, presence is at the core of all virtually experienced environments and directly relates to its counterpart of immersion (Korićanin et al., 2014; Lee, 2004). Immersive qualities of virtual space can be defined by ability of the technology used to simulate isolation within VEs (Slater & Wilbur, 1997) a view that is supported by Korićanin and others (Korićanin et al., 2014; Mestre et al., 2011; Morie, 2008). While this view of immersion is highly attributed to the technological input another view from researchers suggest similar thoughts to that of Lee, believing immersion draws upon subjective belief and rather psychologically attributed (Witmer & Singer, 1998). This being said, the term presence has been largely agreed upon as a universally described psychological state. A Psychological phenomenon of transportation, from 'real location' to VE (Lee, 2004; Weech et al., 2019) or simply quoted "being there" a quote from Reeves explanation on viewer presence when watching television (Reeves, 1991). Lee separates the concept of presence into smaller components believing there are multiple states to presence as a whole; telepresence, virtual presence and mediated presence (Lee, 2004, p. 28). Telepresence was coined in 1980, describing the possibility that workers could be transported to remote work space through teleportation systems (Minsky, 1980) this has relations to previously mentioned telework and the idea of paid work being able to be conducted at remote locations and even the freedom to work from home (Nilles, 1988). Virtual presence refers to the ability to feel physically immersed due to the aid of virtual reality technologies and was coined by Sheridan in 1992 (Sheridan, 1992). Mediated presence is a term used in order to reduce the scope of the general term 'presence' as presence itself does not refer to technological aid and is rather a "natural perception of an environment" (Lee, 2004, p. 29). Mediated presence is then the concept of "being there" with the assumption that there is aid of mediated virtual technology, similar to that of virtual presence but encompasses all technologies including immersive rooms. In saying this it is important to note the usage of the word presence within this literature review will refer to Lee's 2004 definition referencing mediated and virtual presence.

Presence redefined

In Lee's 2004 systematic literature review he redefines presence as "a psychological state in which the virtuality of experience is unnoticed" (Lee, 2004, p. 32). This is useful as previous definitions such as that of Steuer - "the extent to which one feels present in the mediated environment, rather than in the immediate physical environment" (Steuer, 1992, p. 75) – uses language that suggest presence is that of a prescriptive perception and that it can viewed as undesirable. Whereas in fact, presence is more likely desirable than not and acts as a daily psychological phenomenon that allows for human perception to be directly influenced by human sensation (Barkow, 1995; Lee, 2004; Tooby et al., 2006). By using the term "unnoticed" Lee aims to rid of any normative implications (Lee, 2004, p. 33). This then allows for presence to be seen as a phenomenon of both the virtual and real world and by analysis alongside the previously mentioned classification of presence it is possible to identify the elements in which separate real world or natural experiences from virtual or mediated experiences.

Virtual Experience vs Real Experience

It is important to note that "real experience" has been an issue of philosophical debate. The philosophical scope exceeds the scope of this literature review and therefore "real" is used in the term of existing objects or existing experiences that are present within our physical world, whilst virtual experiences refer to those existing in mediated experiences such as VEs. Human experience can be present in both the virtual realm and the real world and can be defined through two depictions; the type of entities experienced and how these entities are experienced. Firstly, the experienced entities are that of the previously mentioned terms such as authentic objects, para-authentic objects and artificial objects. When encountering these object the way in which they are cognitively encountered can be defined as sensory or non-sensory (Lee, 2004, p. 37).

Sensory experiences are defined as experiences in which real life objects are encountered and the sensory effect this has on us as humans i.e. the touch of an object, the smell of an object, the taste of an object. Compared to that of non-sensory experiences which refer to the non-sensory experience found when encountering virtual objects either that of para-authentic or artificial nature. Although it can be argued that VR indeed does appeal to the sense of sight and hearing, it is categorized by Lee as an experience extending to non-sensory as artificial or para-authentic objects may not draw from prior cognitive sensorial experience felt in the physical world and therefore cannot be considered entirely 'sensed' through human means (Lee, 2004). This can be supported by an American philosopher, William James, who likened non-sensory experiences to vague experiences which cover not only the human consciousness but the periphery of sense itself (R. B. Evans, 1990).

Based on these two ideas of experience Lee later redefines presence again and states it is in fact "a psychological state in which virtual (para-authentic or artificial) objects are experienced as actual objects in either sensory or non-sensory ways" (Lee, 2004, p. 37). Another key literature is that of Lombard and Ditton who categorized experience similar to that of Lee and present variables in which define the functions of technological systems and the human experience of the environments created (Lombard & Ditton, 1997). This relates similar to that of non-sensory and sensory experiences creating a coherent understanding of presence and mediated presence which is of interest in this research. Lombard and Ditton then further suggest that photo realistic virtual environments allow for higher results in perceptual realism (Lombard & Ditton, 1997) this is in agreement with Lees two definitions of presence and results in the importance of the VEs created in this research to not be that of completely digitally rendered environments but hold para-authentic qualities allowing for participants within the VEs a previously experienced space and cognitive recognition but through a new medium.

3D Scanning

Through the literature sourced it can be seen that in order to successfully create a mediated presence the presented objects within VEs must hold similar qualities to that of authentic objects and not just digitally rendered artificial entities. To achieve this within this research, 3D scanning and the ability to integrate photogrammetry is of interest.

The implementation of 3D scanning allows for photogrammetry, a technique in which three-dimensional information is accurately and rapidly acquired through laser scanners (Haddad, 2011, p. 111). This 3D representation comes in the form of point clouds or a set of data points in space holding information authentic to that of the real life object. This is key in creating "vivid representation" a term used to determine "valid connection between virtual and actual objects" (Lee, 2004, p. 34) which has been shown as a key determinant of presence. The ability for 3D scanning technologies to represent authentic objects characteristics through a digital medium allows for great potential when having users experience the para-authentic version of it. By show casing this vivid representation within virtual reality technologies it is speculated that deeper emotional connections can be found within para-authentic representations of real space (Diemer et al., 2015; Naz et al., 2017). Research data has shown the hypothesis that emotional response is in fact possible through VR but literature is varied on results.

Scan the QR Code below to view the 3D scanning process:

Emotion within Virtual Reality

With the widespread reach of virtual reality technologies, mainstream psychological research has begun to search the possibilities eliciting emotional response through simulated VEs. It is believed that environments such as VR allow for unprecedented opportunities and potential when examining the psychological responses of users whilst exploring human behavior (Diemer et al., 2015).

Emotional response within VR can be attributed to two previously mentioned categories, the presence a user feels within the VE and the immersive quality of the VE (Diemer et al., 2015). Presence and the ability it has to render emotional response within virtual reality is a topic of debate. Researchers have stated that in order to achieve true emotional response within VEs presence is the core mediator that will allow for this (Parsons & Rizzo, 2008; Price et al., 2011).

Although research has stated this, literature challenging this statement is scarce and therefore it cannot be concluded as fact but rather a potential to further clarify the relationship presence within virtual reality has with emotional response.

Immersion on the other hand has more literature covering the ability to extract emotions. This being said, once again this relationship is of debate with some researchers claiming the level of immersion is of great importance (Botella et al., 1999; Visch et al., 2010) whilst other research suggests this is not the case (Ling et al., 2012). Stated in Diemer et al., (2015) systematic literature review, it is therefore theorized that the nature of the study being conducted will result in different emotional responses regardless of the level of immersion (Diemer et al., 2015). With previous research acknowledged, it is therefore seen as possible for virtual reality to result in emotional response of the user. Therefore there is potential within this field of research as the emotional aspects that effects the well-being of office workers may be able to be drawn out from users through the combination of ‘vivid representation’ from para-authentic objects and the ability to enhance both the presence and immersion within the VE.

Optimal Office Plan

2.5

Introduction

Through the establishment of the contemporary office being that of an evolution of the Hive and that the end users of today are exponentially growing more mobile, it draws the question of what spaces and spatial formation give the contemporary office the optimal layout encouraging innovation, creativity and productivity.

It is clear that there is no one spatial layout that can be considered the 'perfect office plan' but through relevant literature covering the development of contemporary offices it is understandable which aspects and general configurations heighten the end users experience of work, place and overall well-being.

The shift away from open plan

Through the growth of agile workspaces and increased telework, the need for fixed desk space has slowly become more redundant. According to Robbie Robertson an expert spatial designer, the shift from department based work to team based work has for many industries created a need for office space to be just as flexible as the team constructs of the organizations (Skillicorn, n.d.). This statement is concurred through Deloitte organizations recent white paper encouraging the shift of workplace to take a stance that balances the end users of the offices with the workers, work and work place (Redwood et al., 2016). The importance of technology is also stated as it allows for greater opportunities, location flexibility and continuous professional learning, all aspects that 44% of millennial's believe encourage well-being and create a positive office environment (Redwood et al., 2016, p. 7).

Although the idea of fix desk space is thought to be reducing, this creates the dilemma of the previously identified 'hot desking' the evolutionary form of the open plan as the shift from open plan to hot desking although can be considered agile working stations still causes issues that decrease employee satisfaction. In a study conducted in over 300 offices in the United States, it was shown that open plan layouts and hot desk layouts created working environments with increased noise levels, visual distractions and privacy issues (Kim & de Dear, 2013) all issues that previously covered literature show decrease in the well-being of the office workers (Davis, 1984; Nemecek & Grandjean, 1973; Stokols, 1976; Sundstrom & Sundstrom, 1986). This issue with having entirely non-personal working desks also creates a lack of personalization of space, a factor that was shown to be a key benefiting component of worker well-being (G. W. Evans & Johnson, 2000).

Optimization of creativity, productivity and innovation

Future office environments abilities to foster creativity is considered to be an important aspect of the future work place. This is seen as creativity is listed as one of the most desirable employee attributes of 2020 onwards in recent world economic forum 2016 report (WEF, 2016). Creativity is then directly correlated to innovation and ideally productivity within organizational work forces, this leads to key factors that have been shown to improve the originality and inspiration of new ideas. Supporting the previous literature theme of well-being, curved architecture and ceiling heights also contribute to not only the well-being of workers but the increase in creativity. Research has shown that the curvature of objects activates the regions within the brain that contribute to the increase in emotional reward and creativity, whilst angular sharp edged shapes can be related to fear (Vartanian et al., 2013). Alongside the supporting literature previously covered the optimal office space can be seen as an amalgamation of multiple key components, categorized by author and innovation leader Nick Skillicorn in 2019, as zones (refer to Fig 6.1).

Office Environments	Purpose	Spatial Configuration	Noise Levels	Colors	Space
Focus Zone	Highest productivity for staffs individual work	- Partition walls - Lower Ceiling heights - Visual Privacy shields	Low	Red Bright	Constrained Private
Collaborative Zone	Rapid exchange of ideas between staff, discussions and team environment	- Large Display Screens - Group Table - White Boards - Flexible space with ability to divide areas	High	Green Blue Bright	Open Flexible
Lab Zone	Test new products ideas and innovations	- Specialized equipment - Space for "mock ups"	Medium	Red White Bright	Heavily full of equipment
Mind-Opening Zone	Allow for staff to have restful unfocused times of relaxation	- Non stimulating - Greenery - High Ceiling	Medium / Low	Green Dim Light	Open
Communal Zone	Informal interactions	- Kitchen areas - Encourage social interaction	High	Bright	Open
Client/ Feedback Zone	External people for invitation or feedback	- Seating areas - Table/ Screen	Medium	Red	Open
Virtual/ Remote Zone	Ability to work remotely	- Technology based - Seating area - Partitions	Low	Any	Flexible
Function Zone	Set up for business events	- Partition walls - Lower Ceiling heights - Visual Privacy shields	Low	Red Dim	Constrained Private

Zones for the Office

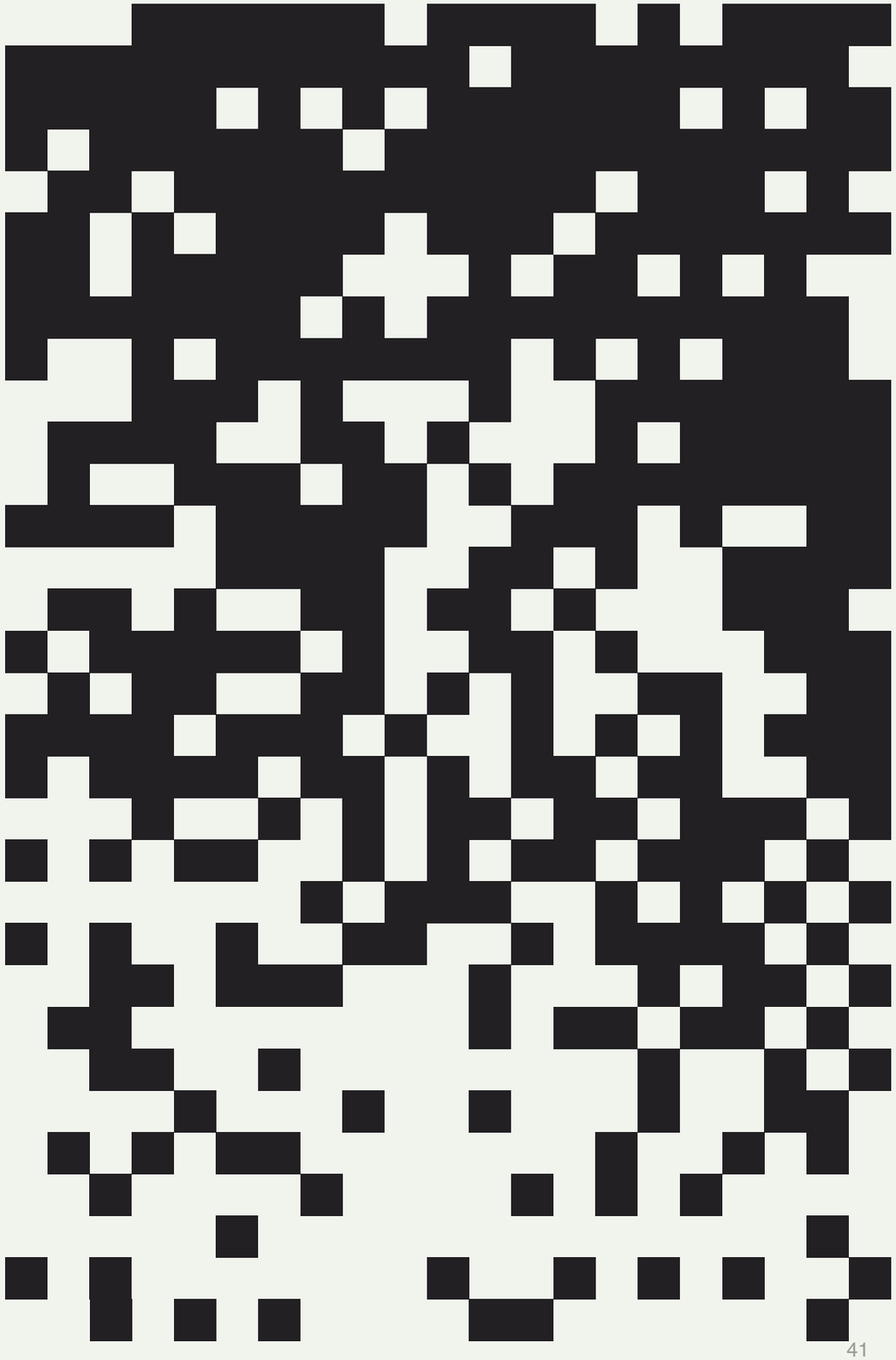
Figure 6.1

These zones can then be configured in two main spatial layouts that promote either "central" or "dispersed" layouts; central being that of programmatic functions within a spatial configuration closer to the centre whilst dispersed layouts spreading the programmatic functions towards the edge of the floor plate. There is scarce literature covering the two configurations and the benefits of each within an office context and therefore no stance can be taken on which configuration betters the well-being of the end users. This being said, the architectural elements covered within the literature themes can be applied to the two spatial configurations which can result in a new office typology that encompasses all promoted zones whilst enhancing creativity, innovation and productivity (refer to Fig 6.1).

2.6 Conclusion

Literature has shown that the most current office typology is that of a Hive evolution. This suggests that the open plan model and variations of this layout are believed to be the most dominant office model of today. This being said, the research has shown there is still debate on whether this model is the most adequate office environment for contemporary work with Covid-19 influencing the majority of the globe into forced telework; show casing the possibility for a higher demand of agile work spaces / flexible work spaces. Recent studies have also shown the shift away from open planned office environments and that newly introduced programs which integrate to the individual company working specifications are growing.

Well-being has also been shown to be highest in Cell office structures whilst other literature suggests both Cell and Hive (more closed versus more open plan) constitute equal results of happy workers. This show cases that the effect this architecture has on the end users of the office has been found to be subjective but ultimately is concluded that all spatial configurations influence the well-being of people in some form or the other. It can be understood that employee well-being ranges depending on one's personal connection with their office space and preference to that said environment. Although this may be the case, key objectives can still be realized when designing office spaces to facilitate well-being. These were found to be a balance of employee privacy, worker interaction, reduction of environmental stressors and awareness of employee personal control. In order to find the data needed to inform these design factors a possibility to integrate virtual reality technologies can be seen. The innate quality of virtual environments causing users to experience visual stimuli in non-sensory ways, creates the ability for the perspective of space, objects and architecture as a whole to be experienced differently. This results in the virtual environment experience to be unlike that of its real world counterpart. Through the use of 3D scanning technologies to inform vivid representations of space, a para-authentic environment can be created. The prior knowledge of the real world office allows for one's experience of the virtual version, which is essentially the same space, to be altered and viewed in alternative perspective. By ensuring that the presence and immersive qualities within the virtual space are present, deeper emotional responses are predicted to be extracted from users. This will therefore inform the previously found design framework for office well-being and ultimately allow for an informed design for the spatial configuration best suited for the end users of individual office spaces.



Office 3D Scan - Services

Office 3D Scan - Services

Point Cloud visualization

Point Cloud visualization

Office Work floor

Office Work floor

3.0
Establishing Methodology

3.1 Building a methodology

Introduction

By aiming to reach a deeper understanding of office workers and their relationship, needs and connections to their own office spaces, the use of virtual reality and 3D scanning are used during this research. Within this chapter the methodology in which these tools will be implemented during the design process is to be established. It is postulated through the collected literature that the current non-sensory world of virtual environments will allow for participants to experience different feelings, appeals, dislikes and personal connections with their office compared to our physical real world counterpart. The participant's (end users of the office space) reactions and responses during and after the virtual experience will be used as the primary data set which will determine a comprehensive understanding of how the spatial qualities and configurations within their office reflect on the well-being of the workers. Ultimately this prior information will lead to design and the improvement of the office.

Through the implementation of virtual reality technologies and 3D scanning, this research is well distinguished to previous research. Replacing the traditional methods of data collection such as surveys, drawings, interviews etc. the use of modern day technology allows for an unprecedented technique with great potential. This potential is that of 'deeper connections' and higher levels of understanding of how end users of an office inhabit and connect to their work place and discovering the answers to the speculated question of this Thesis.

Methodology structure

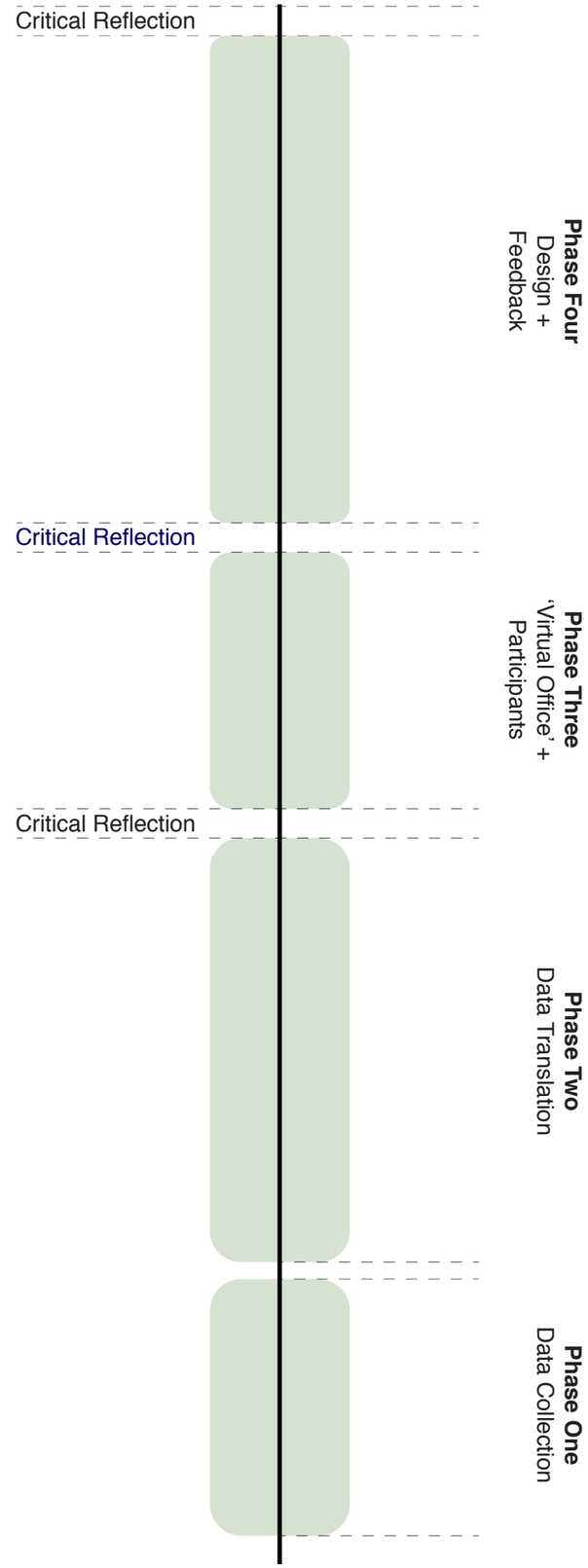
The methodology within this research consists of four separate phases. These phases consist heavily of digital data translation and primary data collection which then informs the design proposals.

Phase one consists of an initial client meeting which acts as an introduction between designer and office workers, this allows for a level of comfort and understanding between the participants and researcher.

Phase two begins with the data collection of the office space. As established in the literature review, the ability to produce para-authentic virtual reality elements through the use of 3D scanning creates a ‘vivid representation’ of the authentic space. By 3D scanning the office this will result in improving the immersion and presence within the VE and therefore it is speculated to extract unseen emotional connections the end users have with their office. After the scanning is completed the second half of phase two consists of translating the point cloud data into an inhabitable virtual reality environment; allowing participants to experience the ‘virtual office’ through a VR headset.

Phase three then consists of the participatory walk-through of the previously created VE. Within this phase the primary data will be collected by having participants experience the ‘virtual office’ through a VR headset and specific questions and tasks will be asked to each individual during the experience, aiming to collect information which will later be synthesized into design solutions.

Phase four, then categorizes the information collected from participants and decodes the data into information that can be used as the driver for design. The produced designs will then be presented to the end users of the office and a debriefing and feedback session with the client will stimulate the conclusions, limitations and potential future research of this methodology.



Methodology Diagram

Phase One

3.2

Introductions

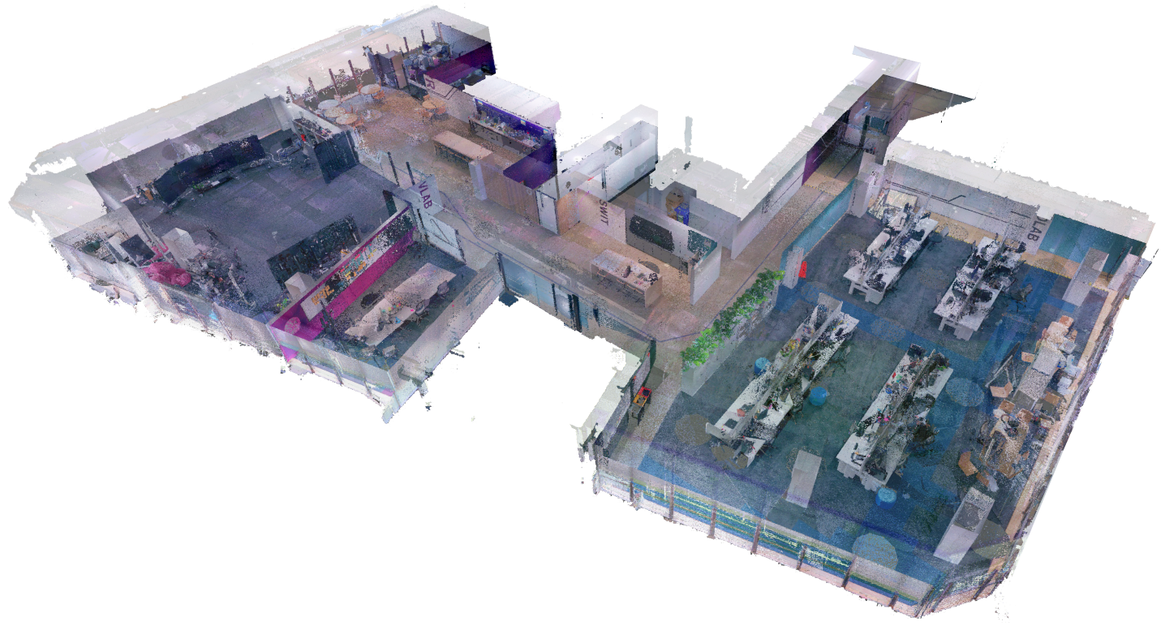
In order to create comfort between the researcher and participants an introductory meeting is needed. This meeting takes the form of an informal conversation with staff of the participatory office, explaining the research and establishing familiarity. This stage is important as without this, participants may feel reserved when answering the researcher's questions during the virtual reality experience. In order to produce the most concentrated primary data set this familiarization between client and designer is key.

