The Office

The impact of the digital revolution on the office practices of early career academics

A thesis submitted for the degree of Doctor of Philosophy PhD at the University of Otago, New Zealand

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Abstract

This thesis is fundamentally about the digital revolution and its impact on the office practices of new academics. It explored the degree to which a group of early career academics were being influenced by ‘new ways of working’—a practice that is currently driving change in many organisations globally. The office activities of five millennial academics were monitored over a six-month period using digital still images to investigate space/place, continuous camera observations to investigate physical behaviour and computer usage logs to investigate visual behaviour. While the findings show the importance of the computer to daily work practice, and a degree of work practices extending beyond the office, the data revealed that the concept of the office, office practices and computer usage were more akin to traditional ways of working. This was a position reinforced by participants who, aware of the pace of technology and change, harboured a feeling of being left-behind. The focus on activity and the use of sensor-based data offered an opportunity to explore ‘new ways’ of undertaking higher education research. Rather than following the traditional perception-based research model, this study adopted activity as the unit of analysis. Digital sensors were employed to capture significant volumes of naturally occurring continuous data. The use of such methods in educational research is new, and for this reason, a central element of this thesis is the development of a preliminary blueprint for a new methodology focused on ‘precision research’. Finally, rather than academics being the drivers of change, it is argued that as a learning organisation, the university is responsible for addressing academic and professional progress in times of turbulent change, and that it is the institution that is best positioned to plan for and drive positive change. Universities that overlook or disregard these progressive, technological practices are unlikely to yield valuable knowledge or relevant knowledge workers. Like so many large commercial organisations already, universities too could be left-behind.

Acknowledgments

This thesis is the result of the collective efforts of a number of important and valued people who have directly or indirectly assisted and supported me in this process.

Firstly, I must knowledge my colleagues who willing offered to be participants in the study. Without their cooperation, honesty and belief in what I was trying to achieve, there would have been no study.

I would like to express my sincere appreciation to my supervisors. To Professor Rachel Spronken-Smith for her helpful comments, guidance and patience over the entire process. In particular, her willingness to accommodate my relentless need to question and disrupt accepted narratives. Secondly, to Associate Professor Ben Daniel for the many discussions that have helped shape this work and for his belief that I was always on the right track.

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Preface

Development is impossible without change and those who resist change are therefore unlikely to develop.

As a senior lecturer in higher education and educational technology, I have had the privilege of engaging in research and teaching in the area of institutional learning. I am referring to the learning that takes place within academic contexts whether by faculty, postgraduates or undergraduates. I am passionate about education as an emancipatory process. This has led me to reflect on and explore various teaching and research ideas that could advance my understanding of how students and faculty go about acquiring the skills and knowledge needed to advance their life goals. Supplementary to this inquiry is the applied ambition of proposing plausible solutions that can have a positive impact on supporting individual growth, the substance of which was the catalyst for this thesis.

There was an opportunity to engage with the unfamiliar, to embrace the innovative and creative in our search for alternative and effective ways to change how we think and act in the process of education. This requires scrutinising the nature of the mechanisms that have formed our understanding of learning and the science behind this knowing. From the outset, two personal interests guided my direction. The first is the importance of the times as we transverse the linear landscape of the industrial revolution to the more lateral, sometimes messy landscape defined by the advances in the digital era. The second concerns my interest in the method of observation, particularly the ability to explore activities in natural settings, to sightsee for purpose and meaning in order to emerge with a new understanding.

Undoubtedly, one of the most influential observational studies on the practices of academic work of the last century is Latour and Wollgar's *Laboratory Life,* published in 1986 (Latour & Woolgar, 1979). Through the act of observation, they sought to, to explore how scientific work was conducted, which in turn served as a catalyst for the development of a new research approach—Actor-Network Theory (or ANT). Similar to *Laboratory Life,* this study represents an initial attempt at a detailed study of the daily activities of workers within their primary natural habitat. As with *Laboratory Life*, this study also struggles with the task of how to pack the world into words. However, unlike *Laboratory Life*, this work is not about scientific facts or the laboratory; it is about a revolution.

Revolutions reflect fundamental shifts in the way we think and behave: the old, no longer desired or useful, is discarded. A revolution in thinking and being has influenced the research approach reflected in this study. At the core of this approach was the need to address the shift from linear processing, synonymous with the industrial revolution, to the more lateral and sometimes chaotic innovative thinking that has spawned the digital revolution. The industrial revolution created ontologies rooted in process. The concept of mechanical automation dominated organisations from factories to offices, creating a fixation with productivity as a process.

The approach forged in this study attempts to break away from the methods associated with productivity as a linear, mechanistic process. Instead, I embark, with a degree of liberty, on a journey to explore, even invent, new ways of thinking about lived experience and how we might research it. Consequently, this work represents various attempts to twist and bend current conceptions, assumptions and pre-suppositions in the hope that it leads to unconventional forms pregnant with potential for spawning new ways of knowing.

Chapter 1

Introduction

> *In the twenty-first century, the technology revolution will move into the every day, the small and the invisible. The impact of technology will increase ten-fold as it is embedded in the fabric of everyday life. (Tugui, 2004)*

This thesis is fundamentally about the digital revolution and its impact on the working practices of academics. As an academic researching in the field of educational technology, I am acutely aware of the subtle but prevailing paradigmatic crises that are taking place as a result of new technological trajectories fuelled by radically changing demands. Early exploratory discussions with colleagues regarding this ‘revolution’ and its impact on their research, teaching and service work revealed an intriguing phenomenon. While my colleagues employed various computer technologies within their work practices, there was a common thread evident, that the pace of technology was moving too fast, meaning that some of these academics were feeling ‘left behind’. In one case, I recall a new academic saying something like:

> I am really keen to push my technology use, but I just don’t have the time. Teaching, research and administrative stuff pretty much uses up every day.…I don’t have the luxury of playing with new programs. I recently downloaded a text analysis package. I spent hours trying to work out how to use it… in the end, I scrapped it and went back to using a printed document with a highlighter.

Comments like these raise some thought-provoking ideas regarding the degree and diversity of computer use within academic practice. In particular, the comments question the role of computers within the daily work practices of an academic and the degree to which this use could be defined as innovative or progressive. In 2007, I undertook a survey of the factors affecting academics’ adoption of web-based teaching (Butson, 2007). While similar comments were also expressed, one of the core findings was a reluctance to innovate. While not explicitly explored then, there were indicators that academic culture/practice did not value innovation and therefore the institution was typically not configured to support, promote or reward academic innovators. That is not to say innovative practices were not occurring; I was aware of many. In fact, this is what motivated the 2007 study. Unfortunately, self-report research is regulated by participant perceptions and as such, it was naïve to expect one could, through the survey method, uncouple participant perceptions/values from their practice (Butson & Sim, 2013). As a result, I was determined that any future investigations I undertook in this area should focus on actual practice, rather than just the perceptions of use reported by the academics.

To avoid relying mainly on perceptions, I want to promote sensor-based approaches to capture specific types of data. The practice of lifelogging (the donning of various digital devices throughout the day) was considered as an appropriate method capable of 1) capturing data from a variety of temporal and spatial settings, and 2) generating a continuous record of activities necessary to meet the criteria of capturing an academic's daily life. Given that these methods had not previously been employed within higher education research, I felt it was appropriate to undertake a number of preliminary discussions with colleagues to establish the capabilities of, and receptivity to, this method, including clarity regarding relevant parameters. A core purpose of these discussions was to explore the types of work practices and the spaces where this work was undertaken. It became clear early on in these discussions that I had underestimated the array of settings that academics define as workspaces: academic office, business office, lecture theatre, various classrooms, cafés, home office, parks and laboratory. However, further probing revealed that while a number of these spaces were common to most academics, the office space was repeatedly cited as the primary workspace. It was also defined as a 'private' space, a space where the academic was able to be 'themselves', as opposed to being, in want of a better term, in 'performance' mode when undertaking duties associated with the lecture theatre, laboratory, classroom or staff room and so forth.

Consequently, I chose the academic office as the setting for the study. Given the spatial characteristics of an office, it was seen as advantageous to equip the office, rather than the person, with the data capture device. A single fixed surveillance camera was seen as an adequate data capture device for the purposes of the study. Cameras, however, only capture physical events;

virtual events such as those associated with working online would not be captured by the camera. For this reason, software designed to capture computer activity was seen as a useful solution. This solution would deliver a combination of video and computer usage logs, which would mean that all behaviour, both physical and virtual within the office would be captured.

Background

We seem to be living in an era obsessed with the idea of progress. Campaigns by governments and institutions championing the need to embrace 'change' is a persistent message of the 21st century (Lee, 2016). Surprisingly, the archetypal factors signalled as the drivers appear to be neither original nor innovative and include such topics as growing economic pressures (Guevara & Ord, 1996), global competition (Cartwright & Holmes, 2006), increased performance expectations (Burke & Cooper, 2006), technological advances and demographic and cultural changes (Alvesson & Sveningsson, 2016). However, the inference, which appears to be implicit in the current social psyche, is clear: change or be left behind. Untangling the various threads of what is actually changing and what is not, is a task that is beyond this thesis. Suffice to say that there is a growing acceptance that technology is affecting every aspect of life. The focus of this thesis is the changing nature of academic work and specifically the impact of computer technology. This requires some understanding of the impact of technology, the changing nature of work, the tension between progress and regress and the current attitude of the university to these forces.

The impact of technology

For many of us, it is difficult to uncouple the notion of progress and change from advances in computer technologies. While computers have always signified the dawn of a new future, there is general agreement that the explosion of computer devices, intelligent applications and cloud-based computing is occurring at a pace that is creating a fear of being left behind (McClure, 2018). It is a situation that is often reflected in the metaphor of a digital divide; a split between those who embrace the digital age from those who do not. Currently, the core technologies often used to define this divide are:

1) Social media, which opens different channels for communication that require new attitudes concerning openness and transparency, and new behaviours like sharing and

commenting. It is an environment where hierarchies are levelled through open interactions across social boundaries with anyone, twenty-four hours a day, seven days a week. These new social networks, while simple in their action, can have an immense impact on personal profiling, global recognition, and web presence: seen-to-be-seen.

2) Collaboration technologies that create virtual environments where a growing number of teams, systems and communities are networked in order to collaborate on complex research projects. It represents a new way of understanding time, space and place.

3) The shift from the desktop to the 'cloud' is creating a change in the way we engage in computer activities. It is a move to a more connected, dynamic environment where applications, processes and data are communal. Virtually every collaboration platform today has a cloud-based deployment option.

4) Mobility advances that allow us to work anywhere, anytime and on any device. This ability to 'connect to work' rather than 'be at work' is causing a shift in the way we define the work environment and is driving the need to adopt more flexibility in where, when and how we work.

It is important to note that the use of computers alone does not define the current conception of the digital era. As with the industrial era before, the digital age comes with various phases. For example, between the 1990s and the rise of the social phase that started in 2010, the presence of the computer (while digital) was understood as a 'tool' that assisted in the process of work. As a result, work processes over this period were typically hybrid in nature, incorporating a blend of computer and paper-based approaches (Butson, 2007). Figure 1 shows the recognised phases of the developing digital era from the 1990s to 2025. The hybrid state (1990s-2010) symbolised work practices that saw the demise of the typewriter in favour of the computer with the introduction of email, advanced word-processing and access to searchable information (World Wide Web). The ability to convert digital information to print meant the computer augmented traditional work practices. It was this ability to convert the digital to print that fortified the hybrid state of digital and paper systems throughout the early part of this century.

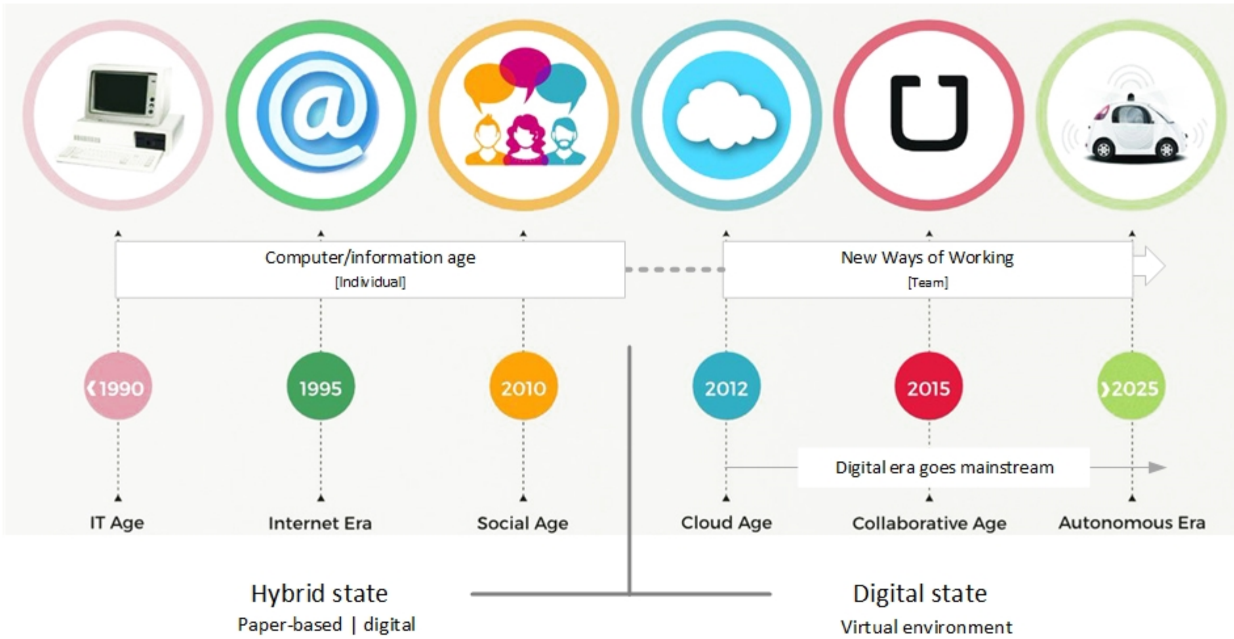


Figure 1. Infographic showing the commonly accepted stages of the digital age. Adapted from Digital Transformation: a Pivotal Moment Entering the 4th Industrial Revolution, Blaise Reymondin Digital Marketing (2010). Retrieved, March 2017 from https://twitter.com/reymondin/status/699153820736233472

It was not until 2011-2013 when operating systems, applications, storage, data, and processing capacity were able to exist on the Web (cloud computing) that the true potential of the digital era began to be realised. While anytime, anywhere had been around since the introduction of small, lightweight laptops in the mid-1990s, activity was restricted to the individual and their laptop. Cloud-based services changed this by offering the ability to work anytime, anywhere on shared documents, resources and applications. It signalled the genesis of a new way of working that was highly dynamic and therefore unlike the previous static style (Sadiku, Musa, & Momoh, 2014). Documents could be shared and edited without being transported via paper-based or digital conduits. If offered a new type of collaboration that was social and instant. It heralded a way of working that was virtual rather than physical, dynamic rather than static, parallel rather than serial and instant rather than gradual.

Changing nature of work

A cursory read through the current online business commentaries (websites, blogs, forums) leaves you with no doubt that our present understanding of the nature of work will soon be replaced by an entirely different concept, both in form and in meaning. However, it is the internet that provides the technological backbone on which this new future is being shaped (Barnaghi & Sheth, 2014;

Heerwagen J, Kelly K, & Kampschroer K, 2010; Wallace, 2004). Just as our current concept of jobs and work was formed as a consequence of the industrial revolution, the new digital age, it is argued, will spawn new notions of work (A. de Kok, van Zwieten, & Helms, 2016; Jooho & Jihwan, 2017; Ruostela et al., 2015). It is worth noting that as early as 2002, the technology-fuelled knowledge sector was already producing much of the globe's wealth (Florida, 2002).

A number of studies (Hauptman, 2015; Lyons & Kuron, 2014; Justin Marcus & Leiter, 2017; Stewart, Oliver, Cravens, & Oishi, 2017; Wilson & Starkweather, 2014) looking at our growing technology dependency and its impact on the way we work are suggesting a key indicator of technology adoption may well be generational. *Figure 2* shows generational differences are well documented; they are often overlooked in research that investigates the impact of change. This is unusual given the evidence that Generation X and Millennials are significantly different from the baby boomer generation in terms of their beliefs, values and practices, particularly concerning technology and work (Napoli, 2015).

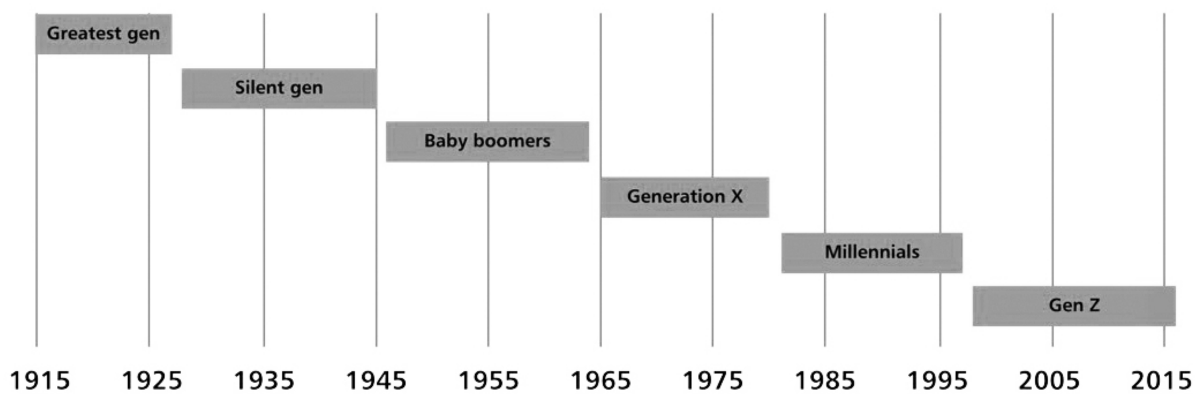


Figure 2. Chart showing the generation slices by approximate birth year/year of birth.

It is therefore reasonable to assume the generational values and practices of the X and Y generations are, through the use of digital innovations, transforming the way we think and engage in work. The early creative office cultures pioneered by the big Gen X tech companies are already being superseded by the newer Net-Gen phenomenon, known as the New Way of Working (NWOW) (Baane, Houtkamp, & Knotter, 2010; A. De Kok, Koops, & Helms, 2014). The New Way of Working consists of three distinct elements that are referred to as bricks, bytes and behaviour:

1) Bricks: the physical dimension, addresses all aspects of physical work environments;
2) Bytes: the technological dimension, addresses all aspects concerning the use and application of ICT; and
3) Behaviour: the personal dimension, which addresses all aspects concerning relationships and the way we work and experience work.

Banne, Houtkamp and Knotter (2010), researching this phenomena in its early form, outlined what they believe to be the four core work principles in the emerging New Way of Working:

1) Time- and location-free work: ‘Anytime, anywhere’;
2) The need to achieve results: ‘Outcomes not busyness’ and the need to ‘Manage your own work’;
3) Free access to and use of knowledge, experiences and ideas: ‘Unlimited access and connectivity’;
4) Flexible work relations: ‘My size fits me’. Unlike traditional work environments, NWOW grants workers the complete freedom to carry out their work in ways, times and locations that suit them.

After considering the work of Banne and associates, I conducted a series of conversations with technology start-ups regarding new work practices. It was evident early on that these four principles were important to the way these start-ups worked. As result, it was clear that this set of features offered a sound and tangible way in which to ascertain the degree of change in any work place.

Progress or regress

It is worth noting that simply using a computer does not guarantee effective, productive practice or improved quality (Triplett, 1999). Nor does it signal a guarantee that workers will willing traverse the digital divide (paper-based to digital). However, computer technology continues to advance to meet the growing demands of complex and competitive organisations. As a result, there is increased pressure on knowledge workers to become proficient and immersed in the evolving technological landscape. For those not loyal to the digital revolution, this new situation is likely to cultivate a state of fear and uncertainty (McClure, 2018). This is in stark contrast to the preceding century where the adoption of computer technology was optional and often perceived to have little practical use, with advocates such as Thomas Watson, president of IBM stating in the 1950's that there was only need for five computers in the world. Similarly, Ken Olsen, founder of Digital Equipment Corporation, stated in the 1970s that there was no reason for anyone to have a computer in their home. In fact, computer technology has a history of being accused of being time-consuming and of little use, a distraction that undermines efficiency and normal living (Sale, 1995). In part, this is due to the prominence of hardware and software glitches that plagued personal computers and the difficulties associated with operating these computers. As a result, the growth of computer technology has suffered from a level of resistance (Jones, 2013). Even today, with the proliferation of applications to aid in almost every aspect of daily life, there is a scepticism and fear of what computer technology is capable of, a fear that the machines and the people that manage them know and control too much. Some even argue that what we think of as progress is actually regress, that we are becoming increasingly dependent on our computers to the point of social breakdown (Fox, 2013; Jones, 2013). As Theodore Kaczynski (2010) maintained, while individual technology advances appear to be desirable, technological progress as a whole actually narrows our sphere of freedom. Kaczynski's idea is premised on the belief that technology is a more powerful social force than the aspirations of freedom for people, of which, he claims, technology will eventually reduce.

The University

How are these changes playing out within the university setting? Universities are human capital-intensive organisations comprising of knowledge workers who are, for the most part, independent and self-governing (Alvesson & Sveningsson, 2016; Davenport & Bruce, 2002; Hunter & Scherer, 2009). Unlike process workers, the work practices of academics do not follow an organised process or flow. This lack of process necessitates the need for a reasonable degree of dedication to the act of personal directives. Academics, like all knowledge workers, are self-determining entities within the organisation who are trusted to pursue efficient and productive means to achieve required goals. It is easy to see why computers have come to play a vital role in this process, given their capacity to process and manage information, automate non-value-adding routine tasks and enable sharing networks (Camarinha-Matos & Afsarmanesh, 2006; Ford, 2015; Phan, Wright, & Lee, 2017; Sanfeliu, Hagita, & Saffiotti, 2010).

However, as stated earlier, simply using a computer does not equate to efficiency and productivity. While advances in computer applications and hardware have been exponential this century, the fundamental applications that became the hallmark of personal computers in the previous century—email, browsers, wordprocessors, spreadsheets and presentations—continue to exist in new technologies today. To what extent these applications promote New Ways of Working is unknown. It is possible that traditional work habits can integrate new technologies with minimal disruption to how we work. This would mean that we are transforming new technologies to function within pre-existing ways of working, rather than new technologies transforming the way we work.

I spoke with a colleague who is a self-confessed technology geek about his procedure for providing feedback on students' draft essays. He prints the assignment and then add comments by pen directly onto the paper. Once completed, he scans the marked-up essay and emails this back to the student, whom, he added, invariably contacts him to query particular comments that they can not decipher, due to his irregular handwriting. I have found this to be a common practice. In fact, I have come across colleagues who have purchased printers with scanner functionality for this very purpose. When I questioned my colleague about this process, asking why he did not simply use the digital version and employ track changes, he replied that while it would be more efficient to do so, he was accustomed to working with paper when it comes to marking. It is not that he was using devices or software for purposes other than they are designed for, but more the sequence of tasks involved in this activity would not be perceived as progressive, productive, or efficient—the core qualities of technology. This situation highlights the hybrid nature in which technology use is often blended with existing forms of activity—the old and the new coming together in novel ways. While some of these blended activities are particular to individuals, I have seen many that have been adopted by others, a process whereby practice is transforming the use of technology.

Throughout my years of working with faculty and students, I have witnessed many similar examples of these hybrid states where computer technology is coupled together with non-computer actions in order to get the job done. These blends are typically inefficient, esoteric in nature and built up over time with no obvious cause or justification for their existence. Nevertheless, there are these sequences of action, blended together in a somewhat hybrid method that incorporates both the old and the new. We can all identify such behaviours in our own work practices as we navigate our way through the ever-increasing shift from paper to digital. In essence, these hybrid assemblages represent a glimpse into the evolutionary landscape that epitomises the colossal transformation symbolic of a particular generation straddling a ‘general purpose technology’; a prodigious group of technologies that can claim to drastically alter human life through changes to economic and social structures (wheel, steam engine, combustion engine, electricity, computers and internet).

However, there is a danger that the hybridisation of work practices can become persistent, resisting the perpetual nature of progress. Emerging and evolving work practices such as New Ways of Working have pursued the opportunities offered by the new digital environment and progressed beyond the hybrid state. The degree to which New Zealand universities have travelled along the continuum from paper-based to hybrid to digital is unclear. Suffice to say there is a view that there is considerable inertia within the New Zealand university sector and an unwillingness to progress (New Zealand Government, 2008; The New Zealand Government Productivity Commission, 2016).

Unfortunately, our ability to measure work states and the impact that progressive technologies have on work practice has a history of being fraught with difficulty, particularly concerning measurement and what is being measured (Drucker, 1999; Haas and Hansen, 2007; Bosch-Sijtsema et al., 2009). Any future studies aiming to address this topic will need to innovate in order to satisfy the issues of validity that have plagued much of the research in this area.

Purpose of the Study

The aim of this study is two-fold. Firstly, it provides a pragmatic investigation to understand how technological innovations have changed the nature of academic office work by early career academics. Secondly, it provides an opportunity to explore new ways of undertaking research that is more appropriate to the digital era. The focus on academic office work offers an ideal vehicle on which to review and practice various lines of research inquiry. Given the extent of technological advancement since the onset of personal computing, office related work was identified as the most likely space that would exhibit the greatest change in daily practice. At this level, the study represents an attempt to understand the degree to which advances in computer technology have shaped how we engage in the practice of academic office work. Moreover, how are we shaping technology in order to minimise change through assimilating technology within existing practices, as with the case of my colleague, discussed earlier? The focus is on the unassuming individual academic who see themselves as no one particularly special. They go about their daily activities interacting with colleagues, fulfilling academic responsibilities and progressing their personal goals. However, they are doing this in a time that is unprecedented in history—where technological advancement is occurring at an astonishing rate, creating a surge of change that has resulted in a shift in the paradigms by which we live and understand reality. It is here, at the intersection where the unassuming daily activity of the academic collides with the aggressive fast-paced demands characteristic of a general-purpose technology: the struggle between humans and machines (Brynjolfsson & McAfee, 2011; Jovanovic & Rousseau, 2005; Lang, 1927; Maurtua, Pérez, Susperregi, Tubio, & Ibarguren, 2006). It is at this intersection where we can observe these struggles and gain fascinating insights into the eclectic nature of how a group of early career academics are reacting to these changing times. It would seem somewhat ironic to engage in such an inquiry without exploring and experimenting with digital theories and practices. In this respect, the study also represents a profound and purposeful inquiry into what research in the digital era may look like.

Research Foci

The study represents an exploration into uncharted terrain and therefore is not well suited to specific research questions. The inquiry was guided by a desire to know how academics were managing daily practice in the mist of technological mayhem The dimensions of bricks, bytes and behaviour that has become acquainted with New Ways of Working, offered an ideal framework on which to situate the study. Three foci—office configuration (bricks), computer usage (bytes) and office practice (behaviour) guided the three empirical studies. Given the exploratory nature of the study, concrete questions were substituted with a series of abstract or soft queries. The list below is a fair depiction of early thoughts and represents the kernels of inquiry that drove the study. While these are addressed in various sections, a more detailed, comprehensive compilation of valuable ideas, practices and opportunities was created. While some of these are consolidated in various conclusions, many are woven throughout the thesis in order to give a contextually situated experience of the various overlapping elements.

Office practice

1. Bricks: The degree to which office spaces are configured to support collaboration, teamwork, digital devices.
2. Bytes: The degree to which computer use reflects current trends in cloud computing.
3. Behaviour: The degree to which academics' work behaviours and routines are grounded in multiple device use, mobility and flexibility.

Research in the digital era

1. The merits of researching activity.
2. The degree to which digital sensors can amplify our understanding of academic activity.
3. The need for a new educational research methodology.

Research Approach

As discussed earlier, research approaches in higher education research rely predominantly on data collection methods centred on surveys and interviews (Wells, Kolek, Williams & Saunders, 2015). As a result, much of our current knowledge of higher education practice is built on perception-based data. This thesis is guided by developments in digital technologies that offer access to new types of data which allow us to investigate what actually occurs (reality of practice), rather than what is assumed to have occurred (perception of practice). The core of this new approach is the use of 'sensor-based' systems that offer live feeds of data over continual periods. These new approaches are built on the emerging interest in understanding the impact that established behaviour patterns have on the learning process. Until recently, it has been difficult to capture the volumes of data needed to compute patterns of behaviour. However, new advances in network infrastructure and sensor-based technologies now allow: 1) the continuity needed to capture data over extended periods in order to analyse at a macro-level, and 2) the ability to capture the detail required to analyse at a micro-level. In both cases, any process employed will result in the generation of enormous amounts of data. Managing these data volumes is one of the challenges of these new approaches. The value, therefore, of these new methods will be contingent on our ability to draw on emerging practices within the field of big data analytics to find and develop relevant methods of data transfer, storage and analysis.

The research schema attempts to address these difficulties in capturing and making sense of academic office work in two ways. First, a relatively open interpretation of academic office work is adopted in cognisance of the unexplored nature of the topic within the university setting. It is, therefore, reasonable to assume that work practices within the university setting are likely to be different to commercial and other community institutions. Secondly, there is a need to engage new interpretive practices because of these new theoretical frameworks. These practices must then be applied so we can situate any new understanding within the contexts under investigation. What is being investigated is a composite of the 'perceived' and the 'real', of the obvious and the peculiar, of the noticeable and the mundane, in the hope of making tangible, any signs of change. It is an attempt to take our gaze away from the recognised measures of academic action that largely focus on outputs and to look instead at the very building blocks that underpin these outputs. In essence, the research concerns the routine and the mundane, but with the belief that within this seemingly ordinary, unassuming, monotonous dimension of daily life, lies the very elements of academic purpose and meaning.

Study Setting

The data for this study was collected between August and December of 2014 at the University of Otago, New Zealand's oldest and most research-intensive institution. The University of Otago has four teaching divisions: Commerce, Health Sciences, Humanities and Sciences with a student population of approximately 20,000. Academic workloads are guided by the traditional 40-40-20 schema, where 40% of the time is allocated to working on research, 40% on teaching, and 20% on service. The University's main campus is based in Dunedin, a city of approximately 120,000 people. Dunedin's small population, together with its close relation to the University makes it very much a university city.

Thesis Structure

In this chapter, I have explained the purpose of the study, provided a rationale and described the context within which the study is located, including a brief outline of the research design employed. The thesis is structured in three-parts, as shown in *Figure 3*. Part one covers the theoretical and contextual terrain. This is followed by part two, which focuses on empirical research comprising three related sub-studies. The third part synthesises and discusses findings from the three sub-studies.

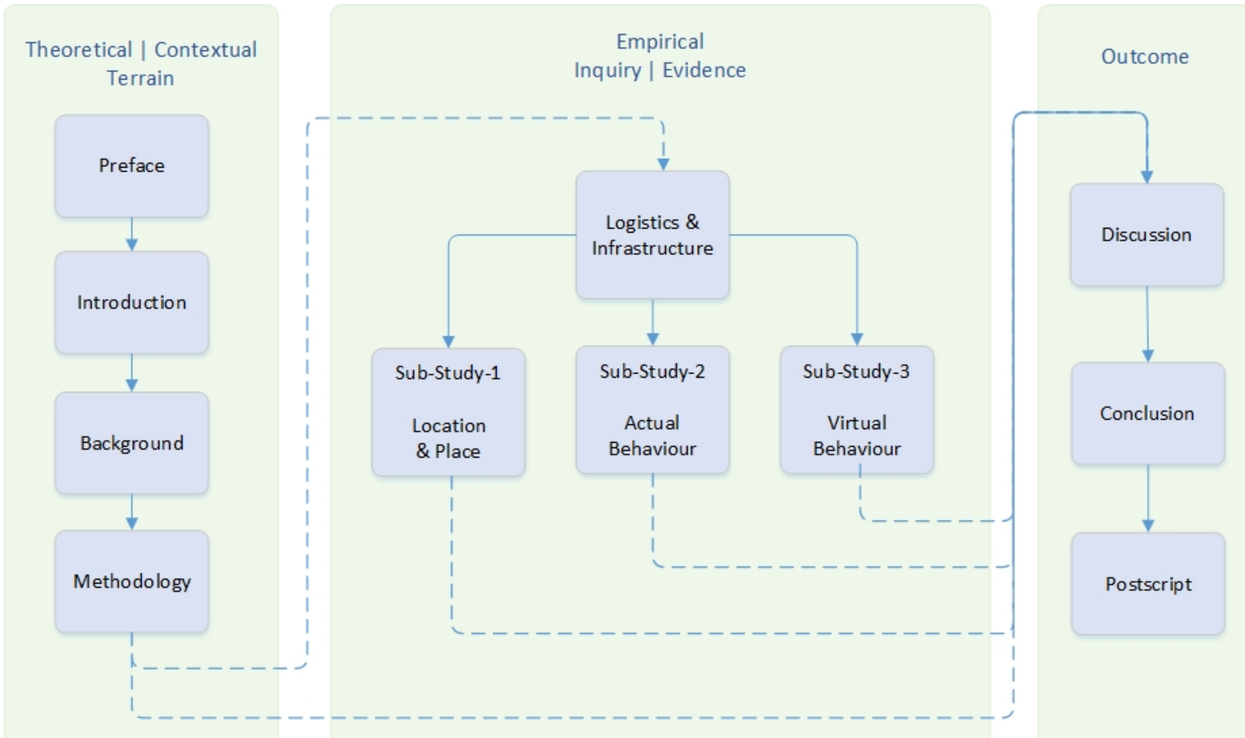


Figure 3. Schematic illustrating the thesis structure.

In the Background chapter, I discuss the five core themes that situate the study within the fields of work, workers, technology and higher education. This chapter begins with a discussion on the impact of technology within the digital revolution, followed by a proposition regarding the importance of generational groupings when investigating work practices. I then explore the emerging domain of ‘new ways of working’ that has spawned from the digital revolution. This is followed by a precis on the institution of higher education, particularly in light of the impact of the digital revolution and its awareness of, and willingness to, exploit future trends. Finally, I raise the theoretical and contentious topics of ideology, progress and the future digital imperative. The section closes with a brief but significant exploration of the challenge of how to address 21st century demands for teleological advancement.

The Methodology chapter sets out the various influences and approaches that underpinned the development of an innovative and appropriate methodology to guide this study. It signifies a tour of the philosophical and pragmatic terrain and the processes employed to fashion a cohesive and cogent research framework that conforms to a high standard of scholarship and rigour. The aim was to conceive of a new, powerful approach to educational research that is situated in environmental, psychological and physiological data.

A Logistics and Infrastructure chapter is included to describe the evolution of various approaches, including the stratum of system complexity and logistics when using digital devices to capture activity. It presents detailed information that could not be incorporated within the abridged sub-studies. The use of innovative approaches entails a high degree of research and development with significant time invested in testing various hardware and software configurations. All three sub-studies employed approaches deemed innovative in the practice of higher education research. As a result, a detailed explanation of the processes and procedures employed for each of the sub-studies has been included. The chapter closes with a short synopsis of pertinent challenges and limitations relevant to the methods employed.

Chapters 5, 6 and 7 are the three empirical sub-studies. Each adopts a particular lens to address the influences of office work: Bricks—the office configuration, bytes—virtual work behaviour, and behaviour—physical work routines. Chapter 5 explores space and place by investigating the digital transformation through office configuration in the university setting. Chapter 6 explores practitioner practices as they relate to the use of their office space. Chapter 7 investigates the virtual environment by probing daily computer work practices.

The independent contribution of each topic is discussed within the particular chapters. For this reason, the closing discussion concentrates on the combined influence of all three sub-studies to consider the broader matter of the digital age's impact on academic office work. It also felt germane to include a discussion on the relevance of the methodology and methods employed, both to the broader findings and to the future of higher education research. The thesis closes with a short conclusion that focuses on a number of core findings and the relevance of these findings to the future of the higher education sector.

Chapter 2

Background

The difficulty lies, not in the new ideas, but in escaping from the old ones, which ramify, for those brought up as most of us have been, into every corner of our minds. John Maynard Keynes (1965)

Unlike the industrial revolution with its focus on factories and the production of physical artefacts, the digital revolution has come to be recognised as the era of knowledge, a situation aptly matched with academia. As such, we would expect to see universities, in both research and education, at the forefront of this revolution. However, this is not the case (R. Harrison et al., 2017; Pereira & Wahi, 2017). While the digital revolution has impacted greatly on social life and business, universities have, to some degree, played a more passive role (Inoue, 2007). There is a long history of research looking at why technology adoption in universities has been low/slow (Butson, 2007). Typically, this is expressed in the form of barriers, such as: lack of time to learn; lack of purpose; lack of support and a general sense that technology is unreliable (Butson, 2007). Such barriers are also true for society generally and yet digital systems/devices in business, social and personal life continue to maintain a rapid uptake' as new technologies come to the market. Universities seem 'stuck' in a somewhat paradoxical state. On the one hand, as a knowledge organisation, they are likely to benefit the most from digital advances, and yet in some respects they appear to be the most hesitant.

This lack of engagement in the digital revolution represents a dilemma needing further investigation. In this chapter, I take a pragmatic approach by exploring five core topics that I believe are essential to understanding the character and trajectory of the digital revolution and the various associations that bind it to academic work. The process of writing this chapter, the physical act of investigating, sourcing, de/reconstructing, juxtapositioning, and assembling through protracted bouts of introspection, frustration and perspicacity, owes much to my insistence on trying to stay true to what I believe are some of the disruptive ideas and concepts that are emerging at the junction of industrial and digital revolutions.

The Digital Age (Impact of Technology)

While we tend to see computers and the Web as a relatively new phenomenon, it has a long and rich history punctuated with major shifts and phases. For the purists, that history started in the Victorian-era with inventors like Herman Hollerith who designed the electromechanical punched card tabulator to calculate census data, establishing a company that would ultimately become IBM. By the 1970s, Douglas Engelbart had built what we now define as the first modern computer that incorporated graphical user interface and a mouse. This marked an important shift in the evolution of the computer from an analytical, number-crunching machine for scientists and mathematicians, to a technology that was more accessible to business. But it was not until the 1980s with the introduction of ‘personal computers’ by Apple, Acorn, Commodore and Digital that microcomputers became truly accessible to the general public, albeit to selective groups. While the internet (connected infrastructure) had appeared in the 1960s, the introduction of the world wide web (a graphic interface) in the 1990s set the scene for the digital revolution. The Web heralded a new era where computers became commonplace in homes. The assemblage of three very powerful general purpose technologies (computer, internet and the World Wide Web) underpinned this surge of interest in information: a ‘perfect storm’ that spawned what we now know as the digital age.

The story of the digital revolution is an unusual one. Given that general purpose technologies are revolutionary (Jovanovic & Rousseau, 2005) rather than evolutionary, we would have expected the digital era to have been a major disruptor across all aspects of society. However, it was not, at least in the beginning. Thus, it was very different from previous technological eras. When compared to say, electrification, which spread quickly and broadly to the masses, the adoption of computer technology has been significantly slower. For many years, computer technology lacked a clear purpose and failed to offer any benefits over existing technologies. As a result, computer/information technologies have often suffered contempt and ridicule. In the 1980s computerphobia (Figure 4) appeared regularly in newspapers and magazines (LaFrance, 2015).

The 1996 publication *Women and Computers* claimed women were afflicted with a variety of conditions as a result of a fear of using, touching, or even discussing or reading about computers (Grundy & Grundy, 1996).

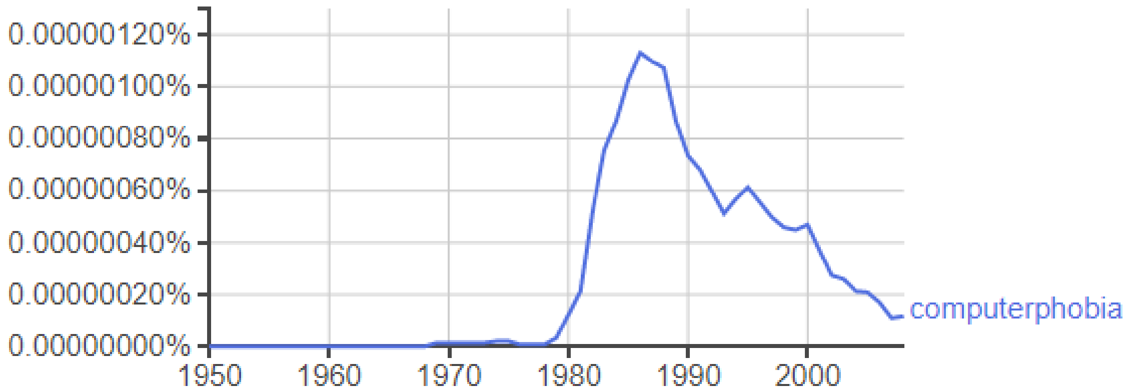


Figure 4. Graph showing Google references to 'computerphobia' in books over a 65-year period. Reprinted from "When people feared computers", by Adrienne LaFrance (2010). Retrieved, September 2016 from https://mashable.com/2015/03/31/people-feared-computers/#nA9ktH_sKaqH

It was not until the introduction of the World Wide Web (Web) that people started to perceive tangible affordances from computers for anyone willing to engage. By the end of the 20th century, computer ownership, internet connectivity and Web access were growing exponentially. At the turn of the century, computer storage capabilities and processing speeds continued to increase, but it has to be said that the main transformations were occurring because of the Web. By the dawn of the 21st century, a shift was occurring from computers as devices for information processing to environments for social networking. This period saw the rise of a second phase driven by Web 2.0 and was characterised by the shift from information-orientated, static web pages to socially-driven, dynamic, user-generated content, which drove the growth of what became social networking (Figure 5).

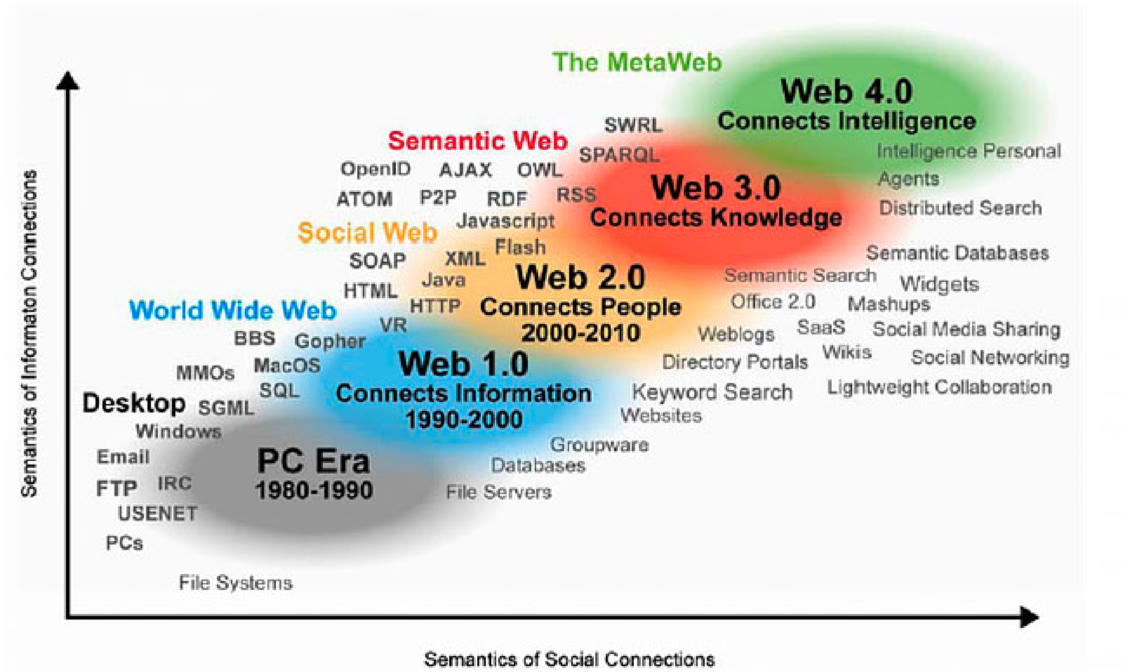


Figure 5. Diagram showing the development and relationships associated with the terms Web 1.0, Web 2.0, Web 3.0 & Web 4.0. Reprinted from Development of the WWW, by Nova Spivack (2007). Retrieved, September 2016 from http://www.radarnetworks.com/

We are now entering Web 4.0 where connectivity has expanded beyond the computer and integrates a level of intelligence previously unknown. This new phase is typically referred to as the Internet of Things (IoT), in which physical digital objects or ‘things’ can, through internet connectivity, assemble and swap data. It is an intelligent networking process that extends our concept of relationship to include people-people, people-things, and things-things. It also extends our action beyond static data to real-time sensor-based automation that leverages remote access to enable Artificial Intelligence (AI) control over many daily processes.

Because of the hype around AI and the IoT, few would question that we are on the cusp of a new digital intensity that is fundamentally altering the very fabric of how we live, work and relate to one another (Schwab, 2016). The digital revolution is redefining progress at an alarming rate; the speed of innovation continues to evolve at an exponential pace, irreversibly transforming systems, economies and the nature of work (Brynjolfsson & McAfee, 2011). On one level, the new era fulfils the quest for better productivity, efficiency and innovation, but on another, it presents the unknown consequence of unrestrained accelerated progress. At the turn of the century, technology futurists like Ray Kurzweil (2001) were already claiming that this would be the case given the hyper-cyclic nature of the digital revolution. Kurzweil predicted that technological progress would replicate ten-fold as digitization became embedded in the fabric of everyday life. Kurzweil grounded his predictions on strong evidence that technologies follow an exponential growth curve based on the principle that computing power doubles every two years. This is clearly illustrated in the now famous graph that plots the influence of core technological developments across time (Figure 6). The point of this graph is to highlight the exponential growth that has occurred since the 1900s.

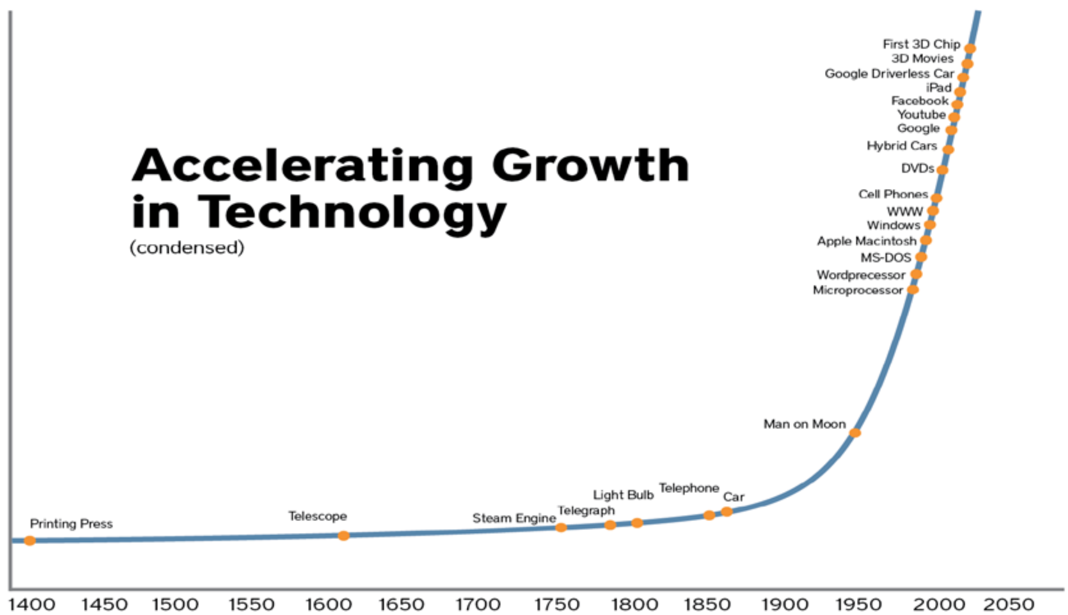


Figure 6. Diagram outlining the accelerating growth of technology. Reprinted from Milford Assets (2017). Retrieved, November 2016 from https://milfordasset.com/insights/missing-xeros/accelerating-growth-in-technology-2017

It is difficult for most of us to grasp the principles, significance and implications of exponential growth. For most of us, growth is generally understood to progress in a linear fashion over time. As a result, we tend to chunk trends of change by periods of years. Computer growth, however, is not linear, but exponential. A good example often shared to illustrate this point is the Apollo Guidance Computer. Built in the 1960s, this digital computer was installed on board each Apollo rocket and allowed for 41.6 instructions per second to be processed. The common iPhone 6, on the other hand, processes 3.36 billion instructions per second, meaning it is more than 80 million times faster than the Apollo computers. Theoretically, an iPhone 6 could guide over 100 million Apollo rockets at the same time. Apple launched its iPhone X in 2017, claiming its processing power has gone beyond that of most laptops. It is incredible to think that these simple looking devices have so much power. In fact, most of us do not perceive our digital devices in this way. We perceive smartphones as devices primarily for communication that have additional novel applications (news, weather etc.). What we are not cognisant of is the shift in the utility of these devices from phones to personal mobile control systems (digital assistants) that will no doubt incorporate many of the current 'new' digital developments: augmented reality (AR), flexible screens, built-in projection capabilities, seamless voice control and 3D screens and holograms.

While few debate the exponential rate at which digital technologies are accelerating, discussion often neglects human change and development. While one might argue that humanity too is developing (maturing) for the better as a result of history (learning from our mistakes), it is clearly not matching the rate of technological advancement. This creates a discrepancy between the linear evolving nature of human development (Kegan, 1982) and the dynamic exponential growth of the technological revolution. However, it is a discrepancy that we seem to be able to manage, in part through denying or rationalising away our difficulties to adapt (Kurzweil, 2001).

If we were to locate a person from 2005 in today's world, they would probably assimilate with a reasonable degree of ease, yet the technological developments from 2005 to 2017 represent an extraordinary growth in technology, economics and collaboration. Sometimes things may be simply too big to comprehend or the consequences incomprehensible for us to grasp. Rather than assuming today counts for a new tomorrow on which we build a better future, we live today as an extension of yesterday and assume growth and development are gradual and linear: the reality of exponential technological growth fails to affect our daily lives. Consequently, some argue that the infusion of AI and digital technology into daily life is in some way constrained by our human nature (Wicks, 2012). A good example of this is the concept of 'disruptive technologies'. While it is a 'slippery' term used in various sectors to either promote or discourage technology growth, it essentially depicts the disparity between the principle of exponential growth of technology and the linear progress of humans. Figure 7 shows an example most of us are comfortable with the now foundational topics in blue, but have little knowledge of the new economic paradigms, innovative accelerators, or disruptive scenarios that currently dominate (green and grey).

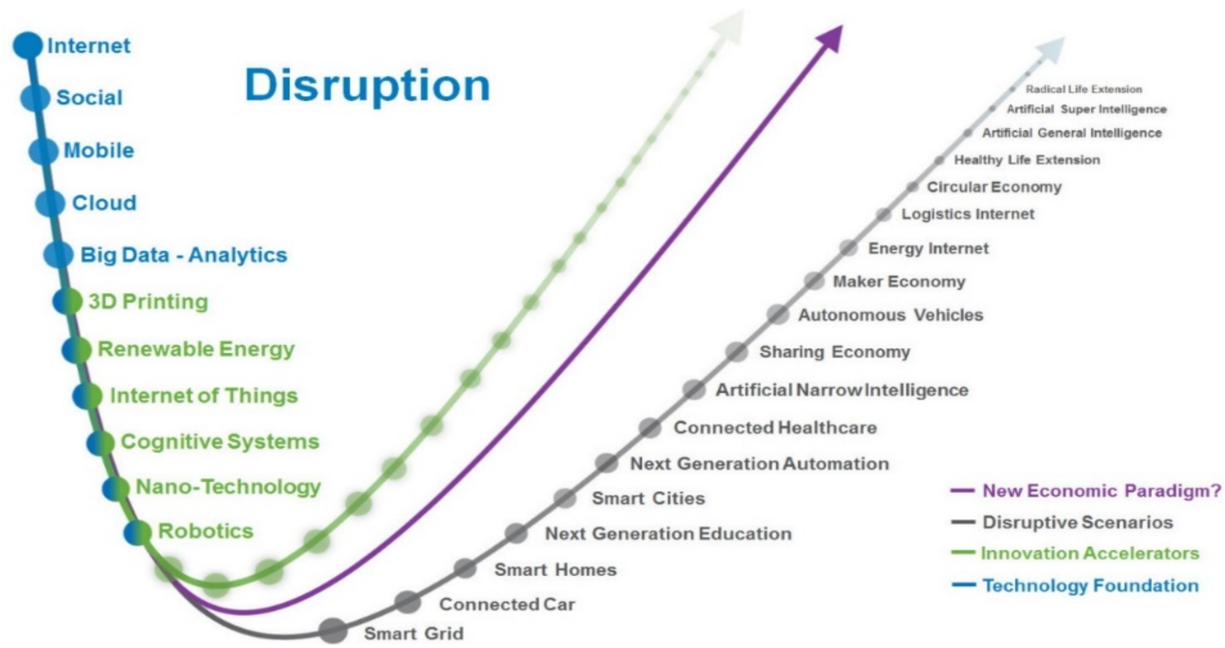


Figure 7. Graph showing the relationship between various cycles of technology innovations. Reprinted from Tata Consultancy Services (2017) by Frank Diana (2015) Retrieved, November 2016 from http://sites.tcs.com/blogs/enterpriseinsights/business-evolution-imperative-disruption/

While recognition of the foundation topics in blue continues to be dominant, there is an emerging view where technological development is perceived as a social process in which humans shape ICTs while at the same time being shaped by technology (Bijker & Law, 1992; Löwgren & Stolterman, 2004; Warschauer, 2003). In other words, our shaping of technology through our particular use of technology is also shaping society (Castells, 2010). Rather than denying technological progress, or feeling out of touch or left behind, many are starting to argue that the nature of humans and the nature of technological progress is different. As such, computer devices, software and networks have transcended from the status of being a 'tool' to something far more pervasive. In fact, Kevin Kelly of Wired magazine argues that we are at beginning of the beginning, barely in the first hour of what he calls the second industrial revolution (Kelly, 2017). The first was based on artificial power, and before that, everything was made with human or animal muscle. Our ability to harness and distribute energy shaped the industrial revolution. The second revolution will follow a similar trend; artificial intelligence or smartness will be distributable and embodied into new efficient and productive agents (robots/bots).

In a world obsessed with smartness—smartphones, smart cars, smart houses and smart buildings etc.,—it is easy to assume Kelly's world is an unpredictable one where many of us are displaced by robots. In fact, websites are now starting to appear that allow you to check the probability of your job being suited to a robot (http://time.com/4742543/robots-jobs-machines-work/). In the area of teaching, many of these sites state 30-40% of tasks could be automated While a hotly debated area, there are already signs that intelligent systems (AI) can guide/perform tasks such as course advice, curriculum development, assessment and develop research resources including bibliographies. This presents a strange juxtaposition given many institutions of higher education are still grappling with, and in some cases still questioning, the relevance of the digital age (Johnston, 2018; Jon Marcus, 2017; McPherson, 2017). In 2013, Time magazine published the article, 'Professor: I Banned Laptops from the Lecture Hall'. The author, James Loeffler, at the time an Associate Professor of History at the University of Virginia, claimed students, distracted by screens, were no longer able to distinguish what was the most important within a lecture, stating,

> To remain attractive and viable, universities will need to think hard about how to integrate technology into the classroom. But my vote is for less, not more. Today's students enter college as digital natives, already more literate and fluent than their professors will ever be. What they need from us is not tutelage in information management but intellectual challenge and core knowledge. Laptops may make us better at multitasking, but they undermine the radically simple mission of higher education: learning. (Loeffler, 2013)

Loeffler is not alone. There are numerous websites, articles, blogs and tweets by teachers/academics that regard technology as subverting true learning by destroying interaction, reading, writing, empathy, language, critical thinking, social life… the list goes on. University education often appears Luddite in nature against the technologically progressive backdrop that exists in the hyper-progressive research and business environments.

In 2000 a new internet company, Netflix, proposed a partnership with the then leader of video entertainment, Blockbuster DVD rentals, but Blockbuster refused. By 2010, Blockbuster was bankrupt and Netflix was a $28-billion-dollar company. Blockbuster underestimated the influence of the digital revolution and the power of networks. In 2012 technology was poised to do the same to higher education. Harvard, Stanford and MIT created Massive Open Online Courses (MOOC) that were freely available to anyone with access to the web.

> I can see a day soon where you'll create your own college degree by taking the best online courses from the best professors from around the world — some computing from Stanford, some entrepreneurship from Wharton, some ethics from Brandeis, some literature from Edinburgh — paying only the nominal fee for the certificates of completion. It will change teaching, learning and the pathway to employment. There is a new world unfolding, and everyone will have to adapt. (Friedman, 2013)

However, unlike Netflix, the MOOC revolution failed to disrupt higher education as expected. Enrolments in traditional colleges continue, even against higher tuition fees and increased student debt. However, many commentators argue that university education represents a bygone era (Barber, 2013; Tapscott, 2009) that will someday be forced into extinction by technology. Continuing advancements in the emergence and fusion of technologies such as robotics, artificial intelligence, IoT and virtual reality are clearly going to have a colossal impact on all aspects of life. Ephemeralisation, a term coined by Buckminster Fuller (Meller, 1970), describes the process of technological development as the capacity to do more and more with less and less, until eventually, you can do everything with nothing. Even universities will have to bend to the force of ephemeralisation. In his book *The Rise of the Robots* (Ford, 2015), futurist Martin Ford warns against investment in education systems that either ignore the impact of 'robotics' on education or believe we can educate in order to 'stay ahead of robotics'. Ford, like many who espouse ephemeralisation, argues that continuing to educate as we have will simply increase the already overqualified job market; a state that will continue to worsen as a result of automation. If they are right, and many believe the trends are already there (Connley, 2018), then universities will have to rethink the future purpose of higher education.

Impact of Generations

A number of studies looking at the growing dependency on technology and its impact on the way we work (Eversole, Venneberg, & Crowder, 2012; Mayer, 2006; Mullan, 2008; Tsai, 2017; Wilson & Starkweather, 2014) have suggested that generational differences are a key indicator of difference between views of technology and progress. While generational differences are well documented, they are often overlooked in higher education research. This is unusual given the growing evidence that generations are significantly different in terms of beliefs, values and practices concerning technology and how they engage in work (Hauptman, 2015; Lindborg, 2007;

McCrindle & Wolfinger, 2010; Napoli, 2015; Ng, Lyons, & Schweitzer). Notwithstanding, there is a well-established theoretical tradition within the literature supporting values, attitudes and expectations that are unique to particular generations. For instance, the technology boom of the 1990s and the formation of Silicon Valley were both driven by groups of people who fell within a similar age group. Although respected as an important field of sociology, the study of generational difference has its fair share of dissenters. Much of this negative press has resulted from misuse of the labels by the media and the general public. However, this does not lessen the extensive evidence that indicates that a generational approach to understanding society and groups of people is scientifically acceptable and well grounded in social science.

German sociologist Karl Mannheim first proposed the idea of generational groupings. Manheim recognised that different age groups experience socio-historical events differently. He reasoned that previous experiences shape and influence new experiences. Generational cohorts, therefore, experience particular events differently due to the level of shaping that had occurred over time: the older the generation, the greater the exposure to socio-historical shaping. Generational cohorts are likely to share similar ideals throughout their lifetime (McCrindle & Wolfinger, 2010). As a result, generational theorists argue that the era in which a person is born (the commencement of their socio-historical shaping) affects the development of their view/s of the world. For example, Kotler and Keller contend that

> Each generation is profoundly influenced by the times in which it grows up – the music, movies, politics, and defining events of that period ... Members of a [generational] cohort share the same major cultural, political, and economic experiences. They have similar outlook and values. (Kotler and Keller, 2016, pp. 235-236)

In this way, these cohorts represent a generational sureness based on major socio-historical events during childhood that influenced later experiences. Distinctive periods or generational states are dependent on the pace or tempo of social change (Mannheim, 1952). Mannheim also suggests that these generational slices are internally stratified by their location, culture, class, etc., and as a result, the homogeneity is not as clearly defined as portrayed in popular media (Lively, 2002).

Nevertheless, the theory of generational cohorts is gaining some pace, with a growing number of studies exploring generational effects. Before exploring the theory of generations in more detail, it is worth noting that there is a less structured, more established view that adopts stages rather than succinct groupings. This conception is psychological in nature and assumes that we ‘evolve’ through various stages across our lifespan. In one such configuration, the stages are divided into 12 distinct periods (Armstrong, 2007):

Stage 1: Pre-birth
Stage 2: Birth
Stage 3: Infancy
Stage 4: Early Childhood
Stage 5: Middle Childhood
Stage 6: Late Childhood
Stage 7: Adolescence
Stage 8: Early Adulthood
Stage 9: Midlife
Stage 10: Mature Adulthood
Stage 11: Late Adulthood
Stage 12: Death

It is important to understand that this framework is coupled to an individual’s development across their lifespan. However, outside of academia, there is a common acceptance that such stages also express a type of developmental hierarchy within society, adopting a maturing life-cycle metaphor in which each level is subsumed by the advancing stage. While most of us are aware of the generational terms silent, baby boomers, Gen-X, Y (millennials) and Z, we are more familiar with the development stage approach, where age and maturity trump youthfulness and naivety. Unlike the theory of generations, which separates by age and promotes solidarity through difference, the idea of a development lifecycle at a societal level is more perception than certainty. In actuality, this error is solely the result of confusing sociological models with psychological ones (pop psychology). While on one level our thinking is individual, our gregarious, social nature ensures it is also collective. As a result, society or groups take on the characteristics of the individual, blurring the lines between individual lifespans and societal lifespans.

To understand the importance of generations, it is essential that we decouple these blurred definitions. Figure 8 shows the overlapping generational segments defined within the theory of generations. Each segment is based on that generation’s lifespan.

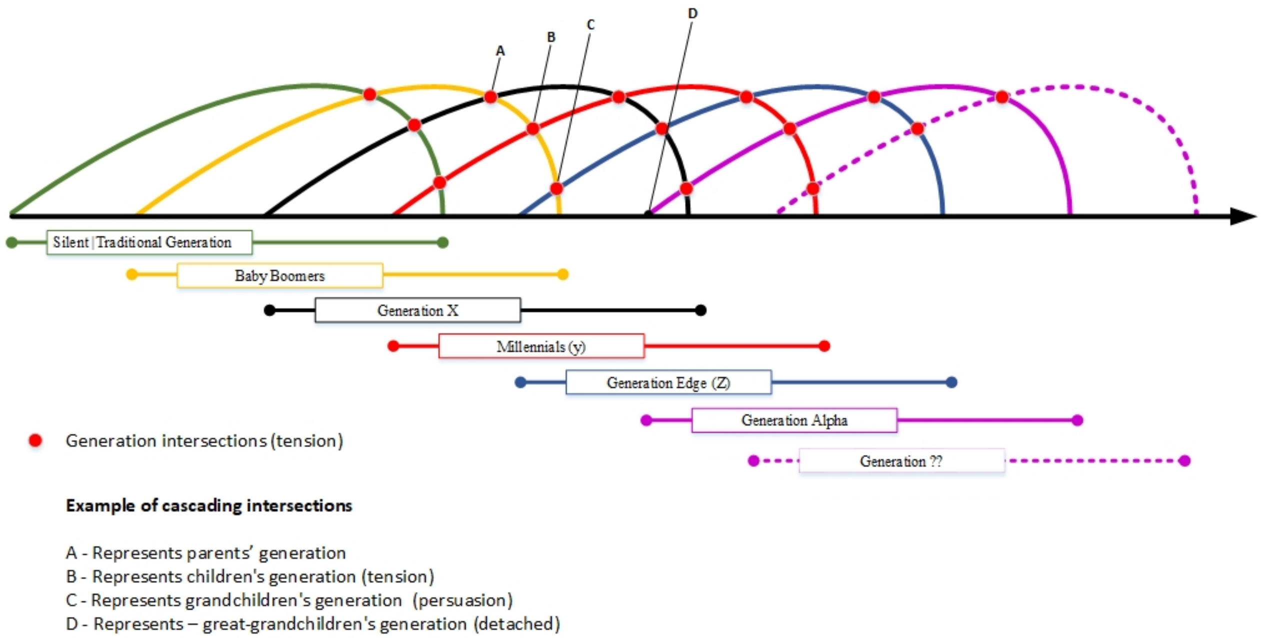


Figure 8. The overlapping generational segments defined within the theory of generations.

In today's developed societies, there are currently six (living) generational profiles. Due to socio-historical experiences, these generational profiles form distinctive expectations, attitudes and values. However, unlike the stage view of society with a single societal lifecycle progressing from inexperience and naivety to experience and wisdom, the generational theory consists of competing societal lifecycles. The individual life-cycle phases are coupled to generational groups rather than society as a whole. In this way, each generational group is defined by the lifecycle of its members. Each will develop through the stages, solidifying certain expectations, attitudes and values that are linked to their socio-historical milieu. In 2000, news of the dot-com crash stunned the world. However, in generation theory terms, 'stunned' is relative. Each generational group at the time would have experienced this differently due to their age/life-cycle stage. In 2000, the control of mainstream information was in the hands of the baby boomers, who were at this time in conflict with the 'new ways' of doing things promoted by Generation X. Without going into detail, a speculative frenzy by the baby boomers in the overinflated dot-com world of Generation X is often alluded to as the caused the crash (Buckman, 2001). In many ways, the transaction of generations shown in Figure 8 as red dots represent points of tension as socio-historical driven expectations, attitudes and values are brought to bear on various constructs and practices—from parenting, to economics, to morals. Each new generation attempts to solve problems of the previous generations, whose approach or style has become dysfunctional in the new era. In the past, the battleground for change was the ‘Mature Adulthood’ stage, with the social role being vacated by the departing ‘Late Adulthood’ (Howe & Strauss, 2000). Generation X has strayed from this rule by striking out early in their generational lifecycle to disrupt existing practices. In a very short time, Generation X in their quest to “revitalize democratic society” (Winner, 2003, p. 167), managed to weaken the level of control by social institutions such as governments, publishing, entertainment, media, transportation, communications and banking etc.. Their aim has been to enable “citizens to command the political and economic resources needed to become effectively self-governing” (Winner, 2003, p. 167). As a result, generational groupings are taken more seriously. It is hard to dispute the influence millennials have on politics and economics through the communication power of social media. However, not as well known, but potentially just as influential is the entrepreneurship of Generation Alpha, the first generation born in the 21st century. Literally thousands of Alphas are running YouTube channels where children produce animated-type series with voice-overs. In a quick search, I located a channel “Come Play With Me”, hosting over a hundred 10-20 minute clips created by two girls between 7 and 12 years of age (https://www.youtube.com/channel/UCQ00zWTLrgRQJUb8MHQg21A/about). The site has an impressive 1,773,754 subscribers and 2,338,371,466 views and includes ‘pay-per-click’ advertising that is likely to produce an impressive money stream.

Given the likely significance of ‘generational cohorts’ over ‘lifespan maturity’ in the matter of the digital revolution, I have included a brief but informative breakdown of the various generational groupings. However, it is important to note that while there is agreement amongst researchers on the various cohorts, the calendar periods (generational location) for each is fuzzy. That aside, I have included a birth date in each description for ease of recognition. I have also included reference to key socioeconomic conditions commonly defined as the catalyst for ‘generational actualities/sureness’ that form a dynamic generational persona (Donnison, 2007; Parry & Urwin, 2017). This latter concept represents a more realistic viewed based on a continuation model influenced by social trends, rather than the fixed date periods popularised by the media. Given these caveats, what follows is a very brief synopsis of the commonly known features of the six living generations.

Figure 9. Five generational groupings. Reprinted from Bridgeworks (2015). Retrieved, February 2016 from http://www.generations.com/2015/07/20/are-you-equipped-to-bridge-the-generational-divide/

Figure 9 shows 5 of the current generational groups. It does not include Generation Alpha, primarily because generations are not regarded as having any influence until they reach young adulthood.

Traditionalist or Silent Generation (born 1920s) represents those who experienced the Great Depression and World War II. As a result, this cohort tends to be conservative, exhibiting a keenness for order through formal hierarchies (Justin Marcus & Leiter, 2017). Their idea of development is slow, incremental advancement through hard work while minimising risk.

Baby boomer (from 1945). If the traditional generation was thought to be silent, then the baby boomers could be described as 'loud'. This is the sex, drugs, and rock n' roll era. They rebelled against the conservatism of the previous generation through activism against the establishment… not to change it, but to take over. By the 1990s, these previously anti-establishment hippies dominated politics and business. They created more wealth and accumulated more debt than any other generation (Lindborg, 2007). They are typically regarded as a goal-oriented, workaholic generation.

Generation Xer or latchkey kids (from 1968). This generation (latchkey kids) was the least parented, least nurtured generation in history. It was a time of high divorce rates and two-parent participation in the workforce, which resulted in this generation having excessive levels of independence and freedom (McCrindle & Wolfinger, 2009). While the traditionalists and baby boomers get credit for developing digital infrastructure, it was Gen-Xers who made it useful (online gaming, social networking, YouTube).

Millennial Generation or Y-Gens (from 1985). Confident, connected and open to change (Pew Research Center, 2010), Millennials are those who grew up in the new era of globalisation, communication technology and wireless connectivity, and as such are regarded as techno-savvy, mobile, global citizens.

Generation Edger or Z-Gens (from 2000-). A generation confronted with a rapidly changing, increasingly complex world with an uncertain future. It is a generation 'connected'. Through social media, this generation knows what is going on. As a result, they are defined as a realistic, resilient, resourceful generation—attributes that many believe gives them an edge (The Sound Research, 2017).

Generation Alpha (from 2010-). This cohort is forecast to be the most formally educated generation in history and of course, the most technologically literate. They are being touted as the entrepreneurial generation, likely to be more self-sufficient and prepared for big challenges (Schawbel, 2014). The rapidly advancing 'global connectivity' represents a substantial leap from the digital environment experienced by Gen Z compared to the Alphas. According to McCrindle, a leading researcher in inter-generational theory and the person who coined the term Alphas—the gap between Gen Z and Alpha is even bigger than that between the baby boomers and Gen X, who experienced the invention of computers (ABC News, 2010; Nader, 2010). The Alpha generation is characterised by 'touch'; these devices are not tools, claims McCrindle, but kinaesthetic processes integrated singularly into their lives.

At first glance, these generational groupings seem intuitive and compelling, but there are inherent dangers with theories that can become popularised while never actually being understood or applied correctly. The idea of generational gaps has been one of these. It is easy to become caught up in the 'ethnographic dazzle' of this theory; a term coined by British anthropologist Robin Fox, that explains how we can be dazzled by highly visible surface features and overlook deeper, more meaningful characteristics underlying human social structures. Dazzle aside, the last 20 years have been awash with studies investigating the significance and impact of inter-generational effects across every aspect of human experience (Bengtson, Kuypers, & development, 1971; Goldman & Schmalz, 2006; Parry & Urwin, 2017). As a result, there is a general acceptance that generational differences represent a legitimate diversity that needs to be recognised and addressed. Nevertheless, there continues to be a lack of appreciation within many sectors, in spite of the empirical research. Much of this is due to the traditional, but mistaken belief that our values, attitudes and preferences change as a function of age (the maturity hypothesis discussed earlier).