Scanning the office

Within phase one the collection of spatial information is attained through the use of 3D scanning. This is using a mounted 360 camera that is placed at specific points across a grid layout mapped over the offices existing floor plan (Refer to Figures 9,10,11 and 12). The collection of this data is what generates the 'virtual office' which participants will inhabit via VR in phase three. The 360 camera used will be the Leica BLK360 imaging laser scanner, a tool provided by the researchers. The information collected from the BLK360 is then translated through "Leica Cyclone REGISTER 360" software and generates point cloud data exportable into the next stage.

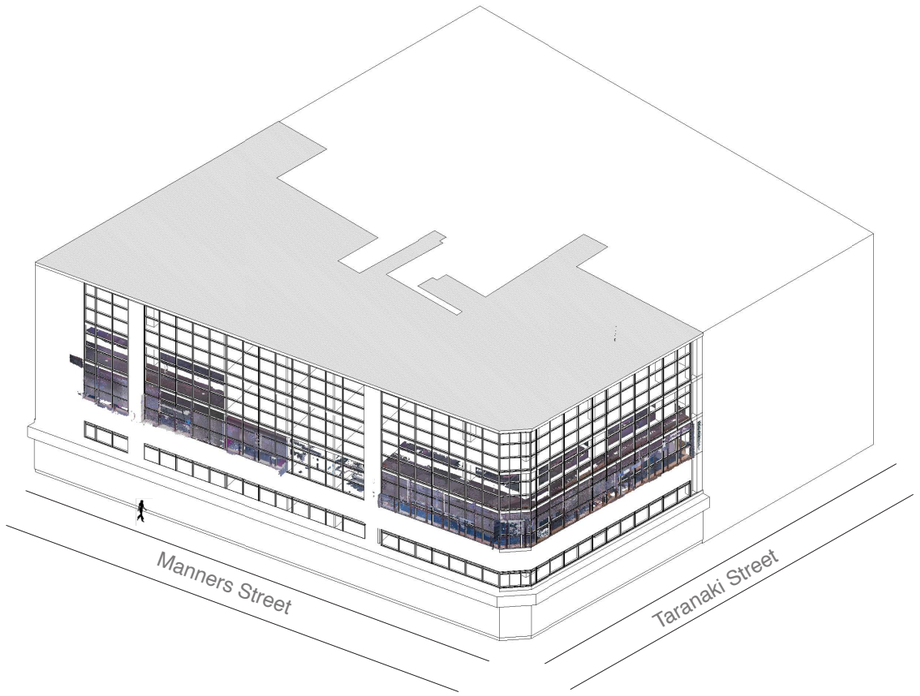
Within the following images the additive process of 3D scanning is shown. Each location on the mapped grid is attached to the previous location, eventually forming an entire model. The presented images of point cloud data were viewed using Autodesk RECAP and Leica Cyclone REGISTER 360 software.

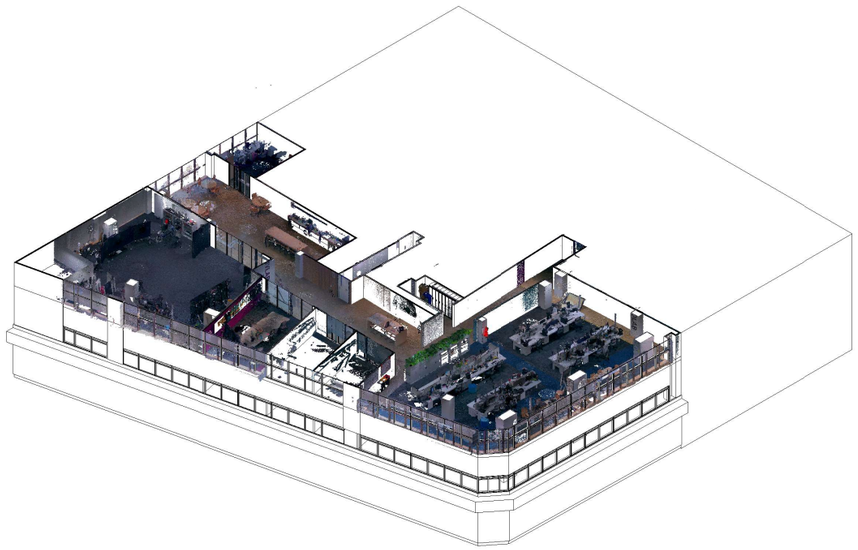
The following images are the 3D scan and diagrammatic floor plans indicating the process of the grid layout. The office presented is the workplace used for the case study within the following chapter – The Computational Media Innovation Centre or CMIC office – this office is located in Wellington on the corner of Manners and Taranaki Street. The grid used is a 4mx4m grid with the 360 camera placed on the nodes of the intersecting grid lines. Additional points were also added to scan areas that were not in the view range of the camera. These areas were off grid and were necessary in order to depict unclear spaces such as behind tables and columns.



CMIC Office 3D Scan	
Rendered Point Cloud Data	
Figure 7	N/A

Diagrammatic Site Representation



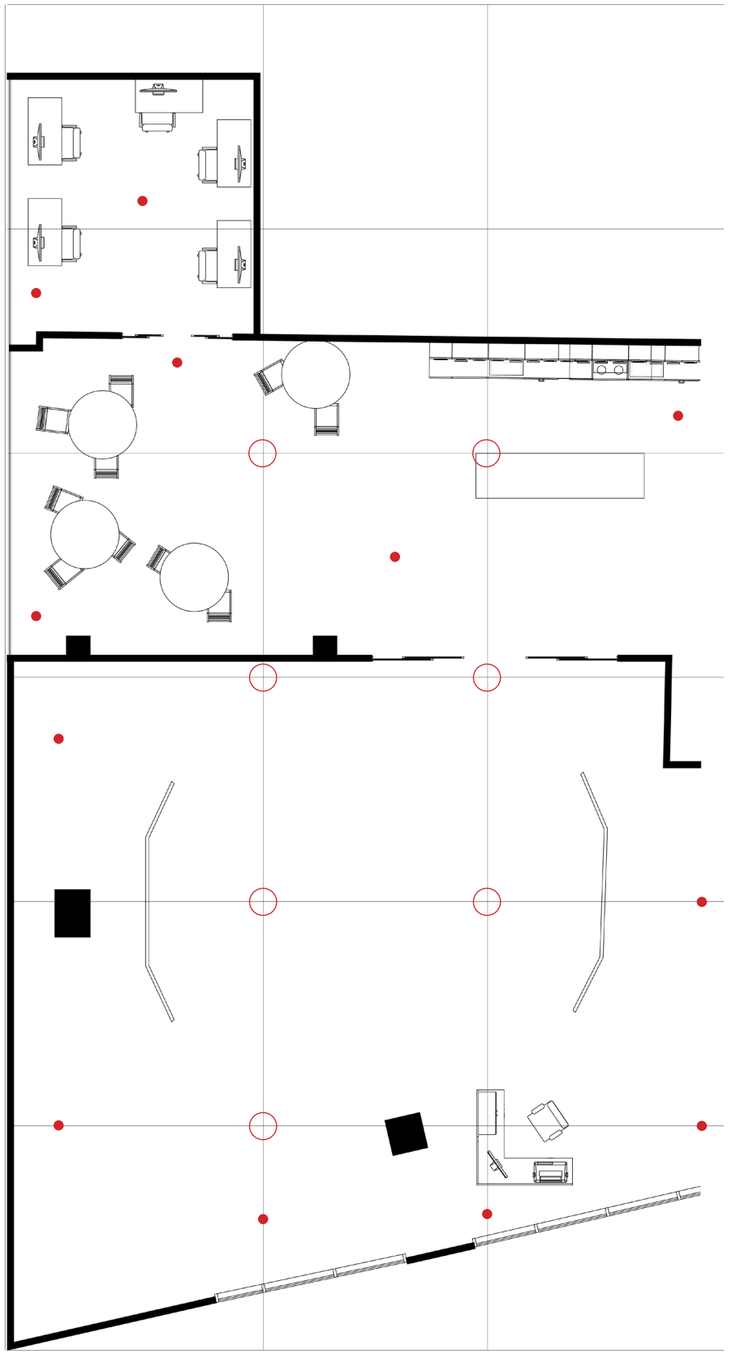


CMIC Office Diagram	
Isometric View / Sectional ISO	
Figure 8	N/A

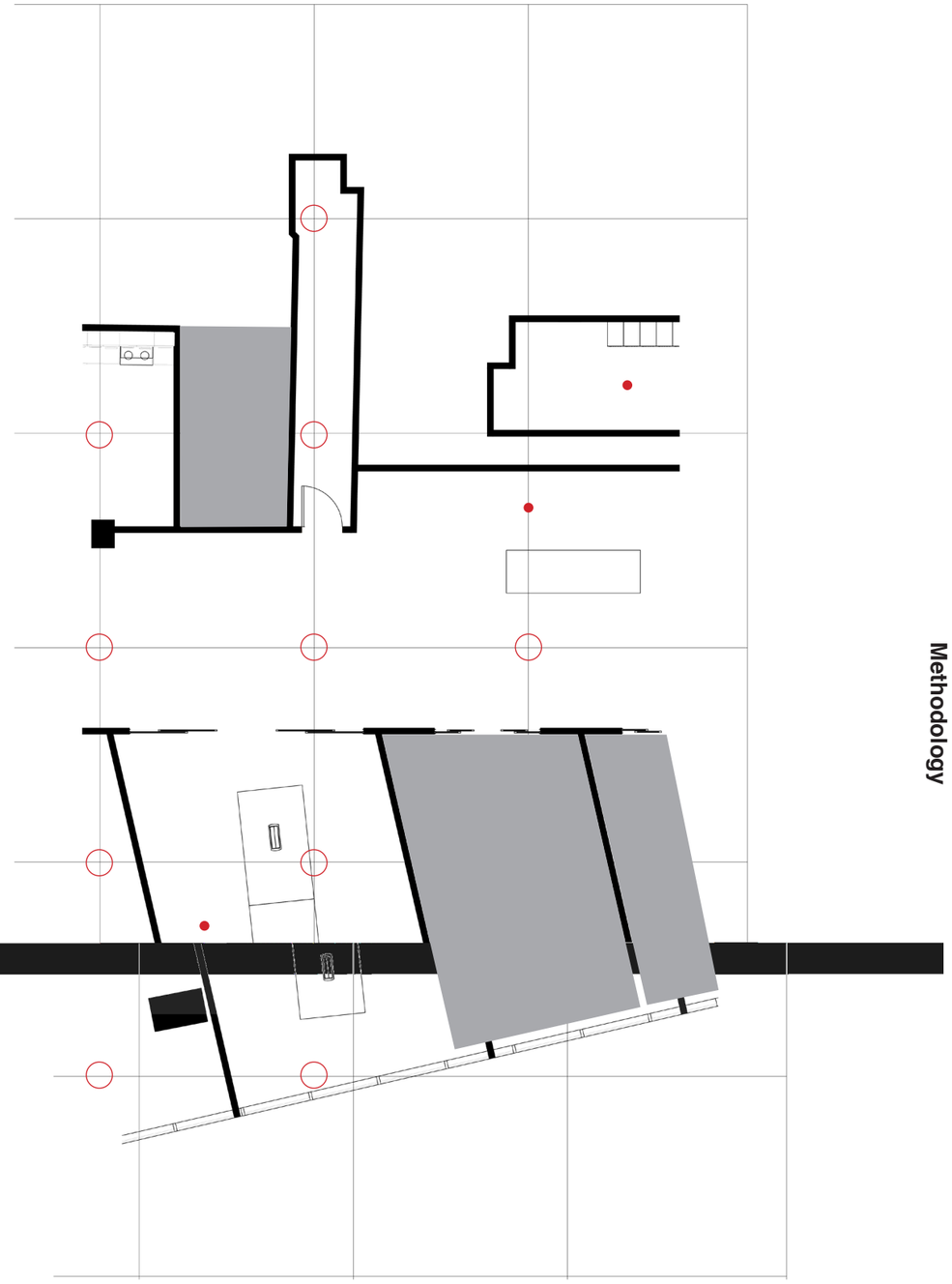
Diagrammatic CMIC Floor Plan

CMIC Office Floor plan	
Not Scanned Areas	
Figure 9	4000mm

Areas that were not scanned were due to organizational privacy. The private cell offices were not scanned as they were management areas with no granted access. The toilets were not scanned due to lighting issues as well as the “material exploration lab” located near the entrance of the office. The BLK360 camera does not register darker areas and therefore the information produced within these spaces are unusable.

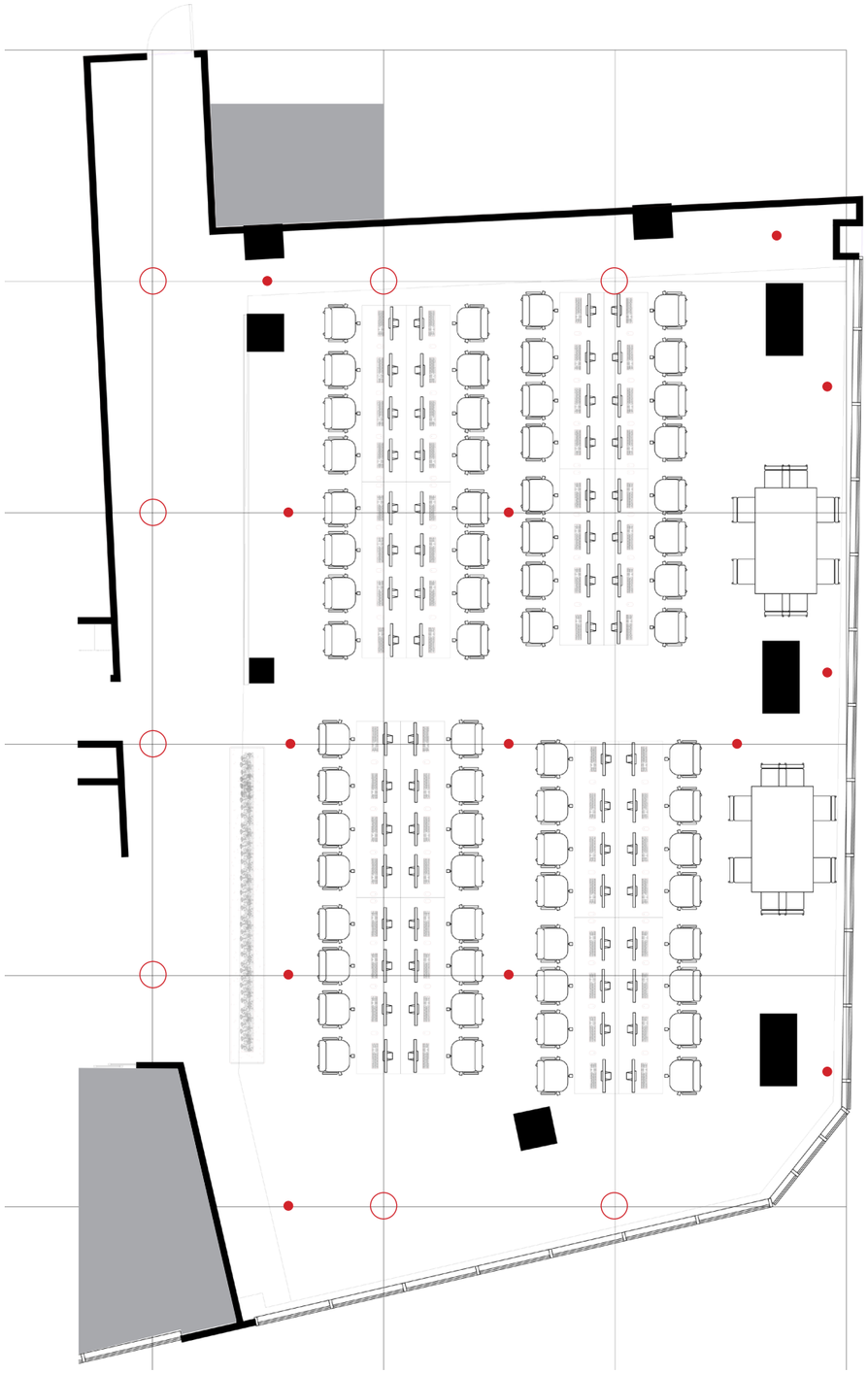


Left Wing Floor Plan	
◯ Scanned Areas • Extra Scans	
Figure 10	4000mm



Middle Section Floor Plan	
◯ Scanned Areas • Extra Scans	
Figure 11	4000mm

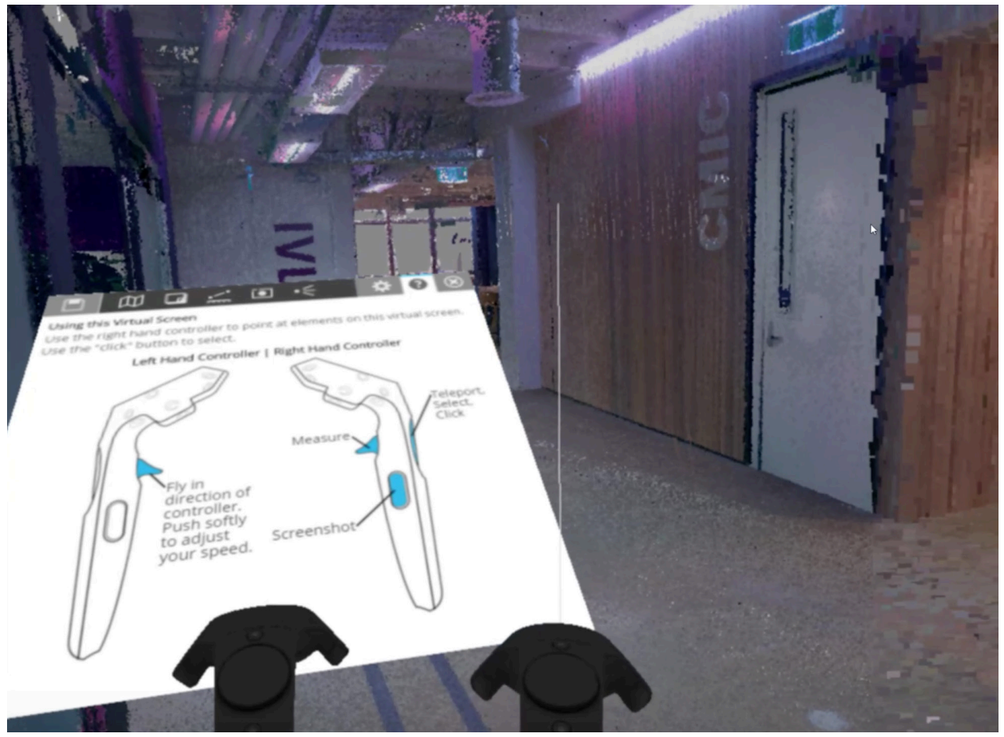
Scanned spatial grid



Right Wing Floor Plan	
◯ Scanned Areas • Extra Scans	
Figure 12	4000mm

Phase I

Phase Two



Within phase two the point cloud data previously shown is to be transformed into a viewable virtual environment compatible with VR headsets such as the “Oculus Quest”. With the capability for software to show case point cloud information within VR, the previously scanned data will be exported as a ‘.PTS’ file which will allow for integration with virtual reality supported programs such as “Unreal Engine”, “Unity” and “Faro LT Scene”. The importance of the point cloud visualization is to ensure that the representation of the office space enhances a sense of realism to the digital model and as stated in the literature review, allows for a higher cognitive recollection of the office compared to a completely digitally rendered environment.

Scan the QR code below with a smartphone to view the ‘digital office’ represented through point cloud visualization and virtual reality.

Phase II

Phase Three

3.4

Within the previous phase the VE was created and able to be inhabited by participants. Phase three, then consists of having the end users of the office space experience the ‘virtual office’ at the location of the physical office setting. All willing office workers are welcome to participate.

In order for the success of this research it is important that the location the participants experience the ‘virtual office’ is that of the real office. As realized within the literature, this methodology relates to the non-sensory experience of virtual reality, as by having the end users of the office experience the VE within the real office, the immersion and presence of the virtual space being experienced is heightened through the place of experience. An example of this would be the ambient noise of the daily office not being able to be replicated in the ‘virtual office’ model and thus by the place of experience being at the office itself, these sensory elements will be in action, creating a more fulfilled immersive experience.

The importance of location also allows for direct comparison of the two environments; virtual and real. This allows for any direct differences between the two environments to be easily recognized by the participants and for the identification of the experienced changes to be noted in real time, as it is theorized that users will take more notice of subtle changes and differences within the VE by being in the existing physical setting.

The virtual office experience

Before participants are to experience the virtual version of their office space a pre-experiential discussion will take place. This acts as the first opportunity for participants to learn how the VR system chosen works; how one navigates through virtual spaces and what controls activate movement etc.

Willing participants then enter the ‘virtual office’. Whilst immersed, participants are asked to describe their experience as the researcher asks open ended questions such as “what do you find different about the space?” and “within the virtual office, what elements feel most distinct?”. Along with questions aimed to get participants to complete tasks, the responses of the office workers will act as the primary data set that will guide design.

Whilst participants experience the VE, it is possible for others to view the immersed users experience through a separate monitor. This monitor will display what is being looked at and what space is being inhabited, also serving as information that contributes to the primary data set collected.

The time limit of the experience is set with a maximum virtual engagement of 45 minutes. This is to ensure sickness in the form of nausea is avoided, as from previous VR experiences, it is apparent that these results may occur. After the user has completed the experience another discussion occurs, this time the goal is to decipher the participants overall experience and build an understanding towards the commentary made whilst in the virtual office. Once again this information is added to the primary data set.

Phase Four

3.5

Phase four acts as the final phase of the methodology and encompasses design led research where influenced design options are explored to better the spatial configurations and well-being of the end users of the office.

Phase four begins with design and the exploration of architecture influenced by the results found in the VR user study. This data is then synthesized and drives the design iterations that follow.

To conclude phase four a brief meeting is conducted with the participants of the office and the design solutions produced are presented in an informal focus group setting. The end users of the office are then asked to provide feedback by filling out a single A4 sheet provided by the researcher.

Pilot Test

3.6

Introduction

As mentioned in the previous chapter during the early stages of methodology establishment, participant sourcing had been completed and the chosen office for this researches case study was a local Wellington office which acts as an independent branch from the Victoria University of Wellington.

The Computational Media Innovation Centre or CMIC was selected as their awareness of technology and availability for the research was key. All members of staff are technologically literate and the objectives of the company explore similar features to that of this research.

Participant Criteria

The participatory criteria when selecting users for both the pilot study and case study was straight forward. The users eligible to fit this research must be end users of the researched office space. All races, religions and genders are eligible for this participatory research, in saying this it is key that the participant is able to communicate at a high level of English. This is to ensure that their experience can be described to the researcher in the clearest way possible and to allow for an in-depth conversation about the experience.

Participants

In order to test the methodology established two participants from the CMIC office were chosen to undertake the pilot. The two participants are end users of the office space and were my main points of contact when collaborating with CMIC. Due to the two having prior knowledge about the methodology the two participants for the pilot test were not eligible to undertake the case study. Although they have had a small amount of prior knowledge of the research and previous experience within the virtual reality environment, by having these workers undertake the pilot study improvements could be made and faults within the methodology could be clearly identified.

The pilot test took place on a Wednesday afternoon and was completed within 40 minutes. Both participants work closely together within the open plan office area of CMIC. When undergoing the test VE the initial comments of the users were positive. With Participant 1 and Participant 2 claiming that the movement and ability to explore the space freely was successful. Both were surprised with the detail and capture of the point cloud data but there were still buffering issues when moving too fast through the space. Both participants responded well to the provided questions asked and believed that the methodology was ready for the participatory case study.

May Review

Supervisor
Regan Potangaroa

Guest Reviewers
Hans-**C**hristian **W**ilhelm – Victoria University of Wellington (Internal)
Wallace **E**negbuma– Victoria University of Wellington (Internal)

The May review acted as a formal discussion over an online video call, where internal reviewers from VUW critiqued and analyzed the established methodology and literature review.

The abstract methodology was received in a positive manner. Reviewers felt as if it was important to have a more in depth literature stance and reasoning as to why VR and 3D scanning was more beneficial compared to a traditional analogue method.

HCW – Next time include more literature as a backing to enhance why this methodology has potential over a traditional method.

WE – It may be useful to edit the point cloud data and then have users experience the edited version to grasp any differences found.

HCW – It may be useful to do a deeper analysis of how light, acoustics and sound affect the well-being of office workers.

Overall the methodology was received well with some confusion as I did not showcase all the literature backing the reasons for this methodology and its potential.

After explanation, reviewers seemed to grasp the idea and were interested to see how this would lead to design.

4.0
Case Study

Case Study

4.1

Introduction

The methodology developed in the previous chapter will be used and tested through a case study, incorporating a local Wellington based office and its end users acting as the participants. Through this case study the research aims to grasp at a deeper connection between the office workers and their work space, generating and exploring personal connections to the space which are surfaced through virtual reality. The findings are then reflected upon and categorized into useable information influencing the design that follows.

Although the pilot test was brief, it is evident that the methodology developed is an iteration of previous research explored at the Victoria University of Wellington. Prior to this research on office space, students have conducted research discovering the potential VR and 3D scanning have on the concept of home and retail space. By using these studies as precedents, it is believed that this methodology has been tested and developed enough to initiate with a case study.

It is important to note that although previous research has been conducted using similar approaches, the new availability of point cloud visualization has allowed for this methodology to approach virtual reality research from a different angle. Instead of converting point cloud information into meshes - which was the workflow for previous theses – technological updates have allowed for the large files produced by point cloud data to be directly viewed through virtual reality, further enhancing the representation of the space and keeping the authentic nature of the real life environment within the para-authentic virtual environment.

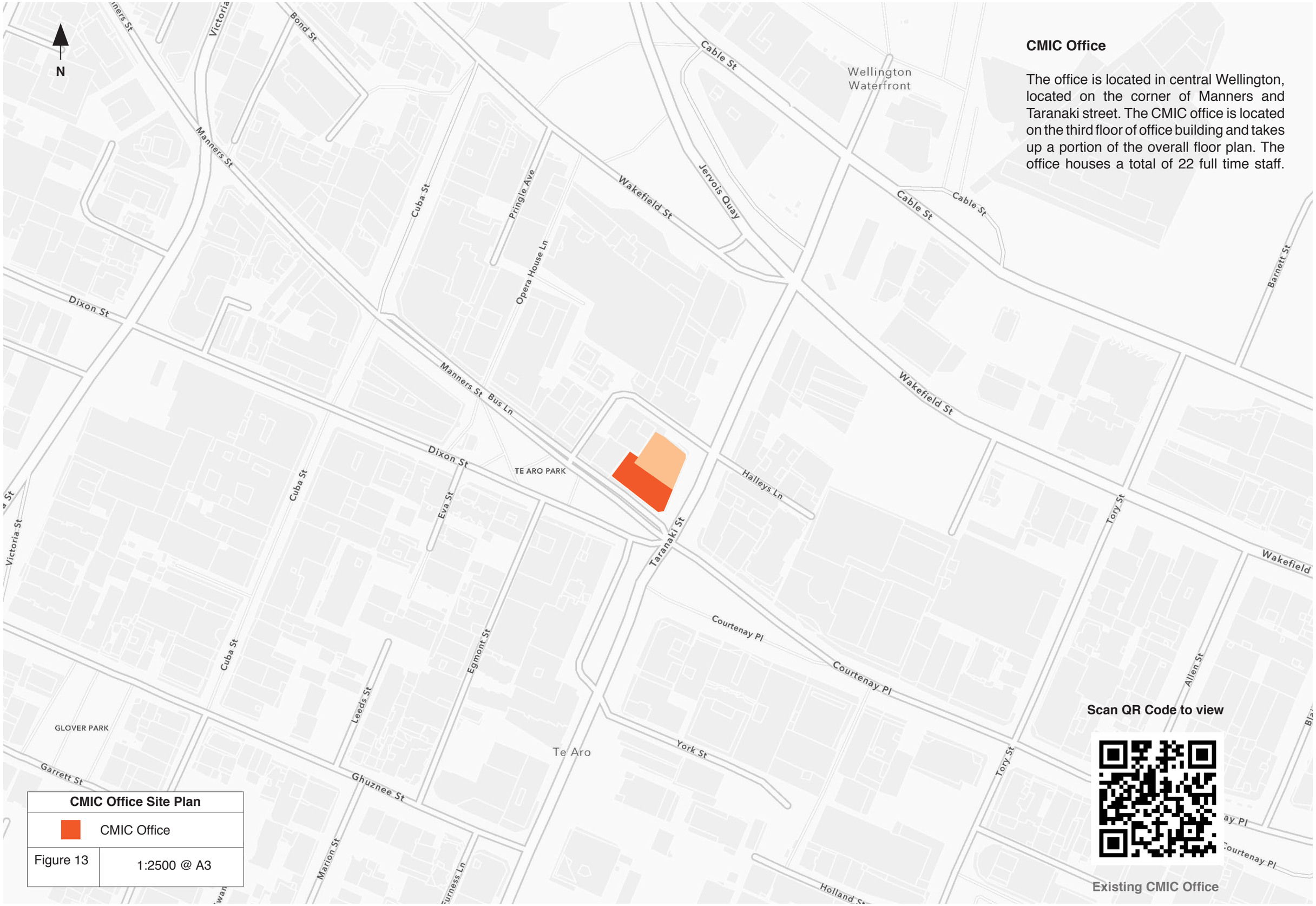
CMIC Participants

The office chosen for the case study is the Computational Media Innovation Centre (CMIC), a user orientated research and development facility that works as an off branch of the Victoria University of Wellington.

The CMIC office collaborates with industry experts and international institutions that specializes in virtual reality, augmented reality, film/animation and gaming technologies.

Ethics approval for the case study was granted on the 22nd of July and participant sourcing occurred the next day. An email was sent out to all staff of the office calling for participants in a user case study, this resulted in 8 participants out of 22 willing to participate in the case study. All staff met the criteria of having a high level of English as well as being constant users of the space. Due to the schedules of the staff the participatory study commenced over several days with staff booking time slots of up to 45 minutes to participate in the research.

Following are office diagrams of the CMIC space, covered in more detail compared to the previously shown images.



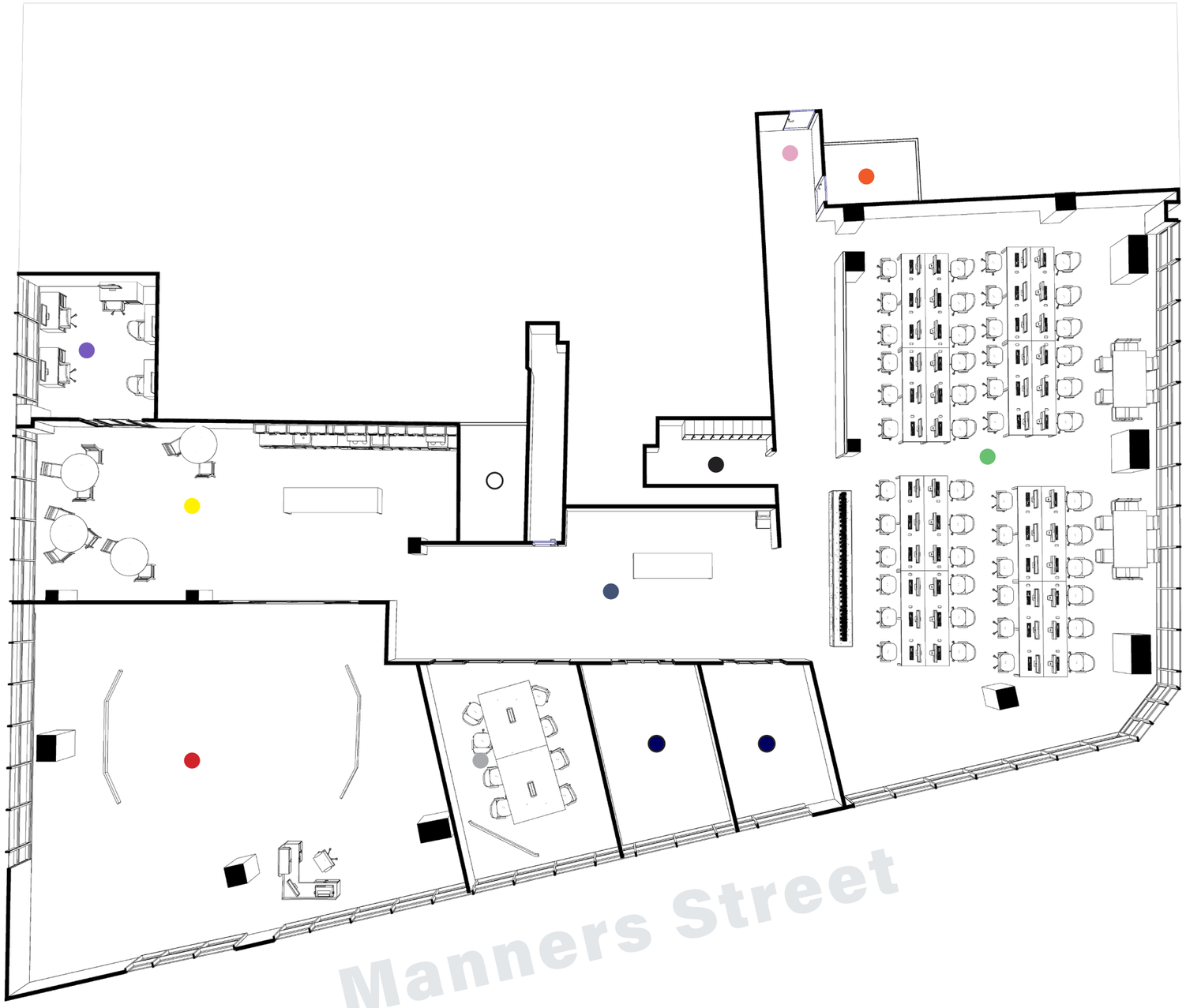
CMIC Office

The office is located in central Wellington, located on the corner of Manners and Taranaki street. The CMIC office is located on the third floor of office building and takes up a portion of the overall floor plan. The office houses a total of 22 full time staff.

CMIC Office Site Plan	
CMIC Office	
Figure 13	1:2500 @ A3

Scan QR Code to view

Existing CMIC Office



- Entrance
- Office Area
- Informal Meeting Space
- Conference Room
- Virtual Reality Room (IVLAB)
- Kitchen Area
- Private working Area
- Lockers
- Material capture lab
- WC
- Management Offices

CMIC Office Floor plan	
Office area programs	
Figure 14	4000mm

Scanned Areas

Following the scanned areas mentioned in Chapter 3, the areas in which were not scanned are noted in Figures 9, 10 and 11.

Physical Office

4.1

Case Study

Existing Office Photographed

❶

❷

❸

❹

❺

❻

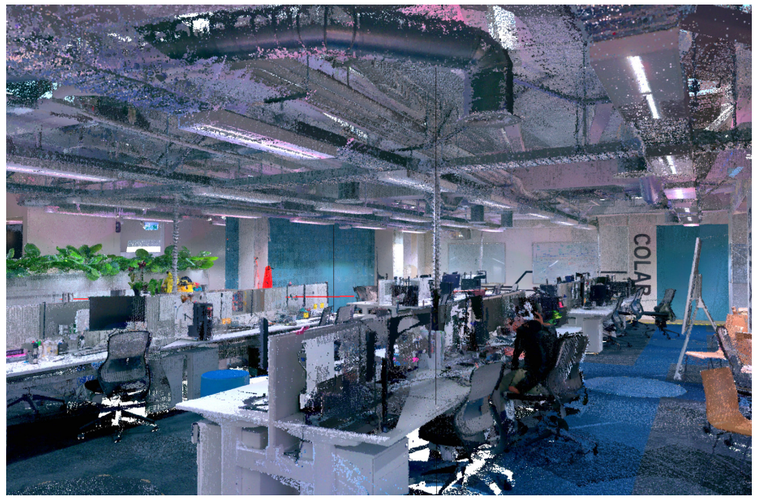
❶ Entrance
❷ Office Area
❸ Informal Meeting Space
❹ Private Working Area
❺ IVLAB
❻ IVLAB

Virtual Office

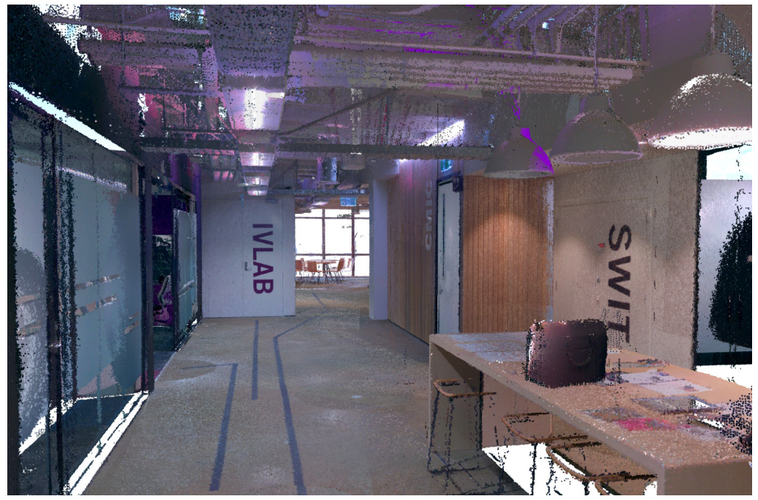
4.1

Case Study

❶



❷



❸

❹

❺

❻

❶ Entrance
❷ Office Area
❸ Informal Meeting Space
❹ Private Working Area
❺ IVLAB
❻ IVLAB

Existing Office capture through point cloud

The Virtual Office – Phase Three

Phase three of the methodology took place over the course of two weeks, as previously mentioned each staff member booked allocated times that suited them. All participants were eager to view the virtual environment with some being familiar to point cloud visualization and others not. All participants were familiar with the controls within the virtual reality and were noted to be extremely fluent with their movements through the virtual space. All 8 participants were audio recorded during the virtual experience and had an average time within the space of 18 minutes and 45 seconds, with participant 5 and 8 having the longest times within the VE at 29 minutes and 2 seconds and 37 minutes and 32 seconds.

All participants gave very insightful answers that seemed to be triggered from the responses within the virtual office space. This being said there are still results from the data gathered that could be defined as information attainable through traditional research methods. Due to this it is important to categorize the raw data into two sets. Set B representing data that could be attained through traditional methods and Set A which is data that can be seen as only obtainable through the use of VR and the 3D scanned representation of the physical office. Although it can be argued that all data was influenced through the use of the virtual reality the ability to categorize the information allows for any contingencies within the methodology to be accounted for.

Within Set B questions about the recent Covid-19 lock-down were asked in order to grasp an idea of each participants preferential working styles and if the working environment / work flow of the organization could be altered due to the pandemic. This data can be seen as supporting information to that of set A and was necessary to obtain in a traditional manner as design interventions promoting remote working were not in place.

It is important to note that the categorization of these data sets are subjective to the researcher and therefore the true depth of the results shown through this methodology is hard to confirm. In saying this, through the analysis of the data collected it is clear to see a distinct difference between both sets of results with the exception of a few which were categorized as A/B. This allows for a clear potential when using virtual reality technologies such as VR and 3D scanning to evoke new information from clients and draw out deeper connections the end users of a space have with their own working environment.

Synthesized Data

Within the following charts, Chart 1 represents the participant's initial comments on the virtual environments and the behavioral observations made by the researcher. This is then followed by Chart 2 which represents the participant's comments in response to the questions asked in conversation / interview that took place whilst users were immersed in the virtual reality as well as their comments on the recent shift in work style due to Covid-19. Following these two charts, the mapping of participants morning routines before commencing work and the areas that participants found comfortable, stimulating, uncomfortable and non-stimulating were diagrammed.

Chart 1

4.1

Questions Asked / Participants / Researchers Notes	Participants Initial Comments	Observations	Data Set
Participant 1 Began VR within the office area	**1.** Initially began giggling **2.** Noticed the rendering quality and the buffering of the visualization and asked “so what’s this?”	**1.** Begins to move around immediately **2.** Participant seemed disappointed with the quality of the rendering and the speed of the buffering within VR	**A**
Participant 2 Began VR within the office area	**1.** “My desk is a mess” **2.** “Surprising Quality” **3.** “Control Method is much more intuitive than I anticipated it to be”	**1.** Participant was very calm and seemed used to the control of movement within VR **2**. Participant immediately went to their own desk and was interested in the items on their desk	**A**
Participant 3 Began VR within the office area	**1.** “Once im close to objects I can see individual points” **2.** “I think the detail is general good” **3.C**olors seem a bit strange...Very purple”	**1.** Participant was very observant of the point cloud information and was critical of the visual representation **2.** Was observant of the walls and writings captured on the white boards	**A**
Participant 4 Began VR within the office area	**1.** “Much better than what we would normally have in the main campus” **2.** “Detail is generally good” **3.** Noticed the hue of the colors were more saturated	**1.** Participant seemed confused and began talking about the previous office design that they had worked in **2.** Participant spent a lot of time within the office floor area and not much time exploring the other areas	**A**
Participant 5 Began VR outside of the model	**1.W**hoa... It’s moving very fast” **2.** “Its pretty cool, you recognize the space” **3.** Noticed that the scale felt a bit strange	**1.** Immediately went to their desk and spent a significant amount of time looking at the desk and surrounding desks **2.** Was slightly thrown off from the controls and moving within VR fast **3**. Noticed trivial items such as a “party hat” left on the desk within the meeting room	**A**

Chart 1

Questions Asked / Participants / Researchers Notes	Participants Initial Comments	Observations	Data Set
Participant 6 Began VR within the office area	**1.** “Its really nice”	**1.** Was very interested in the point cloud data was looking around the space a lot **2.** Was drawn to the surfaces of objects and the floor	**A**
Participant 7 Began VR within the office area	**1.** “Very interesting” **2.** “Pretty realistic” **3.** “Scan is very nice, dense I can see a lot of detail”	**1.** Was drawn to pathways that they would not normally take when walking through the office and moved through different areas suggesting “I’ll take this way because i can” **2.** Spent a lot of time observing the floor	**A**
Participant 8 Began VR within the office area	**1.** “Taken during covid times, so very interesting” - In terms of the scan **2.** Artifacts really stood out “the small subtle things”	**1.** Noticed a lot of details in the kitchen **2.** Drawn to the details of the artifacts	**A**

Chart 2

4.1

Questions Asked / Participants / Researchers Notes	Participants	Comments	Data Set
How does the virtual reality feel? Please describe the atmosphere	2	1. The space feels smaller	A
		2. The atmosphere was described as “A mid 2000’s adventure game”	A
		3. Participant noted the colors are slightly shifted with a still purple hue and the pixelation is okay	A
	3	1. Stated the atmosphere was a “good start”	A
		2. Noted on the gaps caused by the point cloud visualization and noted the surfaces on the walls felt strange	A
	4	1. Felt the colors were darker in the virtual reality / “muddier” and noticed that some objects such as the vegetation and items of warm colors were more bright	A
	5	1. “Sketchy” and that the space felt more enclosed	A
		2. The wall colors and lighting was stated to be very vivid with the purples being very saturated	A
		3. The colors of objects were noticed to be of “pastel” color	A
	6	1. Colors felt darker and the space felt more “silent”	A
		2. The participant stated that the lighting felt “complicated”	A
	7	1. Participant noted the atmosphere felt very dense	A
		2. The participant stated that the lighting felt “complicated”	A
Do any elements stand out to you?	1	1. Jacket on the clothing rack	A
		2. Meeting room / conference room - but the participant did not know why	A
		3. Kitchen area and the lighting / colors of purple	A
	2	1. Participant did not notice a lot of difference and stated “not really, it feels the same” and “pretty complete, good detail”	A
		2. Participant noticed that the curtains had strange patterns of reflections on them	A

Chart 2

Questions Asked / Participants / Researchers Notes	Participants	Comments	Data Set
	3	1. Participant noticed the red colors stood out to them and that the vegetations were “very green”	**A**
		2. Noticed the colors = more saturated and that there were shadows cast throughout the space	**A**
	4	1. Participant noticed the bright colors stood out them the most especially the planting	**A**
		2. The IVLAB stood out to them the most	**A**
	5	1. Noticed the services were different and felt “cleaner”	**A**
		2. Clown hat / trivial items located on tables	**A**
		3. Lighting was noticed to be different but didn’t know why	**A**
		4. The windows were different and participant stated there were no reflections	**A**
		5. The space felt more enclosed	**A**
	6	1. No elements stood out to the participant at first but upon further observation the surfaces of tables were noted to be different and missing	**A**
	7	1. Oranges were noted to be more pronounced	**A**
		2. Floors were noticed to be different	**A**
	8	1. Cabinets / Lifts were missing	**A**
		2. People were missing	**A**
		3. Stairwell was noticed to be missing	**A**
		4. The hallway / waiting space as noticed as being important and a key sense of group social activities	**A**

Chart 2

Questions Asked / Participants / Researchers Notes	Participants	Comments	Data Set
How do you feel about the noise, privacy and light in the office?	**2**	1. The participant noted that noise can be an issue due to collaborations always happening around them and needs to wear headphones	**A/B**
		2. The lighting is only an issue in the winter mornings as the participant chose a desk where the winter suns glare directly shines into the participants face	**A/B**
		3. Privacy was stated to be okay	**A/B**
		4. Noted that useful spaces within the office were the private working room	**A/B**
	3	1. Participant stated that they chose their desk according to the natural light and being closer to the windows	**B**
		2. Participant stated that they chose their desk as it is the most quiet being in the corner	**B**
	4	1. Noise was not too bad for this participant but noted that the office working area can get quite “active”	**B**
		2. The desk of the participant was chosen as it felt the most private, facing away from any other workers passing by	**B**
		3. Participant likes the natural light and therefor chose a seat closer to the window	**B**
	5	1. Noise could be improved, hard to concentrate when there are many conversations	**A/B**
		2. The participant felt the privacy was good and enjoyed the close open plan and the “cosy” feeling it brought	**A/B**
		3. The participant noted that there could be more natural light but needs to have controlled artificial lighting in order to work on the computer screen.	**A/B**
	6	1. “Really Noisy”	**A/B**
		2. “Good Privacy”	**A/B**
		3. Participant stated that the natural light and lighting was satisfactory	**B**

Chart 2

Questions Asked / Participants / Researchers Notes	Participants	Comments	Data Set
	7	1. Participant felt the noise level was good and that the privacy and lighting levels were also good	**B**
	8	1. Noise could be improved a lot, privacy is awkward sometimes due to conversations being heard a lot	**B**
		2. The natural light is great for the participants desk location	**B**
What do you believe are the most important aspects to have in your office space?	**1**	1. “Open plan”	**B**
		2. Improving the privacy levels and the noise levels	**B**
	2	1. Separate the meeting areas acoustically - a comment on what was already existent in the office	**B**
		2. Participant believed that having more meeting rooms were important as there were only 2 currently	**B**
		3. Participant stated the locker area was underutilized and that the material capture space was a project that “was not getting anywhere” and therefor underutilized	**B**
	3	1. Participant believed that vegetation was an important aspect of the office	**B**
		2. Extra private rooms were necessary as the current two were stated to be “usually full”	**B**
		3. The VR Lab or IVLAB was an important aspect of the office	**B**
	4	1. Participant believed that the open plan was important	**B**
		2. The IVLAB was a good area and it is important to have a dedicated space for the experiments	**B**
		3. Participant was happy with the amount of planting and stated that it was “enough”	**B**
		4. A good kitchen area	
	5	1.Overall the participant liked the existing office layout but believed the “sound could be improved”	**B**
		2. The participant believed the meeting rooms / private rooms were good and enjoyed the IVLAB	**B**
		3. A fair kitchen space	**B**
		4. Believed that it was important to be able to “easily find spots” or areas within the office	**B**

Chart 2

Questions Asked / Participants / Researchers Notes	Participants	Comments	Data Set
	6	1. Believed the open plan was important so that “there is not a lot of pressure while working”	**B**
	7	1. Participant 7 believed all aspects within the current office were important and that they were happy with the aspects of the current office	**B**
	8	1. Participant 8 found storage to be an issue within the VE and noted that breakout spaces were personally disliked, in saying this the participant realized whilst observing the existing office pathway that the “hallway” space was an important social gathering space and waiting zone for staff members to congregate and leave for group activities together	**B**
Did you find any differences between the VR office and the physical office? - Asked after the Virtual Reality experience	**1**	1. There were a lot of missing parts - did not specify which parts	**A**
	2	1. “Obviously the items that we have moved around the office” 2. Participants found that the plants were extremely saturated and drew a lot more attention than it would in real life, similarly the participant noticed warm colored objects such as a red Chinese new year object hanging by the kitchen 3. Participant felt they were “always looking down on things” and left the space was small	**A** **A** **A**
	3	1. Point cloud felt static whilst the real office felt dynamic	**A**
	4	1. Participant found that the holes and the reflective surfaces were missing	**A**
	5	1. The main thing the participant found to be missing were the people of the office “Technology does not give the illusion of life” 2. The space felt like a ghost	**A** **A**
	6	1. Not really, felt complete	**A**
	7	1. Almost the same, participant did not find many elements missing or strange differences	**A**
	8	1. Participant noted not much change in terms of atmosphere but interestingly was very talkative about break out spaces / storage	**A**