Large inter-generational environments, such as universities, are starting to explore these ideas in relation to the contribution of academic development on generational cohort formation (Lai & Hong, 2015). It seems reasonable to accept that students graduating during a time of prosperity where jobs are plentiful and research funding is substantial are going to have very different intentions, values and experiences to those who graduate in times of financial austerity (Stephan, 2012). Similarly, a study by Marquina and Jones (2015) of academic perceptions of work practices, found different generations of academics understood the concept of academic work in quite different ways. Universities, however, are more likely to operate under an educational schema that is more akin to a maturity modal where socio-historical experiences (the hallmark of generational difference) do not play a significant role in the experience of higher education. As a result, the conceptions and practices of the older generations will likely take precedence over the variability that defines generational difference.

The Changing Nature of Work

The digital revolution is changing the way we understand time and space, particularly with respect to how we schedule our lives. Trends in mobility and flexibility are changing the way we think about life/work balance. Global networks supporting distribution and collaboration now allow us to operate anytime, anywhere. As a result, the demands of work and life are often mutually tackled through the day with work-based operations becoming punctuated with the demands of family and friend networking and work and non-work schedules sharing the same apps. The very idea of work/life balance is, to some extent, waning under the new and emerging trend of ‘alignment’ as opposed to ‘balance’: work as life and life as work (Forbes Coaches Council, 2016). Even the idea of the workplace for those working in the knowledge world is fading as transitional places such as walkways, cafes, trains, buses, parks etc., are becoming operational spaces. Against this functioning backdrop, is a growing innovative spirit chasing new practices, strategies and meanings.

New work paradigms like New Ways of Working are an example of one of these emerging conceptions (Alvesson, 1995; Burton-Jones, 1999; Davenport et al., 2002). In response to the rise of knowledge-intensive organisations, NWOW offers a vision for making work more effective, efficient, pleasurable and valuable for both the organisation and the individual. NWOW gives members (not workers) the space and freedom to determine how, where and when they work, what they work with and with whom they work (Bijl, 2011). This is a computer-driven phenomenon and without the digital revolution the processes that underpin knowledge work productivity, networking and flexibility simply would not be possible (Ahuja, Yang, & Shankar, 2009; Rodrıguez Casal et al., 2005; Sigala, 2003). The expanding growth of the internet and the World Wide Web are fuelling new types of operations that are violating the traditional structures of work by creating environments that respond to practices best described as non-routine and ill-structured (Reinhardt, Schmidt, Sloep, & Drachsler, 2011).

As an idea, concept or movement, New Ways of Working represents an example of the impact the digital revolution is bringing to bear on the institution of work. The main tenants of New Ways of Working are best understood through three distinct dimensions: Bricks, bytes and behaviour (de Kok, Koops, & Helms, 2016):

- **Bricks** : the physical dimension, addresses all aspects of the physical work environment;
- **Bytes**: the technological dimension, addresses all aspects concerning infrastructure, hardware and software associated with digital work style;
- **Behaviour**: the personal dimension, which addresses all aspects associated with activity.

A core element of the New Ways of Working concept is the character of space and place. Office spaces are designed and structured to accommodate collaborative task-based activity, rather than process-based operations (Figure 10). An underlying principle is one of freedom and trust, where members are free to come and go as they please. The elements of New Ways of Working go beyond the physical and logistical and embody deep attitudes and beliefs where a fusion of work/life is encouraged.

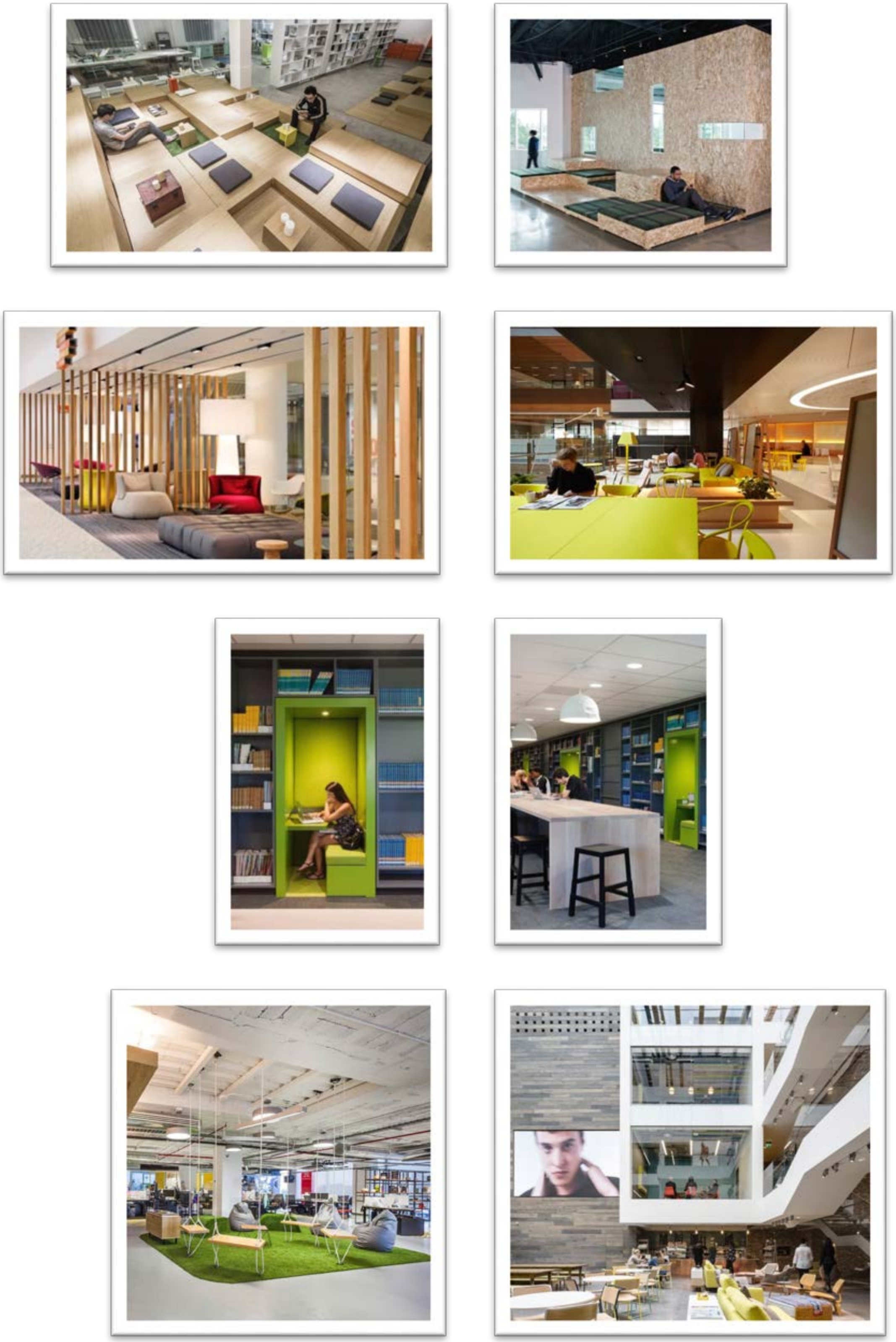


Figure 10. Examples of contemporary knowledge spaces that incorporate a design to support flexible, collaborative self-management practices. Images sourced from public domain sites.

It could be tempting to be seduced by the hip, innovative designs that these spaces present. However, to assume that New Ways of Working is primarily about expensive, trendy spaces would be a mistake. Baane et al. (2010) observed four quintessential principles in the New Way of Working:

- Time- and location-free work: ‘Anytime, anywhere’;
- Self-management and results-centric;
- Unlimited access and connectivity; and
- Flexible work relations.

Bijl (2011) argues the design layer plays a central role in making these functional elements work. Investing heavily in member-centric design to create pleasurable environments leads to positive attitudes and practices. The upshot is that members feel valued and responsible for the way they work, where they work, when they work and with whom they work. Creativity, knowledge sharing and communication are replacing the operational, process-driven structures of the industrial revolution. These new ways of working are carried out not in a particular location, but across a variety of settings, such as: office, home, airports, coffee shops and cars (Bjerrum & Bødker, 2003). It is an era defined not by the factory floor or office block, but by knowledge (Alvesson, 2001; Burton-Jones, 1999; Donnelly, 2006; Swan & Scarborough, 2001).

Most commentators agree that while the industrial revolution was built on financial capital, the digital revolution with its focus on knowledge is built on human capital (Alvesson, 2001; Burton-Jones, 1999; Davenport et al., 2002). As such, innovative, creative knowledge workers are considered the engines of growth in the new digital economy (Davenport et al., 2002; (Yigitcanlar & Martinez-Fernandez, 2007). This is not a new idea, but was proposed in the early 20th century by the economist Joseph Schumpeter (1883–1950). Schumpeter argued that growth came about through investment (human and financial) in innovation and not the supply and demand process that dominated the industrial revolution. It took the rise of the digital revolution before the relevance of Schumpeter’s theory was accepted. Schumpeter argued that growth is a process of ‘creative destruction’ where innovation destroys established practices, yielding new ones. As automation and robotics take over work defined by labour, time and fixed processes, new creative activities start appearing and replace (creatively destroy) old ways (Spencer & Kirchhoff, 2006).

For example: taxis → Uber; books → Kindle; CDs → mp3; telephone → smartphones; car → self-driving cars; shopping mall → online/virtual shopping; letters → email, Facebook, Twitter. In this respect innovation drives development and change. While in the past, innovations occurred at over 30-50 year periods, we are beginning to see rapid change occurring in 2-5 year phases. This rapid cycling has led to the disrupt phenomena (Gans, 2016), a dominant buzzword (disrupt, disruption, disruptive, disrupting) of the digital entrepreneur movement. Disruption is the same concept as Schumpeter's creative destruction. It symbolises a process whereby innovation cycles through phases of booms and busts.

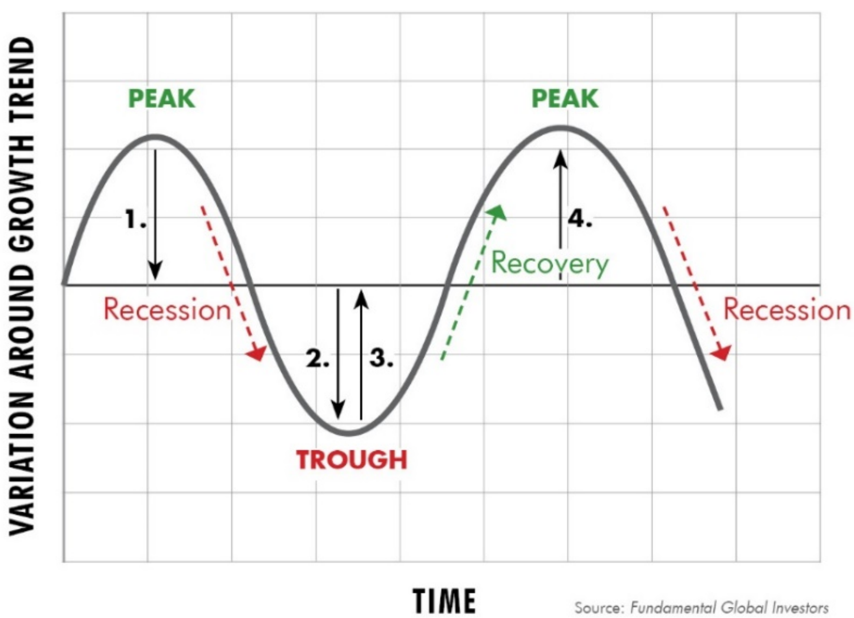


Figure 11. Schumpeter activity cycle depicting time as waves of creative destruction. Retrieved, July 2016 from http://www.capitalwealthadvisors.com/2015/06/demystifying-the-business-cycle/juglar-cycle/

For Schumpeter, progress is represented by a wave-shaped by peaks and troughs, where highs and lows are deemed essential to the very nature of growth/development as shown in Figure 11. In this way, innovation produces change and change procreates fertile ground for further innovations. When change becomes a strategic imperative to survival, organisations and individuals unable to adjust are open to the threat of disruption or creative destruction. In an era where the speed and breadth of digital innovation are producing rapid cycling (at a pace never experienced before), the formation of practices suited to change, uncertainty and complexity are inevitable: old rules or conventions give way to new ones (Simson, 2017), as shown in some common examples in Table 1.

Table 1

Comparison of old rules and new rules

Old Rule	***New Rule***
Daily commute to your office.	Work can happen wherever you are, anywhere in the world.
It is no longer common to know your colleagues by physical presence.	Colleagues are likely to be known by video face, email address and time zone.
Work is 9-to-5.	You are available 24-7.
Need to manage work-life balance.	The line between life and work is almost entirely disappearing with work becoming life and life becoming work.

The nature of connected presence means many of us check emails and read documents whenever we have time and in a variety of places such as cafés, travelling or in bed. It is becoming second nature for many to work wherever and whenever possible.

And what of the university? Like many in the new digital sector, universities are knowledge-intensive organisations that are human capital-centric. In fact, they are the most knowledge-orientated, human capital organisations in society. It would seem reasonable to assume that universities, like strategic knowledge-intensive companies, adopt practices more akin to the evolving new frontier. As early as the 1990s, many of the emerging digital start-ups were moving away from the industry-centric culture of the industrial revolution to a more individual-centric ethos that promoted autonomy and collaboration (Janz, Colquitt, & Noe, 1997). Fifteen years on and creativity and innovation are becoming essential elements of the developing complex digital society.

In such times of fast-paced change, there is a growing need for continuous education and re-education. Universities unaware or unwilling to acknowledge the transformation from industrial to digital are at risk of being left behind in the face of change. However, addressing change is not for the faint-hearted. Universities, like their business counterparts, will need to shift from short-term industry-centric measures such as completion rates, retention and grade-point-averages, to more long-term goals that extend beyond the institution and focus on student and staff life goals and societal goals. It is likely that the newer generations (Gen-Z and Alpha) will demand a career-focused education (Jacobs, 2015). As students pursue learning that is more targeted (precision learning) toward meeting their personal goals, the traditional degree process (the staple of university education) may well become redundant. There are already signs that the traditional 'degree for life' is being replaced by a more iterative development cycle that incorporates a blended model of learn/work balance. Currently, this is being fuelled by business through nano degrees: online, fast track, high-skill and career-specific courses. These low-cost often subsidised, short-term industry run courses (6-12 months at 10-20 hours per week) are aimed at equipping students with the skills needed to meet the requirements for cutting-edge innovations; it is a concept that aligns well with the changing relationship between organisation and employee. Gone are the days of working for one company for 30 plus years. In the digital frontier moving from organisaton to organisation, or blending positions, or blending work with training are redefining the concept of work. These hacked approaches represents a new 'nano' movement that is influencing how training and work are being conceptualised: short, targeted and intensive learning—'nano degrees' that feed into short, targeted and intensive projects, or 'nano jobs' (Ramakrishna, 2015).

The growing appeal for short, targeted and intensive projects (the nano concept) comes from changes in the way new generations define business. In the late 1990s, as the social network movement emerged, a new attitude toward doing business arose: Social Venture Network (SVN). It focused not on profit, but on socially responsible profit. It introduced the notion of businesses as social organisations and the idea of the triple bottom line—profit-planet-people. The movement foreshadowed a growing commitment to a social conscience where stakeholder value and social impact displaced shareholder profits. Social media plays a dominant role in the realisation of a social conscience through digital avenues that equip the public to amass collective voices exposing unscrupulous business practices. As a result, businesses are being forced to be more transparent and socially responsible (Knox & Maklan, 2004; Waddock, Charles, & Graves, 2002; Warhurst, 2005). Businesses unwilling to address cheap labour, worker rights, animal rights and environmental impacts are vulnerable to falling sales and boycotts (Deirdre, Terry, & Roger, 2006; Sassatelli, 2006).

Universities have not gone unnoticed in this trend. Given the depth and breadth of these influences, it is not surprising that universities too have had to engage in social responsibility (Weiss, 2016). However, their involvement appears to be focused largely on teaching social responsibility (Atakan & Eker, 2007; Vasilescu, Barna, Epure, & Baicu, 2010). In order to be more relevant to the complex, innovative and dynamic global landscape developing around social responsibility, universities, inherently social enterprises, will need to be diligent in directing their gaze at their own practices and evaluate how well they know and serve their students, staff and communities.

The Changing Nature of the University

In 2012, the photographic giant Kodak filed for bankruptcy. For those who grew-up in the 20th century, Kodak was more than a company; it was a household name synonymous with photography—'share moments, share life'. There was even a celebrated song by Simon & Garfunkel about their product—'Kodachrome'. They innovated from their inception in the 19th century, inventing the 35mm film that replaced the older glass plates, the box Brownie camera, the first push-button push camera that brought photography to the masses, the renown Kodachrome film, and of course the Instamatic camera, all icons of that era.

By the 1990s digital photography was displacing the need for film and film-based cameras and processing. On the surface, it looks to be a tale of new technology displacing the old, the overlapping lifecycle of one technology with another. But this is not the Kodak story. Kodak invented digital photography, but unfortunately, the company refused to shift its focus and processes to support an entirely new product from its successful film-based effort. Many commentators argue that the company was at the top of its game in the 1970's. It dominated the photographic industry globally and presented as commercially invincible. Digital photography represented an entirely new way of comprehending the capture, processing and distribution of images. It is likely that the innovative space that digital photography inhabited was outside the ontological, epistemological, methodological and ideological space of the Kodak moguls of the time.

The Kodak story represents a tangible example of collateral damage from the digital revolution, not just in the rapid destruction of practices and products, but also the danger of inflexible thinking. Like Kodak, universities hold a place in society that goes beyond their primary function. They are monolithic organisations that have, through history, become woven into the very fabric of society. Like Kodak, they too could be in jeopardy of being shipwrecked in the turmoil of colliding paradigms.

A recent issues paper by the New Zealand Government Productivity Commission articulates the precarious nature of universities amidst technology change "New models of tertiary education" by The New Zealand Government Productivity Commission in 2016:

> Some aspects of tertiary education in New Zealand have transformed nearly beyond recognition in just the last few decades – for example, the ability of nearly every student to access almost unlimited content in real time via the internet. Other aspects, such as a university lecture, would be readily recognisable to medieval scholars. (New Zealand Government Productivity Commission, 2016, p.1)
>
> The terms of reference for the inquiry suggest that there is currently "considerable inertia" in the New Zealand system, and an unwillingness to try new things. This inquiry will consider why that might be if it is so; why some parts of the system innovate more than others; and how the system overall could become more innovative. (New Zealand Government Productivity Commission, 2016, p.1)

This is not to say all universities have resisted innovation. A new and novel education system—Massive Online Open Courses (MOOC) was introduced in 2011. MOOCs represented a revolutionary new way to engage in education (Pappano, 2012). Their presence was fundamentally disruptive, undermining traditional university education through free anywhere access. It meant that anyone with an internet connection could access the world of higher education. Within a very short time, top universities were serving up a plethora of courses with bold promises and audacious claims. What followed was a hype-cycle that had MOOCs soaring to untenable levels, but by 2013 had fallen into what Gartner Research termed the 'trough of disillusionment' (Figure 12).

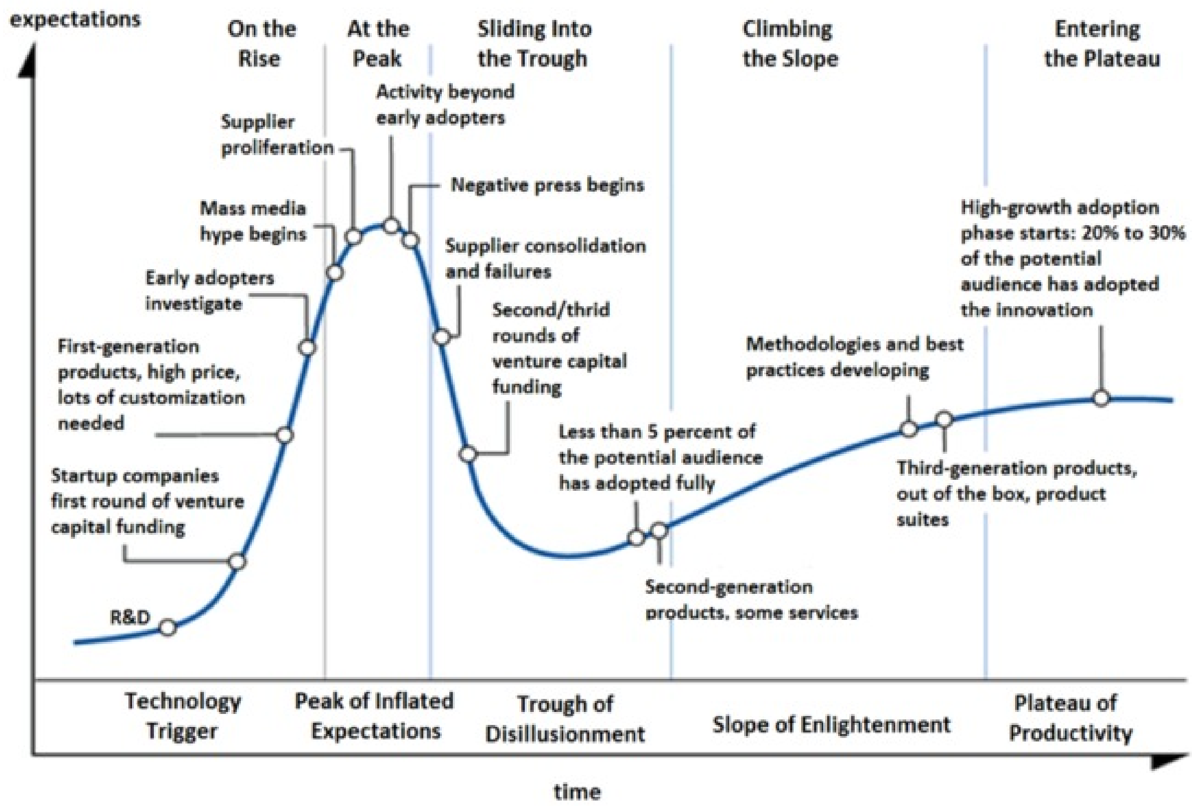


Figure 12. A Gartner “Hype Cycle”. Reprinted from Garner Inc. (2017). By Frank Diana (2015) Retrieved, November 2017: https://www.gartner.com/technology/research/methodologies/hype-cycle.jsp

The rush to serve up courses during the initial hype, and the voracity with which people were willing to be fed on these courses, created a situation where many academics found themselves engaged as online instructors without training or experience. Numerous studies into MOOCs such as Coursera, edX, XuetangX, FutureLearn, Udacity have found that their vision to offer open elite education to the masses has failed to transpire (Osuna-Acedo, Marta-Lazo, & Frau-Meigs, 2018; Pappano, 2012; Parr, 2013). That is not to say that MOOCs have failed, on the contrary, like the development of YouTube and Facebook, the initial purpose is likely to be reshaped by the user/public (Osuna-Acedo et al., 2018). MOOCs have become an important resource in the on-demand/just-in-time education market. There may be no intention to complete a course, but more about accessing, at will and under no obligation, resources that can be consumed at one’s own pace: part of what some refer to as the shadow learning economy (Selingo, 2014, 2015).

The competitive threat of MOOCs to disrupt campus-based education to extinction has passed. Through non-action, many universities have continued unruffled, and in some cases are even more defiant to the pressure of innovative change that can be aligned with trends or hype. The kinds of changes that are typically supported within universities are neither radical nor innovative, but best described as ‘improvements’ to existing structures/systems or practices. In fact, it would be fair to say that rapid, dramatic, changes are seldom seen in higher education (Bimbaum 1988; Cohen and March 1986). As Kerr (1964) has argued, paradoxically, universities have a history of being fundamentally conservative institutions that resist significant change. This spirit of inertia is captured well in a recent publication titled, *What Are Universities For?* (Collini, 2012). The author, a Cambridge Don, Stefan Collini, describes universities as custodians of a complex intellectual inheritance that must be protected from the disruptive influence of the less intellectual government and business worlds. A review of the book published in Times Higher Education Fred Inglis (2012), applauds the polemics of the book and the courage of Collini, while the Guardian reviewer, Peter Conrad (2012), describes the author as a monologuing don in a self-admiring form of academic filibustering and polemics outlining his irritation vis-à-vis the current attacks on the institution of academia. Like many academics affronted by the loss of stability that comes with change, Collini appears myopic, believing academia as a society that transcends the general public, not unlike Kafka’s authorities in the Castle. According to Conrad (2012), Collini never really addresses his question ‘what are universities for?’ Instead, as Conrad argues, Collini presents a form of academic practice that is difficult to square with current reality:

> And how do dons occupy themselves while the students are purportedly studying? "What they, we, are doing most of the time," says Collini, "is worrying." Not having done much of this during my 38-year academic career, I felt curious about the source of Collini's gnawing anxiety. Eventually, he lets slip a diagnosis of his condition: he and his kind are "prone to waking up too early in the morning worrying about the paragraph they wrote yesterday". Ah, the onerous workload of the intellectual: yesterday's output was one whole paragraph!

Collini’s resistance to change on historical grounds has some similarities to another resistance movement that is gaining traction—slow scholarship (Hartman & Darab, 2012; Harland, 2016). Like Collini, slow scholarship is a reaction to economic and political demands invariably linked to technological progress. The result is a resistive, rather than a creative, attitude that overlooks opportunities to recreate academia. There are similarities to the wilful non-action taken by Kodak, and as with Kodak, universities too are in danger of being caught out by time, forfeiting the opportunity for extinction. Both are guilty of standing on their own superiority, believing their utility, size and history offers fortification against external forces. They were ‘established’; a rank allotted to a few that occupy an elite societal layer characterised by security, stability and necessity—a layer that sits above the vulnerable visceral practices of those peddling fashions and trends to survive. But revolutions transform these long-held strong norms by splintering tradition-bound conventions and practices. In the case of the digital revolution, new digital inventions created a vigour that quickly escalated into significant deviations to daily life, promoting a social/cultural climate where ‘change’ replaced ‘stability’ as the new norm. This formed a rich, open climate for scientists, inventors and entrepreneurs. The ‘established’ has had to give way to the ‘visceral’. Since the turn of the century, we have witnessed extraordinary change as innovation reforms society, disembowelling the ‘established’ in its wake.

It would be fair to say the digital revolution is founded on imagination and insight. Many of the stories told by digital pioneers begin with dreams and possibilities, abstract and conceptual, rather than concrete ideas. They visualised a different world. Like artists, they forged their ideas into artefacts/inventions that infused vitality and vigour into the growing digital counter-culture. Like artists, their ideas and creations were not readily received. The history of the early digital revolution is littered with stories of rejection and rebuffs. The fortitude and energy to push on are not driven by fame or finance, but by belief, belief in a new way of seeing and viewing reality. Like writers and artists, many of the early digital thinkers were drawn to ideas/elements located at the edge or borders. These elements, sometimes disturbing and out of character with normal reality, appear as oddities. Yet often, such oddities can contain promise or reveal hidden insights by exposing paradoxes and contradictions. For innovation, the importance of elements on the boundary of our thinking has proven to be indispensable: innovation simply cannot continue to exist without them.

It seems reasonable to conclude innovation, creativity, research and development, are vital elements of a progressive higher education sector and yet it would appear, at least in the 21st century, that levels of resistance to these tenets abound. It is plausible that the current backlash against neoliberalism and technological progress is likely to detain innovation and reform (Smith & Jeffery, 2013), reducing progressive educational concerns or, worse, distorting them through association with the mere necessities of historical safeties. The prevailing cautious and suspicious stance regarding progress means methods reliant on juxtaposition, fusion and paradoxes to promote innovation in higher education remain an exception, leaving the universities present, but stagnant. As the German-British sociologist, philosopher, political scientist and liberal politician, Lord Ralf Dahrendorf (2000) fittingly remarked,

> Stagnant universities are expensive and ineffectual monuments to status quo which is more likely to be a status quo ante, yesterday's world preserved in aspic. ... the realities of some universities fail to match the more ardent detonation of their role in the modern age. (p.106)

Technophobia & Technophilia

As previously argued, it would be a mistake to assume technological progress is exclusively physical. In this way, our conceptions of technology go beyond utility to ideology, arousing a range of reactions from technophobia to technophilia. Arguments based on utilitarian grounds alone fail to address the impact of ideology on people's beliefs regarding the place of technology in society. History is littered with wars over the role of technology and progress in human affairs. The best known of these is the Luddite revolt. The Luddite movement emerged in the 1800s in response to the industrial revolution as workers resisted the expansion of machines that were displacing manual labour. The result was a violent and aggressive battle between the workers and the techno-industrialist/entrepreneurs—a battle that the Luddites of the time lost. In 1995, Kirkpatrick Sale published *Rebels Against the Future: lessons for the computer age* (1995) where he invoked a new-Luddite spirit of rebellion in response to today's digital revolution. He re-echoed the fears of the industrial revolution, claiming the digital age was ushering in a more devastating de-humanising and destructive era, arguing we must resist technology and return to nature and that if we do not, we will become slaves to the machines. While not all Luddites are as radical as Sale, they help perpetuate suspicion concerning technologies and the ideologies behind them. This idea of 'slaves to machines' is one of their common fears and is founded on humanity naïvely forfeiting its sovereignty. It is a position that has infiltrated society through film, novels and comics, with the rise of the Maschinenmensch (robot or machine-person). These stories often depict veiled, suspicious treachery where the elite scheme to overpower the masses through the exploitation of technology. While the first of these to appear in film was Frankenstein, it was the Fritz Lang movie *Metropolis* that screened in 1927 that contained an interpretation of the human-machine debate that is still relevant today. The film is set in 2026; Metropolis is a modern, highly technical world ruled by a powerful industrialist. It is a world where the upper class (thinkers) exploit the proletariat (workers), and where technology is essentially controlling these worlds. The exploited workers, infuriated by their fate, are persuaded not to revolt, but to wait for the arrival of ‘The Mediator’, who will unite the two worlds. An inventor (thinker) creates a robot that is employed to deceive and corrupt the morals of the workers to incite a revolt, in order to give the elite an excuse to engage in violent retribution. The ensuing calamity has the workers destroy the Heart Machine that controls the city, causing a devastating flood that threatens to kill their children. The rage of the proletariat turns on the robot, who is captured and burned at the stake. Eventually, the mediator (the son of the ruling industrialist) brings peace between the two worlds. The movie finishes with the mantra: ‘the mediator between the head and the hands must be the heart’.

The above tale is not merely a story about humans overpowering the machine. It is a story about two worlds: the world of the worker and the world of the thinker. One lives underground and serves the machines, the other lives above the ground and serves the pleasures of the heart. On the surface, the story appears anti-technology and anti-elitist. However, a deeper critique reveals a twisting story that unfolds a very different message: one that upholds the world of the thinker, where the mantra states… in order to keep the worker satisfied, you must capture their heart. It tackles the concerns of those managing the world by suggesting a non-violent solution to repression that does not disturb the status-quo: pacify worker discontent through mediation. Rather than becoming forgotten and obsolete, *Metropolis* continues to be cited. Many of its predictions are seen to be real in today’s rapidly expanding world of robotics and automation. Just as in Metropolis, the efficiency and productivity of robotics and automation have become vital to society. Many corporations have now instigated robot growth schemes. A comprehensive study by Frey and Osborne (2016) of the future of employment concluded that,

> Advances in technology are now making a broader range of non-routine tasks automatable, with computers replacing low-income low-skill workers over the next decade. (p.11)
>
> Recent data from the World Bank suggests that over 50% of jobs are at risk of being replaced by automation systems and robots. In some countries, figures are estimated to be much higher. For example, China and India are 77% and 69%, respectively. (p.11)

The prognosis is that eventually, all human labour will be obsolete. China is a good example of a country aggressively automating its production process through the use of robots. The city of Dongguan in the Province of South China has built 1,500 mechanised factories as part of its “robot replace human” scheme, investing billions in robotic technology. In one company, 60 robots replaced 600 humans, resulting in a fivefold reduction in manufacturing errors and an increase in production output of 250 percent (Ackerman, 2015).

Many corporate technophiles, excited by these developments, are urging boundless growth into cybernetics (a blend of organic and biomechatronic body parts). While the Terminator is still bound to the world of fiction, bionic technology incorporating electronics, robotics and human psychology is overflowing with new creations, giving rise to a variety of speculative future worlds. Cyborg advocates are convinced that if we do not embrace cybernetics, we are at risk of being left behind in a future dominated by robotic accuracy and precision. In this theory, the value of robotics is the augmentation of robotic capabilities in humans through coupling biological intelligence and machine intelligence: neuroprosthetics (Blumberg & Dooley, 2017; Müller, 2017). A recent publication in *Nature Nanotechnology* (J. Liu et al., 2015) described the development of an ultra-fine mesh that merges into the brain to create what appears to be a seamless interface between the machine and biological circuitry. Called ‘mesh electronics’, these thin, supple devices are able to be injected. The result is telepathic-like communication, increased cognitive competencies from extra memory or enhanced sensory abilities and seamless control over attached biomechatronic prosthetics. While short-term robotic thinking ignores the plight of displaced humans, cybernetics is seen as a win-win for both robotics and humans. Theoretically, cybernetics becomes ‘The Mediator’, not of a social system, but a body system, thus offering a tangible solution for the (displaced) workers to transcend the underground and attain value within the upper level of the Metropolis.

Such battles between humans and machines have continued to rage since their inception during the industrial revolution. As suggested earlier, these battles are driven, not by the utility, but by ideology fuelled by human sovereignty, value, uniqueness and autonomy. Early studies into this relationship focused on the socio-technical interplay under the prevailing assumption of the time that harmony between human and machine was deemed desirable. The socio-technical theory has dominated much of this space. It refers to the interrelatedness of the ‘social’ and ‘technical’ aspects of social spaces. The theory first appeared in the labour studies of the 1950s, as a paradigmatic shift toward productivity and automation occurred during the post-war industrial boom (Cherns, 1976; Clegg, 2000). This was a period of rapid, unprecedented technological and socio-cultural change, which signalled a “clear break with the traditional factory system” (Emery, 1982, p. 1120). However, it appeared that despite improved technology, pay rates and productivity decreased and absenteeism increased. The emerging field of socio-technical theory was able to show that this decline in efficiency was due to boredom and alienation engendered by the nature of the work employees were engaged in. The repetitive performance of monotonous tasks by individual workers who had limited responsibility and autonomy was understood to provide little incentive to increase productivity or even to attend the workplace. Job enrichment (the process of giving employees greater levels of responsibility and decision making authority), was seen as a means to improve efficiency, output and quality and to reduce employee problems. Consequently, socio-technical theory focused on the humanisation of work or the ‘Quality of Work Life’ (Emery, 1982; Koch, 1982). In contrast to the traditional paradigm of work as a one-way relationship where humans were dependent on technology (machines), socio-technical theory stressed a reciprocal relationship between people and machines.

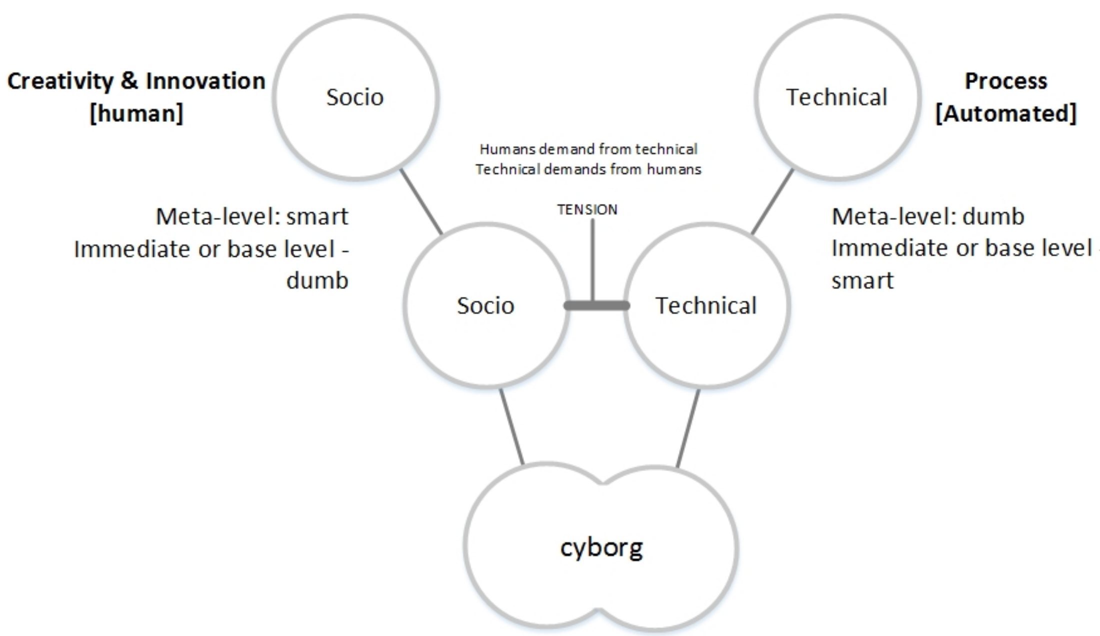


Figure 13. An expanded socio-technical model incorporating cyborg and innovation domains.

In Figure 13., we see this reciprocal relationship between the socio and the technical illustrated. By the 1990s it was assumed that cybernetics would provide the solution to socio-technical tension. This seemed a reasonable conclusion given the progression of technology and the human desire to become more efficient and productive: the created (tool) and the creator become one. The tension created by the disconnect/separation would be mediated/eliminated through the cybernetic union, a union characterised by 'smart'. Under the guise of advancing productivity and efficiency, most of us have happily embraced the concept of smart tech as a unifying theme that underpins innovation and progress in the twenty-first century. It is a powerful movement fuelling mass technology adoption through smart devices: smartphones, smart cars, smart houses and smart offices. While 'smart' technology coupled with 'smart' practices clearly raises the potential for increasing productivity in the world of automation and robotics, there is less evidence that human performance can match the expectations required of this new frontier. It is this concern that stimulates solutions like cybernetic technologies that will allow humans to match the efficiency and precision of robotics.

It is here that Schumpeter's entrepreneur theory, as discussed earlier, has some merit. Schumpeter (2008) separates robotic procedural tasks from practices that are creative and innovative. Unlike the artefact-bound outputs of the industrial revolution that transform society through linear, predictable, one-dimensional processes that are independent of the social context (Bijker, Hughes, & Pinch, 2012; Oudshoorn & Pinch, 2003), the digital revolution courses through every aspect of life, much of it beyond our gaze. For Schumpeter, these dynamic conditions create opportunities for creative innovators to drive progress: the yielding of new ways of thinking and behaving revolutionises meaning and purposes from within, destroying the old and creating the new; it is a process of creative destruction, which many believe is an essential element in innovation and growth (Augello, 1990; McCraw, 2007; Spencer & Kirchhoff, 2006). In this space, innovation acts as a social process in which humans shape technology, while at the same time new technologies give rise to new innovations: humans are shaped by technology (Bijker & Law, 1992; Löwgren & Stolterman, 2004; Warschauer, 2003). In this way, the shaping of a technology is also the shaping of a society (Castells, 2010).

Conclusion

I have argued that we are currently situated on the borders of two great revolutions, with all the turmoil of shifting limits and enduring paradoxes common at such an intersect. As the old gives way to the new, it is vital that we understand the salient features that define and divide these revolutions and in particular, the corridors that delineate the germane from the fad. In this way, we are in a better position to understand the impact on academics and ensure the formation of developmental trajectories infused with conceptions and practices essential in the formation of a 21st century ethos. This will require insights into the extent to which digital technologies are creating change in work practices, not only by perception through asking questions, but through deep analysis of daily practice. At the heart of this proposition is the need to ascertain growth/change by analysing the degree to which practices have transcended the linear procedural structures indicative of the industrial revolution, to the more computer-driven, creative, innovative practices associated with the digital revolution. A good illustration of this is a well-known story by the chess expert Garry Kasparov, who described the winners of a freestyle chess tournament as neither the best players nor having the most powerful computers. Rather, they were a pair of amateur chess players who ingeniously employed multiple computers simultaneously.

> Their skill at manipulating and "coaching" their computers to look very deeply into positions effectively counteracted the superior chess understanding of their grandmaster. Process was superior to a strong computer alone and, more remarkably, superior to a strong human + machine + inferior processes (McAfee, 2010).

This captures the often-overlooked human advantage of creativity and innovation. In this case, it showed that uniquely creative human qualities seemed to spark when coupled with computer technology. The opportunity to unload/delegate procedural tasks allowed the players to concentrate on being creative and strategic, instead of spending considerable time on calculations.

Thus, there is a creative innovative space that sits outside the monophonic dimension represented by the Luddite—cyborg continuum. As already alluded to, the war between human and machine that began in the industrial revolution became fixated on a form of automation where humans (intelligence) were necessary for the deployment of the machine (processes). This co-dependency meant that humans appeared to serve the machines in order for the machines to serve them. This close relationship required both human and machine to work together. The digital revolution, rather than resulting in a rapid fusion of human-machine (cyborg), offers a period where society and machines can, to some degree, operate separately. It is expected that AI and machines will control/manage most, if not all, process-based activities, with little human intervention. This will leave humans with more time to occupy the innovative, creative dimension. How this will play out within academia is difficult to predict, except to say that the transfer of information, skill-based instruction, and the evaluation/measurement of learning are all well suited to AI control. This would open new dimensions of innovative and creative higher levels of learning. How and if academics have a role in this space, will be, to some extent dependant on how we, as a profession create 'teaching' in a new innovative higher education model. As we emerge from a history dominated by process, the challenge will be to perceive/visualise new layers of 'learning' and 'teaching' that sit outside traditional process approaches.

What follows is the result of a theoretical inquiry into the grey misty space produced by the shifting limits and enduring paradoxes that must be tackled in order to analyse existing practice and push into your frontiers given:

> the fundamental responsibility of intellectuals is to doubt all received wisdom, to wonder at that which is taken for granted, to question all authority, and to pose all those questions that otherwise no one else dares to ask (Dahrendorf, 1963).

The practices, artefacts, language and symbols that we have come to accept as particular ontological and ideological frameworks fit within the taken for granted space, which I attempt to question and fabricate new alliances for in the following chapter. As a result, traditional forms are unlikely to be clearly discernible. Instead, ontological, epistemological and methodological states are threaded and woven into a hybrid mesh that stretches across new borders of research practices. For this reason, the study adopted an exploratory, emergent and agile approach that allowed an iterative, trial and error method in order to position the study foci and ensure a degree of alignment across ontology, epistemology, methodology and methods, without diluting the creative disruptive milieu.

As outlined in *Figure 3*, the next two chapters outline the work required prior to undertaking the three empirical sub-studies. The first of these embodies a blueprint of an embryonic methodology that supports and compliments advances in new digital devices. This is followed by a comprehensive account of the practices and procedures required to configure the various infrastructural and associated logistical processes. Immediately following are the three empirical sub-studies. Each of these incorporates separate foci: Bricks—physical space, bytes—virtual space/activity, and behaviour—physical activity.

Chapter 3

Methodology

Methodological thinking: The philosophy of the methods of practice.

At the heart of the research enterprise is the utilisation of a research methodology congruent with one's beliefs about the nature of the area under investigation. However, within social science, this process is not always straightforward and often plays out in a recursive dance as assumptions and presuppositions are untangled and adjudicated in order to address veracity and integrity. While grazing the landscape of the various theoretical, conceptual and methodological approaches was thought provoking and enlightening, there was no 'package' as such that I could merely select and apply. Instead, I was pulled deeper into the theoretical and methodological 'wars' on which our current research paradigms are formed (Bryman, 2006). The cornerstones of social science, such as the scientific and interpretative methods, critical and constructivist theories, and concepts such as truth, validity, objectivity and generalisability were among the many stimulating concepts battling for significance against a backdrop of arguments that appeared to be deeply rooted in the language and ideas associated with the romantic, modern, and postmodern periods.

I was ever mindful of being situated within the dawn of a new era where the unfolding present is, to some extent, uncoupling from a fading past; not too dissimilar to that which occurred as the industrial age laid waste to the pre-industrial age. The new industrialists innovated on speculations concerning the dawn of a new future, discarding solutions rooted in the ways of the past. These were tumultuous times, where diverging ways of doing and ways of thinking created disruption and diversion across all layers of society. It was this idea of ripping the past from future that fascinated me, where thought moved from structured patterns developed within a predefined milieu to one of a nebulous vacuum void of substance, but charged with obscure potential. If I could tap into the obscure potential of methodological thought, I just might create something of value. This, of course, would require aggressive scrutiny of my cultural-historical assumptions and presuppositions regarding higher education research. It would also require me to take high degrees of academic and scholarly risk, both in building conceptual structures/models and speculating on their ecology in order to articulate new realities. I had already received a degree of contempt and reproof from early 'ideas'.

Of some comfort is the social science tenet that research can never claim to be 'complete'; social research is to some extent a form of meaning-making and storytelling. For this reason, it is important that as researchers we are honest and transparent concerning the theories and practices that influence and eventually drive our investigations. All too often, in educational research, theoretical and conceptual elements are ignored or neglected. Conscious not to fall victim to this position. I remained attentive to the importance of staying mindful of one's self and one's research imperatives while trawling through the vast array of competing and complimentary stances. This required a sound awareness of the theoretical fabric of contemporary methodologies, in order to situate any constructions within a meaningful narrative from which the outcome of this study would eventually rest.

Need for a Methodological Turn

While provocative, it needs to be said that methods within higher education research are, for the most part, neither innovative nor progressive, but are instead comfortably situated in the past. When I embarked on my methodologies research, I became aware of a number of critical reviews of higher education research practice (e.g., Tight, 2013; Wells, Kolek, Williams & Saunders, 2015; Kelly and Brailsford, 2013 and Scutt and Hobson, 2013). These identified a narrow core of common research methods in higher education research, namely surveys and interviews. It appears that there is a pervasive belief within higher education research that evidence can be gathered by simply asking people questions. This is played out in a strong reliance on gathering data through self-reporting. As a result, there is a tendency to "fetishise and concentrate undue attention on the spoken word" (Kellehear, 1993, p159). While Kellehear raised these concerns in the 1990s, this state continues to be readily apparent in most higher education journals today. For example, Figure 14 represents a casual manual assessment of data types/research methods for empirical studies (n = 47) published in a leading higher education journal in 2015. It clearly shows that 80% of the studies assessed were based on ‘asking people questions’ (question-centric data—surveys, interviews and focus groups).

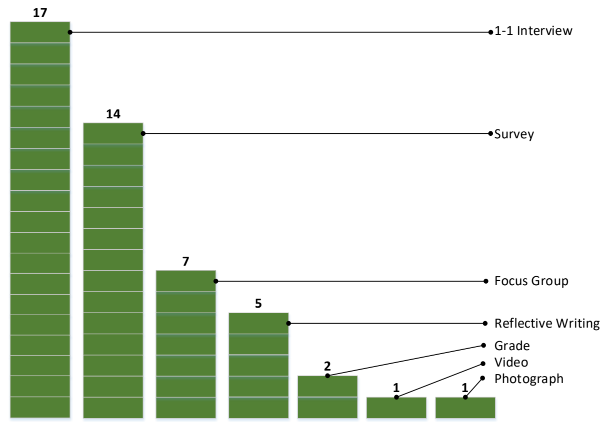


Figure 14. A review of methods from 47 empirical studies published in the *Higher Education Research & Development* journal in 2015. The y-axis represents the number of publications. The x-axis represents the type of publication.

Studies that ‘ask people questions’ will acquire rejoinders typically prejudiced by the person’s values, beliefs or post-event recollections. They reflect the perceptual dimension or reality and may therefore be inadequate as a method for making conclusions about physical reality. The act of responding to a questionnaire or interview reflects more an assemblage of orphan rejoinders rather than what is usually assumed as the unmediated expressions of a respondents’ physical reality (Robson, 2011). This is not to say such methods have no merit in research, on the contrary, they have proven to be a valid and useful measure of perception. Problems occur when we assume perceptions reflect practice or behaviour. That is, there may be a difference between the act of perceiving to that of performing—what you think you did/do may not actually be what you did/do. Research that requires self-reporting of events/action through post-event recollections opens the door for inaccuracies, particularly:

1. When a long time has elapsed between the event and the recollection (Arksey & Knight, 1999; Cohen, Manion & Morrison, 2010, Butson & Sim, 2013);
2. When participants typically attribute opinion (personal interpretations and meanings) to events (Kellehear, 1993).

The intrusive nature of asking a person to ‘stop what they are doing’ in order to complete a survey or interview necessitates a level of extract and detachment from their typical behaviour/s. This can lead to states of compliance or performance behaviours. As a result, the act of responding to a questionnaire or interview reflects more an assemblage of orphan rejoinders rather than what is usually assumed as the unmediated expressions of a respondents' physical reality (Robson, 2011). It is unfortunate that methods within higher education research have not progressed, particularly given that the education profession is characterised by the very act of promoting and encouraging change, and given the new possibilities for capturing data on behaviour in real time. It is as if educational research has become 'stuck' in a static cycle where researchers are comfortable in a particular method, resisting any desire to think outside their 'methods box' or leave their 'methods comfort zone' (Hesse-Biber & Leavy, 20086). Some have argued higher education research has relinquished its responsibility to be innovative and instead yielded to mimic and support the purpose and practice of research that best aligns with the crowd (Hesse-Biber & Leavy, 2008, Keller, 1985). It is an argument that questions the very nature of higher education research, including the role of the academic journals as gate-keepers who fortify the contagion element at play by promoting and legitimising particular, often narrow approaches to inquiry (Wells, Kolek, Williams & Saunders, 2015).

The Formation of a Methodological Turn

The formation of a methodological turn reflects a need to innovate and foster a variety of different shifts in the practice of education research. In my case, this rested on my ability to form new lenses through which to align my developing ontology, epistemology and methodology. What follows is a brief, but informative description of the three core influences that have been woven together to form an initial methodological blueprint: the Transformative Active Stance of the social constructivist Anna Stetsenko, the Idiographic Science of Peter Molenaar and the Reality Mining approach of Sandy Pentland.

However, before discussing these in detail, it is worth clarifying that the practices and ideas presented by these academics in no way resemble an established relationship between their ideas or approaches. On the contrary, in all cases, these academics assert 'ways of thinking' that are more akin to adversaries. In retrospect, it is difficult to fathom precisely why I pursued three disparate approaches. In my defence, all three represent dissenters within their prevailing disciplines and in this way, each represents a form of contemporary disruption. It would be fair to say they disturbed me and over time, all three movements resonated and sustained my emerging acumen. They afforded me the opportunity to be curious and avant-garde as I explored various juxtapositions. Constantly agitated, my mind worked frenetically, fabricating new cognitive maps.

Transformative activist stance

I start with the social constructivist ontology of Anna Stetsenko and her idea of the Transformative Activist Stance (TAS) (Stetsenko, 2014). She fashions a compelling view of people actively engaged in the collaborative transformation of their world through communal modification of existing realities.

> The suggested twin assumptions of the TAS that expand on Vygotsky's project are that, first, the world is dynamic, fluid, and constantly changing (this assumption is broadly shared in critical scholarship); moreover, and most critically, the world is understood as changing through people's own activities and activist contributions to their communities and practices. The world, therefore, is a continuous process that is turned into an act-uality through human action and made real to the extent that it is real-ized by people themselves, in their day-to-day lives, struggles, and pursuits. (Stetsenko, 2014, p.107)

These ideas align well with my social constructivist leanings in recognising concepts such as truth and reality as dynamic and relative to a person's specific conceptual schemes, theoretical frameworks, paradigms, cultures and forms of life (Bernstein, 1983). It also offers me a tangible and pragmatic dimension on which to argue for the purpose of education as an emancipatory endeavour, encouraging the possibility of innovative ways of thinking and acting in order to transform our understanding of higher education. She approaches education as a catalyst for change that is a consequence of the act of meaning-making through purposeful action. The idea of the researcher as 'activist' is a noteworthy concept that is often overlooked in the practice of social science where there is a tendency to decouple data from the individual participants through the act of large sample data aggregation.

Because of these ideas, I was able to envisage an advocacy/participatory approach that could potentially be shaped by a research ethic grounded in the goals, desires and situations of the individuals.. In this way, research could be defined in emancipatory terms of an endeavour to effect positive change in the lives of the individuals..This is not a neutral position, but reflects an explicit desire to focus on transformation in which the intention is always to empower the lives of the individuals I am studying in order to meet their academic and professional goals.

In this sense, my position moves away from education as a process of instruction or schooling and instead adopts a Stetsenkoian approach of deliberate, goal-directed and purposeful transformation, as so eloquently stated by Anna Stetsenko (2014):

> The transformative activist stance is a shift away from the ethos of adaptation that takes the world for granted and assumes that individuals have to fit in with its status quo, towards the notion that the deliberate, goal-directed and purposeful transformation of the world based on a commitment to, and a vision of, social change is the foundation for human development in all of its expressions encompassing processes of being, doing, and knowing. (p.183)

Idiographic science

The second influential idea or movement is that of idiographic science (Molenaar, 2004), which advocates the study of the individual over the group/population. The idea of an idiographic focus is not new; the founder of personal psychology, Gordon Allport, first introduced it in the 1930s. Allport questioned the traditional social science research paradigm of the day, arguing it was founded on inductive reasoning (inference of general laws from particular instances) that relied on sampling populations (nomothetic) to render generalisable truths. Data was aggregated in order to ascertain the central values of distributions through various methods designed to reduce outliers (extreme or abnormal variability). In particular, the process explicitly classifies people into groups in order to establish truth through generalisation. Like Allport, Molenaar (2004) argues that outliers should not be removed, but pursued. In his methodological treatise on the subject aptly titled, *A manifesto on psychology as an idiographic science: bringing the person back into scientific psychology, this time forever,* Molenaar endeavours to restore the individual as the legitimate target of social science. He argues that the customary nomothetic methodology of aggregating data is of questionable validity for the individual and therefore represents a broken methodology. In contrast, he insists, idiographic science with its abductive reasoning offers a form of logical inference from observation to the explanation of individual concrete cases.

While there are ontological similarities between Molenaar and Stetsenko, I was captured not by his Vygotskian ideas and cultural psychology, but by his crusade to promote a new dynamic methodology based on the individual.

Reality mining

New technologies have unleashed a barrage of new devices/measures capable of addressing evolving educational questions. For example, wearable/mobile sensor-based technology now offers us the ability to capture continuous environmental data (movement, spaces, eye tracking and actions) and biometric data (EEG, movement, heart rate, blood volume pulse, EDA). Similar to the invention of the telescope or the microscope, these new measuring devices allow us to 'peek' into new worlds that have been previously unknown to us. For example, environmental data that captures physical, virtual and social dimensions and physiological data that captures the voice of the body. These do not exclude the traditional psychological or perception data, but rather extend it. Against such a backdrop of innovation and change, it is easy to assume the need for tabula rasa[1]. However, as in any revolt, the aim is to disrupt the prevailing hegemony, not by throwing the baby out with the bath water, but through reforming existing artefacts to cultivate new strategies and new voices.

My first step in this new world was nurturing a social constructivist ontology of multiple realities, where truth is created through negotiated meaning within particular contexts at different times. In this respect, reality is not some objective truth that is waiting to be uncovered by means of testing propositions, but rather materialises as multiple realities that compete for truth and legitimacy. In this way, actions are more akin to 'building' than to 'finding' or 'discovering'. From this standpoint, it is essential to maintain congruency between the formation of methodological narratives and the nature of any new and emerging realities. This was an extremely demanding task. My certainty concerning the significance of reality/ies, knowledge and methods were shaken as I struggled to 'construct' a research methodology that would provide an ontological and epistemological fit.

[1] tabula rasa – The theory that our mind is a 'blank slate' at birth, with one's identity and personality being formed solely by one's sensory experiences: all nurture no nature.

This Study – A New Method

While I have lobbied for researchers in the field of higher education to engage in "methodological self-reflection" (Rios-Aguilar, 2014, p. 97), it is also important to address questions concerning methods, particularly the purpose, process and precision of what we identify as data and evidence. This is a challenging proposition, but one that is at the very core of educational research, legitimising its purpose and role in the dynamic, unpredictable future of the twenty-first century. Unless we are willing to persistently reflect on and appraise our prevailing methods to research, of we may struggle to advance the scholarship of higher education. Therefore, as the world and our understanding of it progresses, so too must our repertoire of research methods (Hesse-Biber & Leavy, 2008). I am not advocating for the abandonment of traditional research methods, but rather to balance these approaches with new and emerging methods. The shifting technological landscape is a pertinent reminder of the precipitous nature of change. This new world offers us new research lenses that have the potential to reveal previously unseen data. For example, if we take the two preeminent social science methods of observation (the method of directly observing a person's behaviours (Robson, 2011)) and trace analysis (the practice of analysing artefacts associated with people's behaviour i.e., documents, possessions or garbage (Kellehear, 1993)), and automate these methods through digitised processes, we can start to see the revealing power that new technologies are capable of unleashing.

Conscious of the possibilities, I have played with a variety of hybrid schemas pertinent to the pursuit of new ways of knowing. In doing so, I have come to accept that while new technologies can empower old forms of research such as observation and trace analysis, they also drive new insights as a consequence of the lenses they afford us. For instance, new wearable sensor-based devices are allowing us to understand human behaviour differently due to their capability to amass continuous naturally occurring data across physiological, psychological, behavioural and environmental dimensions. In this way, it is both constructive and legitimate to view emerging sensor-based systems as catalysts for revealing new types of data. At the heart of this approach is the need to understand what it is we are 'seeing' and to comprehend the significance/relevance of these new lenses to the practice of research. Figure 15 shows an example of how we can start to reimagine methodology based on new ways of seeing and new sensor-based technologies.

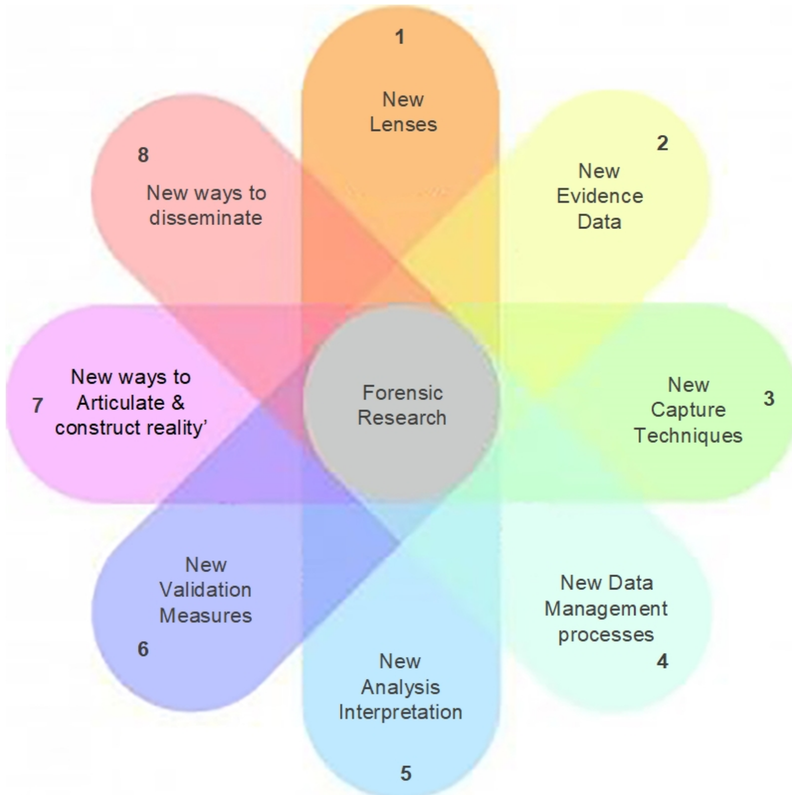


Figure 15. Methodology stack driven by sensor-based data that follows a generative design process.

In this schematic, I have assembled the likely components that would be associated with a methodology driven by advances in sensor-based technologies. In this preliminary outline, the various elements that make up the stack represent a connected, rather than chronological structure/form. While the various elements are not sequential, there is a high level of connectedness in order to create the optimal conditions for congruence and synchrony:

- **1-** New lens/es…
- **2-** Necessitates the need for new definitions of what constitutes evidence/data
- **3-** Necessitates the need for new capture/harvest techniques
- **4-** Necessitates the need for new data management techniques
- **5-** Necessitates the need for new methods of analysis
- **6-** Necessitates the need for new ways of validating measures
- **7-** Necessitates the need for new ways to articulate discoveries/constructions
- **8-** Necessitates the need for new approaches to dissemination

These ideas represent a developing impression or blueprint that, while foretelling in nature, also signals an opportunity to start re-imagining what is possible now. It is of course very different to the six-step process that underpins traditional educational research methodology (Figure 16). While the various stages of this process may be augmented by particular technologies, technology is not typically the catalyst that defines or drives these stages.

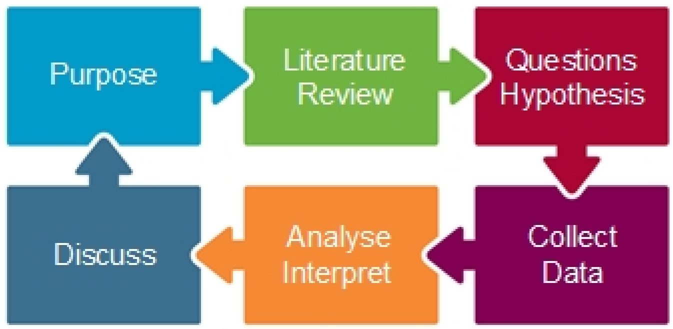


Figure 16. Schematic showing the six-step process of the scientific method.

However, technology as the research driver is precisely what can occur with the generative design process shown in Figure 15. Sensor-based technologies can expose new dimensions that drive new purposes, new areas of inquiry and new forms of data. For example, advances in artificial intelligence (AI) and machine learning make it possible for us to develop algorithm assemblages that draw on real-world networked data to inform us of essential areas of inquiry. These same systems can be used to instigate and manage complex data capture systems from sensor feeds. They can also analyse this data for significant patterns and report these findings in new forms.

Intelligent digital systems have the capability to manage repetitive processes, eliminating the laborious administrative and procedural processes that are indicative of the traditional research process. At the heart of this approach is the concept of generative design, which relies on iterative processing via repetitive feedback loops controlled by automated algorithmic assemblages of goals and constraints in order to produce a solution (Hauck, 2018). It is an approach dependant on colossal data feeds in order to run vast permutations to find a solution. It offers a way to cycle infinite options, learning from each iteration and returning new outcomes beyond what a human alone could produce. Unlike traditional research methods, which typically rely on inductive or deductive forms of reasoning or logic, generative design processes employ an abductive approach.

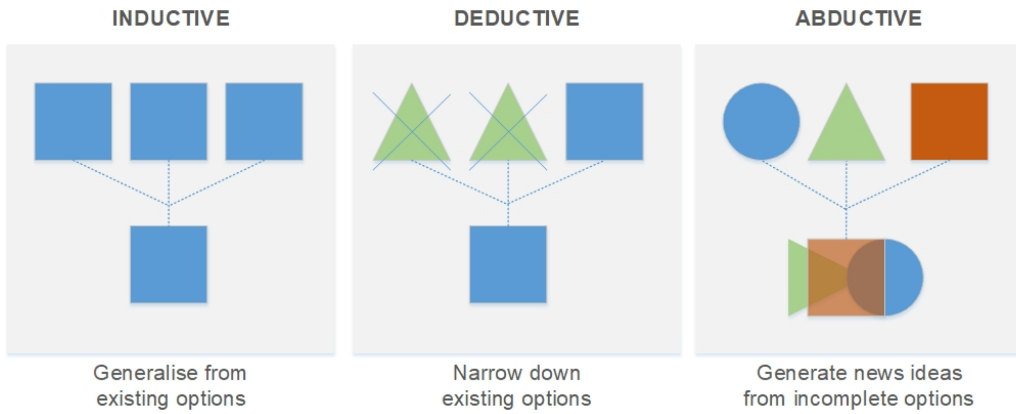


Figure 17. Schematic showing a comparison of the three core approaches to reasoning.

I am persuaded by the intention of an abductive approach to generate probabilities to ascertain levels of likelihood (Figure 17). In the case of educational research, digital sensors could create personalised digital traces that can be transformed into digital artefacts (data) and then evaluated to determine their contribution as useful evidence for personal feedback. Through the process of abductive reasoning, personal solutions could be generated based on probability and/or likelihood as opposed to top-down logical truth (deductive) or bottom-up generalisations (inductive). This could form the backbone of a feedback-loop system that plays a transformative role through an idiographic focus through reality mining methods.

In summary, the methodological ideas presented in this chapter represent an initial skeletal outline of some of the core ideas needed to progress a new sensor-based approach. They offer a framework to steer the current study through the various contradictions that surfaced as a result of using a technology-driven approach to educational research. The generation of digital traces drive the three studies that constitute the core knowledge contribution of this thesis. In this way, the decision to employ devices, such as software capable of capturing continuous computer activity data and surveillance cameras able to capture continuous office activity, necessitated the need to rethink what was defined as evidence and the parameters associated with its capture and analysis.

Unit of Analysis

A fundamental, but often difficult, task of social research is the selection of the basic unit of analysis. It requires a delineation to be made between the object and the background in order to create an entity that connects the various threads of the research (Kuutti, 1991). In this study, that distinction occurred between the unit of observation, in this case, early career academics, and the chosen unit of analysis—activity. Given that the intention of this study was to investigate behaviour over perception, it seemed reasonable to select 'activity' as the primary unit of analysis.

However, activity has various uses within the realm of social science research. The most well-known approach to understanding activity is Cultural-Historical Activity Theory. Underpinned by the socio-historical branch of Soviet psychology, Activity Theory is typically attributed to the work of Vygotsky (1978) and Leontiev (1981). From a Russian perspective, 'activity' refers to the human act of 'doing' and embodies the role of the social in shaping the mind of the individual (Lantolf & Appel, 1994). Its central claim is that the human mind can only be understood within the context of human activity (Kaptelinin, Nardi, & Macaulay, 1999). I would also argue that is it essential to study activity in natural settings in order to appreciate the complexity and essence of any phenomenon.

However, while the concepts, ideas and frameworks of Activity Theory aligned with the intentions of this study, the dominant role of language in Activity Theory, where activity was characterised by dialogue rather than behaviour, did not align. It became clear that the theory had deep roots in language as a proxy for activity. In this study, I refer to activity as human action. In light of this, specific types of human activity were identified as relevant for each of the three studies. In the first study, the emphasis was on activity as a process of spatial configuration, in the second, activity in relation to computer use and in the third, activity as it related to patterns of individual behaviour. In all cases, the Activity Theory proposition of activity as behaviour within context was adopted.

In Summary

In this chapter, I have discussed the preoccupation of higher education research with 'question asking' as the primary source of data. My solution is to emphasise the importance of being cognisant of the changing nature of data and evidence and encourage the need for responsiveness to continuously seek and adapt research knowledge, strategies and practices to suit an evolving environment. These new research ways are unlikely to appear familiar. This is evident in the methodology stack I created for this study and the manner in which I couple objectivist and subjectivist realities. For example, given my adherence to social constructivist epistemology, it may seem problematic that I have chosen to undertake an empirical study that to some degree pairs aspects of positivist and constructionist methodologies. In one way I am advocating that there is a reality and it can be mined, but I do so within the domain of constructivism with its adherence to multiple realities, context and culture. While this may seem contradictory under traditional precepts, the postmodern world in which we currently inhabit offers a fertile ground in which to produce such antinomies. This brings me to my concluding central claim, one that underpins the methodological attitudes, models and practices I have attempted to express here and judicially followed throughout the study—that of embracing 'fuzzy' multi-paradigmatic approaches to understanding and forming new practices, methods and methodologies. For this reason, I had no systematic or serious defence for the ideas that were evolving, except to point out my continuing belief that during rapid, radical change, the pathway of innovation is likely to be paved with confusion, imprecisions and dichotomies. For the innovator, it represents a state of anticipation and excitement, while for the conservator it may besubversive and dangerous.

Chapter 4

Devices, Logistics & Infrastructure

The art of preparation

The terms 'devices', 'logistics' or 'infrastructure' are not typically associated with higher education research. However, I adopted these concepts given their applicability to the current study. They represent processes that are particularly pertinent to digital-based research conducted in natural settings. They emphasise the importance of engineering or staging (pre-data mining) that is required in studies that are dependent on an infrastructural and logistical design. The context in this study is the university office space of the academics being studied. As mentioned earlier, the study was empirical in nature and consisted of three differing forms of analyses, each presented within the thesis as related sub-studies: 1) the academic members' spatial configuration of their office space; 2) the academic members' computer usage; and 3) the academic members' daily physical activities undertaken within their office space.

Five early-career (Gen-Y) faculty members (two females and three males) from a range of disciplines (science, health science, humanities and commerce) volunteered to be involved in the study. Each had responded to an invitation circulated through various ad hoc institutional networks inviting early-career academics. Given the idiographic nature of the study, there was no requirement for formal sampling. Instead, a 'first-in' selection process was employed for those respondents that met the inclusion criteria of being an early-career academic (held an academic position for less than 3 years) and self-reported as being a millennial. Once selected, each was briefed on the nature and mechanisms used in the various data mining procedures. Given the study was undertaken within a research-intensive university, all five early-career academics were employed on contracts that required them to engage in 'research', 'teaching' and 'service'. In all cases, this was defined as a 40-40-20 workload: 40% research, 40% teaching and 20% service.

Each of the participants are presented using the following letters: (A) AC-commerce-male, (B) CH-humanities-female, (C) CS-science-male, (D) DP-health science-male, (E) SP-science-female. Lastly, it is worth commenting on the point previously raised, concerning the decoupling of data from participants during data analysis. In order to mitigate against this tendency, aspects of the study practice were shaped by a more natural, humane research ethic grounded in the people involved. This included participants having direct access to their data, including control over what was included or excluded, knowledge of the other participants involved in the study and opportunities to meet other participants at various times to discuss aspects of the study.

What follows is a breakdown of the various data capture procedures associated with each of the three sub-studies. This is complex and detailed information that does not appear in the dedicated sub-study chapters (Chapters 5, 6 and 7). The material in those chapters has been abridged in order to emphasise the study purpose, analysis and conclusion. In this chapter, I have also included a synopsis of ethical issues that needed addressing and a discussion of the limitations and challenges of my research design.

Sub-study-1: Spatial configurations of the academic office

This study addressed the 'bricks' aspect of New Ways of Working by exploring the degree to which participants' office configurations had been shaped by the digital revolution. It centres on the proposition that the structure, content and process of the way we work as academics is undergoing change as a result of academic work becoming more cognitively complex, collaborative, more dependent on technological competence, more time pressured and more mobile. To understand the impact of these changes on the daily practices of early-career academics, the investigation focused on the office space as a living space that embodies characteristics that, through the analysis of physical configuration, design and visual symbols, may reveal aspects of work practice unbeknown to the academic and therefore overlooked in methods reliant on self-reports.

The intention was to construct meaning through an analysis of physical static space using diagrams and photographs. Critical visual analysis, visual semiotic analysis and visual juxtaposition analysis were employed to guide and create a visual ethnography of the manner in which each academic had constructed their office space. To reduce the likelihood of identification of visible personal artefacts, such as names, photos and drawings, filters were used to convert the photographs into sketched images. A further collection of images drawn from public image repositories of academic office spaces throughout history were acquired for the purpose of comparison. As a result, three datasets were created:

1. Diagrams of the office layout;
2. Photographs of the office space;
3. Series of historical photographs of faculty office spaces.