Chart 2

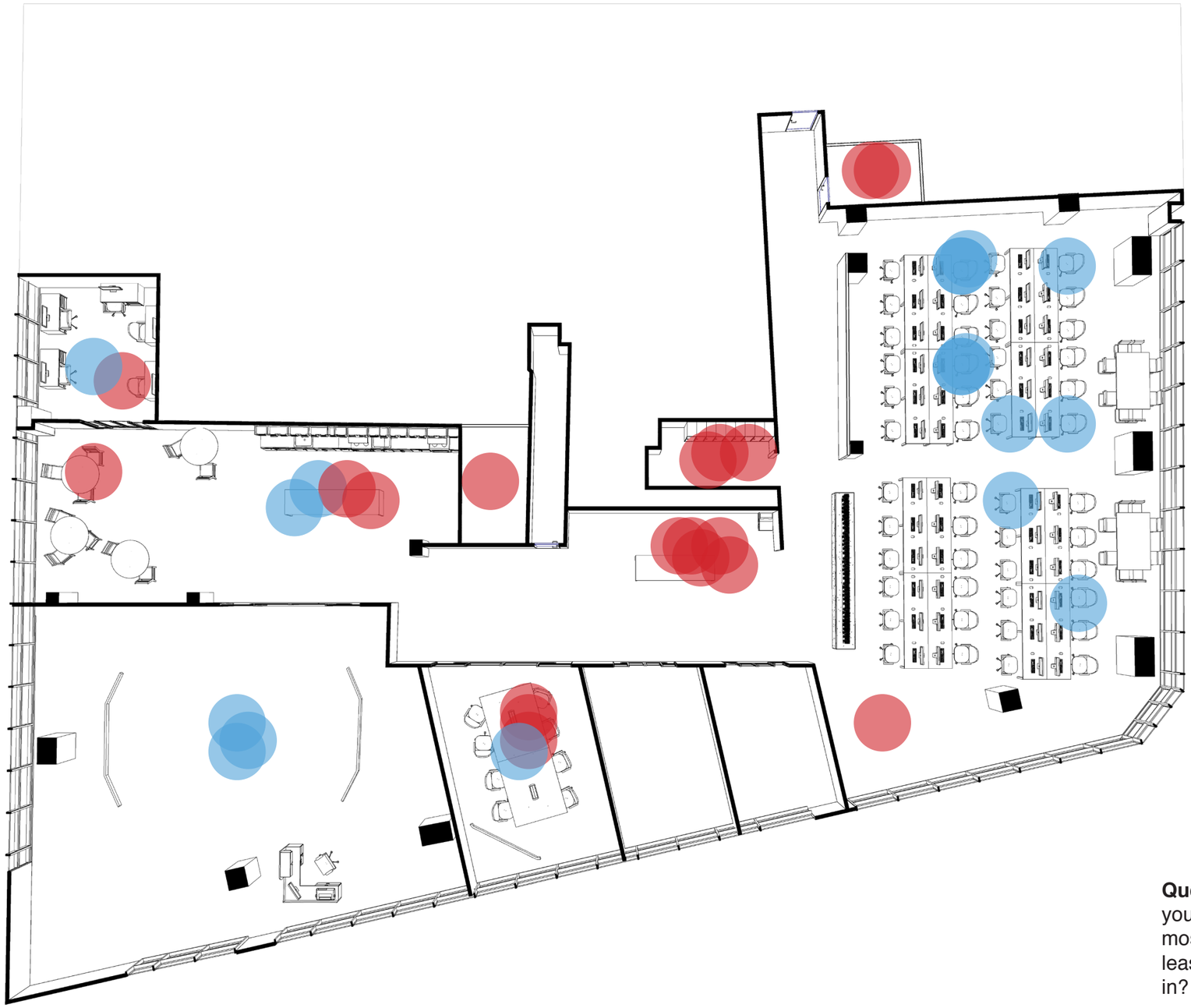
Questions Asked / Participants / Researchers Notes	Participants	Comments	Data Set
With the recent covid-19 lock down, did you prefer the home office workspace? Or would have preferred the office workspace or a mixture of both? - Question was asked after the virtual reality experience	**1**	1. “I prefer the office work space” 2. Participant enjoys the working environment and did not enjoy working at home	**B** **B**
	2	1. Prefers a mixture. Participant enjoys the separation of home and work but stated “I can do everything I can do at work at home...Other than providing a space thats not at home and doesn’t have my fridge”	**B**
	3	1. Participant preferred a mixture of the both. Found that within the office collaboration was easier. The participant found that working from home was easier when the project they were working on was enjoyable and that by working in a mixture the 2 hours of commute time there and back were saved	**B**
	4	1. “It was pretty nice to work at home”. Participant stated that for certain hardware aspects it was easier to work within the office and that motivation was easier whilst in the physical office Participant did not clearly state which they preferred but later stated that they have the option to work from a mixture and enjoys the freedom of the mixture	**B**
	6	1. Preferred working from the office due to the fact that the hardware provided in the office was better than that of their home set up	**B**
	7	1. Preferred a mix. The participant already works partially from another space some days and some days at the physical office	**B**
	8	1. At first participant enjoyed working at home, upon returning to the office environment the participant realized they missed the social interaction of the office floor and the ability to easily talk to colleges.	**B**

Chart 2

Questions Asked / Participants / Researchers Notes	Participants	Comments	Data Set
Did you find remote working to be easier for you? If so / if not, why? - Question asked after virtual reality experience	1	1. Did not find it easier. Found that they did not have a dedicated work space at home and therefor found it harder to work at home	B
	2	1. Participant found remote working initially to be easier due to having their own work routine	B
		2. After a couple of weeks participant felt that the home environment promoted more distractions and found that they would like to be back in the working environment	B
	3	1. Participant found remote working to be easier at times depending on the project they were working on.	B
		2. “With a lot more people you can have more distractions”	B
		3. Felt that at work there was more pressure to get work done which was stated to be both good and bad	B
	4	1. Found it easier in some ways to work at home due to commuting	B
		2. Overall believed that they would still work from the office as they feel more productive in the office environment	B
	6	1. Participant found it easier to work at the office due to hardware	B
		2. Participant believed that if they had the hardware of the office at home they would be able to perform the same stating “If i had those (hardware) at home its supposed to be the same”	B
	7	1. Did not find it easier as they were not used to it and that they needed the hardware provided by the office.	B
		2. Participant stated that if they had the hardware at home and was able to easily communicate with work mates at home then they would be able to get used to working remotely	B
	8	1. Participant found the home working environment easier and greater time was able to be spent with their partner	B
		2. Participant overall was inclining to a more positive view of remote working and seemed like they enjoyed it very much	B

Spatial Diagram I

4.1



Most Comfortable / Stimulated

Least Comfortable / Stimulated

Participant Results	
Comfort and Stimulation	
Figure 15	4000mm

Data Set
A

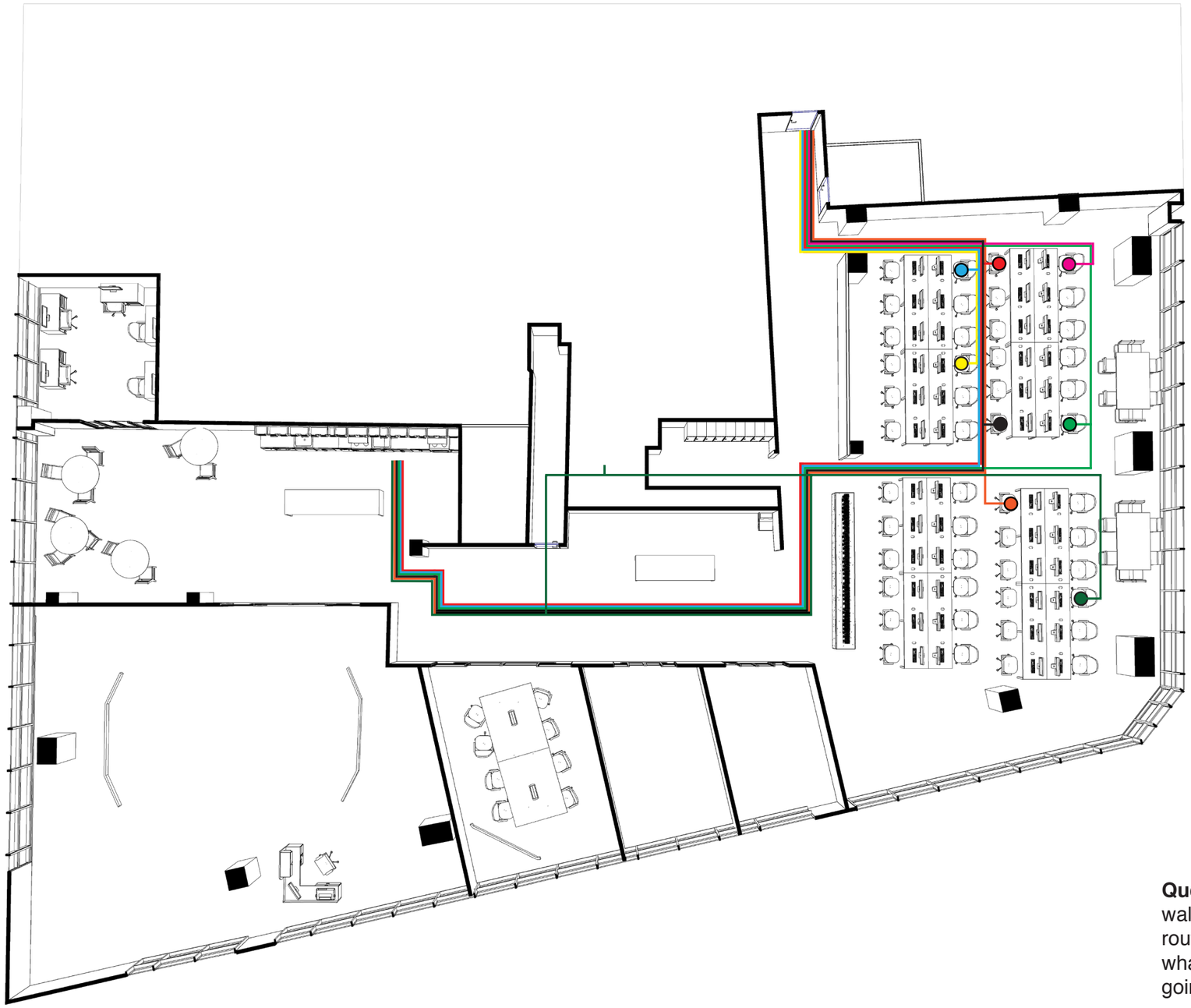
Question asked: Within the VE could you please take me to the space you feel most comfortable in, most stimulated in, least comfortable in and least stimulated in?

Participants were observant of the virtual environment and walked through the VE to the spaces in which answered the questions. Some participants found multiple areas within the office to fit each criteria and therefore there are more locations per participant diagrammed.

Spatial Diagram II

4.1

Data Set
A



- Participant 8
- Participant 7
- Participant 6
- Participant 5
- Participant 4
- Participant 3
- Participant 2
- Participant 1

Participant Results	
Morning Pathways to Desk	
Figure 16	4000mm

Question asked: Could you please walk me through VR your normal arrival routine, which entrance do you use and what route do you usually take before going to your desk to begin work?

Once again, participants were observant of the virtual environment and walked through the VE in what seemed to be the exact route of their daily routine. All participants were very observant of the space looking around the environment whilst walking through their usual pathways.

Case Study

Data Results

4.2

Initial Comments / Reactions

Due to the busy schedule of the workers within the CMIC office participants were asked to block out times that they were available over a two-week period. The first lot of participant user studies occurred on a Tuesday afternoon and three participants entered the virtual reality office one at a time, four participants were tested on the Wednesday mid-afternoon and a week later the final participant study occurred on a Thursday morning.

It was interesting to note that all participants were very calm and capable of using the VR interface and found no trouble when maneuvering through the space. This was expected as the office interviewed was one with technological literacy but was not expected to the extent that occurred. The initial comments from the participants can also be categorized as many seemed to follow a similar pattern. Seven out of eight participants commented on the details within the VE noticing a lot of the artifacts within the virtual space that seemed to be unnoticed in the physical office environment. This can be seen with participant 3 drawn to the writings on the white board, participant 7 observing the flooring and participant 8 commenting on the artifacts within the space. Two out of eight participants were immediately attentive of a color difference within the virtual reality and eventually all participants when asked if any elements stood out to them noted that the lighting/color felt ‘strange’. A key driver to the design phase was also the fact that two out of eight participants were immediately drawn to their own desk space which interestingly correlated with seven out of eight participants finding their own personal desk to either be a space of most comfort or most stimulation within the office. Surfaces within the VE were also noted as heavily observed and all participants took an initial few minutes to gauge the ‘fly through’ movement through the VE.

Question Results

As the interview commenced whilst users were in the VE the initial questions asked were open ended designed to evoke emotional responses participants had with the space. Interestingly participants 2, 5 and 7 felt as if the space was smaller alluding to the exposed services within the building to cause a heightened sense of enclosure whilst in virtual reality. Elements that were noted to be ‘standing out’ or ‘different’ within the space were about the details, mainly pointing out primary colors were more vivid and the space was darker, this could be alluding to the purple wall colors being heightened within the virtual space and due to the innate darkness of the color purple the space was seen as being more dim.

It was clear that the IVLAB which constitutes for the offices main experimental and technology program was very important to the space. The kitchen and storage units were also frequently mentioned and observed throughout the participant’s experiences through the virtual office. When asked to be taken within the VE to the spaces where the most personal comfort and stimulation were felt each participant was very observant of the environment and many found their own personal desks to be both the most stimulating and comforting. Many found that the breakout space and locker area were least stimulating and least comfortable with a few outliers show casing an even mix of comfort, stimulation, discomfort and lack of stimulation within spaces such as the meeting room, private working rooms and kitchen areas. When mapped out in figure 15 it is clear to see an emerging pattern, when the daily routes and entrances were also mapped out in figure 16 it is also clear that six out of eight participants took the same pathway to the kitchen every morning before returning to their desks to begin work.

Conclusion

Overall it can be seen that the methodology has produced a comprehensive amount of data and through closer analysis, patterns and key design aspects that will influence the new architecture have emerged. Interestingly the data can be seen to have produced drivers for both an architectural shift and a systematic shift of work style within the office to better enhance the overall well-being of the end users. Moving forward the synthesize data has resulted in a focus being placed on the worker’s personal desks and the ability to shift this system from a social working zone to focused working zone. The connectivity within the office will also be a focus, with the need to reduce connectivity through uncomfortable and non-stimulating areas and promote pathways between comfortable and more stimulating areas. An opportunity for added programs to better fit the working style of the end users is also apparent, which will be influenced and align with the covered literature in Chapter 2. Within Chart 2, the need for greater control of privacy and acoustics can also be seen with many participants commenting on the distraction and discomfort felt from what can be sourced as the open plan office floor. The interesting aspect of details, lighting and colors will also be taken into account to create a more comprehensive interior to strengthen the new architectural design. Ultimately the results found from the virtual participant study alongside the information gathered within the literature review can be seen as successful and principal drivers proceeding into design.

This show cases the initial potential, 3D immersive technologies have, when used as an applied tool during the design process.

Expand

5.0
Design Intervention

Constrain

Minimize

Methodology Phase IV

Expand

Design Phase I

Introduction

Within the previous chapter the user studies results were synthesized and patterns began to emerge. This chapter now focuses on the translation of the data and how the innate results from the VR user study produced key driving elements for the initial design prior to the second review.

Key patterns

1. Through the implementation of an unconventional methodology, interesting results were found. Comments of interest within the user studies that can be attributed to the virtual reality and point cloud visualizations are that of the distinct observation of lighting, detail and color, all of which were a surprise when conducting the study.

Initial observations made by the users immersed , were also interesting as participants 2 and 5 were immediately drawn to their own desks, whilst participant 7 was attracted and stated that pathways through the office that were not normally taken were of interest. A key observation when aligning the spaces users were attracted to for comfort and stimulation reasons were that the spaces of comfort and stimulation were almost always in the direct route of spaces that users found uncomfortable/non-stimulating. This was interesting as the current layout of the office dictates a direct pathway, one that forces users to pass through spaces that they found to be most discomforting and non-stimulating in order to reach the spaces that were of most comfort and stimulation.

2. Another interesting pattern was the comments when users were asked about key spaces within the office, although this can be attributed to a more traditional form of client information gathering the ability for users to see within VR clearly heightened their choices and allowed for greater more confident answers to be made.

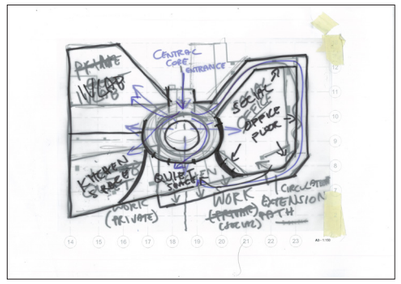
3. The IVLAB which represents a space for experimentation in virtual and augmented reality, a space where users can invite clients to collaborate and a space of relaxation was commonly mentioned as important to the office culture.

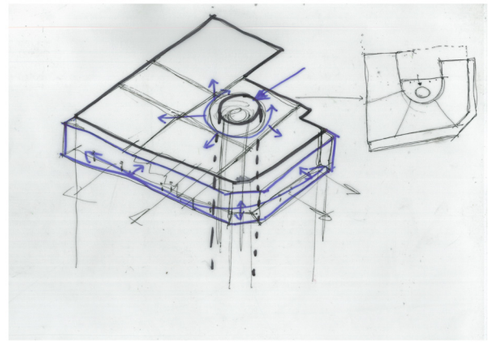
4. Meeting rooms were another area of interest as all participants 1 – 8 noted that noise can become an issue when working in the main floor. This coupled with the comments of participant 2 and 3 about the need for extra meeting rooms alluded to a lack of focus areas within the current office.

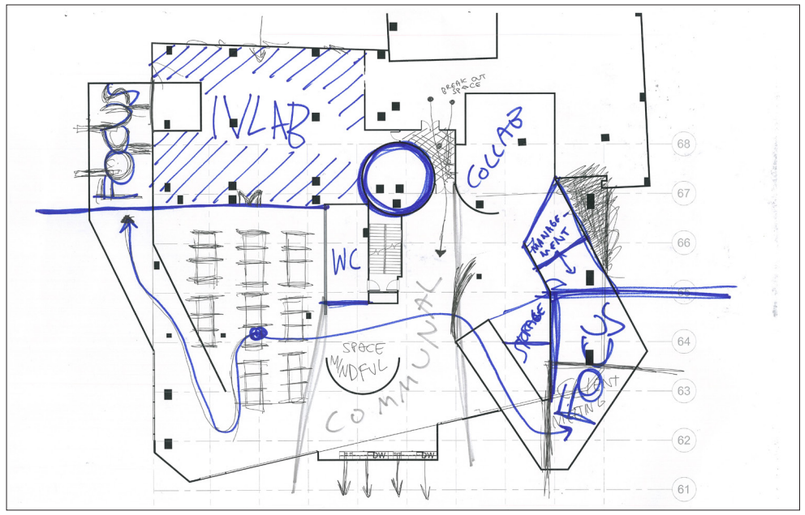
5. Participant 8 interestingly noted whilst observing in virtual reality, that social staff gatherings when leaving to lunch together, were promoted through the hallway, as it acted as a meeting ground or space of congregation.

6. When asked about the impacts of remote working due to recent Covid-19 lock-down, mixed results were found, with participant 1 – 6 strongly preferring the office as a place to work whilst all other participants preferred a mixture. Although the two participants had strong feelings of the office itself, upon further discovery, this was due to their home spaces not housing the correct hardware to allow for the ability to work at home. When participant 6 was asked “if hardware was provided for you during lock-down would this change your answer?”, the participant was quick to believe that indeed it would allow for them to easily transition to remote working.

7. It was interesting to note the pathways each user took when arriving to the office before they commenced work at their personal desk; an artifact that happened to resonant as a space of high stimulation and comfort for a majority of the workers. These pathways when mapped against the spaces of comfort, stimulation, uncomfort and non-stimulation showed that the users were forced to take one specific route through uncomfortable and non-stimulation zones to reach the kitchen, an area that six out of eight participants regularly visited before commencing work and a space that all participants use throughout the day. Other spaces of dissatisfaction also included the conference or meeting room, which also was along the same single pathway users were forced to take when going about the routes of the office.







Floor Plan Expand	
Concept Sketches	
Figure 17	

Expand

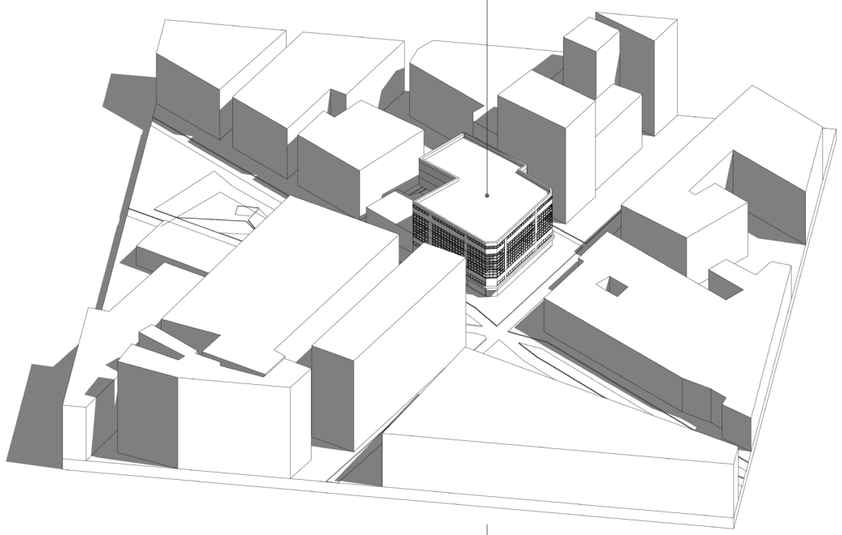
Expand

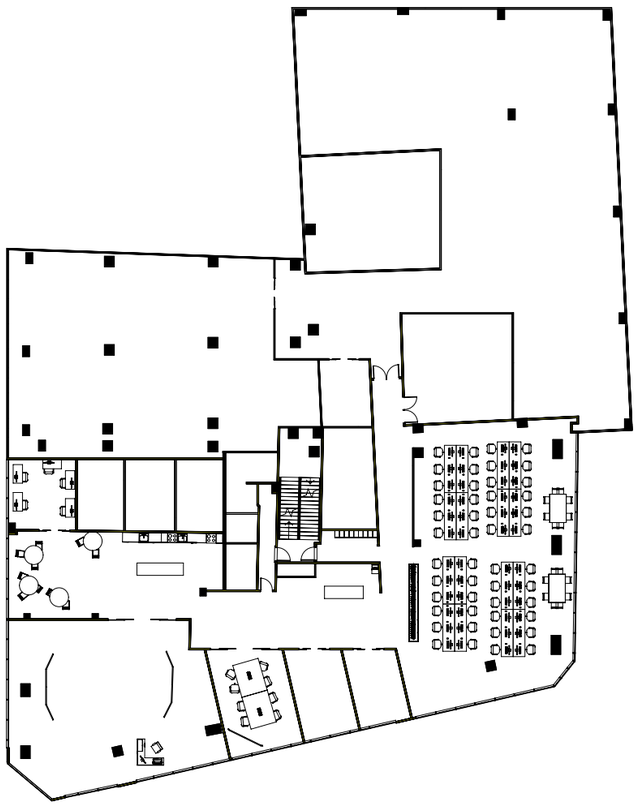
Through the key patterns found, the first design intervention aims to tackle the spatial configuration patterns noted in pattern 7. And reducing the need for users to pass through uncomfortable and non stimulating spaces. Pattern 6 was also a key driver for the first phase as more focus work and quiet meeting zones were incorporated to allow for a decrease in noise and clear definition of private and collaborative work zones, also promoting the ability for remote work a key pattern found in user preference.

Overall within this design phase, all patterns were taken into consideration with the aim of improving the spatial configuration for the end users, improving their well-being whilst also contributing to the companies' goals and mission. This being said, a large amount of focus was not spent on the details noted by users in pattern 1. Such as lighting, color and artifacts as the first phase was aimed to produce architecture that could evoke feedback and criticism from reviewers in August, allowing for the following design phases to be improved through an additive design process.