While there is a tendency to define offices aesthetically, it would be a mistake to assume these interiors are constructed solely by visual imperatives. Rather, the forms of work undertaken are more likely catalysts for space configurations and typographies. For example, in the case of the academic office, the organisational focus on knowledge-based activities defines the chattels (purpose), while the working methods of the academic dictate their arrangement (process). The creation of spatial diagrams as shown in Figure 18, depicting the configurations (dimensions, chattels and their arrangements) provided a transparent way of examining these two dimensions.

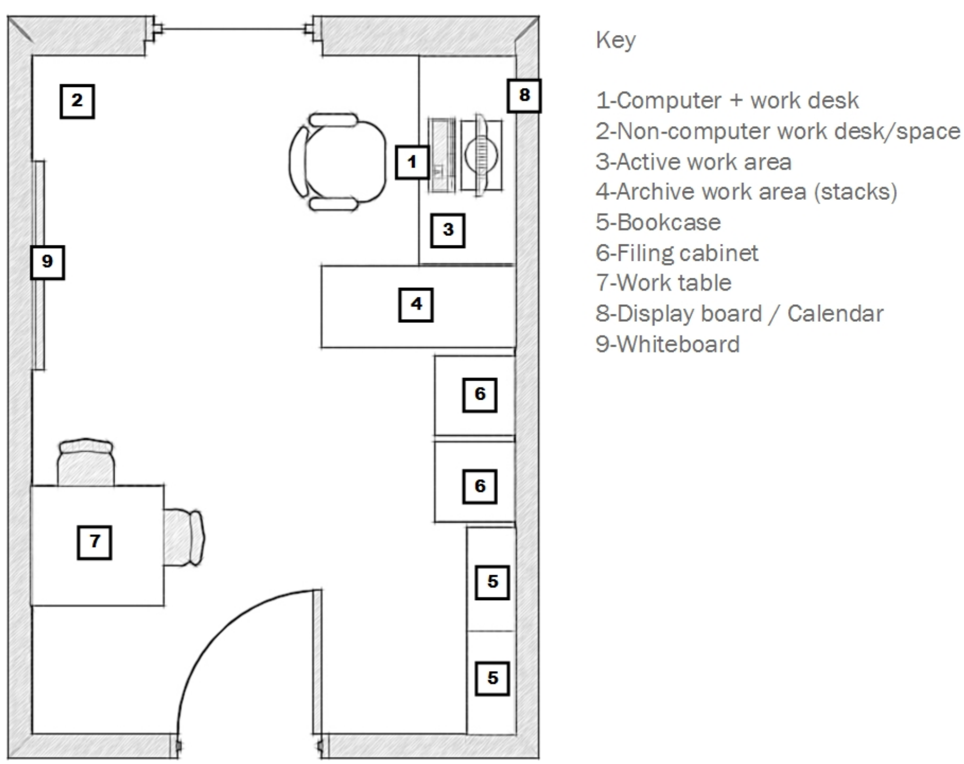


Figure 18. Diagram depicting an example of office space configuration.

The addition of photographs offered a more comprehensive investigation of artefact selection and arrangement associated with either form (aesthetic) or function (processes) and dynamic and static conditions. Two photographic series were created for each office. The first was wide-angle photographs capturing large views of the office, as in Figure 19. These were useful in understanding the various chattel assemblages and the relationships between chattels. They also offered a ‘feel’ of the overall space. The second series of photographs were detailed slices of each wall sequenced in a 360-degree rotation. This allowed for a detailed inventory of all artefacts present. These were categorised as institutional or individual, static or dynamic, purpose or process related or aesthetic.

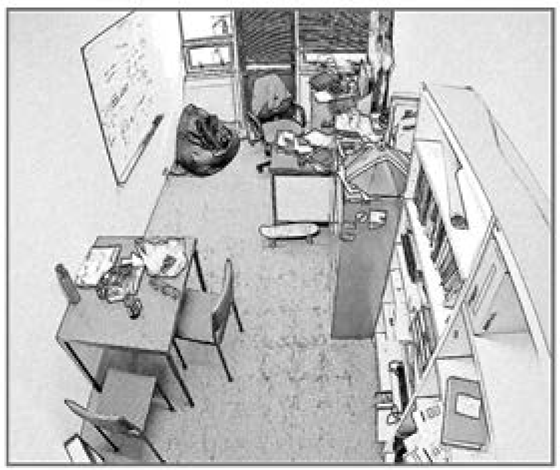


Figure 19. Photograph of an academic office space.

In order to determine influences over time, the collection of historical photographs of academic office spaces from the past 50 years were obtained from various public archived sites (Figure 20). The selection process for these photographs was based on the degree of clarity the offered concerning office layout and work process. While only eight photographs were eventually selected for inclusion in the thesis, the arguments made and conclusions drawn were based on a more substantial collection of over 50 photographs.

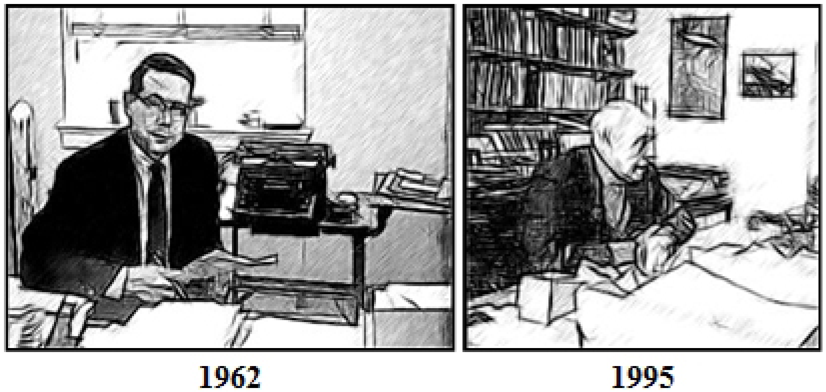


Figure 20. Historical photographs of academic office.

Sub-study-2: Patterns of spatial behaviour in the academic office

The collection of data is never as straightforward as assumed in the honeymoon phase of study design. No matter how fastidious and systematic one is in planning the process it seems you can never fully envisage the outcome. In this sub-study, the focus was on ‘behaviour’ regarding New Ways of Working and in particular, the level of amalgamation with technology. It extended sub-study-1 but examined in more detail the elements of ‘process’ by investigating participants’ daily office practices through video footage. The decision to use video was driven by the rich, complex data of daily practice that this media afforded. There was also an exciting and appealing aspect to the use of video data that was clearly detached from the logistics of actually doing it. In theory, video capture is relatively straightforward, however, in this study any notion of simplicity was soon overtaken by a series of complex issues that required resolution. The following section outlines the processes, issues and solutions that formed the working method. The first part explains the infrastructure, followed by an overview of the processes involved in the analysis of the video footage.

Video capture process and infrastructure

The best way to conceptualise the numerous aspects involved in the resulting infrastructure is by using the processes involved in the capture, storage, and analysis. The initial task was to decide on the type of camera to use. This involved testing USB driven webcams and standalone wireless surveillance cameras, as shown in Figure 21.

Figure 21. Generic USB Webcam and wireless surveillance camera

While the output from both cameras was reasonable, both required participant input to activate and manage the process. This meant that participants would be required to manually start the camera and activate the recording procedure each morning and then stop this process at the end of each day. Early testing with a colleague revealed this was an extremely demanding requirement. In the case of the webcam, a laptop computer was needed to control the camera and store the video footage. The laptop storage capacity allowed five days of footage at which time the data would be transferred to a larger storage device. However, during the testing phase, the camera was inadvertently left on a number of times, causing recording to continue throughout the night. The result was that the hard drive on the laptop became full, which compromised the functioning of the laptop with the loss of video footage. Preventing this required an additional monitoring process of the data storage. It soon became clear that the webcam would require daily input from both the participant and the researcher.

The second option was wireless indoor surveillance cameras. Rather than continuous footage that required enormous amounts of storage space, these cameras used motion detection. This meant that recording was only occurring when a person was in the room. The participants were no longer required to activate the system—it just happened. Unfortunately, these systems used SD cards for data storage. High capacity SD cards were expensive and lacked the storage capabilities of a laptop. By reducing the video quality, it was possible to capture five days recording. As before, at the end of each week, a new SD card would be fitted and the full card was taken away to be transferred to a data storage device. This option appeared to be a useful approach. However, initial testing found that video footage was compromised when staff decided to work at night, with SD cards very quickly becoming full, causing the system to shut down. While workable, the ongoing attention required to manage this system was of concern. It entailed a person to visit each camera at the beginning of each day or week (depending on the volumes of footage captured) to maintain the SD card. However, this process of regularly checking and clearing data storage devices was both time consuming and intrusive. Given these factors, the use of portable data storage devices in this study was going to be unsustainable.

A third, more technically sophisticated option was investigated whereby video data was streamed directly to a central data store via the University internal Ethernet cabling/network. In this schema, HD cameras would be situated within the academic's office and connected to the university Ethernet network. This would allow for transmission of video footage from the camera directly to a high capacity data storage device (Figure 22), thus addressing the data storage issues associated with the two previous approaches and removing the need for participant input.

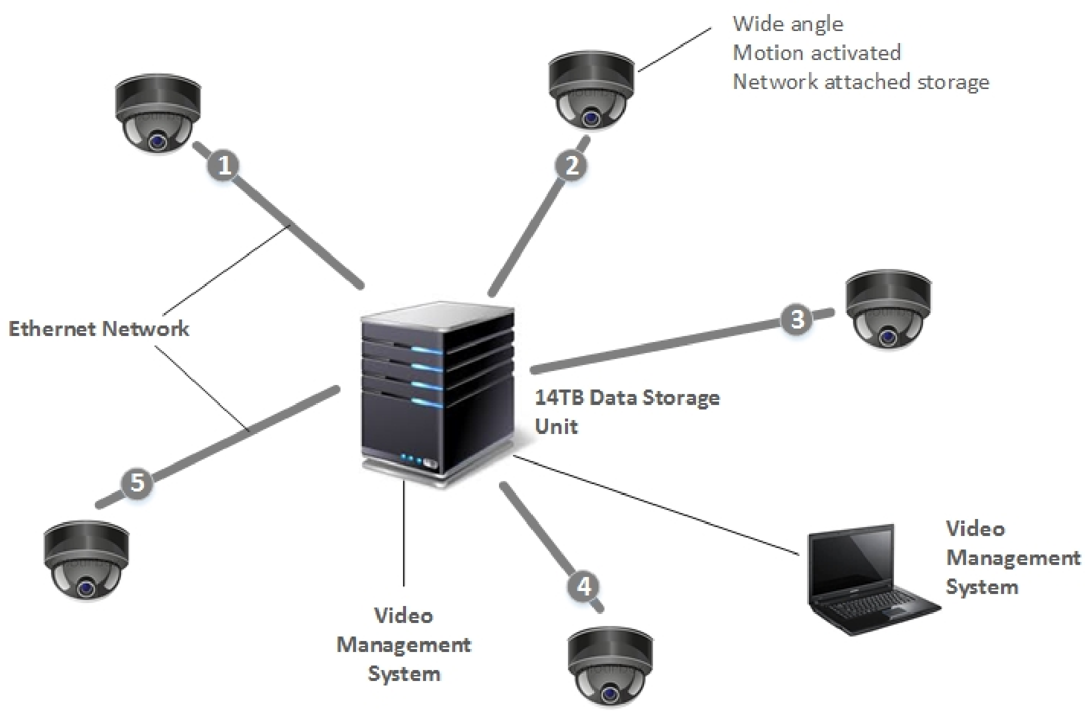


Figure 22. Schematic showing video capture, monitoring and storage configuration

While this model appeared feasible by design, the actual building of such a system required input from a team of advisers and technicians. The first phase was to enlist the expertise of a reputable security company who could advise on the design, supply the hardware and help with the roll out. Given that the system was to operate on the University's internal network, it seemed prudent to recruit the company already contracted to manage the University's video surveillance network.

Technical discussions and initial testing of continuous data feeds soon revealed that this type of data capture comes with an entirely new set of difficulties. Continuous video capture generates considerably more data than the earlier approaches I had been exploring. Early calculations predicted video footage at the resolutions required for analysis would mean file sizes of approximately 12-20 GB per person per day.

A number of camera types were carefully reviewed before selecting the Axis 3354, a high-performance surveillance-type video dome camera as shown in Figure 22. These cameras fulfilled the core features I was looking for, namely, superb video quality in HDTV 720p, excellent light control through Axis Lightfinder technology, and H.264 video codec that can achieve high-quality video in relatively low bitrates. The bitrate refers to the amount of data measured in bits per unit of time being captured. The benefit of H.264 is that it offers high-quality video in half the size of traditional formats. This means it would be faster to download or stream and consume much less storage space than other formats.

Figure 23. Axis 3354 camera

The cameras were also configured with Digital PTZ, the ability to remotely pan, tilt and zoom, and P-Iris control, a new form of iris control that offered more precise control over the aperture size of the iris than traditional manual and auto systems. Axis also offered a free Video Management System (VMS): The Axis Camera Companion. It was clear from the video tutorials that this software would be ideal in terms of its functionality and ease of use. It came with a client-side application that installed on a laptop to allow live monitoring of camera activity, camera behaviour and recording status. It also allowed playback of pre-recorded video and segment slicing for export.

Video feeds from the cameras were streamed live to a high capacity data storage unit. An Asustor AS-604T multi-functional 4-bay Network-Attached Storage server, or NAS, was selected for this purpose (Figure 24). The NAS was organised to receive data feeds from the five cameras through a RAID configuration that managed four physical, four terabyte drives. A RAID refers to a single (virtual) usable disk, supported by several physical disks that are combined into an array to improve speed and protect against hardware faults. This server was also used to run the VMS-Axis Camera Companion application.

Figure 24. AS-604T Network-Attached Storage server

The role of the NAS box was to receive the video feeds from the cameras and store them in a manner that allowed for storage and retrieval. The VMS played this role, both in the manner in which the video footage was stored and the management of monitoring and retrieval requests. The automated features and high capacity data storage meant the system would operate independently of the participants.

It is worth noting that before attaching the devices to the University network, a risk assessment was conducted with key Information and Technology Service (ITS) staff responsible for networking and security. While no major changes were made to the overall blueprint, detailed knowledge of the security processes and network configurations were useful in guiding the eventual installation. All devices were checked to ensure they complied with University standards regarding networked devices. Approval to fit the cameras to the office ceilings was also required from the Property Services Division who was given a brief outlining installation guidelines aimed at reducing property damage and compliance to safety standards.

The final phase was to install the various components. This involved commissioning a preferred University installer to supply, configure and fit the dome cameras in each office in accordance with the brief from the University’s Property Services Division. These cameras are designed to receive electricity via the Ethernet cable, the same cable that is used to transmit the data. The benefit of running the power through the Ethernet cable reduced the need for plugs, power adapters and a second cable. As shown in Figure 25, the hardware for installation per office consisted of three items, making the process simple and clean. The camera was fitted to the ceiling and connected via an Ethernet cable to an Ethernet wall socket.

Figure 25. Core components: Ethernet socket, Ethernet cable and Dome camera used to generate a continuous data feed from camera to data store via institutional Ethernet infrastructure.

Unfortunately, a number of sub-networks within the university network infrastructure were not fitted with PoE—Power over Ethernet capability. Consequently, PoE adapters had to purchased and installed at network substations situated within the various buildings in order for selected Ethernet office sockets to transmit electricity to power the cameras (Figure 26).

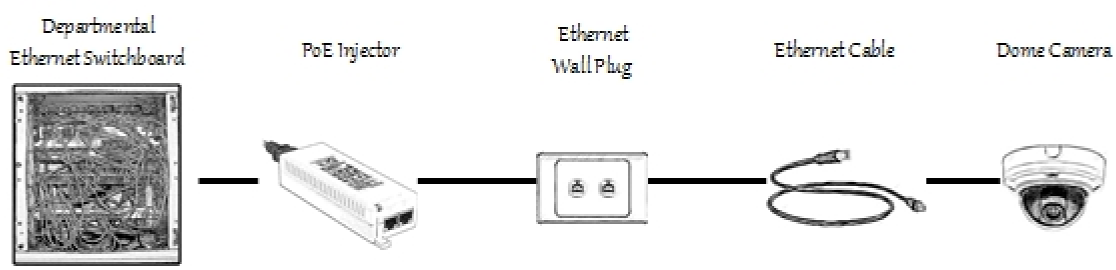


Figure 26. Schematic showing the configuration of the various components fitted within the departmental infrastructure.

Once PoEs were installed, cameras were fitted and configured for the best-fit image. A further week of programming and testing followed before the system was deemed ready for use. However, within three days of recording, the NAS storage unit started to shut down intermittently. After significant testing, it was found that the server reached an indeterminate threshold after 45 hours of continuous capture and would shut down. Consultants contacted for guidance on the issue were not able to give a definitive reason for the behaviour. Rather than embarking on an exhaustive testing regime, it was decided that the best option was to replace the faulty machine. The replacement server was configured and tested prior to use. Unfortunately, the same shutdown pattern continued, suggesting it was not due to hardware, but something more serious concerning the way the NAS was handling the video feeds over the network. After consultation with the various technical groups involved, the decision was made to replace the NAS AS-604T with a DELL PowerEdge Server and to upgrade the software that controlled the video feeds with a more sophisticated VMS. Changes made to the blueprint also allowed for the application of a more advanced forensic video analysis package (AgentVi). This platform became the cornerstone of the new infrastructure design. The reasons for this decision and its capabilities are discussed in detail later in this chapter. The shift to a more sophisticated infrastructure required input from technical staff familiar with video capture and forensic video analysis software. Figure 27 the outlines the various components associated with capture, transfer, storage and analysis that make up the subsequent or second design.

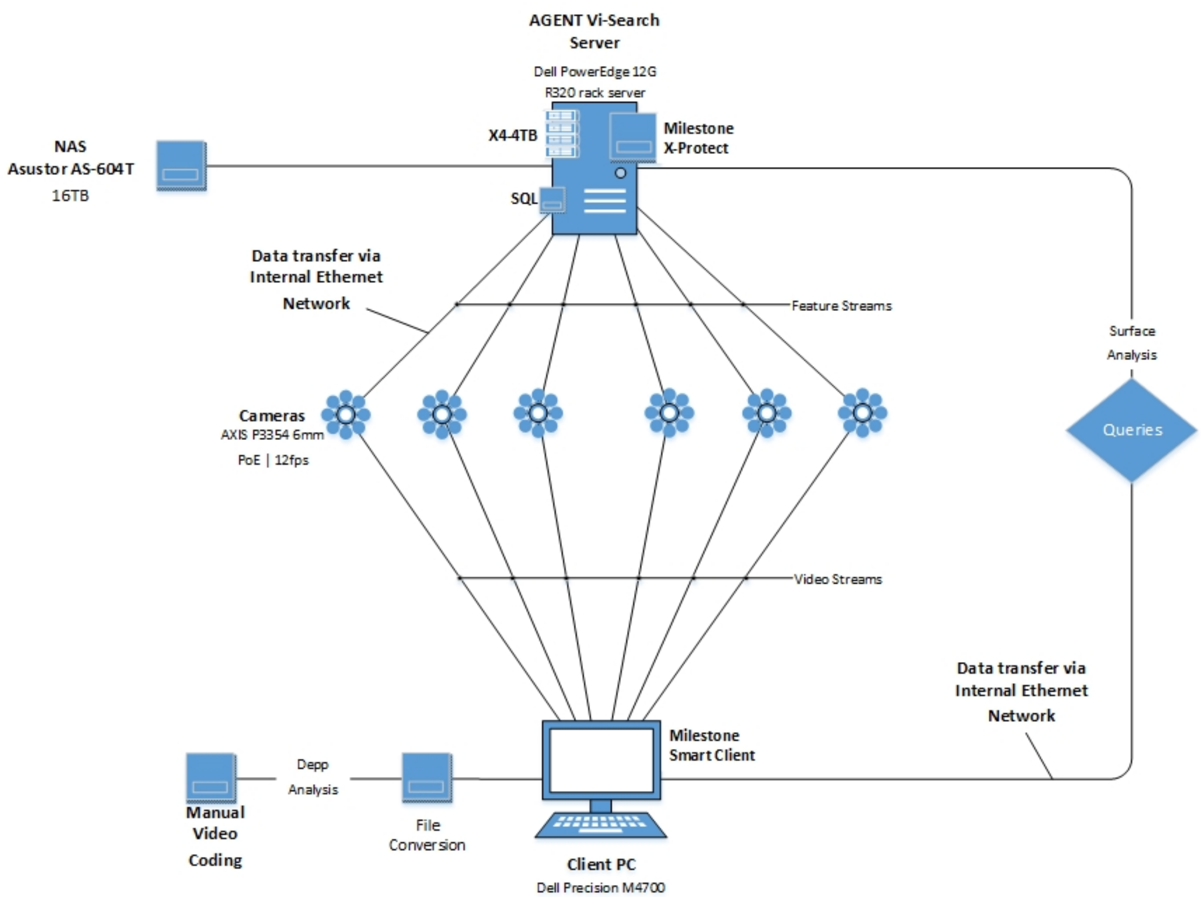


Figure 27. Schematic showing the upgraded infrastructure. This includes the addition of the forensic software (AgentVi) and Milestone xProtect VMS.

Three key changes were incorporated into the new design. The first was the replacement of the NAS AS-604T with a Dell PowerEdge R320 rack server with 16TB of data storage (Figure 28). This server was a high spec 20 core server capable of running a Video Management System (VMS) and an integrated forensic video analysis package while simultaneously handling the live camera feeds. The server was installed within the institutional server facility in order to make use of the high-speed Ethernet connectivity for internal use.

Figure 28. PowerEdge™ [R320 Intel Xeon processor E5-2400] with 16 terabyte RAID configuration.

The NAS AS-604T was retained and configured as an additional backup storage space. The second change was the addition of xProtect, a more advanced VMS for managing the live feeds. This included camera configuration, data quality, storage, and, most importantly, monitoring of the system and integrity of the data captured. Changes in light or data transfer feeds can/could reduce the quality of the data. xProtect actively monitored these processes and notified the researcher when either of these reduced the video quality below my desired threshold. The software also monitored the state of the camera (focus, direction and motion detection features). The third major change was the employment of savVi™, a video analytics software solution that offered a variety of analytical capabilities that included advanced forensic functions. savVi™ offered automated video analysis that allowed post-capture queries to be run across thousands of hours of footage, replacing manual and time-consuming processes.

High definition camera data was sent as live streams to the central server (DELL PowerEdge R320) (Figure 28). The cameras were motion sensitive, allowing the cameras to be active at all times, but only streaming data when people were present. This process reduced capturing redundant footage and minimised the volume of data to be analysed. All streamed data was stored on the central server according to date/time information. During this process, the VMS monitored the quality of the data feeds and physical condition of the cameras, notifying the researcher of any anomalies. To facilitate this procedure, live monitoring of the video streams was made available to the researcher. In this way, system-identified anomalies could be quickly addressed. Coupled to this system was the additional analytical layer consisting of the savVi™ system, a video analytical suite. This system analysed the streamed footage prior to saving. A classification of various attributes administered through a rule-based approach built on a set of assertions was developed to collectively define the analytical schema. These included such states as zones or areas within the room, major changes to artefacts (papers/books moved, cabinets opened, relocation of equipment) and the composition of people present. To achieve this, savVi simultaneously monitors the various cameras streams for the desired attributes, creating a metadata record of when these occur. This is an extremely complex process, resulting in the ability to search, by query, any of the desired attributes across extremely large volumes of video footage post-event.

Video data analysis – take 1

Typically, the analysis of video data follows a two-element process: events are captured in video format (element-1) and then analysed by a researcher (element-2). The process of interpretation is based on human observation. While there are a variety of interpretative methods, the underlying idea has not changed since the introduction of the camera. There are two obvious limitations to this approach. Firstly, the act of having to physically view the video footage limits the volume of video data that can be analysed and secondly, the degree to which the video data can be interrogated is going to be dependent on the observational skills of the researcher. This study adopted new developments in video forensics that extends video analysis capability beyond short-term researcher-dependent methods. These applications automate the capture and analyse the process by incorporating fast processing and artificial intelligence that can perform continuous, sophisticated processing of extremely large datasets. In the current study, this involved a multi-layered design that integrated the Axis intelligent cameras, xProtect VMS and savVi™ video forensic software.

The intention was to use the video query capacity of savVi™ to undertake targeted investigations by identifying and isolating particular behavioural events. Unfortunately, the expertise of the New Zealand company supporting the product was ill-equipped in configuring the system to analyse video data in small, enclosed spaces. A critical calibration process undertaken during initial setup was incorrectly configured, meaning the level of live metadata being captured was weak. It wasn't until much later that this problem was discovered. By this stage, it was clear that for the sake of data integrity, the best option was to continue the data capture, albeit without the useful metadata. Once completed the system could be recalibrated correctly and the video footage re-run to assign the metadata.

Video data analysis – take 2

In theory, *take-1* was a plausible option, however, on completion of the study period it was discovered that 1) it would take 30 plus weeks of continuous processing to run the recalibration process, and 2) that while it was plausible, this process required a degree of system manipulation in order to force the process. This solution was discussed, but not tested as there was no guarantee of success.

Nevertheless, the concept was explored but was found to be far more difficult than originally assumed. The process involved configuring the stored data within the capturing software (xProtect) into feeds that would mimic camera feeds. In this way, we would 'trick' the analysis software (SavVi) into thinking the stored data were actual live camera feeds. The relationship between the two systems in this configuration was unstable. While successful from time to time over short periods, we were unable to succeed in creating a robust arrangement that would maintain the quasi-relationship over extended periods.

Video data analysis – take 3

One plausible solution was to use post-capture analysis software, of which there were a number of products. One of these was Video Search, a product by AgentVi. Initial testing showed excellent results. However, the analysis method required the video to be in a standard video codec such as H.264 / MPEG-4 AVC. The Video Management System (VMS) xProtect used to capture the video did not use this format. To employ the AgentVi application would require converting hundreds of thousands of 3 minute sequenced video files to MPEG-4. Video file conversion is a slow, often manual process. A number of applications and process were explored in order to identify ways to incorporate a degree of automation. In the end, I had to accept that there was no easy way of converting this massive volume of small files (10 TB). As a result, this option was simply untenable.

Kinesense, a small company developing video forensic software, claims their software offers the ability for rapid video searching without having to engage in complex configuration or file conversions. Instead, the platform offers a rapid analysis and indexing engine that supports rapid searching (Figure 29).

Figure 29. The Kinesense model of video forensics

This application, like AgentVi—Video Search, employs video processing algorithms, which eliminates the need to manually sift through video feeds to discover key events. These algorithms search for the key events using ‘spiders’. These ‘spiders’ are a type of bot that systematically crawls through the database for the purpose of indexing objects and events by colour, shape and direction of movement. Two benefits of Kinesence over AgentVi’s Video Search are: 1) the algorithms offered rapid processing of video, and 2) the application connected directly with the xProtect VMS databases where the raw video data was stored. This eliminated the need to engage manually with the images files. Once configured, the Kinesense application would extract all of the marked video sets. These video sets would then be indexed within a SQL database that supports search and filter queries to be run in order to extract pertinent evidence. The indexing process captures a vast array of what we would define as ‘attributes’ and ‘variations’. For example, any movement is defined as a variation. At this point, the algorithms detect a change in the position of this object. The coordinates that define this movement, including start and rest positions, are also captured. This process is activated with every movement over the entire video footage. The result is a colossal volume of structured geospatial tracking data. To make sense of this volume of data, the software includes support for the identification of objects so they can be isolated and tracked over time. For example, face recognition allows for detailed tracking of persons both entering and exiting, as well as their movements within the office. This is essential when trying to develop a picture of the core work areas within the office, a central objective of this study.

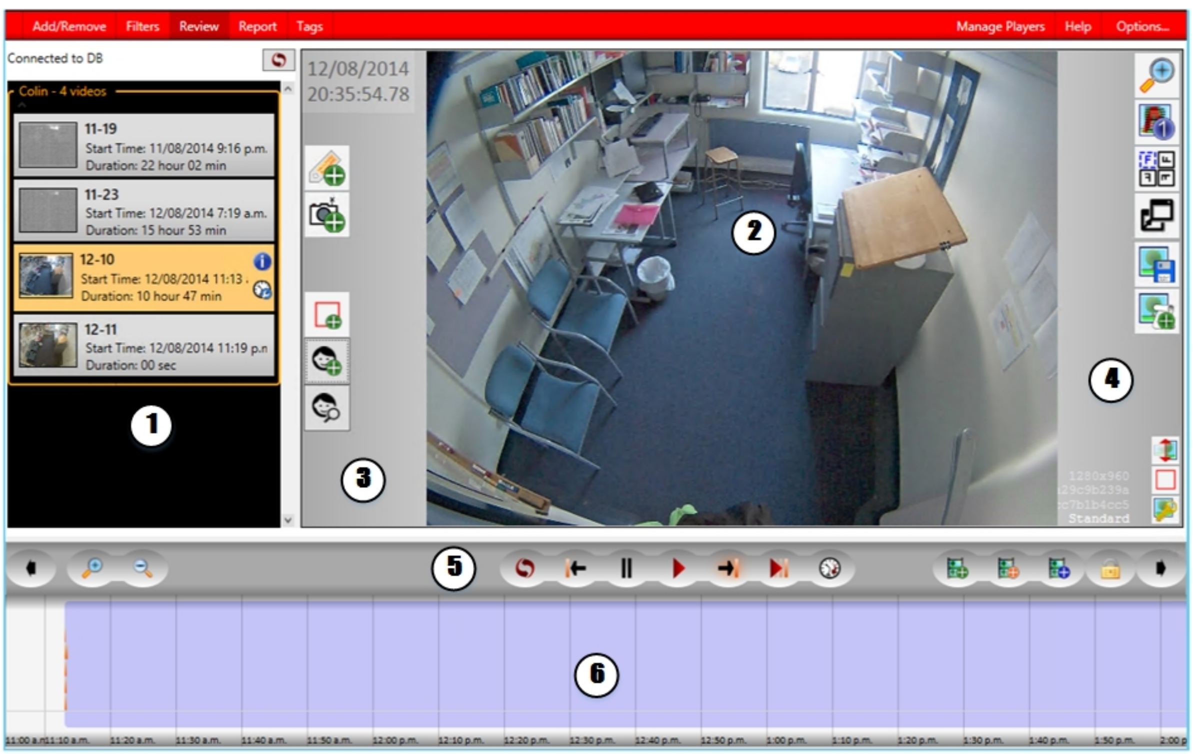


Figure 30. The main screen of Kinessense video forensic software. The area identification numbers have been added to support descriptions presented in text.

As shown in Figure 30, the software interface is divided into six function areas. Area 1 lists the various datasets selected, in this case, particular days. The actual video feeds are presented in area 2. Area 3 sets out the various search, filter and query functions. Area 4 lists a range of screen configuration and associated file functions. Area 5 is the control bar for governing the video feeds. It also includes a range of associated video feed functions. Area 6 is a timeline where events and mark-ups appear. More detailed control of the database can be gained directly via MS SQL Server Management Studio. The process for doing this entailed the identification of movement ranges presented in image sprites (a collection of movement images put into a single image).

1. Video metadata based on movement is captured using video forensic software;
2. This software stores the metadata in MS SQL Server;
3. This data can then be accessed via MS SQL Server Management Studio;

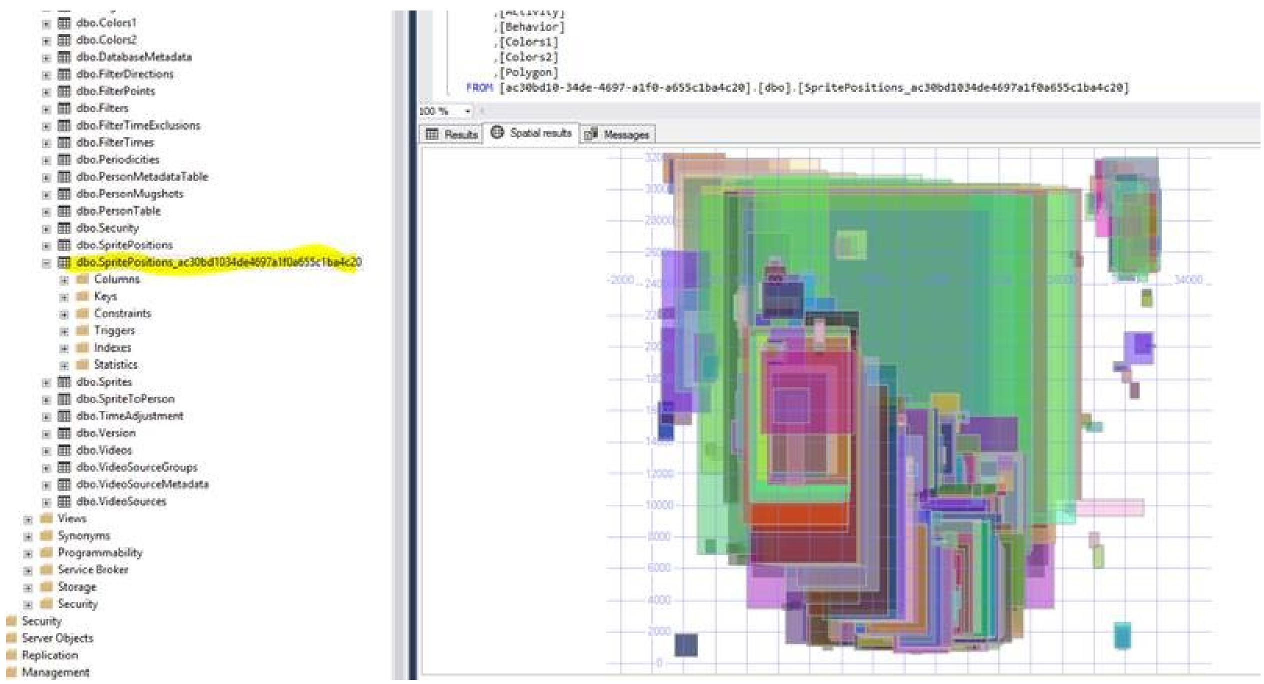


Figure 31. MS SQL Server Management Studio—Visualisation of positional data

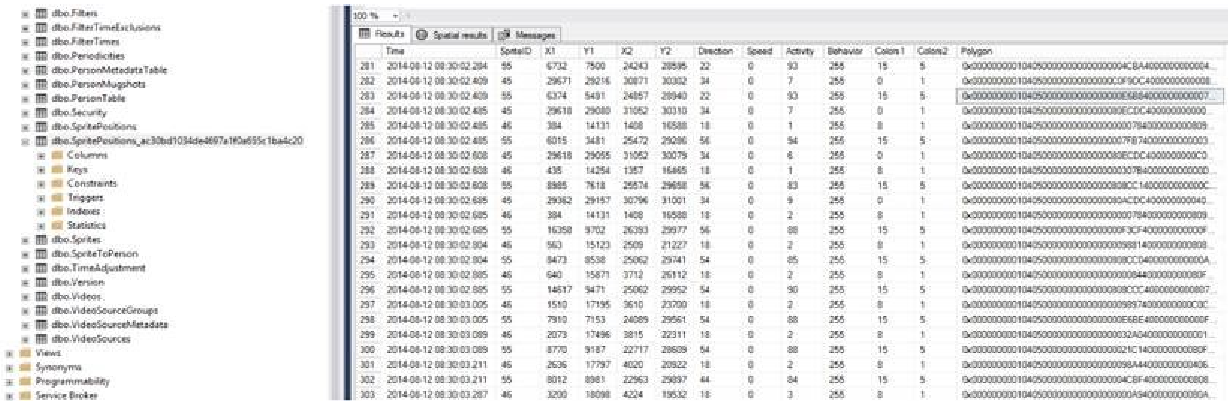


Figure 32. MS SQL Server Management Studio—Raw positional data

In Figure 31 and Figure 32, the spritePosition values refer to:

1. *Time* = time of the frame containing this spritePosition
2. *SpriteID* = this number links SpritePositions together into a single tracked object (a 'Sprite') over time.
3. *X1*, *Y1*, *X2*, *Y2* = These are the bounds of the detected 'blob' of movement in the frame. X1, Y1 is the top left corner, X2, Y2 is the bottom right corner. The coordinates normalised, and range from 0,0 (top right of the frame) to 32,768, 32,768 (bottom right of the video frame. It is a SmallInt.Max in SQL).
4. The direction is the estimated angle of movement, normalised to range from 0-255.
5. Speed, Activity, and Behaviour are not used.
6. Color1 and Color2 are bitflags representing the detected colours in the sprite position.
7. Polygon is the SQL spatial indexing representation of the X1, Y1, X2, Y2 data. This is used to improve search speed for SQL.