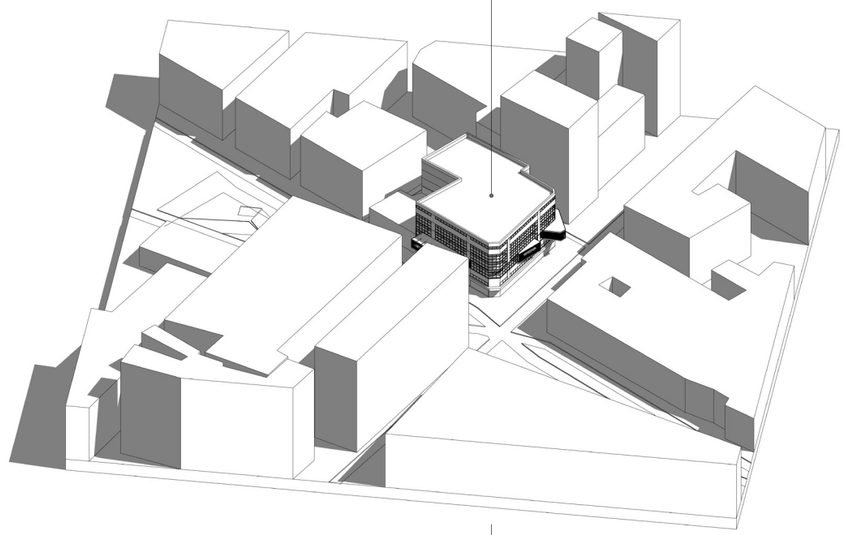
Isometric / Plan	
Existing / Concept	
Figure 18	

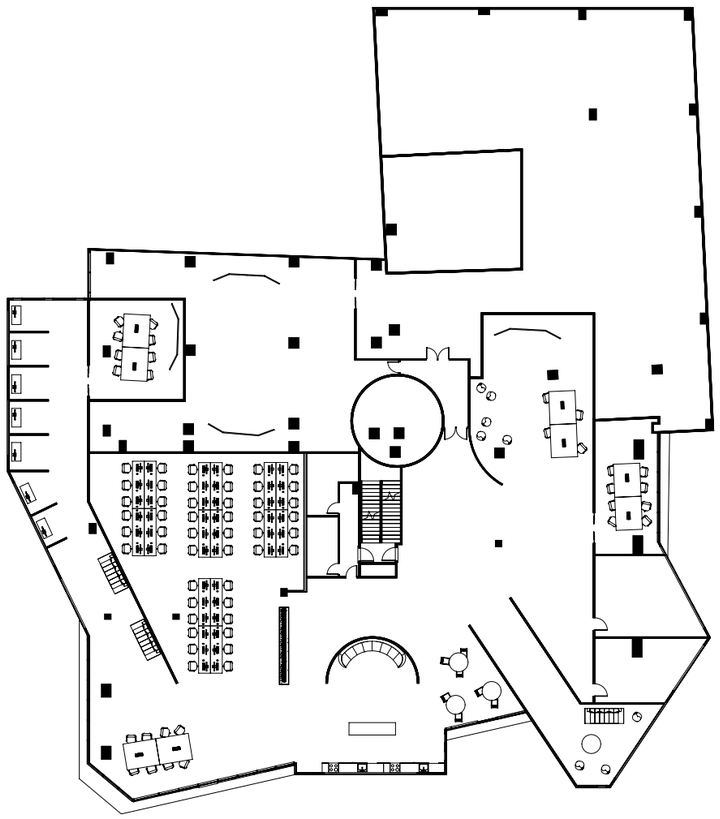
Existing

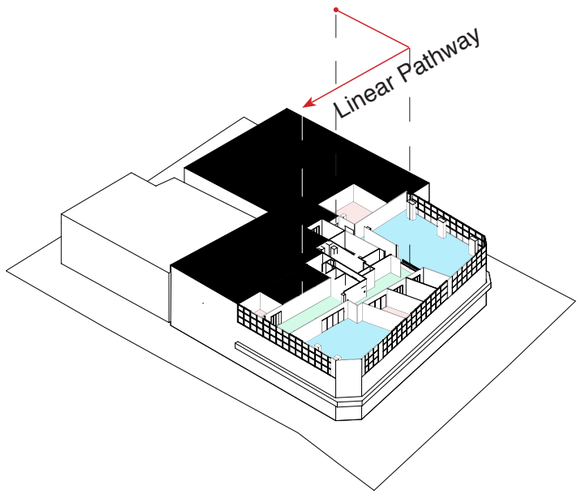


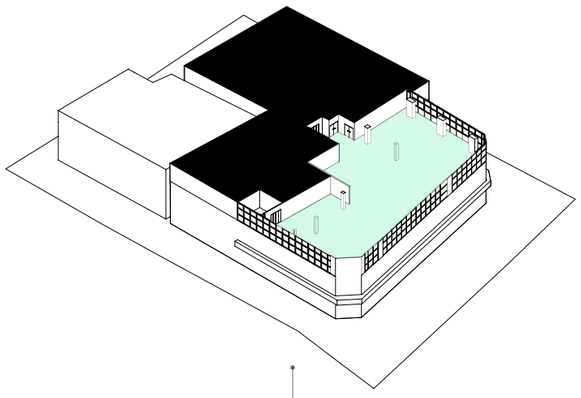


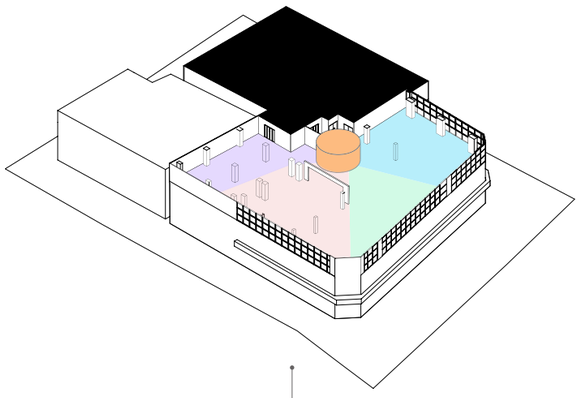
Proposed

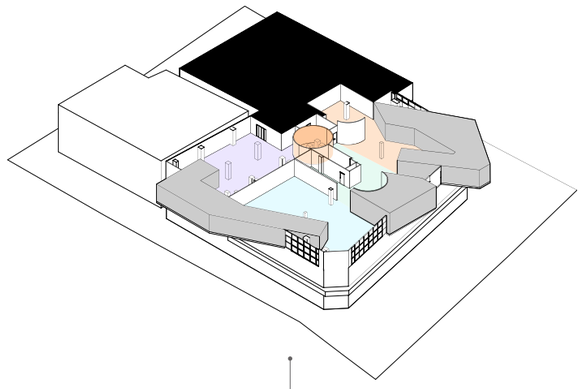












Spatial configuration

Through relevant literature covered in Chapter 2, a dispersed model was chosen to allow for programs within the context of the current office layout to be pushed towards the skin or the structure.

Within the current spatial configuration, a clear linear path is apparent. This path not only limits the user's choice of connection but forces users to pass through the spaces that were noted as uncomfortable and non-stimulating in order reach spaces of comfort and stimulation.

By breaking this path and opening up the space intruding into the lecture room, a new form of spatial configuration is introduced.

A central entrance is created, promoting curved site lines and welcoming view shafts throughout the office whilst dispersing the programmatic functions of the office towards the outer edge of the floor plate.

"Nodes" are then placed to dictate focus, collaborative and regular work zones whilst introducing a unique form extruding outward from the existing orthogonal structure.

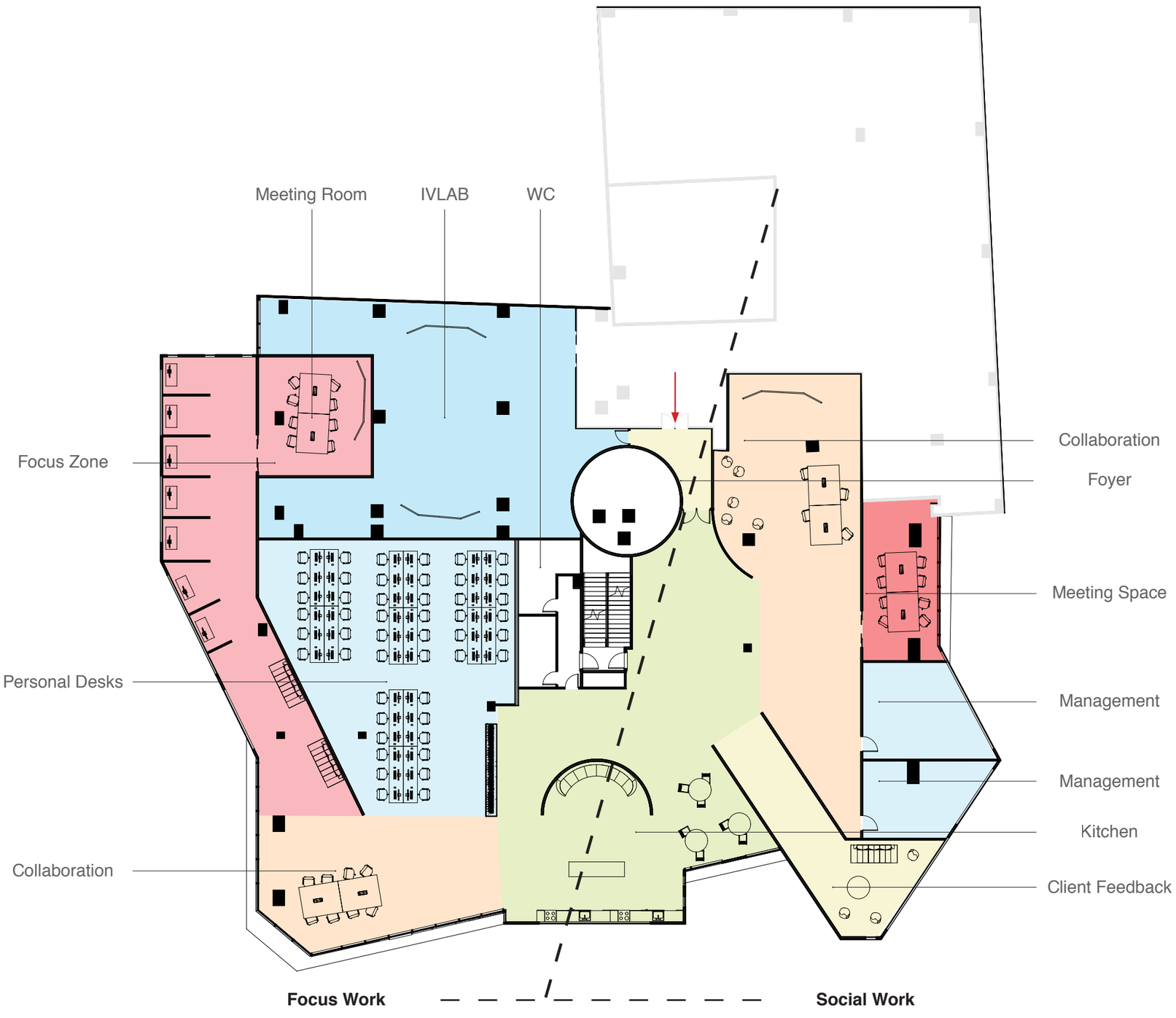
Expand

Floor Plan Expand	
Conceptual Parti	
Figure 19	

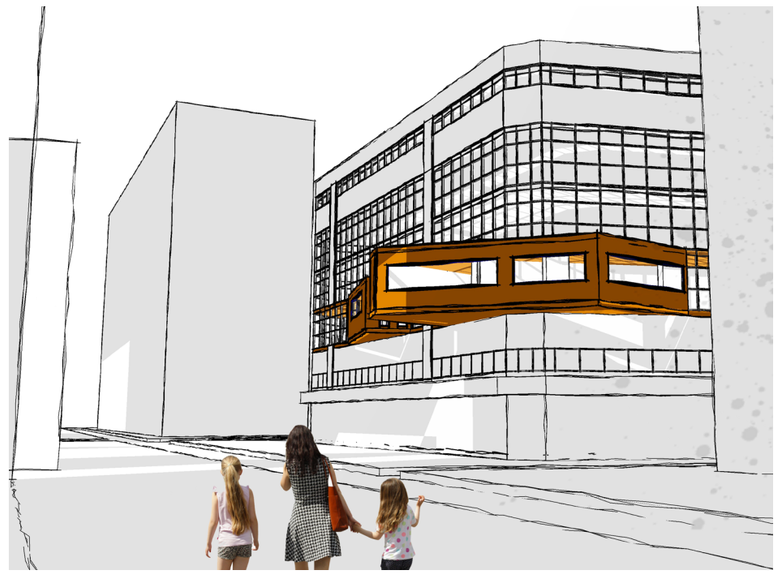
Within the new proposed floor plan the dispersed model is then centrally split creating two wings that promote focus work on the left and social work on the right. This new architecture alludes to the ability to re design the artifact of the personal desk, creating a new system that allows for workers to easily transfer from the office floor to more remote/singular working zones as well as collaborative areas of work.

The newly introduced central entrance not only introduces a foyer area designed as a congregation space for staff to collectively gather before leaving the office together. The foyer also works as a break out zone allowing for a smooth transition in and out of the work place. This also promotes new client invitation and collaboration as view shafts are directed to open up the office floor, aiming to be in line with CMICs company mission, promoting collaboration, client invitation and the awareness for a greater technological ecosystem within New Zealand.

The work floor users are also not isolated to their respective work wings as easily accessible pathways to more communal areas can be found without having to pass through uncomfortable and non-stimulating spaces.



Floor Plan Expand	
Programmatic Diagram	
Figure 20	



Expand

Expand

Scan QR Code to view:
Critical reflection of Phase I: Expand

Floor Plan Expand	
Concept Renders	
Figure 21	

August Review

Supervisor
Regan Potangaroa

Guest Reviewers
Rohan **B**ailey – Practice (Studio Pacific)
Kimo **G**riggs - University of Washington, Seattle
Joanna **M**erwood **S**alisbury – Victoria University of Wellington (Internal)

The August review acted as a formal discussion over an online video call, where both external and internal reviewers critiqued and analyzed the presented design work at roughly the half way milestone of Thesis research.

The abstract methodology and implementation of 3D technologies as applied tools in order to gather client information was received in a positive light. A large emphasis of the questions was placed on the design outcome due to this methodology and queries of whether the space needed to be expanded or not.

JMS – Think about a stronger argument to extend the buildings skin.

RB – Try to keep the programs within the existing architecture.

KG – A slight shift in the orthogonal split of the programs could suggest a great visual representation of why the plan is laid out into two wings.

RB – It may be a good move to put users back into the VR after design is completed.

JMS – Introduction of these new programs are successful in lining up with the company mission, though try keep this within the existing floor plate.

Conclusion

Overall taking into consideration the comments of the reviewers it is important to consider why extruding programs past the skin was necessary. As noted, pragmatically this will cause great costs. A pattern of comments was the idea of keeping the programs and enhancing the space whilst remaining in the existing office footprint as well as placing users back through the VE once the design intervention is completed.

The methodology of this research was taken well and high interested was noticed across the reviewers. This was a great sign as it shows cases and re assures the potential immersive 3D technologies have when being applied early on during the design process.

Through critical reflection of these comments and my own contemplation, moving forward into design phase II the aim will be to constrain, designing to enhance space whilst restricting the floor area to that of the existing office. Exploring the findings of the VR user study but through spatial configurations within the existing architecture.

Constrain

Design Phase II

Introduction

Through reflection of the August review, it was clear that the methodology was received positively and the potential this methodology has is significant. The other critical point made was that there was a need to constrain the spatial configuration of the design within the existing boundaries of the office floor plan.

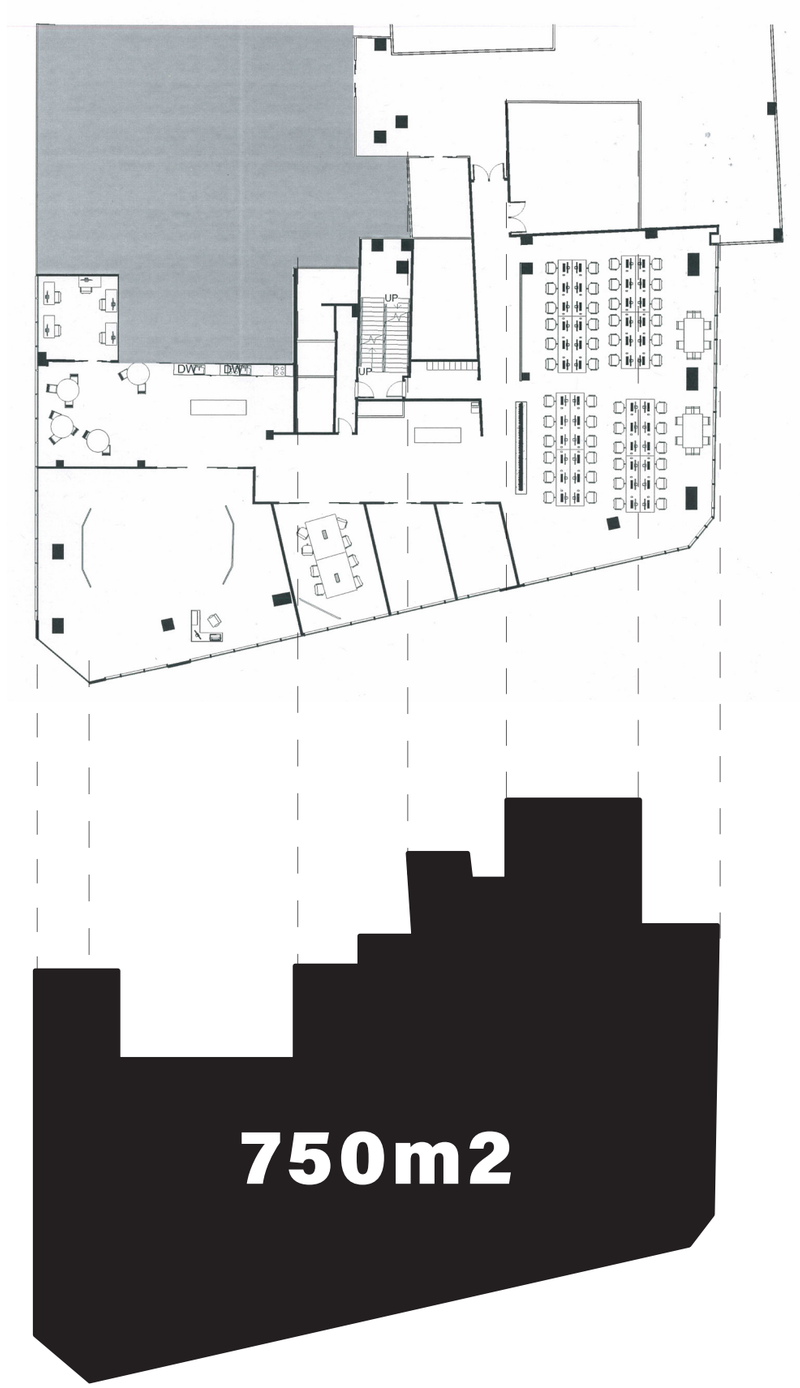
This has led to the exploration of spatial configurations that still reflect the findings of the data collected but confining these solutions within the existing space. It is important to note that like the previous exploration, structural elements such as columns are to remain the same as well as that of the vertical connections and placement of the stair case. These elements along with the existing skin create the brief in which the space can morph to improve connections, stimulation, comfort and well-being of the office space.

Constrain

Reflection on the previous design phase has concluded the need for new programs such as focus zones and client feedback areas. These proved to be successful spaces to tackle the problems found during the VR user study, therefore these programs are aimed to be kept within this design solution. All programs within the previous design phase will also be integrated into this design phase with the aim to produce not only a similar configuration to the previously explored dispersed model but also a ‘centralized’ model. These two options alongside the new programs follow the literature stance for contemporary office configurations as well as provide design solutions to the end user’s needs.

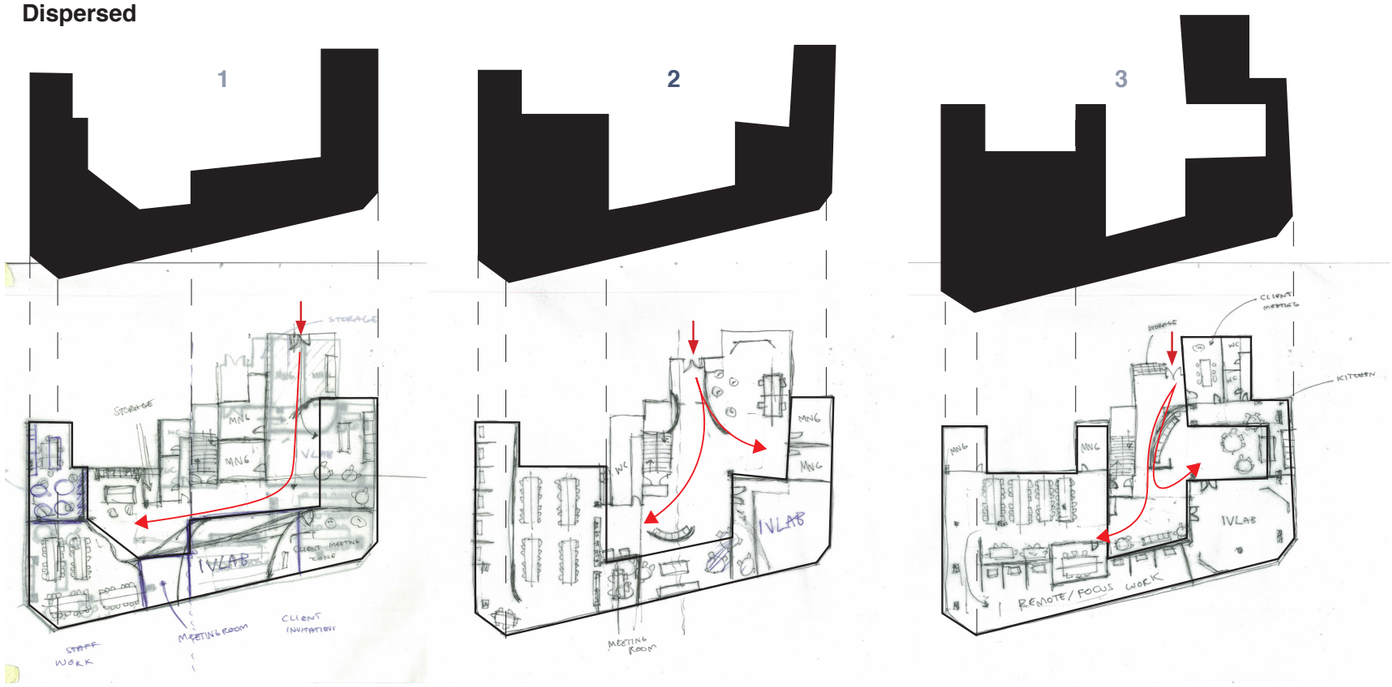
The exploration of the dispersed model aims to push important programs towards the skin and create connections spreading outward from the core of the floor plan whilst the centralized explorations aim to keep the important programs within the core and create more connections around the edge.

Due to the floor space there can be overlap found between the two exploration, although this is the case the ideal layout within this constrained floor plan would be a combination of both a dispersed and centralized model, finding the balance in which emphasis is placed on the liked spaces and subordination is placed on the disliked spaces.

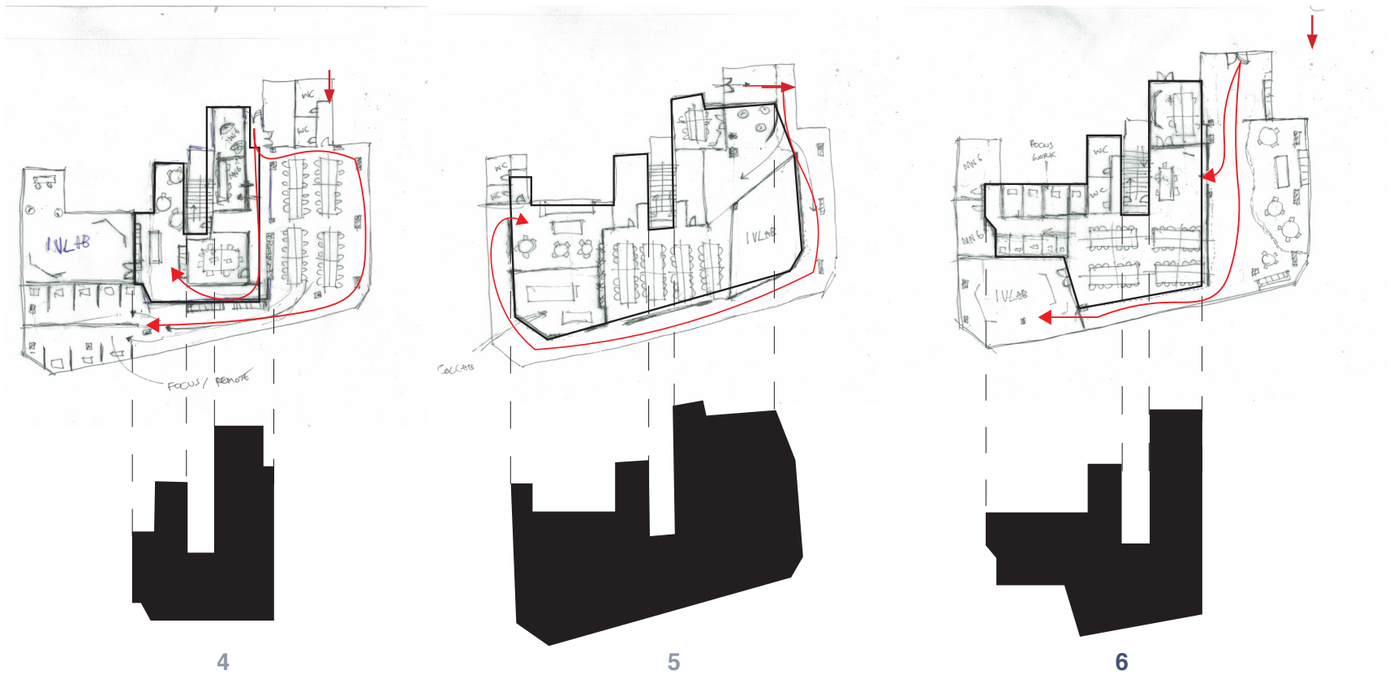


The existing floor plate is roughly 750m2. design phase two will be constrained by this floor area and design solutions accordingly.

Dispersed



Centralized



Dispersed Program

As previously mentioned the dispersed programmatic layout aims to have the key programs of the CMIC office spatially configured towards the skin whilst promoting connections and pathways that disperse from the centre or entrance. The explored series showcases iterations of this and within all figures user's pathways start from within and move outward to reach amenities around the office.

Centralized Program

By centralizing the most important programs such as kitchen space, work stations and the IVLAB the centralized programmatic configuration allows users to connect from the outside and move inward to the spaces of interest within the office.

Within the series and through reflection the successful iterations were diagram 2 and 6 of figure 19; interestingly a configuration from both explored configurations.

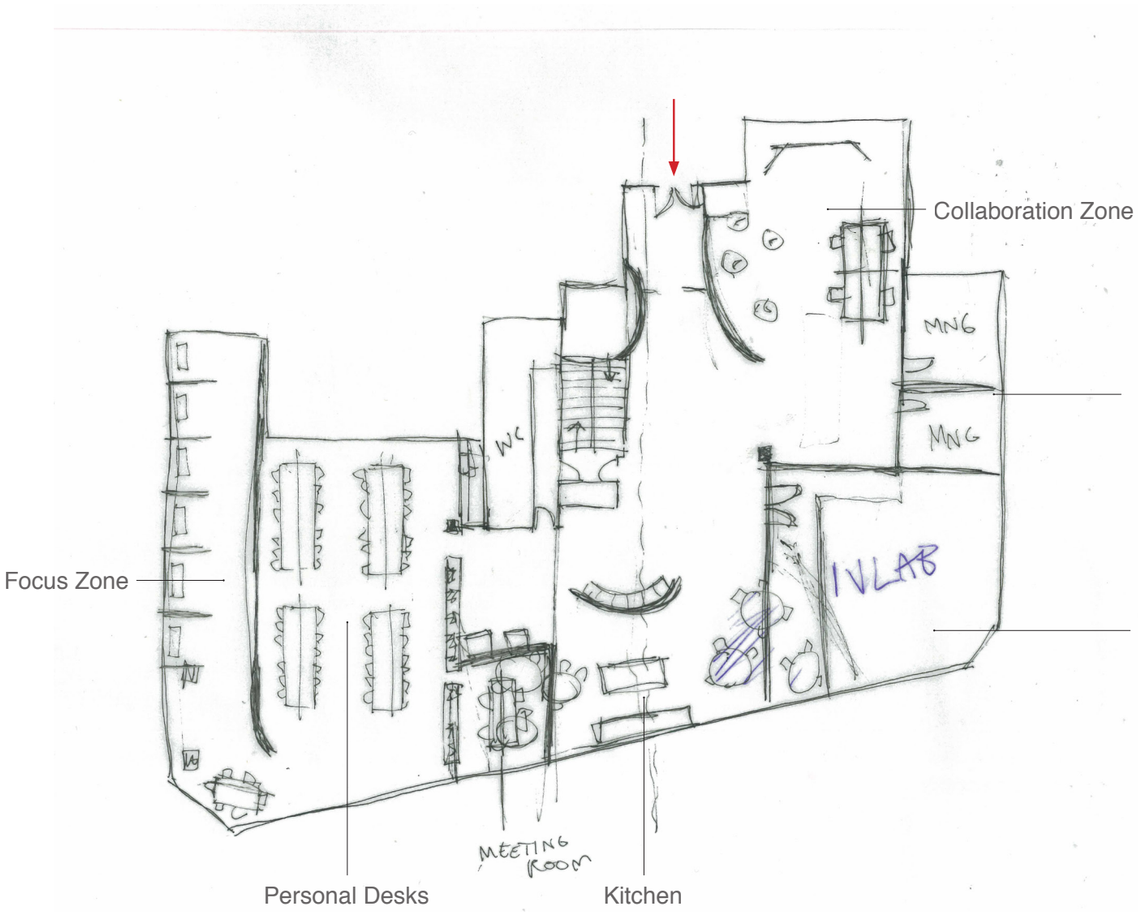
Diagram 2 draws from the previous design phase and successfully opens up the initial view shafts of the office upon entrance. This creates choice in user pathways and allows for a reduction in disliked spaces whilst promoting kind welcome to clients and visitors, aligning with CMICs company mission. Once again diagram 2 divides the office into two wings respectively allowing focus work to occur on the left and more social integrations and collaboration to occur on the right.

Diagram 6 matches the opened view shafts from the entrance but this time immediately drawing users to the social space of the kitchen. This was found as a highly active program for all users of the office and by situating it towards the skin allows for both immediate invitation and social setting but promotes active light. By creating two pathways upon entrance one around the edge of the floor plan towards the IVLAB and one to the left where the work office is centralized, programs can be broken up. Once again creating key distinction between social setting and work setting. By pushing management offices towards the very left a soft gradient in working hierarchy can be found with management roles at the edge of the skin, focus/remote working areas found in and then the general working floor found in the centre.

Through analysis of these two models a final design proposal for phase 2 can be produced. One that encompasses both configurations to the best of their potential.

Floor Plan Constrain	
Diagrammatic Sketches	
Figure 22	

2



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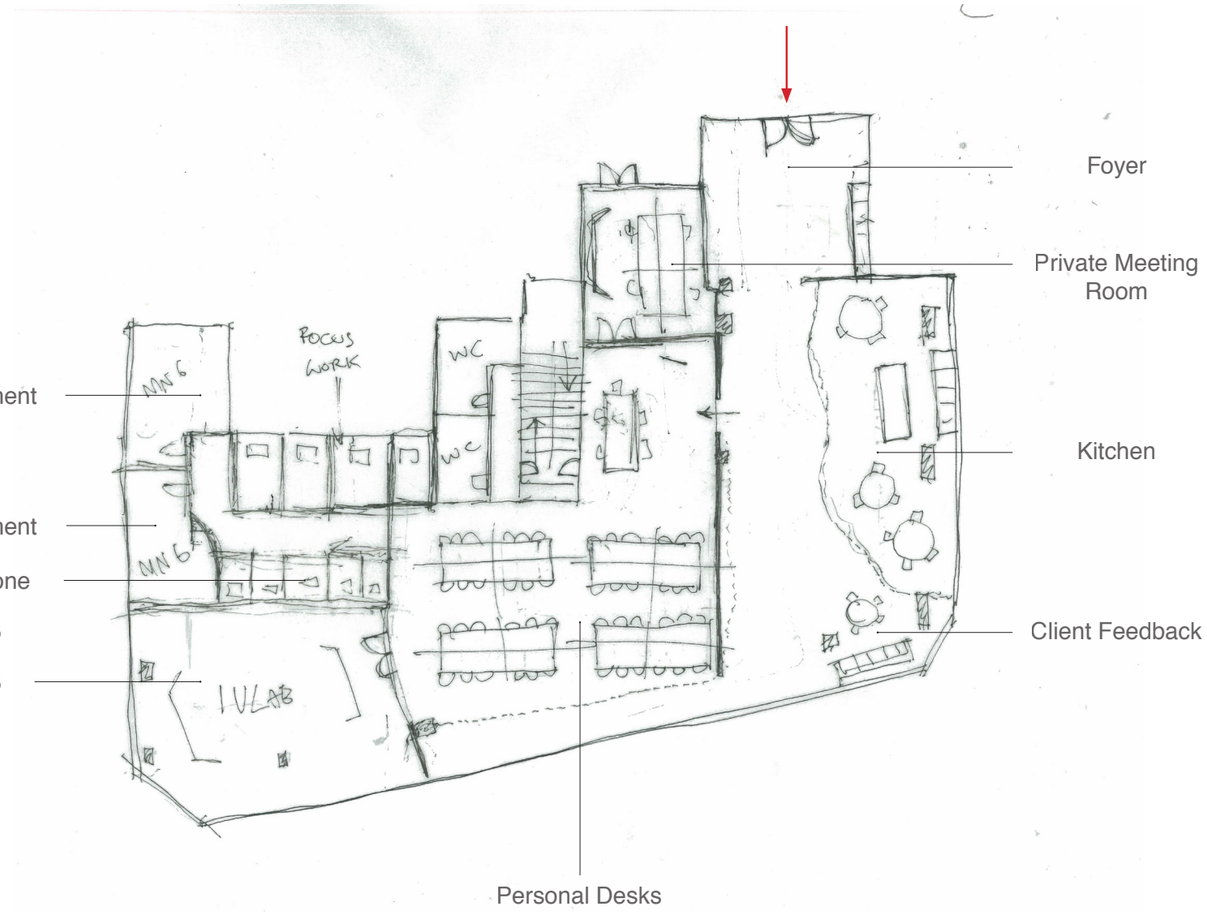
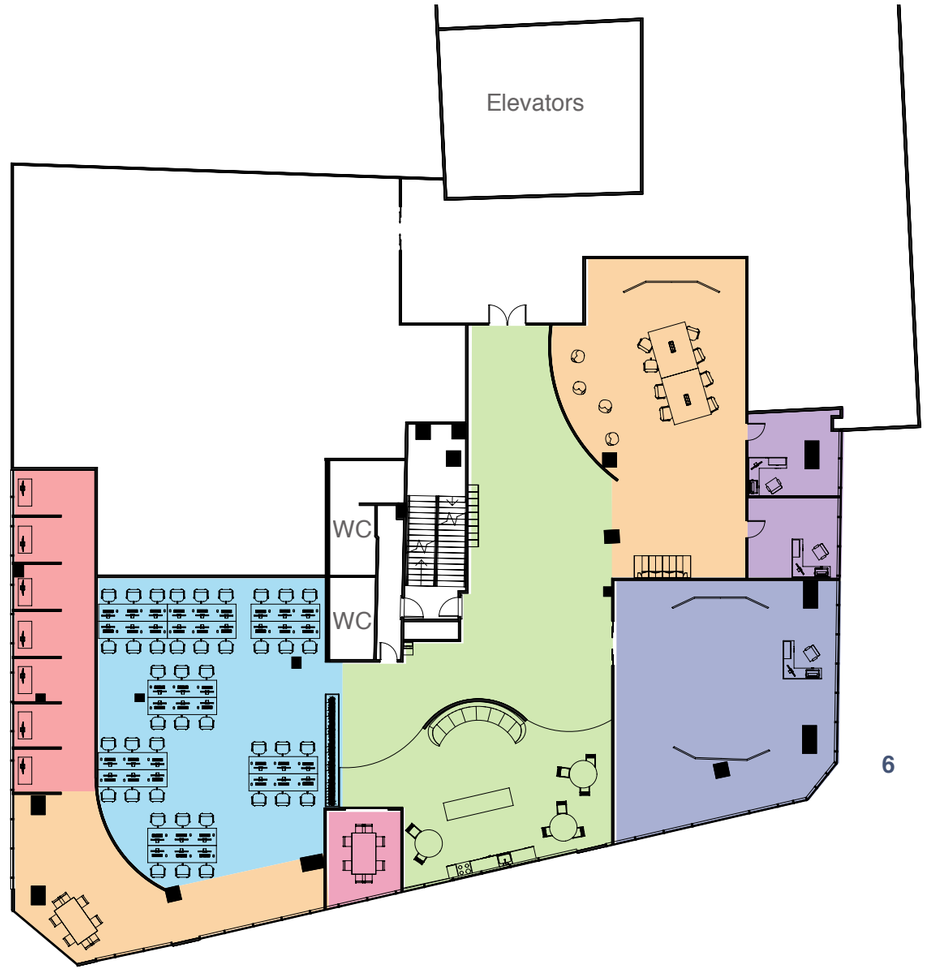


Floor Plan Constrain	
Concept Sketches	
Figure 23	

2



6

Management

Collaborative Zone

IVLAB

Focus Zone

Foyer

Meeting Room

Communal Area

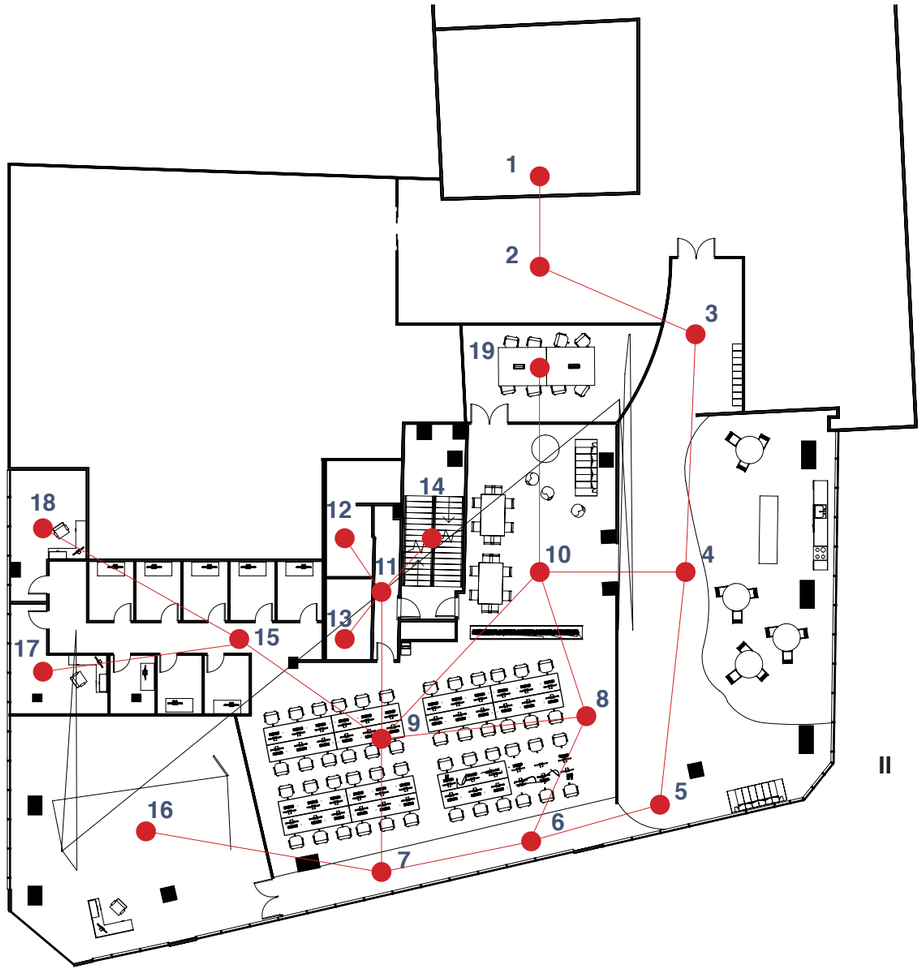
Work Floor

Scan QR Code to view

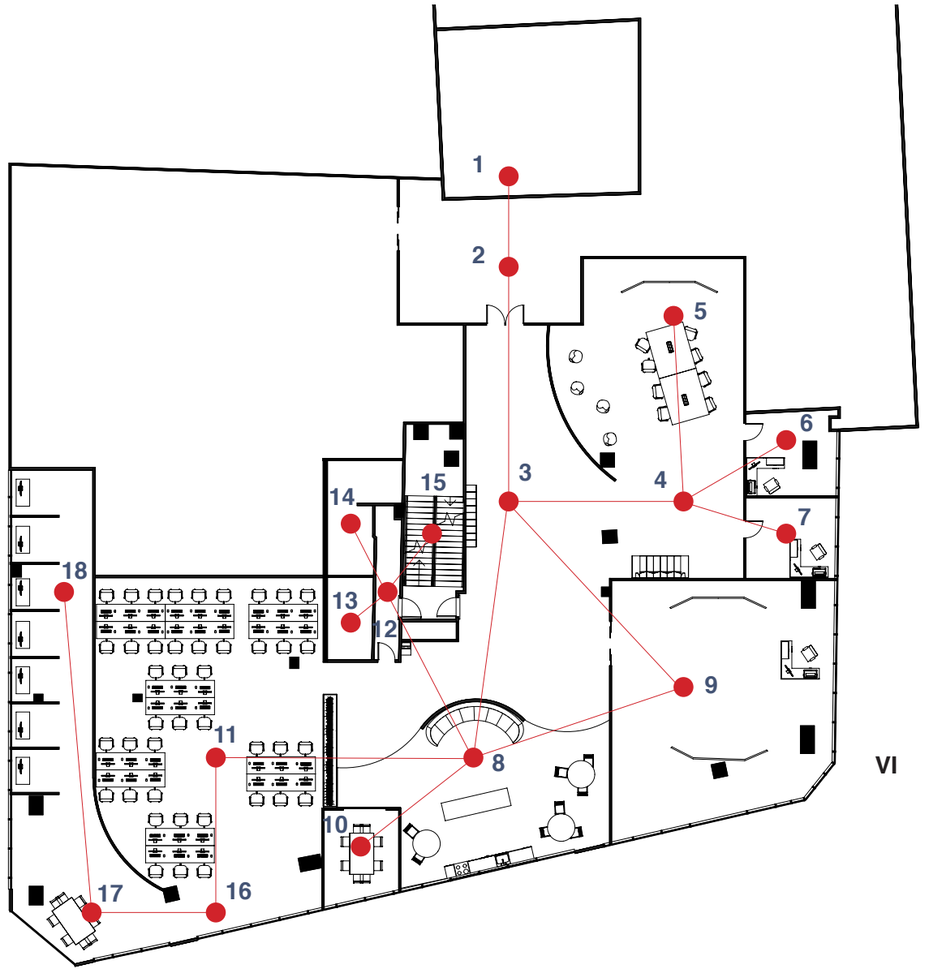
Critical Reflection

Floor Plan Constrain	
Programmatic Diagram	
Figure 24	

Constrain



II



VI

Constrain

Scan QR Code to view

Connectivity Analysis

Floor Plan Constrain	
Connectivity Analysis	
Figure 25	

Minimize

Design Phase III

Introduction

When designing for phase III the reflection and insights discovered from the previous design phases were critical. Within phase I and II the optimal spatial configuration for improving the well-being for end users were found, this was discovered to be that of a dispersed programmatic model which branched connectivity from a central axis which was the communal area of the office; an area that promoted kind welcome, collaboration, comfort and stimulation. All insights found during the user study were successfully translated into a new floor plan which also allowed for successful private and social work styles - another key discovery found through the user study.

By successfully aligning a spatial configuration that enhances the well-being of the end users and aligns with CMICs' company goals the next design phase aims to reduce the office footprint entirely. This design phase aims to keep all spatial knowledge and configurations discovered within the previous stages but minimize the floor area, thus allowing for the focus to be place on detailed components – an element discovered to be key to the end users during the VR study but yet to be addressed through design. As noted in the data analysis of the user study in charts 1 and 2, key components that were recorded to resonate to the workers of CMIC included: The personal desk, detailed components such as lighting, height, color and services.

Throughout design phase III all key components will be addressed and designed to complement the dispersed programmatic configuration. Another incentive for minimization of the office floor plan is the monetary savings the company can achieve through less square meter renting. In saying this, it is important to note the actual circumstance of CMICs' property finances are unknown but from a design stand point and the comments received during the August review, it was clear that the reviewers were alluding to the idea of floor space consistency and/or reduction.

Ultimately through minimization, specific systems within CMIC will be re designed to work with the newly architectural layout, this will target and address all insights discovered through the VR user study and show case the potential 3D technologies have when applied as a design tool during the architectural process in order to enhance and better not only CMIC as an office but the well-being of end users.

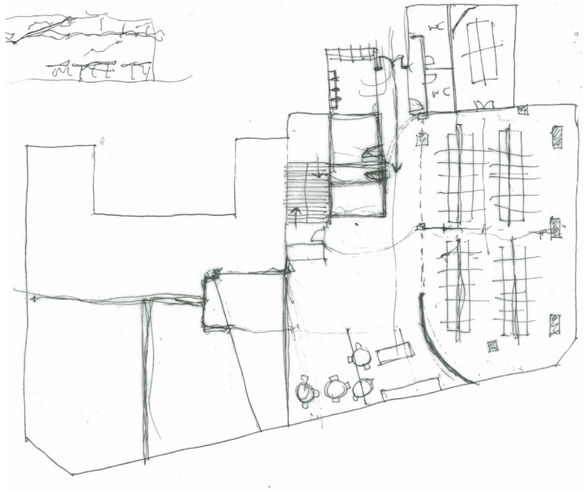
Minimize

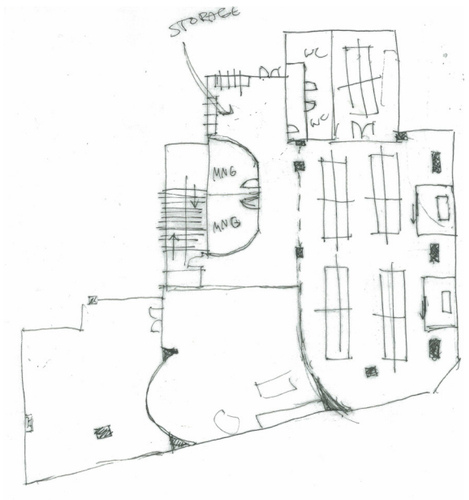
Minimization of office floor space was in conjunction with the previous design phase. Within the following diagrams the floor plan was redesigned to keep the most important programs noted during the VR user study. These programs were – The IVLAB, the work floor or personal desk stations, the kitchen and communal areas and a space of private meeting / work. The need for storage, bathrooms and management offices were also taken into account and therefore the existing two cells for management were translated into the minimized design, alongside storage areas and the relocation of the bathrooms. Matching the previous design phases, the constraints of the minimization were to ensure the staircase and all structural elements remained the same.

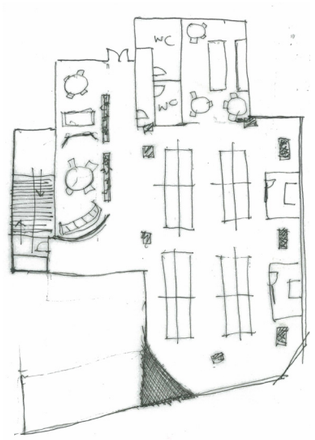
Two designs were produced and range from a more conservative approach of 32% minimization and a radical approach of 56% minimization. Within the conservative floor plan (Fig. 25) the central axis from design phase II remains identical. The kitchen and communal space acts as the spatial connection between two wings, only in this case the left wing consists of a condensed IVLAB whilst the right wing hosts the working floor area, providing both private and open working styles.

By introducing a curved seating area within the central axis the concept was to allow for a welcoming client feedback zone without having to compensate for extra space. Through a slight insertion within the IVLAB clients are able to comfortably interact with CMIC without having to pass through work spaces whilst also being in close proximity to the IVLAB, a space previously noted for experimentation and show casing of work.

Through minimization of 56% seen in figure 25 the more radical approach eliminates the IVLAB completely and relies solely on the work floor to be the space of client interaction, collaboration and user work. This forces the communal area to be pushed to the west of the office and can be argued that the connectivity and spatial configuration morphs from a dispersed model to a more centralized model.

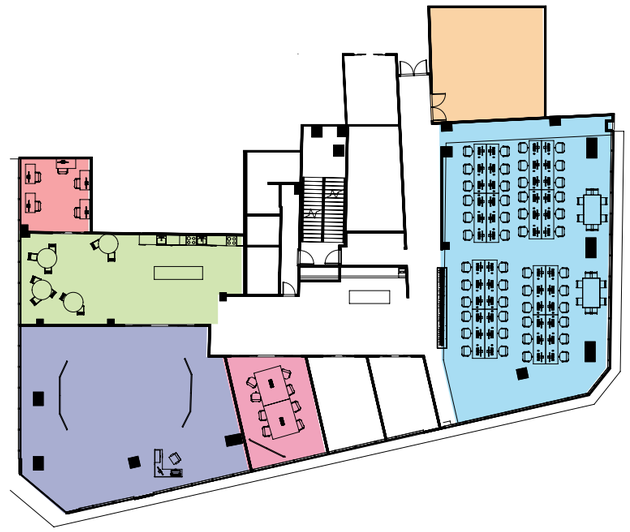


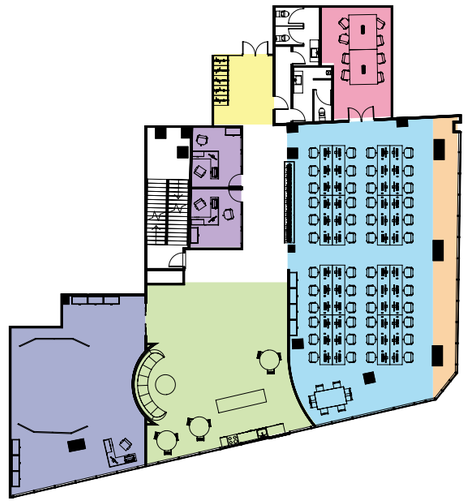




Minimize

Floor Plan Minimization	
Concept Sketches	
Figure 26	





Foyer

Meeting Room

Collaborative Zone

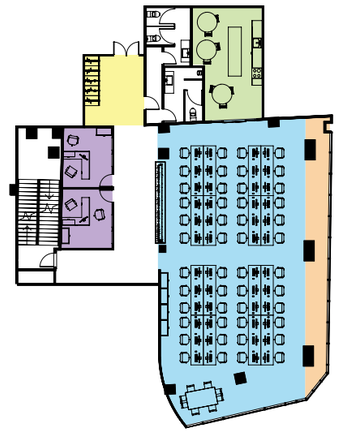
Communal Area

Work Floor

Focus Zone

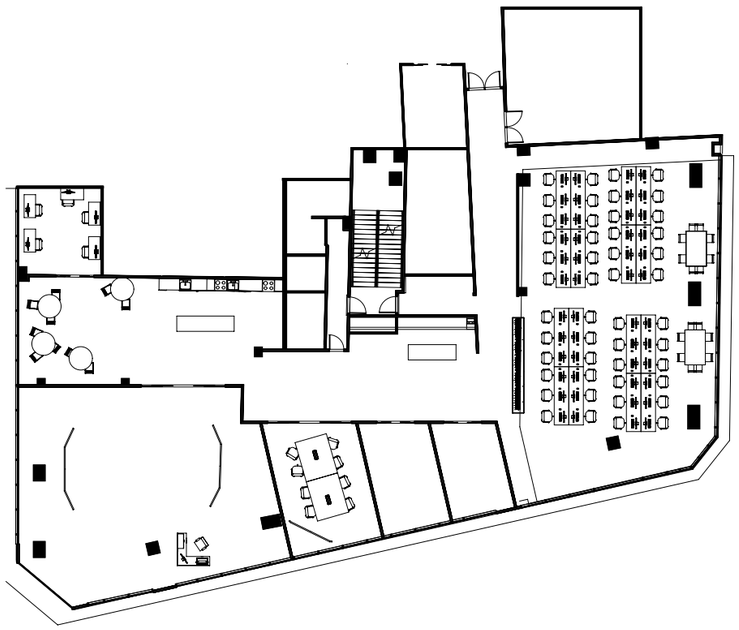
Management

IVLAB

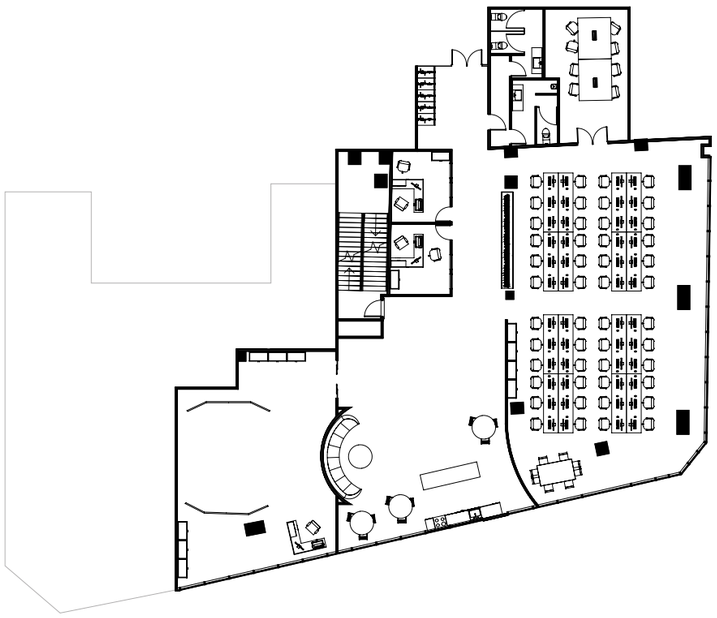


Minimize

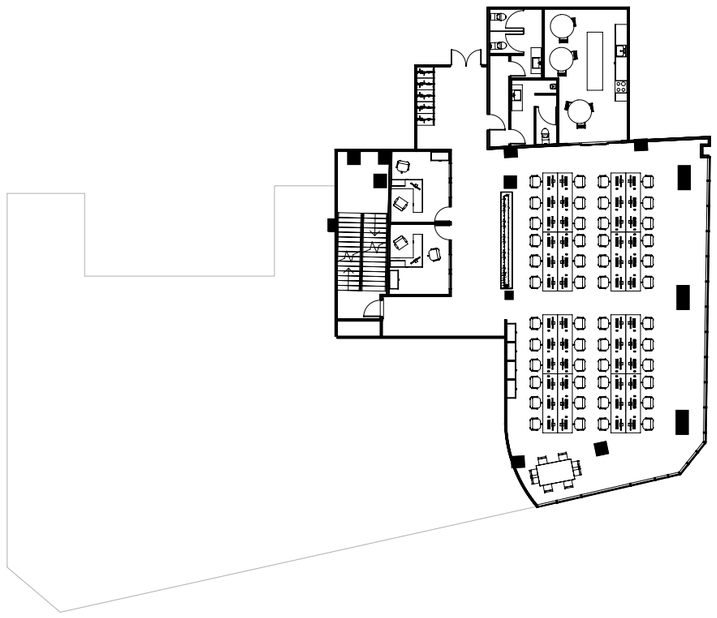
Floor Plan Minimization	
Refined Concept	
Figure 27	



CMIC Office
750m2



Minimized 32%
510m2



Minimized 56%
330m2

Minimize

Floor Plan Minimize	
Office Minimization Diagram	
Figure 28	

Similar to diagram II in figure 22 within the 56% minimized model, the heart of the office becomes the office work floor, which identified in the previous design phase does not align with the design goals sought out for the end users of the office space. This along with the fact that the IVLAB although may be able to be shifted to a more remote style of working is still crucial to that of CMICs' business.