Direct access to this data allows for data manipulations beyond what is offered within the software interface. For example, Figure 31 and Figure 32 show position data associated with movement and position. This data can be manipulated by defining the SpritePosition centre points as "votes", then summing the votes over time across the image space and then normalising and colour coding to create positional heatmaps (Figure 33) that can be overlayed on office images.

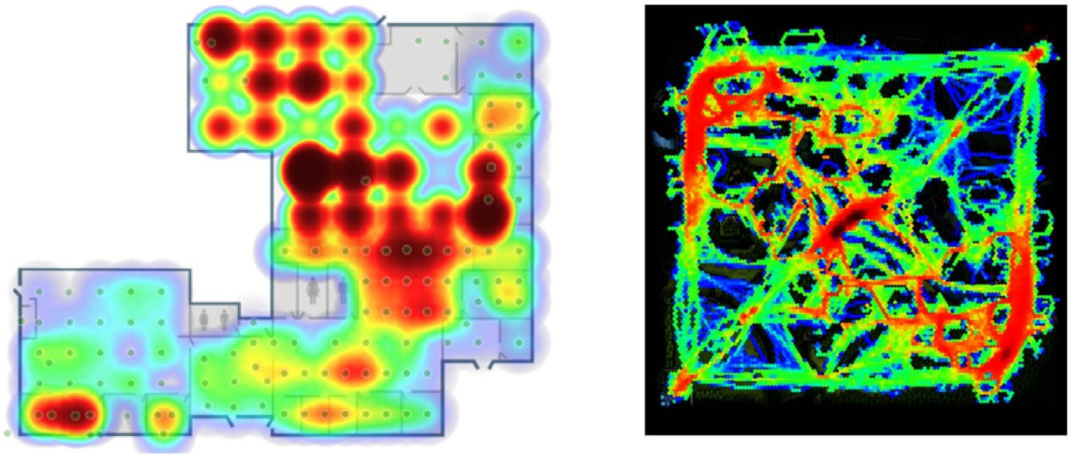


Figure 33. Examples of Heatmaps derived from position data (left) and movement data (right).

Heatmaps offer a graphical representation of data where position and movement are represented by colours: the greater the density the deeper the colour. They offer a way to visualise the vast array of captured/analysed video data in order to uncover behavioural patterns or action patterns. For this study, these action patterns represent sequences of movement that occur repeatedly within the environment over extended periods. Heatmaps reveal repetitive sequencing of movement/position through colour coding, making it easy to determine the geospatial location where activity is predominantly occurring. Unfortunately, generating heatmaps from SpritePosition values required a level of expertise that involved considerable financial investment.

Video data analysis – take 4

An alternative heatmapping application was eventually found that could produce modest but useful behavioural patterns. A second measure of movement frequency was also included. The result was an approach that rendered movement frequency and density, but only over brief periods (6 hours). The details of this approach are outlined within Chapter 6.

Sub-study-3: Patterns of computer usage

This study addressed the ‘bytes’ aspect of New Ways of Working by exploring the degree to which the digital era was impacting on the use of personal computers for academic work. This is a particularly pertinent area of inquiry given the growing pressure on academics to become digital to meet the demands of a productivity orientated, technology-driven, networked world. Currently, participant self-reports (questionnaires and interviews) are the preferred method of measuring computer-usage. The problem with these approaches is that they both rely heavily on memory (post-event recollections) to determine behavioural practices and in so doing injudiciously present perceptions of practice as a legitimate proxy for actual practice. In order to address this unreliable exercise (R. Butson & Sim, 2013), this study adopted a new research methodology known as Reality Mining (Eagle & Pentland, 2006), a process of capturing continuous, naturally occurring behavioural data in real time. Rather than the recall of gross events, this approach allows for the capture and analysis of unnoticed micro-processes that underpin behavioural sequences and routines within real-world settings. The ubiquitous nature of this process allows for data capture to continue without intervention or disruption to the participants' daily activities.

Computer usage capture process

A cloud-based personal productivity application known as RescueTime was installed on the participants' computers to capture the date, time, duration of access and the activities being undertaken and applications being used. The capture frequencies were set at 5 second intervals (computer activity was captured every 5 seconds) and the capture period was set to the second part of the academic year (25 weeks). The ubiquitous nature of the data capture software meant participants simply carried on with their daily activities. They were, however, able to access the various dashboards at any time to review what was being captured (Figure 34).

Figure 34. Screenshot of a typical RescueTime dashboard

The application was pre-configured with various categories designed to meet productivity and efficiency demands of the corporate sector. These categories were, unfortunately hard coded and therefore unable to be customised to align with the themes and categories required in this study. Notwithstanding, it was imperative that the participants were able to access their data and gain some insights, albeit in business rather than academic language. For this reason, a schema that approximated academic practices in the generic terms coded within the system was created. This quasi-approach allowed participants to monitor various analytics such as application use, tasks undertaken and the percentage of work to non-work related applications. From these data, the system produced various indexes of efficiency and productivity (Figure 34). Participants regularly examined the dashboards throughout the study (accessed via a taskbar icon), despite the crude and sometimes misleading data the dashboards provided. Although participants stated the dashboards were informative, there was no mention they had any impact on practice. A number of other features were also offered in the application (Figure 35). While the degree to which participants used these other features was unknown, the accessibility, usage dashboards and the additional features assured participants they would find a level of efficacy from the application.

Figure 35. Additional features of RescueTime

Each participant was given an orientation session on how the software worked, what is collected, how to access it and read the dashboards, including how to turn tracking on-off. An added function was included within the software to capture participants' non-computer activities. This was achieved through the activation of an onscreen 'where have you been' dialogue box (*Figure 36*). When participants were away from their computer for more than 30 minutes they would be presented with the dialogue box asking them to define the purpose of their absence as either: Research, Teaching, Service or Break. No response was used for all other (non-tracked) activities.

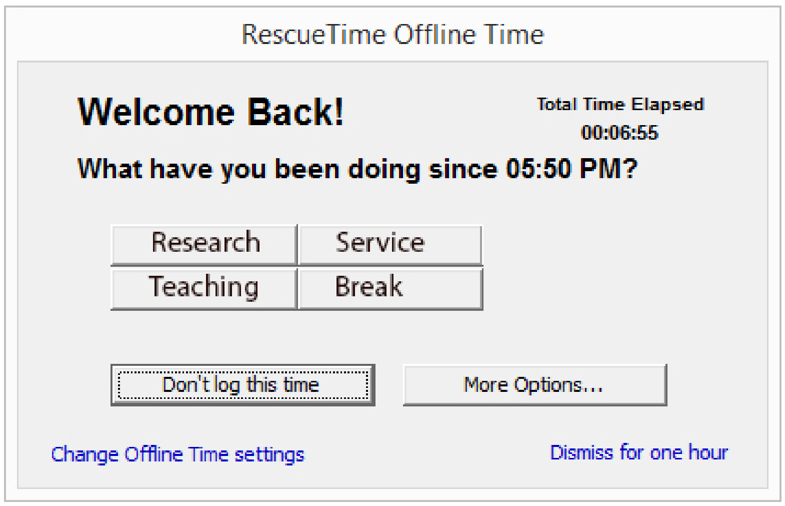


Figure 36. RescueTime prompt for requesting 'away from computer' activity

Computer usage data infrastructure

The capture and analysis of digital traces are often more complex than they appear. It is never immediate or straightforward. There are no design blueprints, no tutorials to follow or buttons that 'turn on' these types of data harvesting systems. Instead, they require a considerable investment of time and energy in designing and testing various processes in order to create a method or system that would yield the desired states in order to generate the required data. As shown in Figure 37, the final design schematic for the capture of computer usage data integrated a variety of layers and processes.

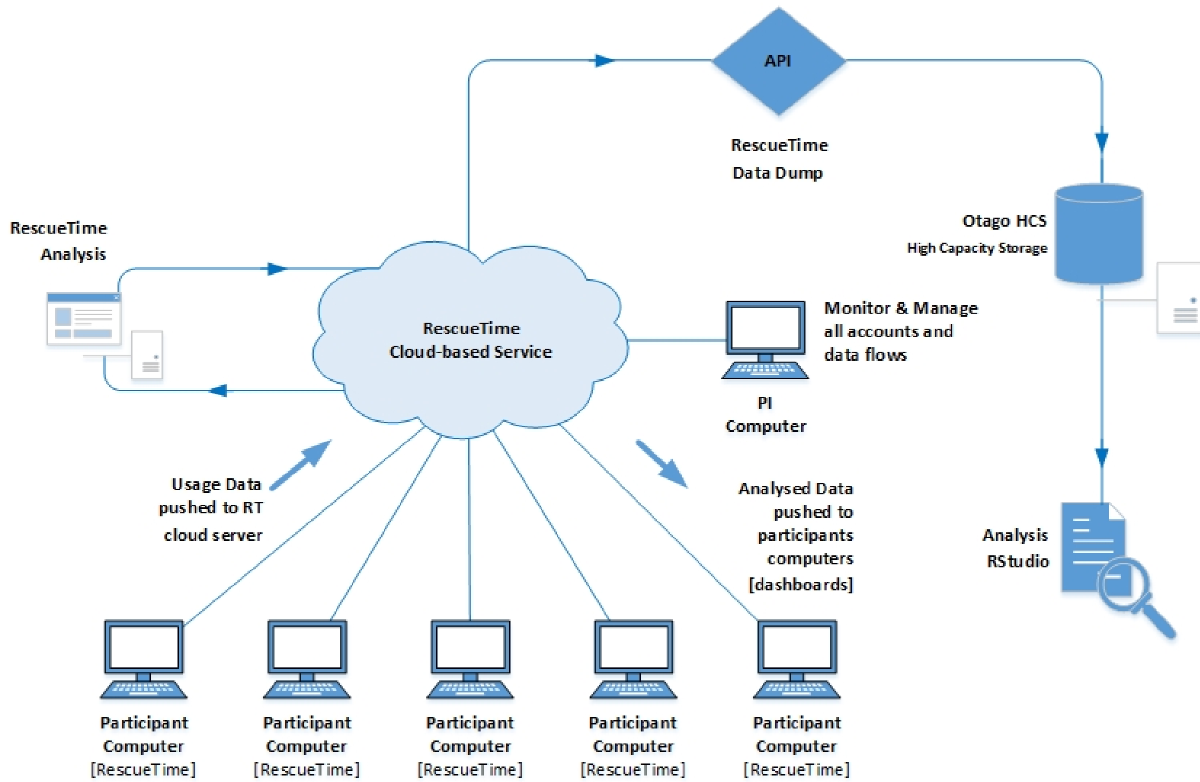


Figure 37. Schematic showing RescueTime data process network

Participants operated independently through personal accounts that were linked to a cloud-based service. This service incorporated three core layers: a data store layer, analytical layer and a presentation layer. In lay terms, the process involved computer usage data being pushed to the data store where the data were grouped and calculated in various forms in order to populate the many dashboards that were then available to the participant. These processes occurred simultaneously in real-time, ensuring a dynamic, instant picture of the participant's computer practice. Two extra layers were added to support the research purpose. These included a managerial layer that allowed the researcher to monitor participant activity through a centralised dashboard that amalgamated accounts by participants into a single multilayer interface—a critical feature for ensuring sound data capture operations. A second layer related to the process of data extraction and analysis. RescueTime is marketed as a closed system, however, to be of value the raw data needed to be extracted and re-coded by academic language/practices. A data mining schema was developed in collaboration with the software company that allowed relevant data fields to be harvested from the dataset and exported as CSV files (comma-separated values file that stores tabular data in plain text) for analysis.

Computer usage data cleaning

Five datasets were created (one for each participant). These datasets incorporated a series of date/time/period variables that defined application start-stop metrics across various duration measures. The second data dimension concerned the applications used. A core analytical capacity of the software was the capture of data file titles, document titles and web URLs associated with the various applications. Whenever an application was run, the associated data file or URL was also logged. This afforded a deeper analysis beyond software applications. As a consequence, the datasets were extended to include three new fields: location, theme and activity. Location data was defined as either ‘computer or ‘non-computer’. Applications were grouped by coarse-grain categories of producing, consuming, networking and computer related (background) processing. A more fine-grain dissection by activity was created from an analysis of the application type and the details associated with file/URL titles being accessed. On completion, each CSV file included 40k to 60k measurement points across 17 variables.

Computer usage analysis

The datasets were analysed using RStudio (an integrated development environment) for the statistics package R). The primary aim was to explore the patterns of usage by time and frequency. A series of exploratory R scripts were generated along these lines. The initial scripts (A-B) were generated in order to gain an overall understanding of usage across the various variables (Table 2). The second series of scripts were then created (C-E) to investigate more complex relationships and patterns through hex plots and heatmaps. Unlike the aggregating of data points employed in scripts A-B these scripts generated visualisations depicting raw individual data points.

Table 2

RStudio Scripts

```
#=====================================================
# A1= Person - Breakdown of Total Computers Hours by Week
# A2= Person - Breakdown of Computer & Non-Computer Time
# A3= Person - Breakdown of Non-Computer Activity
# A4= Person - Total Computer & Non-Computer Hours by Week Stacked bar
# A5= Person - Breakdown by Themes (CPN) by totals
# A6= Person - Breakdown by Themes (CPN) by week

# B1= Person - Breakdown of Computer Applications
# B2= Person - Breakdown of computer Activity

# C1= Person - Multitasking by hour across full Day
# C2= Person - Multitasking by min across hour of Day
# C1= Person - Multitasking table data - by Application

# E1= Person - Heatmap
# E1= Person - Hex Plot
```

A complete collection of the scripts is included as Appendix C.

Management of Potential Ethical Issues

The unique nature of capturing data from digital traces as in the computer usage data and video feeds can create a degree of concern. What follows is a list of apprehensions that surfaced over the course of discussions pre-study, by both researchers and participants. Each includes a resolution, often jointly created and always mutually agreed.

1. Participants may become aware of difficulties regarding their involvement only once the data collection has commenced. Given the unique nature of the study, it was imperative that participants felt they could withdraw at any time. A series of review sessions were incorporated into the weekly interview session where anxieties regarding the study were openly discussed. This also concerned the right to and process whereby participants could delete data. While this was a core area of discussion at the beginning of the study, specific concerns were only raised after the first two weeks as participants increased their knowledge and control of the data capturing processes.

2. Departmental colleagues may find the video monitored office intrusive or uncomfortable. Participants sought feedback and endorsement for the presence of a video-monitored office from their departmental colleagues, including the Head of Department.

3. There will be people entering the room who are unaware of the presence of a camera. This is particularly true in the case of after-hours staff such as cleaning and maintenance staff. This was resolved by the addition of signage to the door explaining that the room was part of a research study and was fitted with a motion sensor camera that is operational at all times.

4. Participants may, from time to time and in certain circumstances, need to stop recording either computer usage or video for a period. For video, this was managed by participants simply unplugging the camera lead from the network adapter on the wall. This immediately stopped the recording process. The transmission was only resumed when the cable was reconnected. For computer usage, this was managed by simply selecting the ‘stop data capture’ option that was listed on the program’s menu located in the bottom right corner of their computer screen.

5. The Human Research Ethics Committee of the University of Otago granted approval for the three empirical studies on the 27th March 2014: reference number 14/042. A copy of the information for participants is included as Appendix A.

Limitations and Challenges Pre-studies

As in any project, there is a continual need to address matters not envisaged during the concept and design phases. While many of these could be regarded as trivial, a small number were more serious, having the potential to derail aspects of the study. What follows is a list of the core issues that caused considerable unease and in some cases, stalled progress until solutions where found.

Anonymity and confidentiality

It is worth noting that anonymity was not an element of this study. Participants were transparent with their departments, colleagues and friends, regarding their involvement, openly relating the aims, types of datasets and methods being used. It would be fair to say the study generated a degree of interest due to its novelty. The participants regarded the degree of transparency as acceptable and even natural. However, it seems I had overlooked the importance of anonymity within educational research. This first came to my attention during ad-hoc discussions at an education conference where colleagues raised concerns regarding the ethics of anonymity and confidentiality. Although my institutional research ethics process had approved the study, I had to accept there was a 'feeling' within the higher education research community that anonymity and confidentiality played a central role. While I was able to make subtle changes to the manner in which I presented the three empirical studies, it caused difficulties for Sub-study-1: Spatial configurations of the academic office, where I amalgamated office configuration and office identity. The aim was to establish the juxtaposition of institutional space with personal space. The core dataset was photographs. Initially, these photographs would include images of the participants in their office engaged in positions/forms that they felt characterised them. Given the concerns over anonymity, I abandoned the biographical approach and adopted a system that employed sketch filtering. This required each series of panoramic photographic images likely to be used in presentations or publications to undergo a process of sketch rendering where clarity is reduced.

Data capture

Infrastructures designed to automate data capture represent complex systems. Both Sub-study-2: Spatial configurations of the academic office and Sub-study-3: Patterns of computer usage were reliant on such systems. Sub-study processes were incorporated into the software and did not require the development of additional systems. Sub-study-3 relied on multiple systems designed specifically for this project. As discussed earlier in this chapter, the layered systems for video capture, storage, retrieval and analysis were complex. They required considerable knowledge acquisition in order to design the various elements. The final design incorporated intelligent agents that required considerable knowledge and expertise to calibrate and configure the system to run in the manner required. For this reason, consultants were employed. Unfortunately, the requirements of the closed-space (office) and the intensive systematic nature of the study was beyond the knowledge and skills of consultants. Regrettably, these deficiencies did not surface until the data capture was complete.

Data cleaning

Working with multimodal datasets is always challenging. Each dataset has particular requirements regarding capture, cleaning, processing and analysis. While this was the case for all three sub-studies, the challenges raised with photographic and video data were solvable through training that was readily available within the respective fields. Cleaning and preparing computer log data for analysis was not straightforward. The application loaded on participants' computers employed a particular schema for categorised data as it was captured. Unfortunately, the categorisations were not suitable for this study. Numerous avenues were investigated in the hope that an automated approach could be deployed. This was not the case, and a post-capture process involving a series of semi-manual procedures was undertaken on each computer log to create the new category schema. Discussions with the software company regarding a better solution for future studies considered the use of middleware that would convert the fixed categories to the desired categories and save these to a SQL database on-the-fly. This solution, while plausible for future use, will require considerable investment to produce the middleware.

Data analysis

The problem with systems is their dependency on other systems; the failure of one system affects another. The failure to generate metadata at the time of video capture negated the analysis process. As a result, I was obligated to undertake considerable training in the area of forensic video analysis in order to rescue the project from what was a major blunder by the consultants (as discussed earlier in the chapter). This issue has been included here as it represents a major limitation to the study. The failure of the video system meant forgoing the opportunity to identify complex activity patterns. An inferior product was utilised to extract some data and while not as comprehensive, proved valuable. A drawback of this software was its design. While it was able to generate metadata on movement/spatial position, it was not designed for use as an analytical tool. As a result, the analysis was reliant on harvesting analytics directly from the metadata stored in the SQL Database.

Summary

While the aim of this chapter was to explain the detailed systems and processes that underpinned the studies' data capture and analysis, it also highlights the difficulties that are inherent when you couple expectations with untested approaches. While simultaneous investigations across a range of unknown elements would normally be deemed unwise, the liberty bestowed upon doctoral research afforded me the opportunity to explore multiple realms. The outcome was not to construct a sound, definitive answer as much as to lay down the foundations for a worthwhile research programme. I am certain that my work of defining data and the processes employed to harvest and analyse this data offers wide-ranging potential for future work in measuring activity.

The following three chapters present the three empirical sub-studies.

- Sub-study-1: Bricks—Spatial configurations of the academic office
- Sub-study-2: Behaviour—Patterns of spatial behaviour in the academic office
- Sub-study-3: Bytes—Patterns of computer usage

Each is represented as a stand-alone study. The initials AC, CH, DP, CS and SP are used to represent the participants in Sub-study 2 and 3. Sub-study 1, an earlier study, employed the letters A, B, C, D and E. These equate to:

A = AC commerce
B = CH humanities
C = CS science
D = DP health science
E = SP health science

Chapter 5

Smart People in Dumb Spaces

Exploring digital transformation through office configuration in the university setting: dumb vs smart spaces

Computer technology is reshaping virtually every aspect of our daily lives. The university is not immune. The technological developments are also affecting the purpose and function of today's modern university. New information and communication technologies are driving institutions to globalise their research and teaching programme. Higher education is becoming more global, multifaceted and competitive. It is a situation that the 21st century academic knows all too well as universities around the globe undergo major restructuring to accommodate these changes. For the academic there is a sense of needing to keep up, to innovate and cultivate new or 'smarter' ways of working. This study represents an initial exploratory investigation that is part of a broader study looking at academic practice in the 21st century.

The context is the private and personal space of the academic office, space where work is conceived, organised and undertaken in order to meet particular goals. It is a place pregnant with meaning that can be 'read' to reveal, through the artefacts and configurations, the principal activity flows and purposes of the occupant. Heidegger (1962) referred to these personal configured spaces as a place 'to-be-in'. It is an idea that captures the sense of belonging to one's place or space, illustrating the relational reciprocity between the human and their environment.

Unlike lecture theatres, laboratories and tutorial rooms, the office represents a private space, a place where academics carry out many of their personal work activities, a space that has existed as long as the university. However, when compared to other university environments such as lecture theatres, laboratories and classrooms, the office is, for the most part, less significant in the research literature and yet these are places where academics spend a considerable amount of their time. The work academics undertake in their offices and how they accomplish this work is to some extent hidden, not because it is secret, but because it is simply deemed unimportant (Gornall, Cook, Daunton, Salisbury, & Thomas, 2013). It would be fair to say that if you want to know something about an academic, visit their office. It is here that you will find an environment with distinct and personal qualities (Entrikin, 1990), charged with purpose and meaning, a space where collections of artefacts old and new, useful and decorative come together in a hybrid fashion telling stories of the inhabitant's past, present and future.

I use the terms 'place' and 'space' but acknowledge that while these terms are commonly used interchangeably, they represent concepts that are difficult to define (Grene, 1968; Tuan, 1974). One particular interpretation is that space and place refer to two distinct qualities. Proponents of this view, in particular, Harrison and Dourish (1996) argue that space is a natural fact represented by a collection of properties that define the essential reality of a setting and place. Space, therefore, is a social product signified by a set of understandings that come about only after spaces have been encountered by individuals and groups. From this perspective, the relationship between place and space is one in which place comes after and is layered on top of space. However interesting these deliberations are regarding place and space as separate or similar, it is not the purpose of this study to contribute to this debate. For this reason, rather than attempting to understand the features of space that are conducive to the creation or emergence of place, I will forego the Harrison and Dourish duality argument in favour of a more pragmatic view of space as a geographical location that we inhabit for various purposes, and that incorporates both static (artefacts) and dynamic (actions) qualities. In this way, I will be treating both space and place as a product of embodied social practice. This approach presupposes a relationship between spatiality and practices, but sidesteps the necessity to scrutinise the association.

It is also worth noting that the growing development of networked technologies has further complicated our understanding of space. Information and Communication Technologies (ICT) allow us to operate within intersecting multiple spatialities that cut across traditional geographical boundaries. For instance, the networked nature of computer devices adds a new dimension to understanding everyday encountered space. Introducing the virtual into physical settings does not simply create new opportunities for sociality; rather it transforms the configuration of those traditional settings, thus developing new spatiality.

However, the focus of this study is on the physical rather than the virtual setting, and in particular, on what we can learn about the changing academic landscape from the way academics fashion their workspace as a means of organising the self—the creation of spatial arrangements and the resulting spatial flows. Knowing about how we situate ourselves within space reveals aspects of who we are in relation to our space, our body, our past, our position, and our relation to other human beings (Sartre, 2003). It is this sense of self or identity within this space that exemplifies the relationship between human and environment. This relationship is best understood in the work of Frederick Taylor, who is credited as the first person to actually design an office space in order to influence the way people work. Obsessed with efficiency and oversight (dubbed Taylorism), he created a two-tier format where administrative workers in large open environments were over-looked by management from private offices (Pruijt, 1997; Waring, 1991). By the 1950s, Taylor's experiments emphasising the relationship between the worker and their environment were becoming better understood. The impact that design and structure could bring to worker habits, identities and status evolved into office landscaping, incorporating not only the functional but also the aesthetic. The result was an explosion in the design and production of office layouts and accompanying furniture, much of which was inspired by Herman Miller (Berry, 2005) who created social spaces by incorporating low dividers and flexible work surfaces that have evolved into what we know now as cubicles and pods. While office design has become lucrative and trendy, the underlying intention of workspace architecture has been to affect behaviour.

Studies on the impact of these developments flourished in the 1960s and 1970s (Brookes & Kaplan, 1972; Davis, 1972; Hall et al., 1968). A number of studies also focused on the faculty office in the 1970s. These were typically perception-based studies investigating academic satisfaction concerning the degree to which the office space augmented the academics' activities (Farrenkopf, 1974; Farrenkopf & Roth, 1980; Zweigenhaft, 1976). It was a time when researchers interested in organisations were becoming fascinated with the concept of place and space within organisational settings and their relevance to productivity. Much of this early interest came from the developments in office space design and from the work of Edward Hall in the 1960s. His popular book *The Hidden Dimension* (1969) changed our view of space. In this text Hall illustrated how we are connected to our spaces, reasoning that our perceptions of space are forged by culture and that different cultural perceptions for organising and understanding space are unconsciously internalised, particularly the concept of personal space: how we structure and use our space is a reflection of who we are. For Hall, understanding human behaviour requires an understanding of the relationship people have with their space/s and therefore spaces are not static but dynamic. To view space is to view the owner/creator/culture and therefore to understand the space is to understand the owner/creator/culture (Ruth, 2016).

In this sense, offices are living spaces that embody personal and career characteristics and therefore will, through configuration and design, embody visual symbols of the times. By investigating these configurations, particularly the individual and collective input that has created and ordered these spaces, we should be able to identify particular work customs that exist through certain configurations and artefacts (Hillier & Hanson, 1984). The aim is to explore these institutional workspaces in order to identify elements of change that may be surfacing as a result of the impact of technological change and the 21st century drive for efficiency.

Method

Five early-career academics (two females and three males) from a range of disciplines (science, health science, humanities and commerce) who were participating in the broader study on academic practice at the time, volunteered their offices for this study. Prior to this point, the participants had already contributed six months of their time to the collection of dynamic data in the form of computer usage data and office video footage. This study focussed on the static by using photographs as data. The intention was to 'see' the 'physical' through an interpretative iteration approach in order to discover what meanings might be present. In this sense, the study was idiographic in nature. Photographs were taken during periods when academics were present. During these visits, many informal and unsolicited conversations took place that were relevant to both space and change in the 21^{st} century. While not playing a major part, these comments comments, were used to qualify the observational and interpretative aspects of the physical spaces.

The use of images as a data source is particularly germane in studies of lived experience (Rose, 2012). The visual has always been understood to have an inescapable quality (Ilford, 1950): it is the first thing we experience, and therefore it is the first thing to influence our thinking.

Photographs literally act as a lens through which we see (Harper, 2012; Warren, 2002) and therefore can provide us with important physical data (Collier & Collier, 1986).

Three distinct image-based datasets were created: floor plans of the five offices, photographs of the interior of the offices and a collection of photographs of academic offices taken in the last century. Firstly, a typological analysis of the office floor was undertaken followed by an interpretative analysis of the various office elements added by the occupants. Finally, the visual juxtaposition comparative method of Metcalf (2013) was employed in order to identify various changes over time by comparing photographs of the five contemporary academic offices with the images of academic offices from the last century.

The floor plans for each office were created depicting the presence and position of various furniture items. A series of photographs from each office were then taken. Filters were applied to these photos to generate sketched images. Converting the images to sketches reduced complexity in order to make the process of gross comparison more effective. It also resulted in increased anonymity by reducing the identification of personal artefacts such as names, photos and drawings that were in the offices. Several photographs depicting academic offices from the last century were downloaded from various public websites and used to offer a comparative historical perspective. These too were converted into sketch form to reduce density for analysis and increase anonymity.

Analysis software (NVivo) was used to mark-up various aspects of the photographs and code these mark-ups by descriptive categories relating to office configuration, artefacts and relationships. Interpretive notes were then generated from a more selective process of critical visual analysis, drawing heavily on visual semiotics in order to construct and assign meaning to the identified configurations, artefacts and relationships. For historical comparisons, visual juxtaposition as described by Metcalf (2013) was considered the most suitable method for analysing photographs over time periods. Employing a comparative schema, the photographs were placed in a side-by-side format and analysed for contrasts (Ragin, 1987) using the previously developed codes.

The three distinct image-based datasets (floor plans, contemporary office images, and images from the last century) were each analysed. The floor plans were compared in order to identify similarities or differences in office layout (spatial unit). Images of office personalisation, such as personal photographs or decorative items, from the five contemporary offices were examined to develop a schema for deeper analysis of office components (spatial identity). Finally, contemporary images were compared with similar images from the past to determine aspects of office changes (spatial history).

Findings

The findings have been divided into three layers:

- Office layout—a focus on the spatial unit, in particular the configuration
- Office personalisation—a focus on the degree to which personal artefacts are present
- Office changes—spatial history

Each of these layers are discussed in detail. While there is an inclination to speculate on various configurations and artefacts, the analysis employs a conservative approach grounded on what is visual, but entertains reason and rationality in cases where it appears plausible to do so. It is important to acknowledge that this study, as with the other two, represents an exploration and as such, the analysis follows a probing rather than fact-finding schema.

Office layout—spatial ynit

Office floor plans were generated for each of the five contemporary offices (Figure 38). A typological analysis of the furniture and layout was undertaken to identify purpose, roles and actions. This involved classifying various areas based on purpose and functions:

1 - Computer + work desk
2 - Non-computer work desk/space
3 - Active work area
4 - Archive work area (stacks)
5 - Bookcase (books + archived material)
6 - Filing cabinet
7 - Work table (social)
8 - Display Board/Calendar etc.
9 - Whiteboard

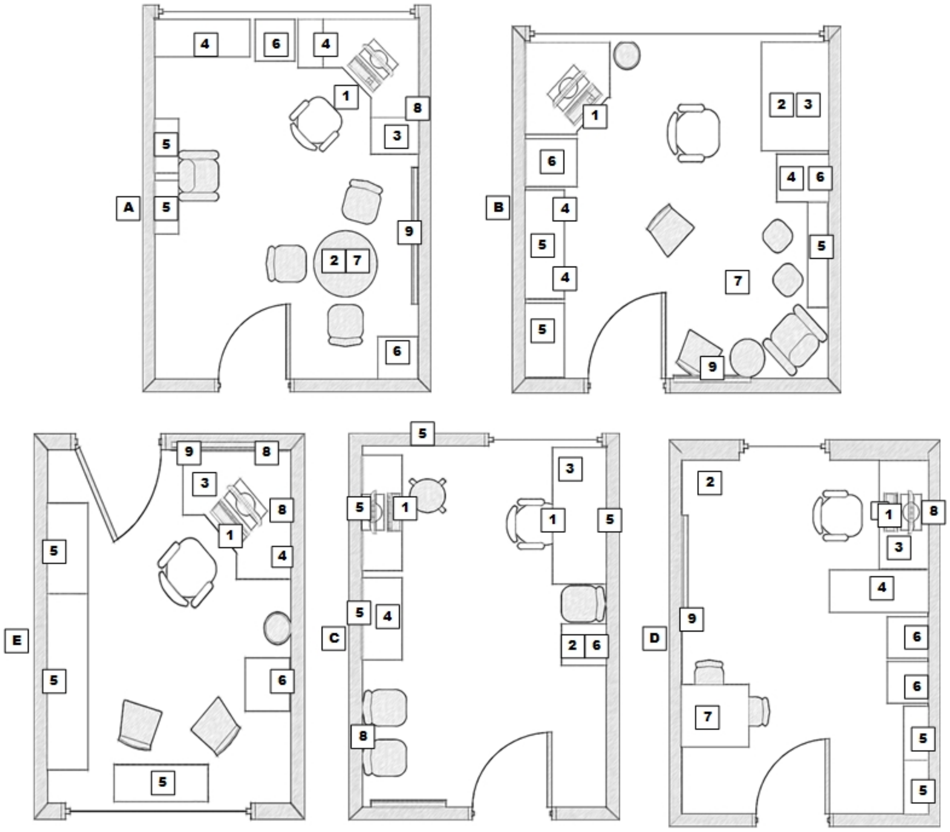


Figure 38. Office floor plans showing the arrangement of furniture into work related configurations A=AC, B=CH, E=SP, C=CS & D=DP. For descriptions of 1-9 (see office layout—spatial unit).

The primary configuration of space often occurs as a result of limitations such as the arrangement of windows, walls and doors, and the type of office furniture that is present. In all cases, the institution supplied the core office furniture/equipment. In addition, staff could request extra furniture and/or appropriate superfluous items from colleagues and various storerooms, but typically, items conform to the stock variety: desk, chair, bookcase and table. Nevertheless, the layout of the furniture is a result of the occupants engaging in a process of space arrangement based on their conceptions of the 'best' form to meet their needs.

Discussions with the academics concerning their office spaces revealed a variety of approaches and definitions concerning the notion of 'needs'. In many cases, these needs were articulated in terms of well-being, for instance, the need to be near the window for the views and to catch the morning sun, or the need to structure the room to create empathy and connection for student meetings. In one case, the office configuration did not change from that of the previous occupant, a senior academic. It was assumed that this layout was seemingly ‘sanctioned’ and therefore kept as is. Overall, the layouts did not differ greatly.

In all cases, offices were configured around the primary work area of the desk. In the case of E, there was only one work desk and this desk was where they positioned their computer. Offices of A, B, C and D included a second work desk that did not include a computer. In the case of B and C, there was a clear relationship between the close position of computer and non-computer work desks. For A and D the presence of a second work desk, while noted, was not as conveniently positioned in relation the main work desk as it was for B and C.

Office configurations were similar irrespective of the occupant’s discipline areas (S-science, D-, E-health science, B-humanities, A-commerce). This would suggest that the office activity associated with being an academic may not differ greatly across disciplines. Alternatively, it could suggest that academic office space has a particular form that is defined by the furniture allocated to shape the room for practice. If this is the case, then the office space may not necessarily reflect the desired configuration. This is not surprising given that the academic, regardless of their particular discipline and work practice, simply takes possession of an ‘office’ outfitted with furniture that reflects a one-size-fits-all model. If environments influence behaviour to the degree discussed earlier, then it is likely we are underestimating the importance of the office space to behaviour. This highlights the need to explore the value that discipline-specific workspaces may bring to academia and similarly the barrier that standardised office spaces may be having on motivation, innovation, collaboration, efficiency and productivity.

Office personalisation—spatial identity

Unlike the arrangement of furniture, personalisation of space is a deliberate act of creating a place that connects and reflects the occupant (Wells & Thelen, 2002). It is often relational and aesthetic (Bryant, Tversky, & Franklin, 1992), with objects typically falling into two types: those that relate to the work being undertaken and those of a personal nature such as ornaments, plants, and pictures.

While the inclusion of work-related artefacts such as books, articles, notice areas etc. gave the rooms a particular character, such items offered little insight regarding the personal life of the occupant. This insight comes from personal artefacts such as photos and ornaments. It was interesting to note that the inclusion of personal artefacts was very low in each case. The sample of objects shown in Figure 39 represents most of the personal objects present. This reflects a low level of association to life outside academia.

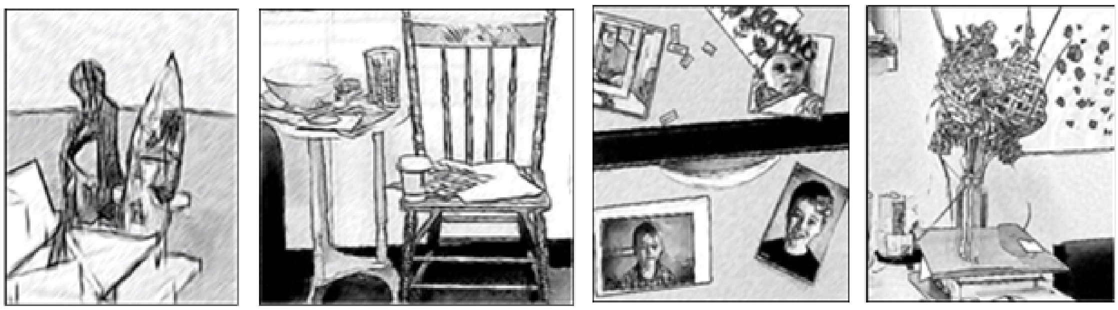


Figure 39. Various personal objects present in academic offices

There was also an absence of the aesthetic, possibly exacerbated by the fact that the institution did not supply decorative artefacts as part of the office outfitting. Personalisation of these spaces was produced, in the main, through the inclusion of work-related artefacts. Figure 40 offers a glimpse into the overall configurations that have resulted as a consequence of the inhabitants' initial design and subsequent outfitting of work-related items. All offices were rectangular in shape with offices A, C, D and E having a desk/computer area that was easily identifiable. In office B, the arrangement of books and documents and the inclusion of a social engagement space dominated the office realty while the work desk was marginalised.

Figure 40. Overall layout and configuration of academic offices

A first-pass analysis of the images in Figure 40 was undertaken to identify and label relevant objects, while subsequent passes considered various groupings and locations. Employing an iterative approach of repetitive passes helped form particular interpretations and allowed initial assumptions to be challenged. This then led to a form of latent coding (Ryan & Bernard, 2006) where objects and grouped objects were assembled and dissembled until meaningful explanations could be created (Dey, 1993). The result was the following succinct set of labels created by reducing individual and grouped objects to their lowest form:

Primary work area
Books
Papers
Whiteboard/Display areas
Decorative/personal objects

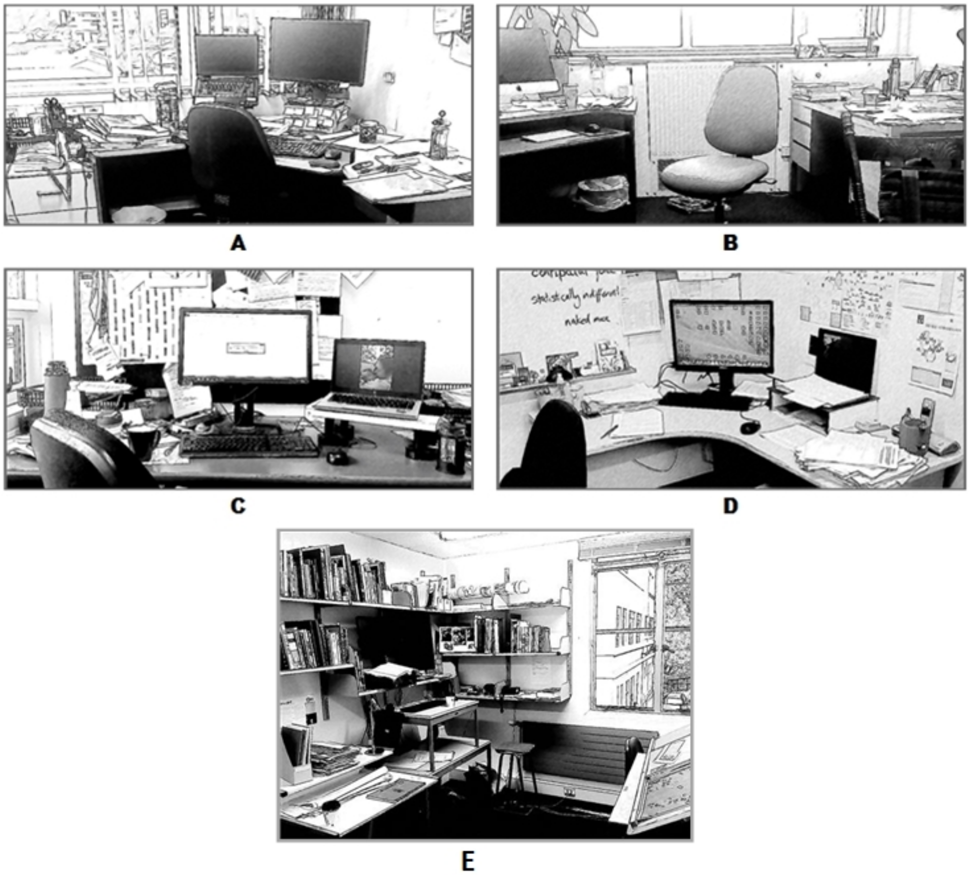


Figure 41. Primary working areas of five academic offices from 2015 photographs.

As shown in Figure 41, the configuration of the computer desk was similar across three of the five offices (A, C and D). These comprised a chair, computer desk and computer. In some cases, desk trays were present. In all three of these environments, the computer, positioned in the centre of the desk, indicated its primacy to office practice. Archived materials were stored on one side and the opposite side was the ‘active’ space for papers or books currently in use. Signs of planning or scheduling in the immediate area were limited to the occasional use of notes and sticky notes. Office B employed a combination of two work desks. The main work area was the desk on the right that did not include a computer, with the supporting computer desk situated opposite, on the left. In the case of E, the main work area focused on computer use, however it did not employ the conventional desk-chair configuration. Instead, the computer was elevated via a series of stacked tables that allowed the academic to work in a standing position. Like B, E deployed a two-desk configuration. It was interesting to note the standing position for computer work and the seated position for non-computer work. Clearly, those with the two desk configurations were comfortable operating in a hybrid style where work practices were divided into tasks that were computer-dependent and tasks that were not.

Various types of bookcases and shelving were included in all offices. In fact, shelving dominated all five offices. While the style of shelving varied from office to office, its use followed a similar pattern, as shown in Figure 42, with storage of books, archive material (folders), the odd ornament, and printed material organised in stacks.

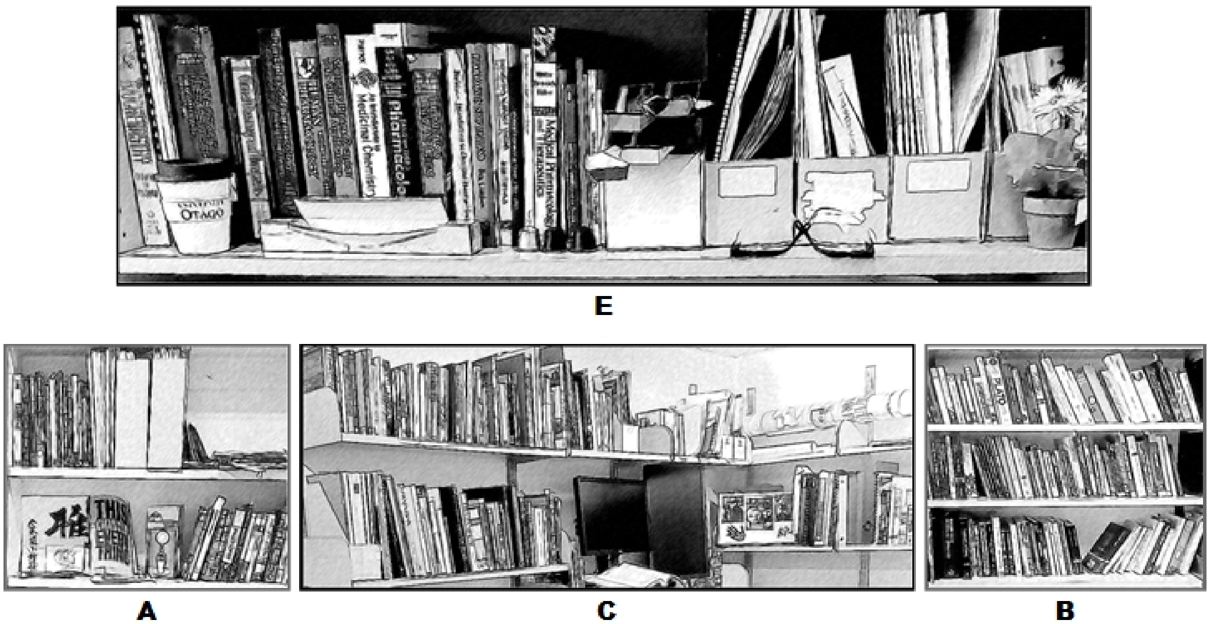


Figure 42. Bookcase configurations from 2015 photographs

It was clear from the very presence of these structures propagating much of the wall realty that this was a space where information/knowledge was paramount. Yet confessions from the occupants revealed that their use was very limited: the items stored, while considered useful, were actually used infrequently. These structures and the texts they contained occupied much of the physical and visual space. On the surface, they seemed relevant and in place, but on reflection, they presented more as icons of a previous information age.

Undoubtedly, the most common artefact that represented the academics' day-to-day work and history were the various stacks of printed articles. Archived articles typically ended up on bookcase shelves or stacked on the floor, while current articles were stacked near the main work area. The archive stacks positioned some distance away from the main work area showed little sign of use. These represented piles generated by the completion of projects as an act of clearing but did not include disposal. Why many academics retain these stacks could be due to the hassle of disposal, although it is possible, as some argued, they are kept in case they are needed in the future. However, it would be a daunting task to wade through the sheer volume of unorganised piles in search of a particular article—a task probably often rejected in favour of the quicker option of an online search and reprint.

As shown in Figure 43, these 'paper stacks' are a hallmark of academic offices. Another explanation may be that an emerging collection of stacks represents a degree of academic growth or status. As with the nineteenth-century surgeon's apron adorned from a history of procedures or the martial artist's tarnished belt as it changes from white to black, so stacks could represent an emerging knowledge base, a mark of academic eminence based on this physical history of academic growth. A third view may be that the stacks could represent a workflow. They show clearly that a work process is part of this space: the consumption and production of knowledge existing in these articles. In this case, these stacks could signify the traditional outbox: a very sizeable one.

1953 1995 2015

Figure 43. Comparison of article stacks across years.

Noticeboards and whiteboards have become synonymous with the concept of the office. Like the desk, chair and shelving, they are a standard university office object that comes with all offices. Use academics made of these objects was standard—reference materials, awards, the odd card etc. (Figure 44). There was no indication that these boards played any part in the day-to-day activities of the academic. While it was clear that dedicated time had been spent crafting them at some point, most of the material looked to have been added some time ago, i.e., they could be referred to as static in nature. It was interesting to note that while all five offices were fitted with whiteboards, only one whiteboard showed signs of use.

Figure 44. Examples of pinboard use.

Although the furniture components of the academic office are similar to those used in the business sector, once populated with the academic's work-related items, it was clear the academic office was different. The business office is typically structured according to processing or workflow—traditionally represented by in-box and out-box configuration. These academic offices, on the other hand, were different; there was no in-box out-box arrangement and, after reviewing the configuration of office items, no obvious indication of workflow processes. As an outsider seeking to understand the purpose of this space, you would conclude that while the occupant clearly engaged with information (contained in the various texts and articles), there were no hints as to the processes or purposes of consumption and production of any sort or any relationship between these. Moreover, the offices revealed no discipline-specific characteristics. The only way to distinguish the various discipline differences would be an examination of the titles of various books and articles.

Office changes—spatial history

From the analysis so far, it is clear that what distinguishes these offices as offices within an academic institution is the inclusion of books (bookcases) and articles/paper-stacks: whether in a stark postgraduate office, the office of a professor or Einstein's office (Figure 45). From this comparison, it would be reasonable to surmise that books, and in particular paper-stacks, appear to be archetypal of academic practice.

Figure 45. Office configurations showing the arrangement of furniture into work-related layouts. Left to right represented by a postgraduate office, the office of a professor and Einstein's office.

A review of photographs from as far back as the 1940s would suggest this has been the case for some time. It could be reasoned that the more books and more stacks you have the more 'academic' you are. This is not an uncommon notion given the stereotype portrayed by the media of the academic as one obsessed with consuming information, typically absent-minded, unkempt and unaware of social norms and conventions (stock character of popular fiction). Such 'types' represent more myth or folklore than reality. Nevertheless, like all such myths, their beginnings often have their roots within the target group.

More importantly, the expectation was that comparing photographs of academic offices from the past century to photographs of current academic offices would reveal interesting changes in academic practice. However, that does not appear to be the case. The two images juxtaposed in Figure 46 are uncannily similar.

Figure 46. Comparison of work desk area from 1970 (left) with 2015 (right).

Equally fascinating is the change in communication devices over the same period. The differences between the 1970 occupant's desk phone and the 2015 occupant's mobile phone (loaded with a variety of productivity, social and recreational applications) reveals radical developments resulting in major changes in the way we now communicate in 2015 compared to 1970. The time lapse between these images is 45 years. Both office images show the main work areas of each occupant. The configuration of the offices is very similar: private room, office chair and table (against the wall) and the presence of a noticeboard on the wall above the desk. Both have personal artefacts present, but these are hardly noticeable. More books and more paper items are present in the 1970 office than are visible in the 2015 office. The inclusion of the computer in the 2015 image is the most striking difference from the 1970 image. However, this difference becomes less significant when we review the images shown in Figure 47. In this time phase selection of images, we find a second desk configuration employed in the 1960s, 1990s and in 2015. In each case, a second desk is used to situate a piece of technology adjacent to the main work area.

Figure 47. Comparison of work desk area from 1962, 1995 and 2015 focusing on the place of the manual typewriter, electric typewriter and desktop computer respectively.

All three images show a two-desk arrangement. All three images have the primary desk for paper-based work and all three employ a second desk in close proximity to situate a piece of technology aimed at augmenting their activities—in essence, the tool of typewriters and computers. Apart from the obvious difference between the two typewriters and the computer, these three offices are set up and operate in a very similar way, both conceptually and in practice. It is stunning to see that the 2015 academic office appears to exhibit few differences when compared with the earlier images from the 1960s and 1990s academic offices. The configurations of the chair, desk, filing cabinet, noticeboard, bookshelves have not changed. The personal work artefacts of books and paper stacks are also similar across all three eras. Even the addition of the computer does not alter the general similarities between these images.

Given the images used in this study, it would be fair to say that there is very little difference between the last century images of academic offices and those of this cohort captured 2015. From a historical perspective, the relationship between books and academia is so entwined that it seems impossible to conceive of one without the other. Nevertheless, the creation of the internet and World Wide Web is a game changer. There was a time when universities were regarded as the guardians of knowledge and their libraries as knowledge vaults. That is no longer the case. Instead, there is now more information outside the university than within. The digital revolution combined with the internet has resulted in a major shift in how and where information is stored, how it can be accessed and by whom.

It is also worth noting that informal discussions with the occupants of these offices during data capture revealed that all five academics preferred to work with documents in hard copy and that a core activity was printing off these documents. While the evidence of printing was observable in the offices, the means of creating these stacks of printer documents were not. In all cases, the printer was situated in the adjoining hallways. As one occupant explained, "I can't read articles online. I need to feel the paper and see the print." In this sense, the printer weakens the current digital paradigm—it offers us a way to communicate with the developing digital world of information, but within the terms of the preceding paradigm—the digital is converted back to hard-copy print.

The office structures and configurations in this study suggest that the academics have opted, not for a radical change, but a process of acclimatisation. Aspects of new technologies (headsets/cameras for video conferencing, mobile devices and access to cloud technologies) were present and there is no doubt that their presence will be reconfiguring aspects of practices. However, the presence of the new did not interfere with the existing configurations of the old.

This is in stark contrast to the modern corporate office, which is becoming reliant on digital technologies—books, papers and filing cabinets are replaced with large touch-screens, and the desk with various touch-screen table options (e.g., Figure 48). Unlike paper, digital systems are dynamic, promoting transparency and connectivity, and the individual becomes networked within the collective. While it is recognised that the pictures presented in Figure 48 are still out of reach for most, there are still many aspects that are already available, enough to warrant a considerable change to our conceptions and practices of academic work.

Figure 48. Future office spaces showing office with wall screen and touch table (left) and holographic interfaces (right). Reprinted from public domain area of Bay Integrated Marketing & Woobleweb.

Discussion

This study is situated early in the 21st century, a period that typifies the end of the industrial era (Rifkin, 1995) and the beginning of the digital age. It represents a period of immense change, not only in regard to the way we live out our daily lives, but also the impact of transforming the very nature of work in terms of place, time, content, structure, and processes (Heerwagen J et al., 2010; Landry, Sathi, & Hartman, 2005; Lee, 2016).

This preliminary investigation or profiling of the academic offices of five early career academics raised some provocative findings. I expected that changes over the past fifty years in academic office configuration would reveal insights into the way institutions and academics were dealing with the major shift in work practices that have resulted from the computer age, particularly, the shift from a paper-based approach to digital methods. It is surprising that office configurations and practices of contemporary academic offices are similar to those of the last century, with the only noticeable change in appearance being the replacement of the typewriter with the computer. It is difficult to understand why this is the case given universities are knowledge-based entities operating within the backdrop of radical advances in technology. To some extent, the following four interrelated themes discovered in this study go some way to addressing why this might be the case.

The Office

As discussed earlier, the design of workspaces played an important role during the industrial revolution. In particular, the work of Frederick Taylor and Herman Miller established the office space as an essential component of work (Berry, 2005; Pruijt, 1997; Waring, 1991). They successfully coupled the office to the overall processes involved in the organisation's goals. It was a period where investment in research and development regarding efficiency and productivity at the office level was greatly valued. This has not been overlooked by current organisations, particularly knowledge-based organisations, who are redefining our concept of the place and role of the office. These new forward-thinking approaches are grounded in an ethic of work-life balance and personal well-being. As a result, staff are encouraged to be actively involved in creating spaces and practices that best enable and motivate them to be efficient and productive (de Kok et al., 2016).

It could be reasoned that the university as a knowledge organisation is ideally positioned to be a catalyst in such forward-thinking, forward-looking and forward-acting practices. However, my study reveals that the university has not embraced current trends in this regard. This creates an awkward situation for a knowledge-based organisation given that the traditional elements of office configuration (layouts, furniture, fixtures and fittings) do not integrate well with the emerging digital paradigm, but instead conflict and therefore thwart any real change. Undoubtedly, the current university conceptions and provisions regarding academic office spaces are inadequate for the complex and diverse demands that academics are currently operating in. The simple adoption of a one-size-fits-all approach to office furniture reinforces the traditional paper-based schema. While there is considerable investment into bridging the architectural divide in relation to campus design and learning spaces, there is little indication that the academic office has been considered in these developments.

Paper and digital paradigms

It has been predicted for many years that the rise in digital systems would reduce the reliance on paper and lead to high-tech paperless offices. This, however, has not been the case. A study by Sellen and Harper (2002) found the reverse; the growth of digital processes was actually increasing the consumption of paper. This was certainly evident from the physical appearance of the offices in this study. It was clear that paper was the media of choice for important information. The stacks of printed articles, the various notebooks and the filing cabinets all bear witness to the importance of paper-based artefacts. However, this did not diminish the importance of the computer to the participants' workspace. All five commented that most of their office time was spent at their desk in front of the computer. There was no sign of the high-tech or any indication that the occupants were moving toward a paperless office.

Instead, these academics appeared to be caught in a hybrid state (Liu & Stork, 2000) where they straddled the paper and digital worlds simultaneously, duplicating many actions in both forms; a case of serving two masters. The result implies busyness that, while appearing purposeful, is fraught with difficulty and frustration. On a number of occasions, the occupants of the offices in this study commented on mishaps due to these duplicated processes. One of these was the frustration of managing two calendars—one paper-based and one digital. Similarly, the capture, storage and retrieval processes involved in reference materials, such as articles, was complicated by some documents being stored within the physical (filing cabinets and stacks) and others within the digital (computer apps and folders). The orchestration of these two approaches was haphazard. It would be fair to say that veiled within the daily practices associated with working within two distinct systems (digital methods on the one hand and the routines and methods bound within traditional paper-based structures on the other), was considerable tension and frustration, often unrecognised to the academic. They appeared to accept the assimilation of two systems simply as part of work expectations.

The importance of the printer

For these academics, printed material played an important role in daily work practice. In all cases, there were numerous signs of the need for information to be printed in order for it to be processed. In a number of cases, comments were made to support this practice, given the apparent difficulties associated with reading documents on screens. This style of working with information represents a hybrid form where the computer is used to source information, which is then converted to paper form for processing (reading, editing, categorising and filing).

It appears, ironically, that the printer, a digital device, is creating a counter-technology state by supporting the continuation of a paper-based, or hybrid models of working. As a mediating device, it allows people a means to operate within the digital, while simultaneously serving the conventional practices associated with paper-based approaches by converting pixel to print. Given that many academic resources such as articles are predominantly stored in digital formats, the printer has become an essential component in sustaining the traditional office configuration (designed for paper-based practices) and nourishing the dependency that seems to exist between text and academia. In this sense, the printer represents a subversive or destabilising technology in the current emerging digital (pixel rather than print) space.

The burden of change

Resistance to change is a complex phenomenon, particularly regarding information technology implementation (de Guinea & Markus, 2009; Klaus & Blanton, 2010). In these contexts, behaviours simply continue to support the status-quo rather than adopt changes to accommodate new systems or approaches (Markus, 1983). In the current study, the convenience of the printer maintained a bridge between the new and the old, alleviating the pressure to embrace change. Change requires effort and resistance to investing effort can manifest in direct opposition, or in a less obvious action of inertia—as in this study (Alia, Zhoub, Millerb, & Leromonachoub, 2016). As one colleague shared, "I know where things are going and I know I need to catch-up, but at the moment I am simply too busy to worry about it." Further informal discussions during the investigation also revealed that while there was a fear of being left-behind, which is often the catalyst to at least consider a different future, there was also a lack of access to and awareness of new digital technologies. When the topic of new software was raised, the reply typically centred on the lack of time to investigate relevant software and particularly the burden of learning how to use it. It can be deduced from these interactions that the burden of change resulted in an approach that focused on adopting a core set of well-known applications that facilitated stability within the established daily routines that were grounded within traditional paper-based sequences of action. For these academics, this practice sufficed in creating a feeling of progress.

Conclusion

This was an exploratory study based on five cases, guided by the principles of idiographic research and visual semiotics. We know that the nature of spaces depends on the cultural contexts in which they are constructed and arranged. In this sense, office spaces are living spaces that embody personal and career characteristics and therefore will, through configuration and design, embody visual symbols of the times. The aim of this study was to investigate the transformational impact of the digital revolution on the configuration and work customs of the academic office space. The result is an insightful picture of the academic office space and features of the occupants that inhabit them. Each of the offices are depicted as private spaces where the academic centres their daily academic life. We see the importance of the configured desk/s to work practice and we see the typical arrangement of bookcases, papers, filing cabinets that we have come to expect in the workspace of knowledge workers. As shown, these office features and configurations are not dissimilar to those illustrated from previous decades. The core difference is the replacement of the typewriter with the computer. It could be assumed that the time spent on the computer is likely greater than would have been spent on the typewriter, given that computers allow multiple tasks (writing, reading, annotating, searching etc.). However, this too may be misleading, since documents appeared to be regularly printed for reading. The offices, while incorporating space for visitors (student consultations), tended to be configured to support independent, private work. There was no sign of a shift toward digital information devices such as smartboards or larger digital screens, no indication of flexible office configuration to support the emerging growth of team-based work, nor any indication of a shift toward the paper-less office.

However, the study does not address how academics can be supported in moving past this point; suffice to say that the current office environment was created to address solutions that are no longer part of our unfolding digital reality. There is clearly more work to be done in order to find new ways to uncouple academics, particularly new academics, from the controlling artefacts and practices of a past era of which they were not party to.

As pointed out by Edward Hall (Hall, 1969), particular behaviours and identities are created and reinforced within these spaces, spaces forged by history and culture and unconsciously internalised. We could speculate that the digital world too has its own particular physical, conceptual and emotional dimensions that will one day dominate once they have become unconsciously internalised. However, these worlds appear to be situated within distinct paradigms, with no obvious or convenient way to outrun the growing divide. The move from paper to pixel is required; a radical move that will require new solutions to shift from the old to the new, one that will not only result in new practices, but in new academic identities.

The critique of office spaces undertaken in this study highlights the importance that paper-based text still has in the daily operational practices of academics. It is therefore likely that these practices play an important role in the formation of academic identity. Unfortunately, this reinforces the need for paper-focused approaches that are dependent on traditional office artefacts, processes and configurations. As a result, it is expected that the current co-dependant relationship between academia and paper, no matter how regressive, will continue for some time—impeding the appearance of the truly digital academic.

Chapter 6

Office Activity

Exploring the impact of the digital revolution on the office behaviours of early career academics

The study of behaviour or activity within the context of physical settings is neither novel nor aligned to one particular academic field. There exists a substantial collection of research on the implications of human behaviour in spaces, much of which has been forged over a considerable period, from a diverse range of disciplines: management, education, psychology, sociology and anthropology. Although he was not the first to explore the domain of human behaviour and spaces, it would be negligent omit the work of Edward T. Hall, and in particular his ideas on the way space mediates behaviour. In this way, he fuses the physical features of spaces (types and configurations of spaces), with the traits (intentions, actions, relations) of the people who inhabit these spaces. According to Hall, the interplay between the inhabitants and the physical space is hidden and only able to be revealed through observation. In Hall's time, these observations were undertaken through a process of shadowing, where the researcher 'shadowed' the subject/s under observation, in order to gain insight into the activities undertaken. These ethnographic approaches, popularised by Latour and Woolgar's study in *Laboratory Life* (1979), were arduous and time-consuming. It is also fair to state that there are limits to the types of data/evidence that could be captured through such observations.

The growth of the digital revolution has triggered the proliferation of increasingly complex devices that can take us beyond traditional, manual and often intrusive forms of capture. The core difference between these new digital approaches and their analogue predecessors is their reduction in size, increased mobility and the addition of intelligence systems. These developments have led to videography and photography appearing as standard functions on many mobile devices: laptops, tablets, smartphones, watches, glasses, jewellery and various other wearables. This has ignited an explosion of the capture and sharing of 'lived experience'. The soaring interest in broadcasting lived experience, via video and photographs (Flickr, Instagram YouTube, etc.), signals a subtle but powerful acknowledgement that activity actually matters.

While video is seen as the ideal method for observation research, the volume of data able to be captured means analysis will always involve some sort of filtering/reduction process. This does not mean any loss of evidence, but denotes practices aimed at creating meaningful abridged footage from the rich but unfocused whole. The traditional method employs timelines, picture boards and documentary, generated and refined through hours of pre-views and re-views of the evolving accounts. Through the compositional process of pre-view and re-view, the researcher is able to construct a targeted process of identifying significant elements. There is, in this process, a pre-responsiveness to the footage as containing evidences—signs, signals, markers of the topic under review. This is of course a researcher-centric method that relies heavily on researcher proclivity. It reflects an approach reliant on 'seeing' and 'feeling' the relevance of particular gestures and behaviours as they unfold through activity sequences. Supporting this is an array of mechanical practices, geared toward identifying, documenting, extracting, categorising and archiving. As a manual method, this approach is restricted to relatively short periods of data. Processes involved require considerable investment of time and effort to process. The result is microanalysis of micro-behaviours.

The digitisation of video footage and the rise of the surveillance sector, with its requirement for instant analysis, has stimulated considerable research and development in the field. The volumes of footage generated from continuous feeds means it is no longer possible to employ viewing as an analysis technique. New generation, intelligent video monitoring systems are able to analyse the data as it is captured. This process relies on the creation of metadata which permits the captured footage to be monitored (in real-time) for vital triggers, providing the capability of post-capture filtering and searching, essential for rapid identification or retrieval. The result is intelligent cameras controlled by intelligent hardware and software generating rapid, live video identification of objects, people and faces (Figure 49).

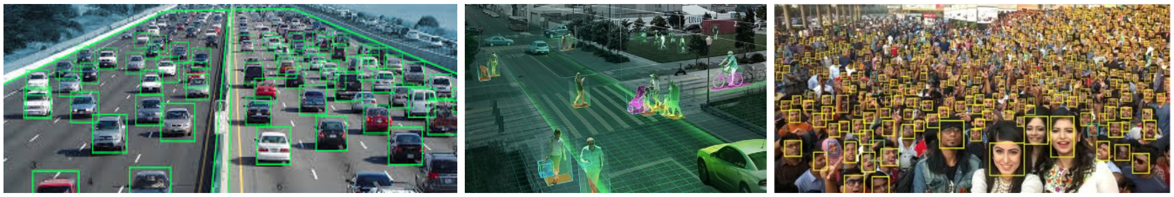


Figure 49. Example of rapid, live digital recognition from vehicles, to movement to face. Images retrieved from google image collection using the search term image recognition.

It is common in observations of behaviour in natural settings to see approaches that are more ad-lib than systematic, and more manual than automated. Given the advantages of these types of technologies to monitor the unstructured, often messy states formed in natural environments, you would assume a steady rise in their use in social science research. However, this does not appear to be the case. The traditional microanalysis of distinct behaviours, over short periods, continues to dominate behavioural research. In cases where delineation of dense behaviour data is required, manual researcher-centric analysis, involving mark-ups of short, punctuated video footage, is likely to be the favoured option. However, the data forms that drive behavioural analysis are very different to the activity rich data that can be gleaned from more substantial periods of footage. The capture of activities in natural settings over extended periods of time, that is weeks to months as opposed to minutes to hours, generates massive data streams that go beyond the traditional ad-lib, researcher-centric method and demands the presence of complex automated AI systems. This represents a significant change in how we undertake observational research, creating obstacles for many researchers trained in microanalysis. For example, a research team recently asked me to assist in devising a method of analysis for photographs and video data captured over many months. Their design incorporated the standard microanalysis approach, where the researcher would view the captured footage and generate observational side notes. The team was shocked when I calculated it would take one researcher five months to view the video and image data through once; this did not include the stop/start/pause procedures required in taking notes. The group were simply unaware of the volume of data and the implications that ensued. This oversight is a result of not understanding that these approaches require different methods. Part of the challenge of my study was to confront this issue by attempting to establish new protocols for capturing, analysing and extracting evidence from video footage of peoples lived experience, which could then offer possibilities beyond traditional microanalysis techniques.

The primary objective of this study was to explore the 'behavioural' element of the New Ways of Working by analysing academic practice through observing behaviours as they occurred within the office space. An exploratory approach grounded in the creation of time rich, massive data meant the exclusion of prescribed behaviour taxonomies. Instead, the types of activities of interest ranged from the degree of movement, identification of primary work areas and identification of the level of socialisation. The objective was to ascertain the degree to which a cohort of five early career academics were engaging in practice that could be identified as traditional or reflect New Ways of Working.

A secondary objective concerned the research method, in particular, the merits and affordances of extended continuous video footage as a valid data source of activity. While the use of video in educational research is not new (Erickson, 2011), the volumes generated through deployment of continuous capture over extended periods was. The volume of data created meant traditional behavioural analysis through video observation and mark-up was not possible. Instead, methods that incorporated advances in algorithm-based analysis were explored.

Methods

The study was guided by Reality Mining (Eagle & Pentland, 2006), an emerging research approach developed for studies that deploy digital technologies to harvest digital data from sensor-based devices in order to assess daily human behaviour. The study was not targeting isolated phenomena, but sought to document the lived experience in its entirety; the natural fusion of the mundane, the remarkable and everything in-between. As discussed earlier, this aspiration was well suited to idiographic research, and as such, there was no requirement to employ formal sampling. Instead, a 'first-in' selection process based on 'convenience' was used to recruit five Gen-X early career academics (two females and three males) from a range of disciplines (science, health science, humanities, commerce).

Data capture

Ceiling mounted dome cameras were deployed within each participant's office to harvest continuous, naturally occurring activity data over a period of 25 weeks from August to December in 2014. The sheer volume of data produced necessitated the deployment of intelligent video management and video analysis software systems capable of controlling video capture, indexing, storage and playback. A detailed breakdown of the procedures and logistics involved in the construction and configuration of the data capture system is discussed in Chapter 4. A total volume of 15 TB of video footage was captured. This represented approximately 150 weeks or 6,000 hours of footage. To give some appreciation of the volume, it would take a person working 40 hours per week over two years to view.

The initial design blueprint employed a fully automated video system that allowed for continuous behavioural analysis over an extended period. Unfortunately, as discussed in Chapter 4, the initial configuration of the infrastructure was compromised, causing failures in the creation of the essential metadata required. While a number of other systems were explored (discussed in Chapter 4), it was evident that reproducing metadata post-capture was not feasible. A final hybrid method was eventually adopted. While not as comprehensive as the original method, it incorporated a degree of Artificial Intelligence rendered data that was adequate to gauge the potential contribution that these approaches could bring to observational research.

The disadvantage of the approach selected was the lack of integration. The coupling together of a series of standalone applications required a number of manual procedures that followed a set series in order to harmonise the disparate elements. This hybrid model increased the time it took to process data. Data needed to be shuffled across various systems, including the conversion of file types. As a consequence, not all data could be processed. Instead, a method of random time sampling was employed to select a series of dates from each participant, from which the associated footage would be selected for analysis.

Data analysis

Data analysis involved the generation of a series of heatmaps in order to gain a picture of office movement and position behaviour within daily office activity. It was hoped that from this picture a differentiation might be made between actions and states. By actions, I am referring to rapid, short activities with clear goals, as opposed to states that entail significant durations where the goal is not explicit. Consider the act of walking from a desk to the filing cabinet and back. This is an activity that occurs within short timeframe and is therefore an action—retrieving a file. The activity of then reading the file would be an example of a state—the state of reading. In heatmap analysis, these states can be distinguished by image density from weak (aqua), to strong (yellow), to intense (red). The heatmaps were created with a Python script using OpenCV (Appendix D), an Open Source Computer Vision algorithm, for processing video frame by frame. It extracts the moving foreground from static background, and generates a density map with colours, from blue (static) to red (dynamic). This density image is superimposed over the original image allowing for context-based density images of all movement.

Heatmaps present static measurement of location by density; therefore, a separate frequency analysis was added to complement the heatmaps by showing the degrees of movement over time. Frequency graphs were created using a video movement frequency application SwarmSight (Birgiolas, Jernigan, Smith, & Crook, 2017). The SwarmSight algorithm detects changes in pixel colour between video frames. Research literature on the analysis of image recognition refers to this technique as background subtraction via threshold frame differencing (Courtney, 1997; Hashimoto, Izawa, Yokoyama, Kato, & Moriizumi, 1999). Analysing pixel activity is an ideal way to track the scale of movement. As new pixels appear and previously occupied pixels disappear, the changes are counted; the number of changed pixels correlates with the density shown in the heatmaps across time. These changes in pixel behaviour are counted, and the number of changed pixels correlates with the density shown in the heatmaps across time. Within the activity settings, motion thresholds were set (30) to minimise background noise, and motion contrast and speed were adjusted to 1X and 100%, respectively. Each video recording was analysed in its entirety, with the number of changed pixels for each frame tabulated by SwarmSight.