This has led to the minimization of 32% being the ideal spatial configuration of this design phase and as noted in design phase I the next focus will be to continue design for the key patterns identified during the VR user study. The systems within the architecture that will be redesigned will consist of the central axis which as noted by participant 8 was a key area for users entering and exiting the building, this area will be designed to encompass more storage (a need noted in charts 2) and greater comfort / welcome as the pathways recorded in figure 13 show case very few users take the path of the central axis. The working office area will also be an area of focus, focusing on the personal desks and how this system can reinforce a change from private and social work styles without having separate focus zones as explored in previous design phases.

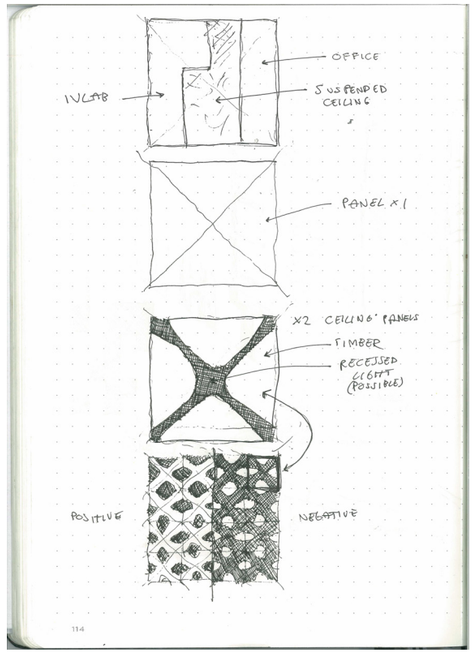
Finally, the interior materiality, color and lighting will be re-designed as although not noted as a problem during the case study the vivid notice-ability of these elements present an opportunity for these elements to be enhanced through re-design.

Central Axis

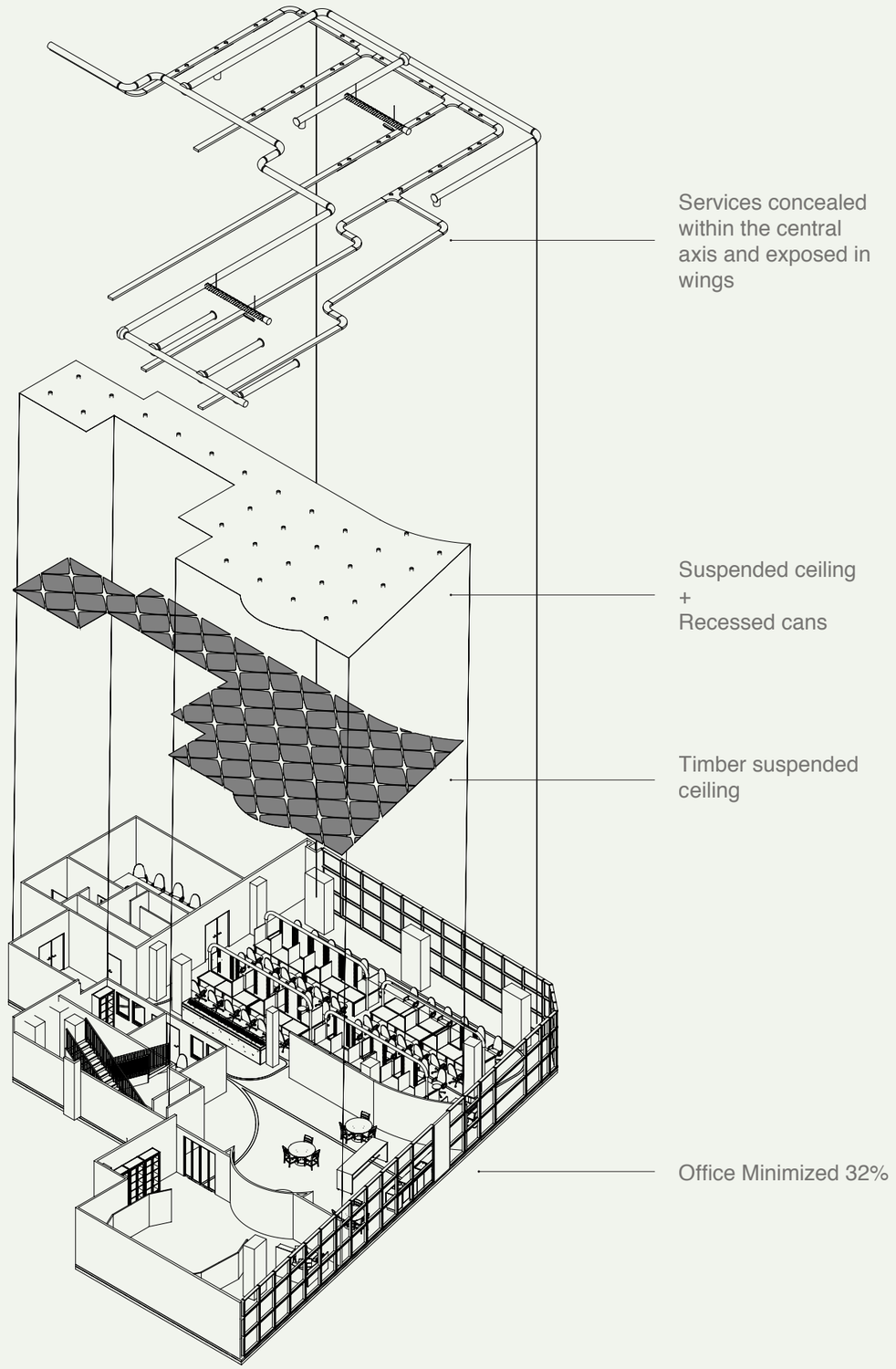
Central Axis

When visiting the CMIC office it was clear that cycling was an existing means of transportation to and from the office. In order to promote sustainable transportation for CMIC whilst providing a break out space / area of welcome and congregation, mounted bike storage and accommodation for personal items are introduced as soon as one enters.

To improve the welcome and comfort of the central axis the design solution chosen was to conceal the services and integrate a warm timber suspended ceiling running through the communal area. This design consists of strong linearity that is supported by the introduced embossed pathways located on the floor slab. By concealing the services within the central axis a key distinction is made between communal spaces and working spaces. Both the IVLAB located on the left wing and the work floor located on the right expose all services providing extra ceiling height to encourage creative thinking and subconsciously delegating spaces of relaxation and work.



Central Axis	
Ceiling Concept Sketches	
Figure 29	



Central Axis	
Exploded Isometric	
Figure 30	

The timber ceiling was chosen as the innate warmth and comfort of the materiality provides the space with affability, an element that was thought to be missing within the previous office space. This material is then accented within the floor slab, certain walls and furniture. This aims to successfully promote the central axis connectivity, reduce the need for users and clients to pass through non stimulating and uncomfortable spaces and promote a heightened interconnectivity between spaces of comfort and stimulation.

Central Axis

Entrance / Communal	
Central Axis Visualization	
Figure 31	

The client feedback area located at the heart of the office is then recessed into the IVLAB not only creating a space of solace but achieving a programmatic integration without having to create an isolated room. Within the IVLAB the curvature of the feedback area creates a gentle accent that angles the view of users along the curved wall and into a space of collaboration, interaction and creativity.

IVLAB

IVLAB	
Visualization	
Figure 32	

Work Floor

Minimize

5.3 Design Phase III

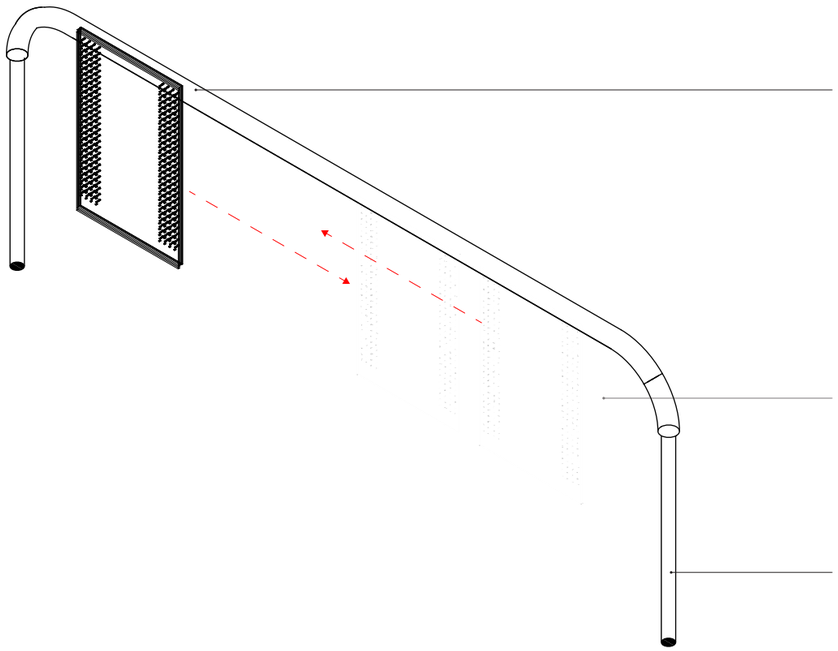
Working Office Floor

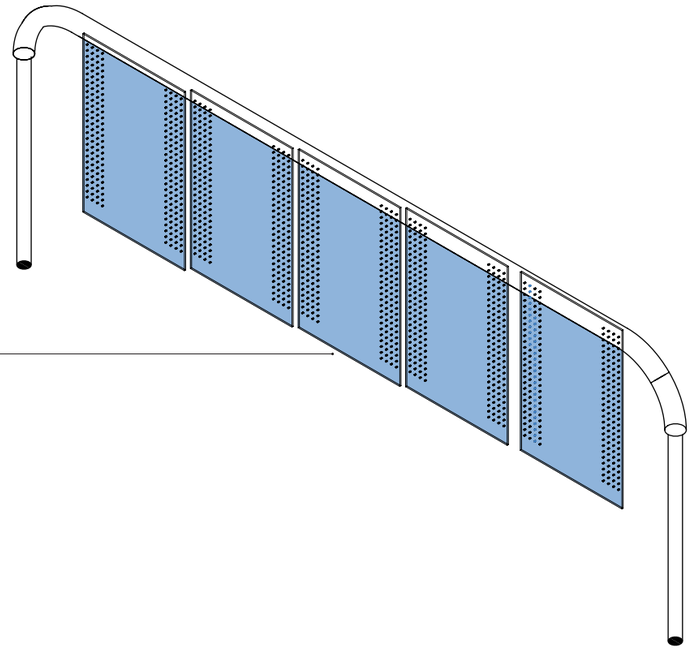
When re-designing the office floor plan it was important to note that the original orientation was favored by the end users. Upon reflection this was shown through the user study data and mapped out in chart 1. This led to the design decision to keep the work floor in the current position and slightly shift the configuration of the meeting room to the west of the working floor. Although the program of a private meeting room is still existent in the proposed floor plan, many focus areas from the previous design phases were excluded as the proposed floor plan does not accommodate enough floor space. This created a demand for end users to have the flexibility of changing from collaborative work and open plan working styles to more focus work without having isolated rooms to escape to. In order to achieve this, the work floor systems were redesigned.

The proposed work floor design consists of two newly introduced components that allow for the workers at CMIC to retain the ability of both a collaborative working environment and an individually focused working environment without having to compensate with added floor space. The floor area, desk space and seating arrangements are kept consistent to that of the original office but now the users are introduced to adjustable partition walls, acoustically treated that create both peripheral focus and noise reduction. The first component is that of a double desk length light weight frame that hosts a recessed sliding rail, in which acoustically treated panels are able to be slid to the desired area, in order to accommodate for either social working or individual working environments (Fig. 30). The second component is that of the desk redesign where light weight bamboo partitions lined with acoustic panels are vertically lifted and latched to create visual and noise barriers between desk spaces, once again allowing for shifts in work styles without having to move hardware, paperwork or the individual to a separate space (Fig. 31).

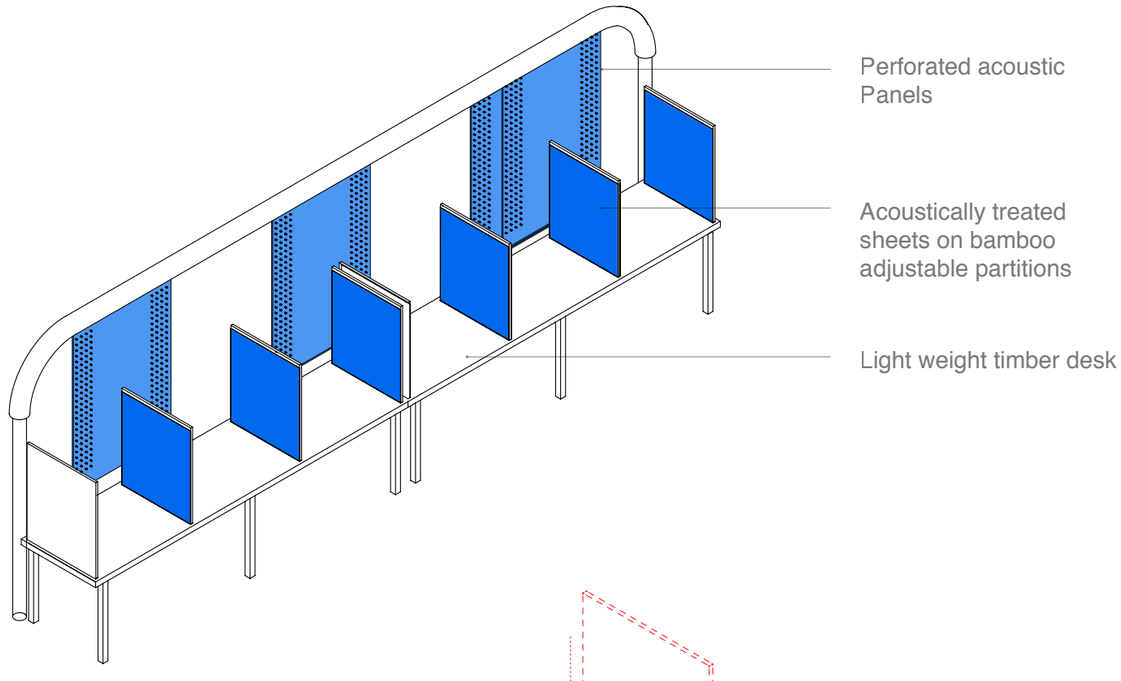
By designing a new working system that eliminates the need for dedicated private working rooms, the office floor space can remain minimized. This in turn not only allows for the end users of the office to have deeper connections and spatial usage within the areas that were recognized to be the most stimulating and comfortable (chart 1 user study) but successfully creates reduced connections between disliked pathways and areas of the office.

It is important to note that the conceptualization of these new components are in order to visualize the new architectural systems for phase III. The exact dimensions of these new components are to be determined.

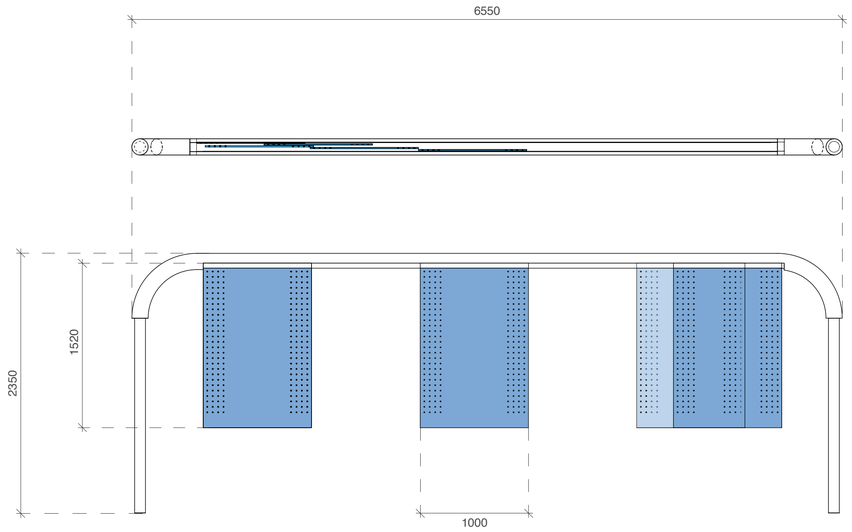




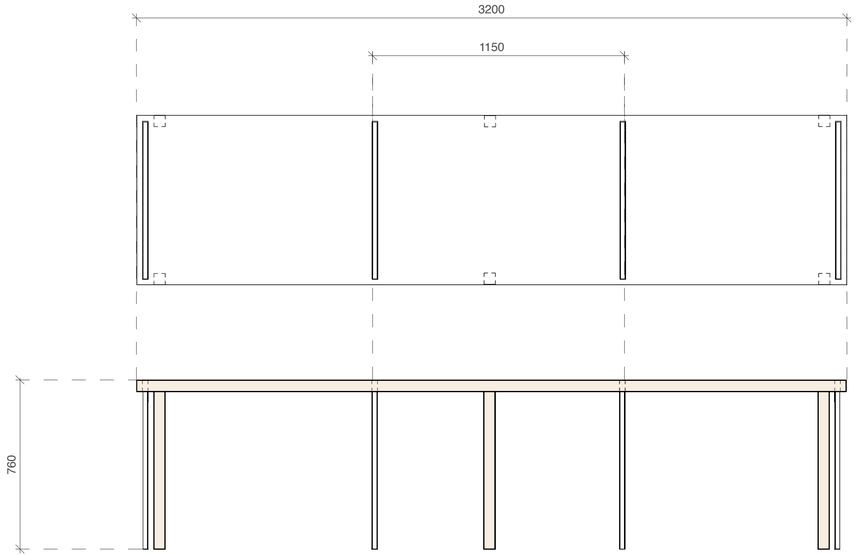
Partition Wall	
Mechanics Diagram	
Figure 33	



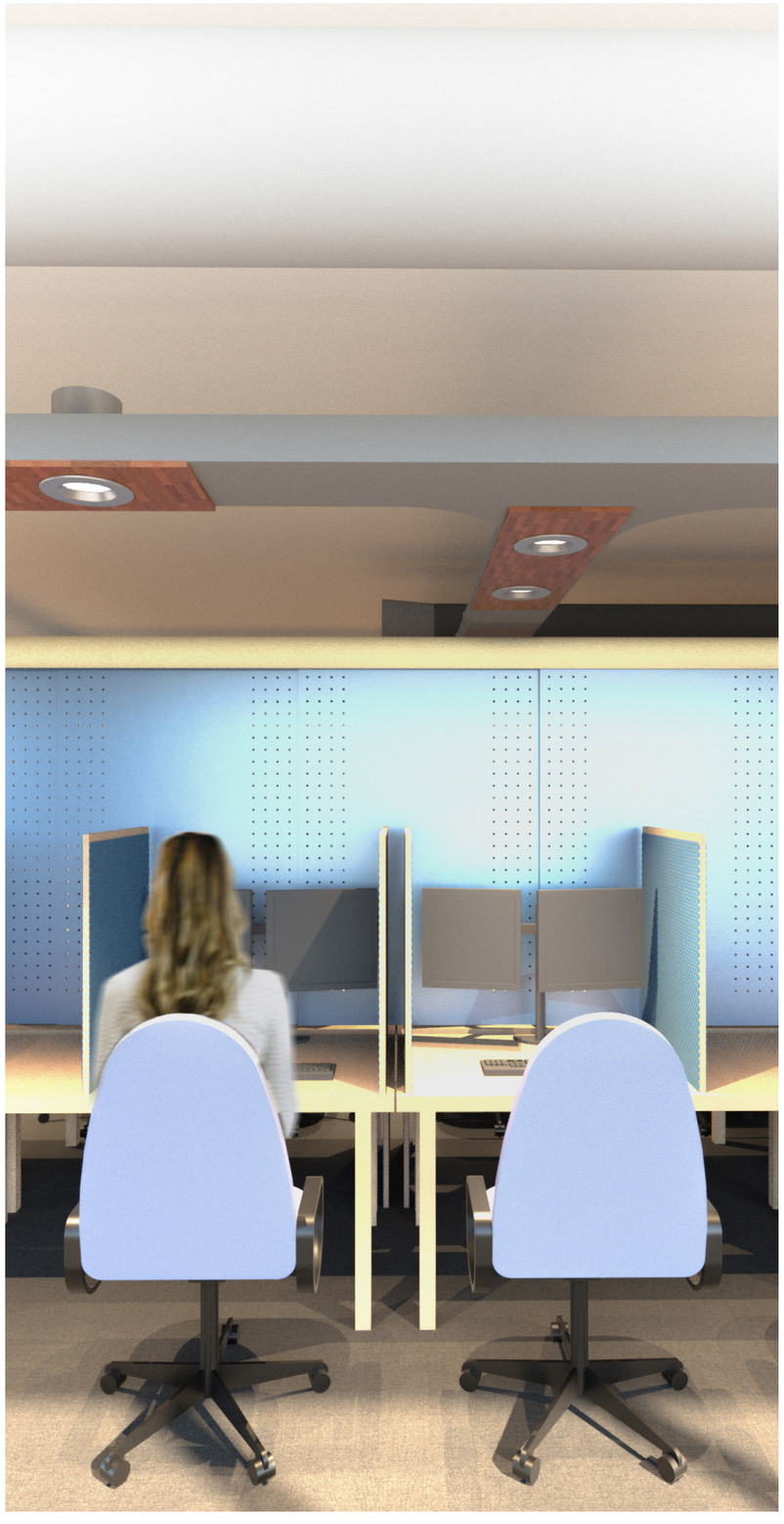
Desk System	
Mechanics Diagram	
Figure 34	

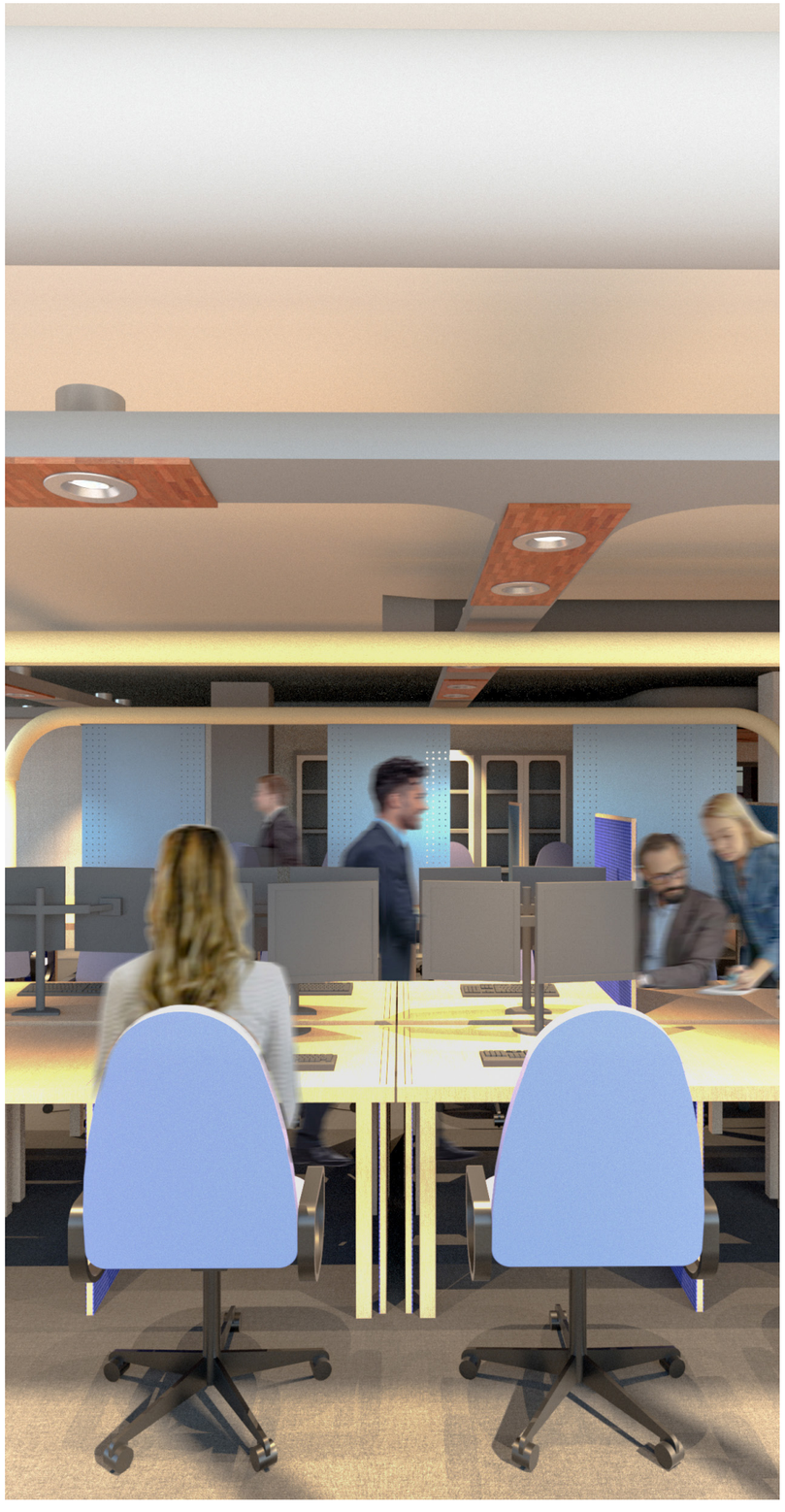


Partition Wall	
Plan and Elevation	
Figure 35	



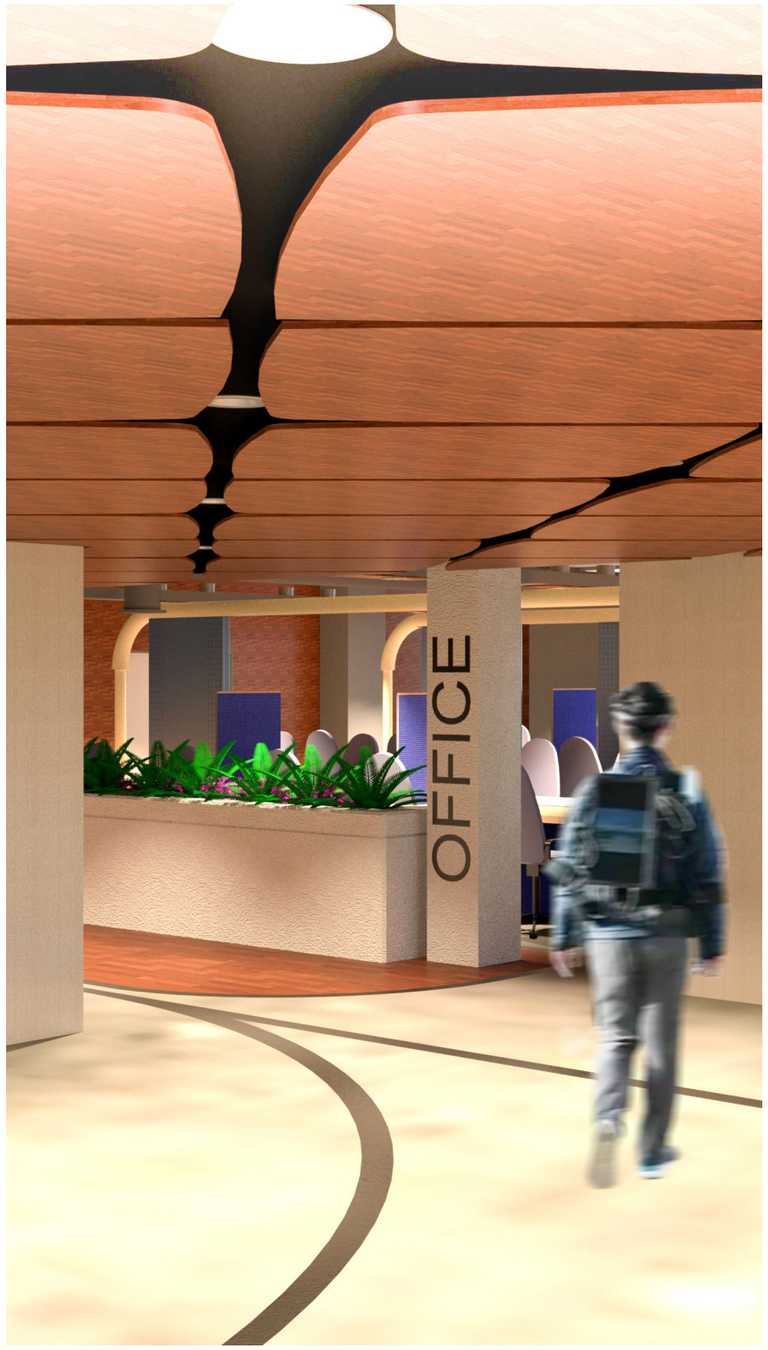
Desk	
Plan and Elevation	
Figure 36	





Seen within figure 32, the work floor systems adjustable partition walls create a clear, innovative and flexible work space. Storage units for VR equipment, robotics equipment and or other needed tools can be stored in units located to the south of the work floor. Interchangeable desk configurations are also easily managed as the designed components are not only modular but built with structurally lightweight materials, maximizing flexibility within CMICs' collaborative and creative work culture.

Work Floor	
Focus and Social Work Visualization	
Figure 37	



Minimize

Communal Area	
Work Zone to Communal Space Connection	
Figure 38	

5.4 Design Conclusion

To conclude the design phase, three conceptual design methods were explored; expand, constrain and minimize. Each design phase was a continuous and additive process where knowledge from the previous explorations informed the following through both internal and external critical reflection.

The resulting design draws influence from the relative literature sourced, encompassing the known programmatic office spaces and spatial configurations defined in Chapter Twos framework. This alongside the frame work used to improve well-being for office users created an opportunity to explore an architectural design process unprecedented; through the use of virtual technologies as an applied tool during the design process for New Zealand offices and end users.

Minimizing the CMIC office floor space was an attempt to solve the spatial comfort and stimulation found within the VR study whilst improving the details of working systems, materiality and lighting, all of which aim to answer the ability to improve the well-being of the end users. Following this design, the need for client feedback allows for an external form of criticism that will alongside an internal critical reflection will inform the conclusion of this research and the potential this methodology has when designing in architecture.

Upon critical reflection, I believe that the integration of materiality and lighting to improve the usage of the central axis, detail components of the office, as well as acting as a subconscious informant of programmatic functions creates a successful solution to the opportunities found within a methodology of office design previously unexplored.

The reduction of CMIC offices footprint, in turn improves the financial attractiveness of the office space. This design phase not only retained the spaces of comfort and stimulation within a minimized area but reduced the disliked spaces and improved the overall connectivity leading to what can be theorized against the framework produced in the literature review as a successful intervention. At this stage, the potential for design through the methodology of applied virtual technologies can be seen as a strong motive to continue research within this field.

Scan the QR code below with an iPhone camera or QR code viewer to watch a complete walk through of the design phase three proposed CMIC office design; Minimized

Client Feedback

Clients
CMIC office workers

The participating office workers included participants of the case study, those who did not participant and some management staff.

The client feedback acted as an informal presentation where I proposed my design solutions to some of the end users of the CMIC office and in turn the end users filled out provided feedback forms indicating how the performance of the proposed designs compared to their existing office.

This stage is the final stage of my research and integrates with phase IV within the methodology created.

The presentation took place on a Monday afternoon with a total of seven end users attending in person and two remotely over the teleconferencing platform, Zoom.

The presentation itself was received well with high discussion and questions being raised throughout the presentation. It was clear that the methodology and design outcomes sparked interest for many of the workers and the feedback forms reflect this, with all three options rated highly, all seen as to improve the well-being of CMIC rather than worsen it.

Key questions were raised about the potential this research methodology has in future projects with many end users curious as to what the next step was. The CMIC staff were interestingly convinced by the design proposals for connectivity and enhancement of liked spaces seen in both phase I and II.

The translation of this data into the minimization phase III was also appreciated with one participant stating that the material and detail change indeed improved the welcome and invitation of the central axis.

Overall the engagement of staff discussion was greater than expected and the feedback received was collected via an informal discussion, recorded on zoom as well as through a provided questionnaire/feedback form. The total time of the presentation including the questions and answers was roughly 1.5 hours long with only a 30 minute time slot estimated for the presentation.

The raw feedback forms from the presentation can be found by scanning the QR code.

Feedback / Questionnaire

Compared to the current CMIC office how does the proposed design compare?
1 = Worsened
5 = Same
10 = Improved

Expand
In terms of creating a balance between collaborative, private and focus work how does the proposed office compare?
1 — 10
In terms of reducing unwanted noise and work style ,how does the proposed office compare?
1 — 10

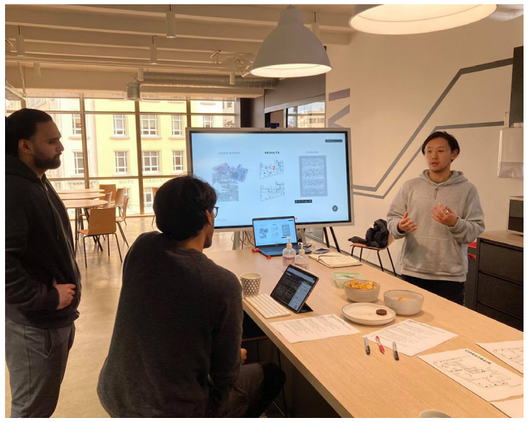
Constrain
In terms of creating a balance between collaborative, private and focus work how does the proposed office compare?
1 — 10
In terms of reducing unwanted noise and improving work style ,how does the proposed office compare?
1 — 10

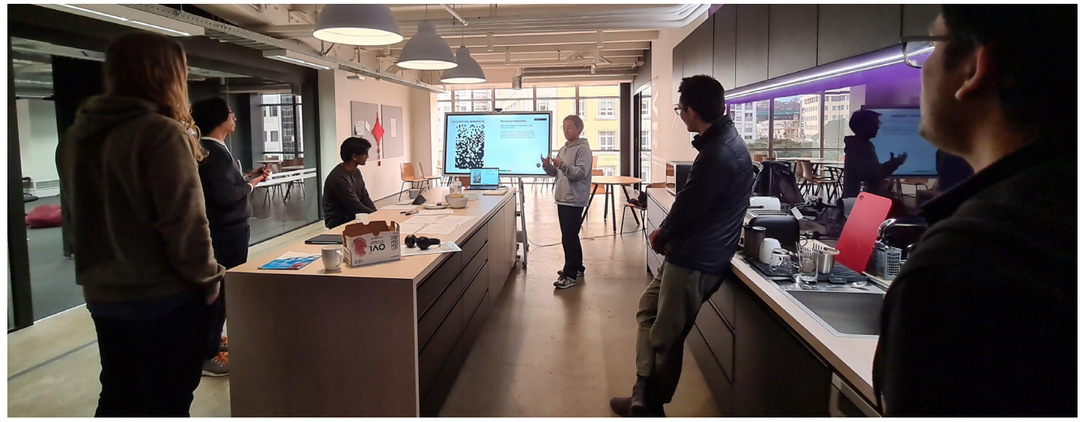
Minimize
In terms of creating a balance between collaborative, private and focus work how does the proposed office compare?
1 — 10
In terms of reducing unwanted noise and work style ,how does the proposed office compare?
1 — 10
In terms of improving the materials, how does the proposed office compare?
1 — 10

Overall which of the proposed office design can you see being most successful for CMIC in order of 1-3, with 3 being the least successful.

- Expand
- Constrain
- Minimize

CMIC Feedback	
Client Feedback Form	
Figure 39	





CMIC Feedback	
Client Feedback Presentation	
Figure 40	

Critical Reflection

Post presentation and client feedback, as a measure of consistent internal analysis it is important to once again critically reflect on the process of this research. Taking into account the process, outcomes and final developments produced to answer the research question.

Prior to the client feedback session, it was believed that the architectural interventions produced were successful. It is clear that this claim remains consistent, with feedback from all clients show casing both expand and constrain design phases improving the office in terms of noise, privacy, collaboration and work styles. Design phase III was then less successful with two out of six of the clients believing the minimize phase did not succeed as highly within the mentioned fields but greatly succeeded with the materiality of the office space.

Overall the office concept that resonated the most with the end users of CMIC was the expand phase, with an average rating of 7.9/10 (10 representing the greatest improvement, 5 representing no change and 1 being a worsened space) the rating taking into consideration the offices collaboration, noise, privacy, work style and connectivity. The constrain phase was preferred next with an average rating of 7.6/10 and the minimize phase was noted as 6.8/10. All concepts, through the eyes of the clients, successfully improving the spatial configuration and well-being for end users within CMIC.

These results can then be seen to support the success in using immersive virtual reality technologies as an applied tool during the design process. The benefits of this methodology and the ability to extract unprecedented information from clients not only created the opportunity to identify the architectural implications the CMIC office had to on the end users but also demonstrated a highly implacable methodology that has great potential for commercial application within future design.

Although the architectural proposals range along the scale between more speculative and practical design, the feedback and comparison with the existing office showcases how minor details and artifacts can influence the well-being of end users in the built environment. This is shown through how the architectural exterior of the office was kept relatively original whilst focus was instead placed on key elements that were noted as “important” or for some reason “symbolic” to those who participated in the user study. The function of these elements then can be seen to serve not only a practical role within the office but an emotional role to the end users.

This discovery then fruitions the concept that an unconventional process of architectural research, allows for designers to not only produce specific requirements for architectural elements seen in traditional research methods but tap into deeper spectrum of spatial configuration and the emotional relationship users have with space.

Ultimately this research method has allowed for the culture of an office to be discovered. By implementing 3D scanning and virtual technologies the understanding of CMICs' cultural values created avenues for design solutions that improved well-being and spatial quality. This methodology brings the emotional concepts of space and molds additional information about spatial requirements and architectural components to create great depth and layers, addressing both a functional and emotional aspect of space.

6.0
Conclusions

Commencing this research, it was clear to me that virtual reality and immersive technologies were beginning to strike as impactful tools for more than just presentation / visualization in architecture. My realizations on the potential were yet to be discovered but at the time of entering this research my curiosity was highly present. With very little experience and slight exposure to 3D technologies in relation to architecture, my understandings of these tools were small and therefore my initial understanding of the potential these tools had as a means to research were restricted by my own lack of experience.

The May review posed opinions and views that contradicted the ability of the methodology I proposed. At this stage of the research, reviewers were still skeptical about the “difference” a virtual replica of an existing space had when exploring the needs of spatial re-design and the relation it has with improving well-being.

In hindsight, this was to be expected as the application of previous precedents were not in the same context of mine and were not exploring office spaces in relation to well-being. It was only after August review, following my established methodology and completing the user study, creating a virtual version of an existing office for end users to experience, that the concept of extracting deeper layers of information directly from the client was realized and appreciated by reviewers.

After the user study, I realized the spatial and emotional relationships discovered were not directly correlated to the technologies themselves but through the application of these technologies, using them as combined apparatuses during the design process. Through the combination of 3D scanning and virtual reality a fundamentally different environment could be experience through a virtual replica of an existing space. This alongside the support of the previously found literature re-ignited my curiosity and allowed me to realize the potential the application of these technologies through design.

The research question asked within this Thesis was “What is the potential of immersive virtual reality technology - using 3D scanning, as an applied tool within the design process, to better understand the spatial requirements and well-being needs of contemporary office spaces and their end users?”.

To realize this, the Thesis followed an ordered and additive process which can be represented in three sections:

- Establishing a methodology
- Development of the methodology / Testing the methodology
- Show casing the potential through applied architectural design phases

Within the first chapter of this Thesis a framework was created through relevant literature. This was critical as it allowed for a basis to which the results of the design phase could be evaluated against. The literature themes identified that the crucial components for well-being within an office were influenced by elements both architectural and non-architectural, elements that were both physical and ambient and the relationships and interactions between people; a component that lies on the foundations of emotions. These components were later realized to be the crux in discovering the company culture.

Through the change in experiential mediums, virtual reality provided an avenue in which an alternative perspective of the physical environment could be experienced in an immersive setting. This alongside the literature supporting a deeper potential in emotional connection between users and space when in VR, allowed for the tools applied to be show cased as successful instruments when identifying the emotional connections end users have within their offices.

The establishment of a methodology was then produced. Due to the nature of the well-being of individual workers being subjective to each other, a human centered client research method was developed. This methodology was centered around immersive virtual reality technologies and interactions, observations, comments and responses of each end user acted as the primary data set needed to produce design. By responding to workers one at a time, this allowed for individually specific information to be extracted from multiple end users of the office, and when collated produced an overview of personal preferences and key patterns used as the raw data to inform design decisions.

This methodology was then tested and refined before being implemented on a group of end users from a chosen office in Wellington. The data produced two sets of information show casing a deeper connection users had with their space. One set emphasized emotional aspects whilst the other show cased more pragmatic requirements of the office, specific to their place of work. These results allow for information unattainable through traditional research methods whilst still providing the technical information attainable through the said traditional route. Both aspects necessary to directly inform the spatial qualities needed to enhance the well-being of the end users.

The design process was then an exploration of the opportunities identified during the user study. Each design phase directly aiming to address both the emotional and technical aspects noted within the primary data sets. This resulted in the spatial configuration of the office space to focus on the improvement in programmatic connectivity redefining the spatial configuration of the office. Detailed components within the new spatial qualities were then also designed to support the new proposal whilst simultaneously enhancing the well-being of the end users.

The discovered culture within the office was the combination of end users as individual entities responding to a fixed space with unwritten social rules. By tapping into the emotional level and relationship workers have with their spaces, opportunities arose for detailed components, artifacts and elements to be re-designed with the aim to better the spatial experience for the end users resulting in an improved overall well-being.

This extraction and look inside company culture show cased potential unprecedented by traditional research methods and created avenues for other possibilities when applying technologies as tools to provide spatial qualities that improve the well-being for end users in their respective offices.

My realizations to date are that the establishment, development and application of this explored methodology were key to presenting the potential immersive reality technologies have as an applied research tool. When coupled together, the 3D scanning process allowed for a realistic representation of the physical space and VR as an immersive technique of visualization. The point cloud visualization provided qualities that were unmatched through digital renders, this allowed for higher presence within the virtual environment and through VR and the location being that of the office, the immersive experience was enhanced greatly. By situating the virtual office experience within the context of the original office a potential for direct environmental comparisons can be present. This created greater awareness of elements and subtle details that may have appeared different / stood out within the virtual realm compared to the physical.

Through the application of this methodology three design phases were developed at three scales in relation to the existing office space. All designs were realized to have enhanced both the spatial quality and well-being quality within the office but not necessarily through architectural intervention alone but rather through the discovery of company culture and the ability to manipulate space at an emotional level, benefiting and encouraging an enhanced working culture for the end users of the office. All three design proposals were then presented to the end users and feedback suggests all three designs can be considered as offices for CMIC that improve the spatial quality and well-being for the end users. This successfully achieves the aims and scope of a Masters research project and clearly show cases a potential for the implementation of immersive virtual technologies such as 3D scanning and virtual reality as applied tools during the design process.

Limitations

Upon reflection several limitations can be found which are in relation to costing, quality of captured environments, software capabilities and participant information gathering.

This research heavily relied on the usage of 3D scanning as a means to capture the surrounding environment of the explored office. Due to accessibility and costs there was a limited range to the options available when selecting the 3D scanning hardware for this Thesis. In saying this the quality of the BLK360 is high but not considered the leading piece of equipment within its field. The ability to have access to higher quality scanners could have enhanced the point cloud information and reduced the time of scanning greatly. This would in turn allow for a more immersive virtual environment when establishing the “digital office”, model.

A large limitation also falls upon the capabilities of the software chosen. The registration of the 3D scan was completed through Leicas “Register 360” program, a software that was in fact very successful at exporting the needed file types. The limitations came through the visualization of these point clouds in virtual reality. The nature of point cloud information is dense and this density directly influences the size of the exported files. Currently the ability to load and view point cloud information in VR in real time is limited and programs such as “Unity” and “Unreal Engine” compromise the size of the files by reducing the image quality when viewing the virtual environment in VR. The chosen software “Faro LT Scene” produced a smoother experience but buffering and lag were still experienced within VR, with the quality of the files viewed on Leicas registration software being reduced as well. Point cloud to mesh was an alternative option, but once again the soft wares available did not provide solutions that sustained the quality and density of the original scanned environment. Due to this, through future improvements in software capabilities and file size handle ability the overall immersive quality and visual representation can be increased. This being a key component in refining the methodology and presence whilst in the virtual office.

Finally, the participatory data collection can be seen to have limitations due to the fact that all individual participants hold subjective opinions of the space creating information that can be viewed as contradictory. This can be seen in “Figure 12 – spatial diagram 1” where spaces such as the kitchen and the south western private working space have equal amounts of dislikes and likes in terms of comfort and stimulation. The fact that only a portion of the end users of the space were the generators of all the primary data sets also raises the question of what significance the proposed design solutions hold to the entire company rather than the participating staff. This information was handled through subjective design methods where spaces of importance outweighed those of less importance within the eye of the designer. In saying this, a method to mitigate this limitation could be to increase the overall user pool, recruiting more end users within the case study stage and therefor reducing the amount of outliers and increasing the chances of pattern generation.

Future Research

Future research following this methodology would seek to improve the quality of the representation of scanned data, through cost, time and software.

A note of success within this research can be seen through the final presentation of proposed designs, where staff of the office were able to critic the architectural interventions and compare them against the existing office. Subsequent research following this stage would aim to once again integrate an immersive experience of the final design options and therefor allowing users to experience both the existing and proposed through a virtual immersive experience.

By increasing the scope of office typologies, future research may be able to correlate and extract re-occurring themes within office culture, end user behavior and over all understanding of worker and work place at both an emotional and technical level. This would then produce a deeper, wider understanding of the underlying components of office design that inhabits and enhances end user well-being. Eventually a framework can be postulated, identifying the rudimentary spatial qualities needed when designing to improve the well-being for office end users through the use of immersive virtual technologies.

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Figure List

7.2

QR Code Links:

Acknowledgments - https://docs.google.com/document/d/1Qr6jNqBoMnMdKIXWJ5MfOXgjBlxOYxohbIHDBPGWf8I/edit?usp=sharing

A Brief History of the office - https://docs.google.com/document/d/1wA8gVPOIxojd_9nlzJIpSCin4nXlRB-Ioap1WAZedeg/edit?usp=sharing

3D Scanning Process - https://docs.google.com/document/d/1YVXnI91R-WJcssx0fyJBoOC6UPS0KoCq8bQ0sPXHDpI/edit?usp=sharing

Existing CMIC Office - https://youtu.be/korOHnGUSsU

Methodology Phase II 'Digital Office' - https://youtu.be/rsSxufyCW4U

Design Phase I Critical Reflection - https://docs.google.com/document/d/1RiMFy5Xp4x7z2XwP7QPHNmQ3q6d8LAYcmtjP68ALEy0/edit?usp=sharing

Design Phase II Critical Reflection - https://docs.google.com/document/d/1zYqvXK7gT7SLFK-qpwKvE3IDWKG6anDysvg9S6uOQi8/edit?usp=sharing

Design Phase II - Connectivity Analysis - https://docs.google.com/document/d/17eGNm73-YCJxmEg5a6G2Vt6TxZKAZ1k2AxEia9KEJc4/edit?usp=sharing

Design Phase III 'Minimize' Walk-through - https://youtu.be/2xG34inXIVk

CMIC Client Feedback Forms - https://docs.google.com/document/d/1NR_i3zu7zNRflUjvJ8lyCmfiDxd0m_VLRSf8QI97cls/edit?usp=sharing