It is worth noting the danger of overstating the analysis of the heatmaps and the movement frequency graphs by imposing evidence where there is no evidence. For this reason, a cautious approach to data interpretation was followed, observing that these analytical devices represent proof-of-concept testing and therefore require a conservative approach to drawing evidence from the analysed data.

A third form of analysis involved Rapid Scan Analysis, where video footage is viewed by the researcher at high speed. This process offers a fast way to ascertain the gross features, without indulging in time-consuming detailed inspection. In the study, the 425 hours of footage were run at x40 times the original speed. This process was also used to cross-check the evidence drawn from the heatmaps and movement frequency data.

Process

A series of 12 days per participant were randomly generated using an online randomiser ((https://www.randomizer.org/). Twenty five numbers were generated for each month. Selection was sequential from the generated list. Where a selected date had limited or no video footage, a subsequent number from the month series was then selected. The resulting selections, including associated file sizes and approximate period recorded for each participant, are shown in Table 3.

Table 3

The 12 days of video footage selected for each participant across the total pool of recordings captured over the study period.

ID	Dates	File size	Hours of footage
AC	10/08, 20/08, 22/08, 01/09, 02/09, 26/09, 15/10, 17/10, 20/10, 24/10, 11/11, 17/11	50 GB	102
CH	11/08, 02/09, 23/09, 03/10, 08/10, 09/10, 13/10, 05/11, 11/11, 13/11, 18/11, 20/11	34 GB	40
CS	16/08, 19/08, 21/08, 03/09, 25/09, 30/09, 01/10, 09/10, 17/11, 19/11, 24/11, 26/11	50 GB	95
DP	11/08, 14/08, 29/08, 03/09, 08/09, 03/10, 06/10, 08/10, 11/11, 13/11, 17/11, 18/11	43 GB	78
SP	10/08, 20/08, 22/08, 29/08, 02/09, 18/09, 26/09, 08/10, 11/10, 12/11, 17/11, 21/11	50 GB	110+

The video footage associated with these dates was exported from the Video Management System (VMS) as Matroska Video files MKV, a flexible, open standard video file format ideal for high definition video. The resulting MKV files were then processed using the Python Open Computer Vision (OpenVC) script to generate a series of participant-specific daily heatmaps. The movement frequency graphs were also generated from the MKV files using Swarmsight. The practice of setting thresholds and processing each file for both heatmaps and frequency graphs was considerably time-consuming give the size of the files.

The two measures applicable to the analytical techniques employed in this study are the location in the room (captured by density measures), and the scale of movement (captured by frequency values generated by pixel changes). The truncated video datasets (12 days for each participant) created from the larger video streams were used to generate associated density heatmaps and movement frequency graphs. These are grouped by participant and identified as AC, CH, CS, DP and SP shown in separate figures (AC-Figure 53, CH-Figure 54, CS-Figure 55, DP-Figure 56 and SP-Figure 57).

The heatmaps employ colour density to identify dominant spatial locations, while the associated frequency graphs depict an automated quantitative appraisal of the temporal progression of the activity levels over time. In both cases, minor movements fall below the thresholds set and therefore do not trigger colour rendering on the image, or pixel counting on the frequency graphs. However, extreme light causes reflection and shadow movements that are registered above the minor threshold. These are noticeable in a number of images where light from windows has permeated the scene. While these cinematic effects can reach levels that degrade the image, the 60 images presented here offer acceptable density imaging in order to identify the dominant spaces occupied. The corresponding pixel variation graphs denote the intensity and frequency of movement, where the x-axis represents time by frames per second (FPS) and y-axis the number of pixels changed.

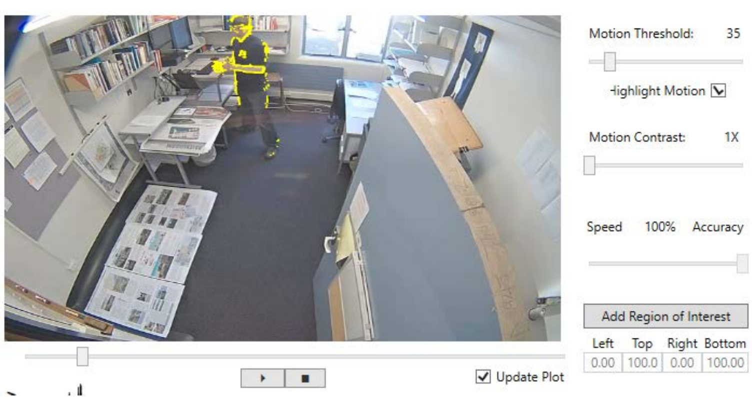


Figure 50. Image showing the movement capture process where pixel changes are presented by yellow markers.

As shown in Figure 50, the software captures variations in pixel use that is then converted into movement sequences. The individual changes are recorded as numerical values associated with the FPS. To minimise erroneous values spontaneously created by flashes of light reflecting on items within the room, values (typically not clustered) that were above 1200 variations per frame sequence (15), were removed. This allowed for a clear interpretation between seated activity and that of standing, or walking activity. As shown in Figure 51, where density is isolated in one place and movement frequency values are low (less than 200), this represents low levels of movement, typically associated with desk work. Where movement frequency values are dense and greater than 200, this is likely to reflect movement values of two or more people. Multiple people increase not only the spike range, but the density. When less dense spikes are greater than greater than 200, this is the result of active physical movement, typically standing and walking. A continuous flat line of 0 values for a period of time represents an out-of-office condition.

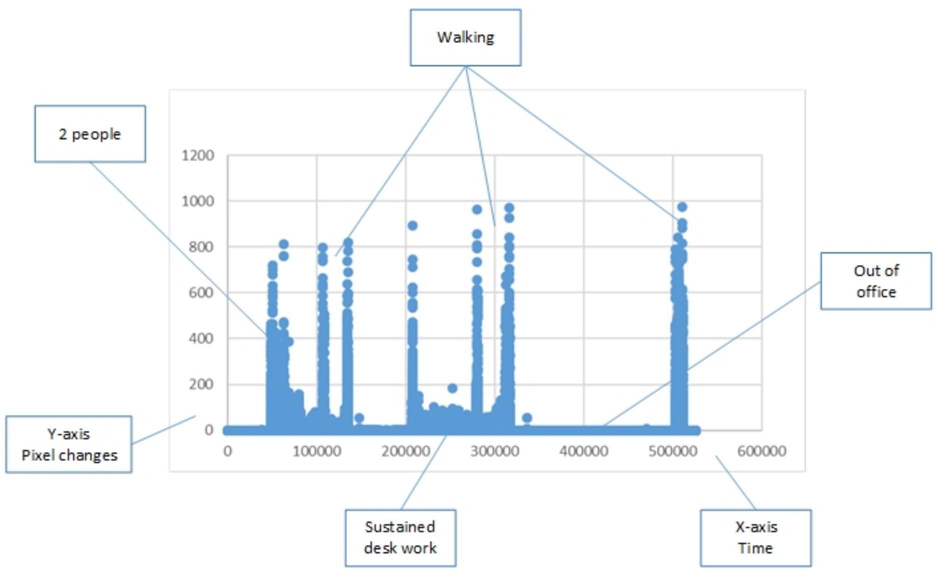


Figure 51. Explanation of the various elements generated by the movement data (SwarmSight).

The idea of office 'place' was predicated on the spatial zones developed in Chapter 4. Each office was demarcated prior to heatmap analysis in order to identify various spatial relations. However, the data showed that spatial zone activity was relatively limited. As shown in Figure 52, the prevailing zones were limited to: computer desk (A), non-computer desk (B) and social space for visitors (C).

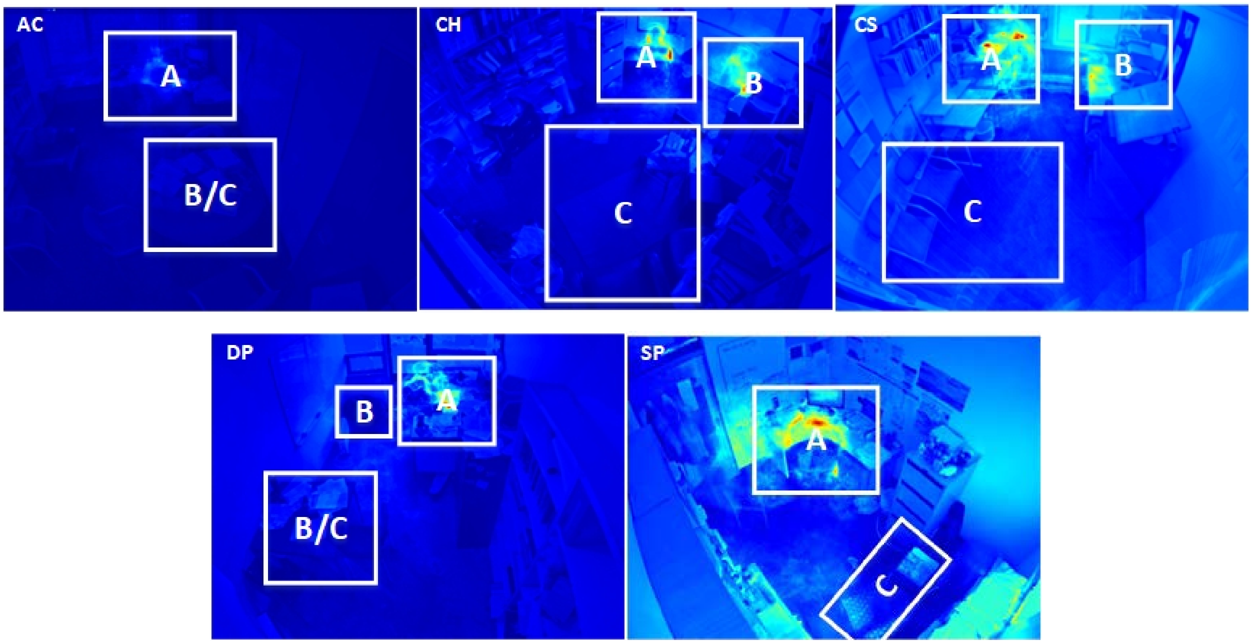


Figure 52. Schematic showing the three dominant zones: A-computer desk, B-non-computer desk/area and C-social/visitor area.

The office spaces of AC, CH, CS and DP incorporated non-computer space, while DP did not. Similarly, AC, CH and DP had dedicated work spaces for visitors, while CS and SP included the chairs pushed against the wall.

Findings

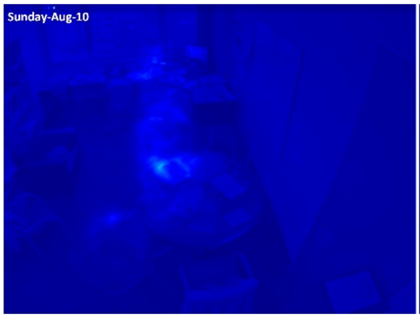
Movement frequency graphs accompany each of the corresponding heatmaps for each of the 12 days sampled. As shown in Figure 53, the heatmaps offered a valuable measure of the core work areas as expressed by location density. They also revealed the presence of others in the room for periods lasting more than 15 minutes. The corresponding movement frequencies added a useful dynamic element by illustrating the transfer points between assertive, high frequency values (measuring walking related movements), with the passive, low frequency values (associated with deskwork). Generally, data less than 200 on the y-axis represents desk work activity. When frequencies are greater than 200 it is an indication the person is moving around the office in a more active manner. As revealed in the heatmaps, these movements tended to be between the computer desk and non-computer desk, or the area for visitors.

Academics in office space

The heatmaps for AC showed that 11 of the 12 sample days were predominantly centred at the computer desk, with the remaining days focused more on the non-computer desk. The maps also show three days where interactions (a social condition), although not dominant, were noteworthy. The movement frequency graphs show significant indicators of sustained desk related activity (activity less than 200).

Over the twelve day period (which equated to 102 hours of footage), AC engaged in five sustained consultations. These occurred in what AC defined as their non-computer desk (area of B/C). This is represented on the movement frequency graphs as thick-density areas above 200 (e.g., 20/08, 02/09, 17/10, 20/10). Of the 105 hours of active time recorded over these 12 days, AC spent much of their time at their computer for sustained periods. Time out of the office is shown as low. Overall, physical movement is significant across most the 12 sample days. It is difficult to interpret this movement, except to acknowledge it was common and shows sustained work was punctuated by regular movement. The use of Rapid Scan Analysis revealed that the repetitive movement frequencies were generated as a result of toing and froing between the computer desk and the non-computer desk, punctuated by a sporadic exiting and entering the office.

AC – Commerce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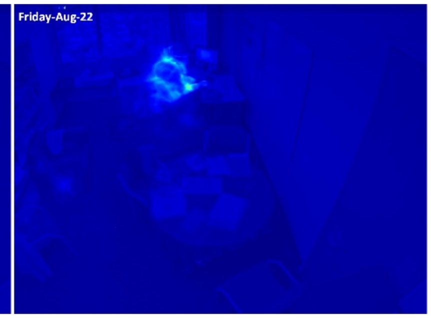
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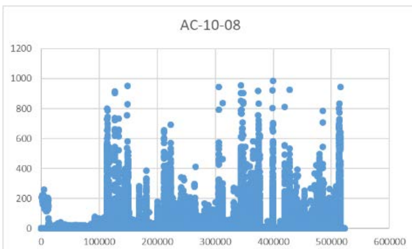
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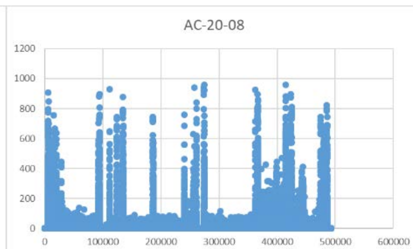
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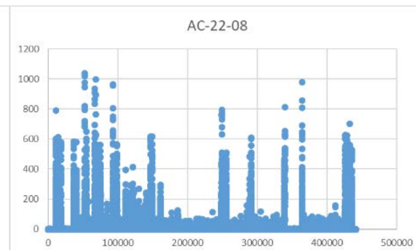
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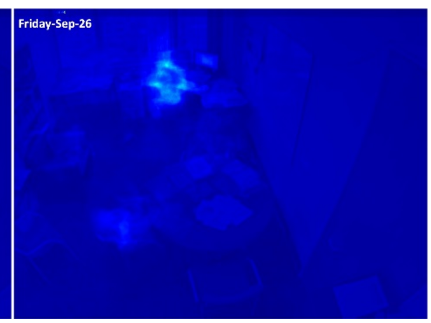
Tuesday-Sep-02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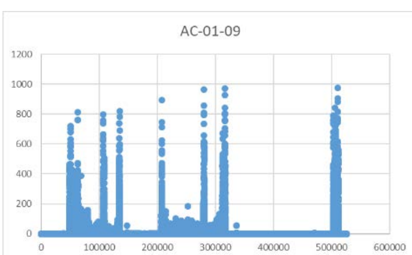
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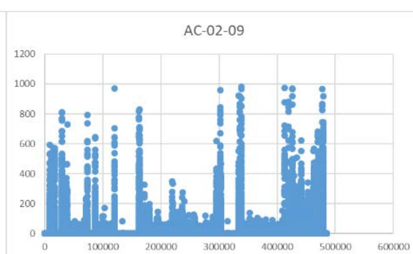
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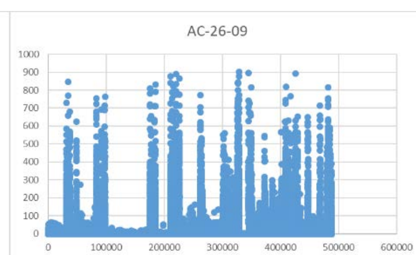
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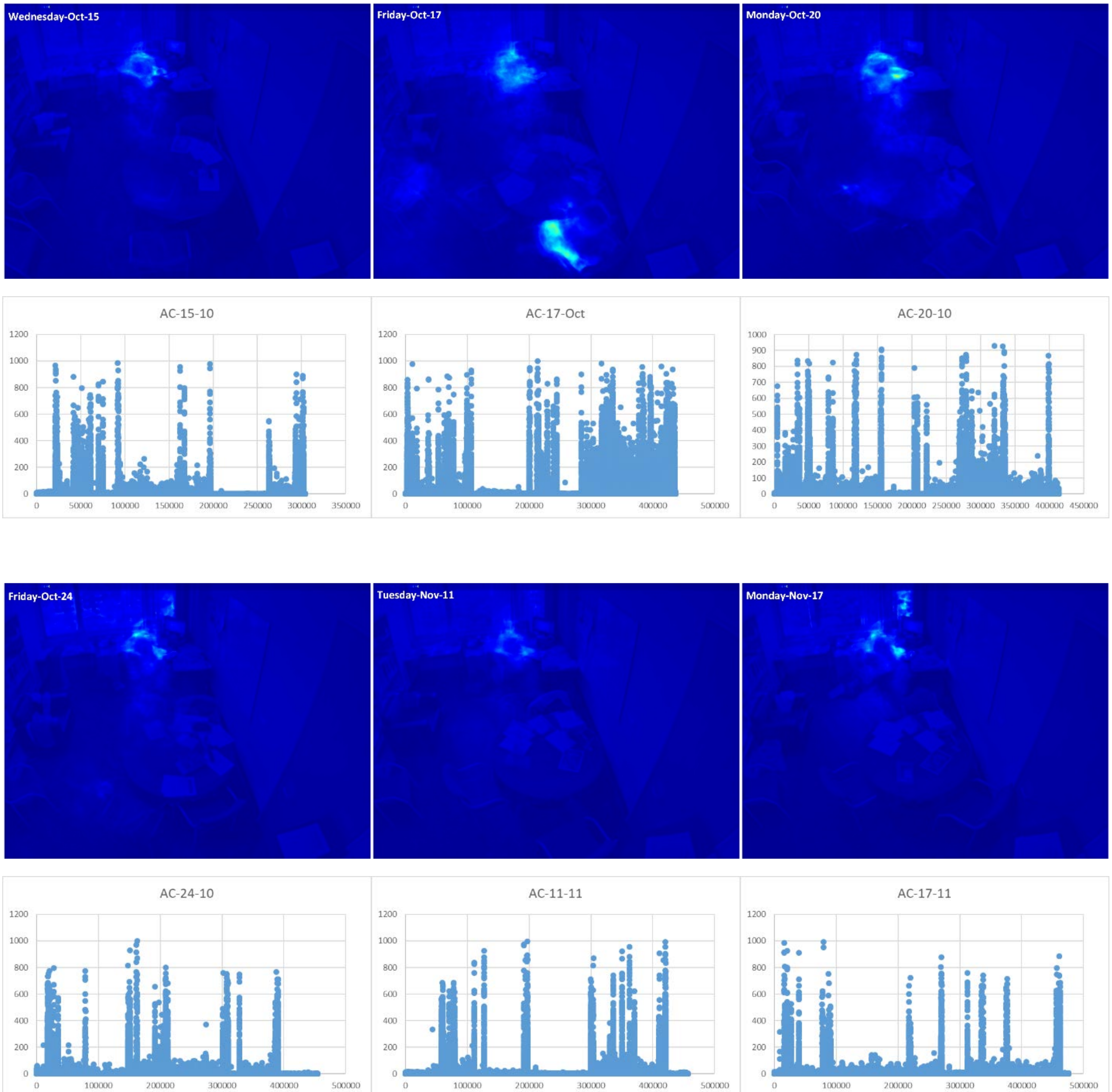
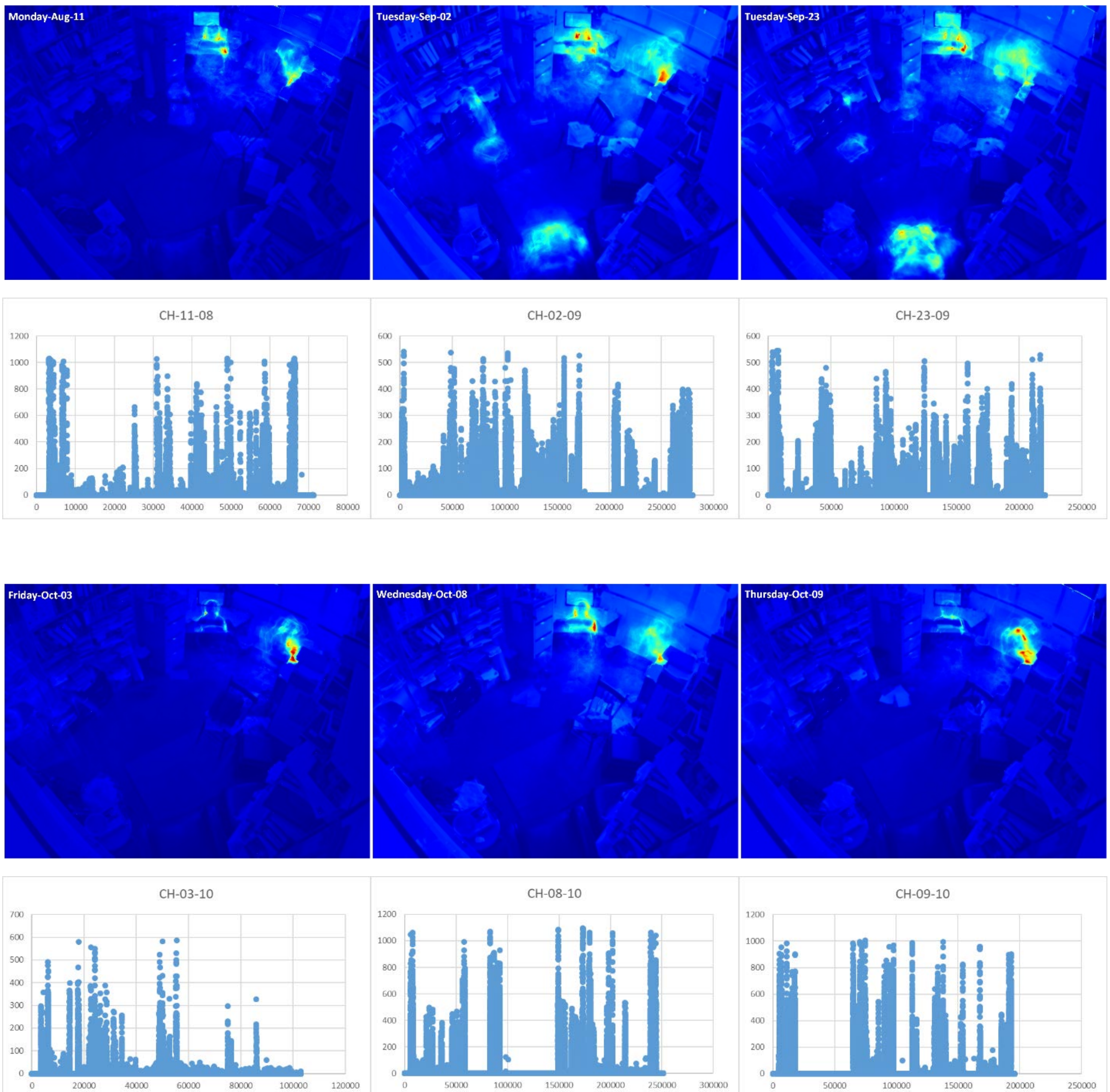


Figure 53. Heatmap showing density values associated with spatial location and corresponding graph of pixel change frequencies identifying the level of physical movement for participant AC. The x-axis represents time (FPS) and y-axis the number of pixels changed.

For CH, the heatmaps showed the significance of the non-computer desk (Figure 54). Like AC, the critical evidence revealed by the heatmaps was the centrality of the office desk to daily work practice. In CH's case, the non-computer desk was shown to be the primary desk. The desk activity (computer and non-computer), like AC, was punctuated by a number of student or colleague interactions which occurred in CH's meeting area shown as C in Figure 52 (e.g., 02/09, 23/09, 11/11, 18/11). The movement frequency graphs show, like with AC, significant patterns of movement. They also show a number of periods where CH was out of the office. The Rapid Scan Analysis revealed that toing and froing between desks was the dominant cause of movement. Apart from office exit and entry behaviour, some movement measures were generated from accessing the filing cabinet (8) and bookcase (3). The total footage of 40 hours captured of CH's office time was substantially lower than the other participants. There was no indication of what CH was engaged in during these times while out of the office.

CH – Humanities



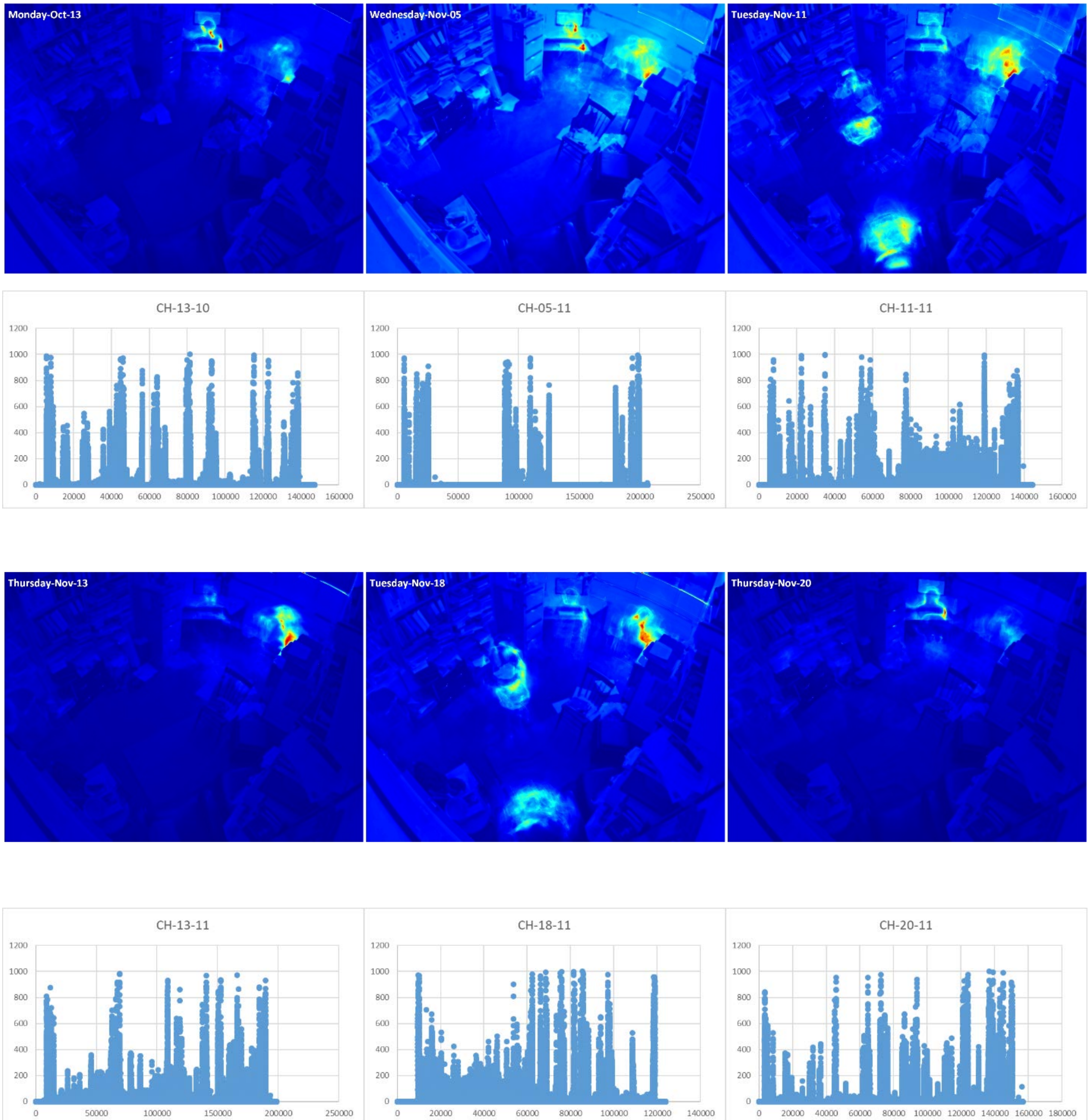
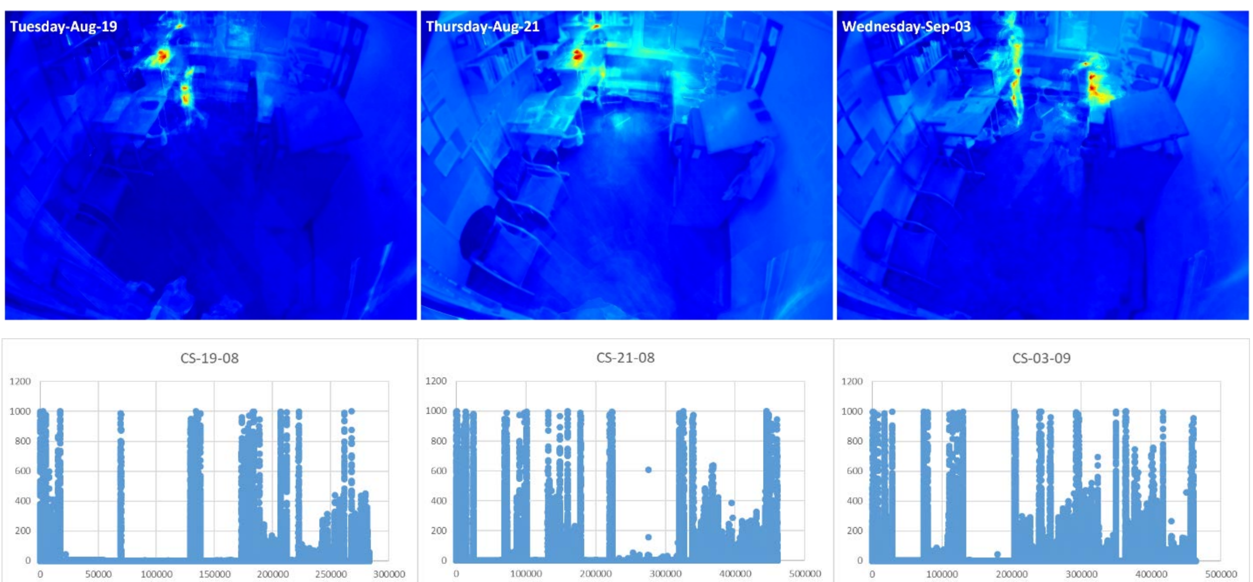


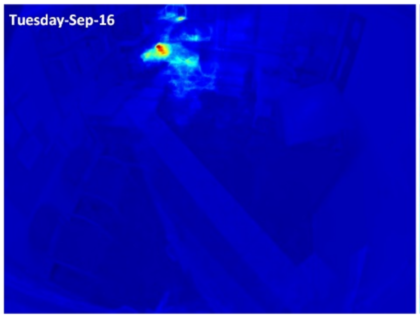
Figure 54. Heatmap showing density values associated with spatial location and corresponding graph of pixel change frequencies identifying the level of physical movement for participant CH. The x-axis represents time (FPS) and y-axis the number of pixels changed.

The heatmap data analysed from the 95 hours of footage for CS (Figure 55) followed a similar pattern to AC and CH. Like AC and CH, CS deployed a two-desk configuration. One of these contained a computer (A); the other did not (B). The heatmaps show the two desks as the primary zones for activity, with the computer desk as the dominant of the two. It is worth noting that the computer desk (A) deployed an elevated desk configuration created from various stacked tables.

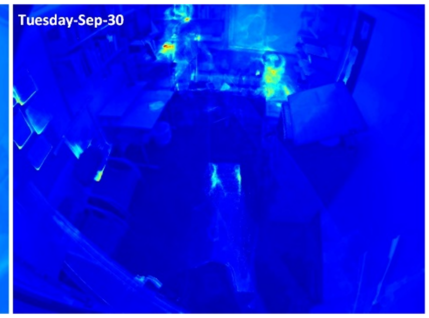
As with the others, movement frequency graphs reveal high levels of active time. The Rapid Scan Analysis revealed that some of this was due to increased movement caused by the use of a high desk that required CS to stand when working at this desk. However, the dominant cause of the high value movement frequency data was the toing and froing between the computer desk (primary) and the non-computer desk. There were frequent colleague interruptions, including a number of short student consultations. These are identified by the density of blur on heatmaps. It was intriguing that these consultations were typically undertaken in an informal, standing manner, given the room configuration was not designed for student interactions. During the rapid scan analysis, the awkwardness of some students was noticeable. In one case, the student held the door for some time before shuffling into the room to rest their hand on a chair, before eventually sitting in the chair, from what looked like a beckoning gesture from the academic to do so.

CS – Science




Tuesday-Sep-16


Thursday-Sep-25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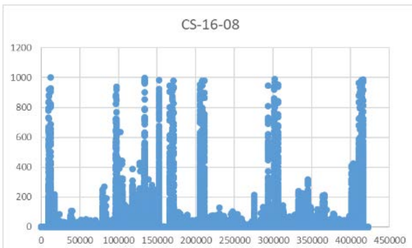
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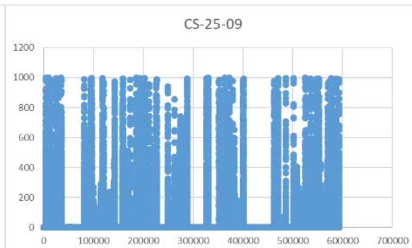
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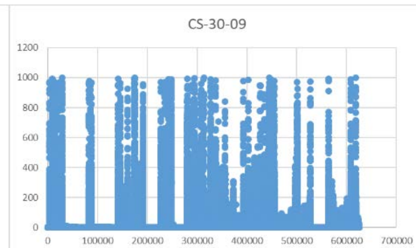
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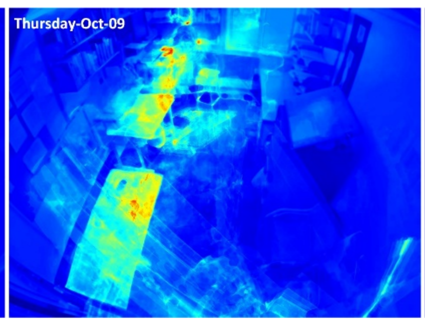
Wednesday-Oct-01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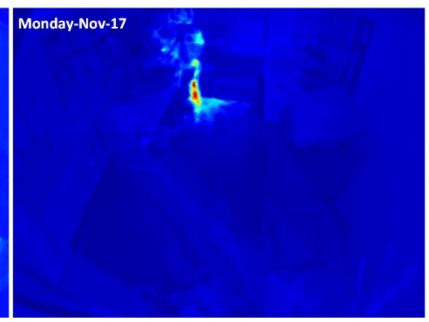
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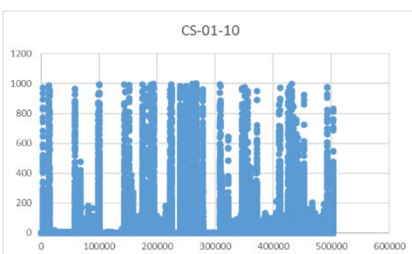
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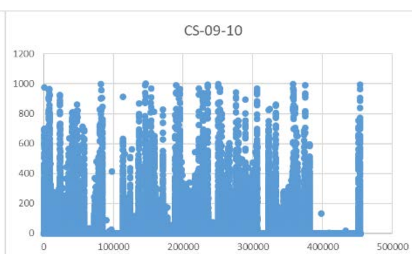
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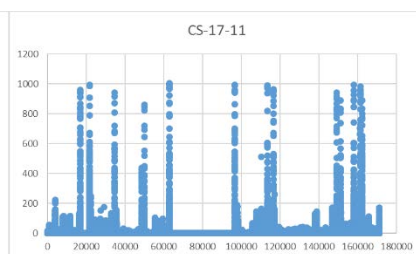
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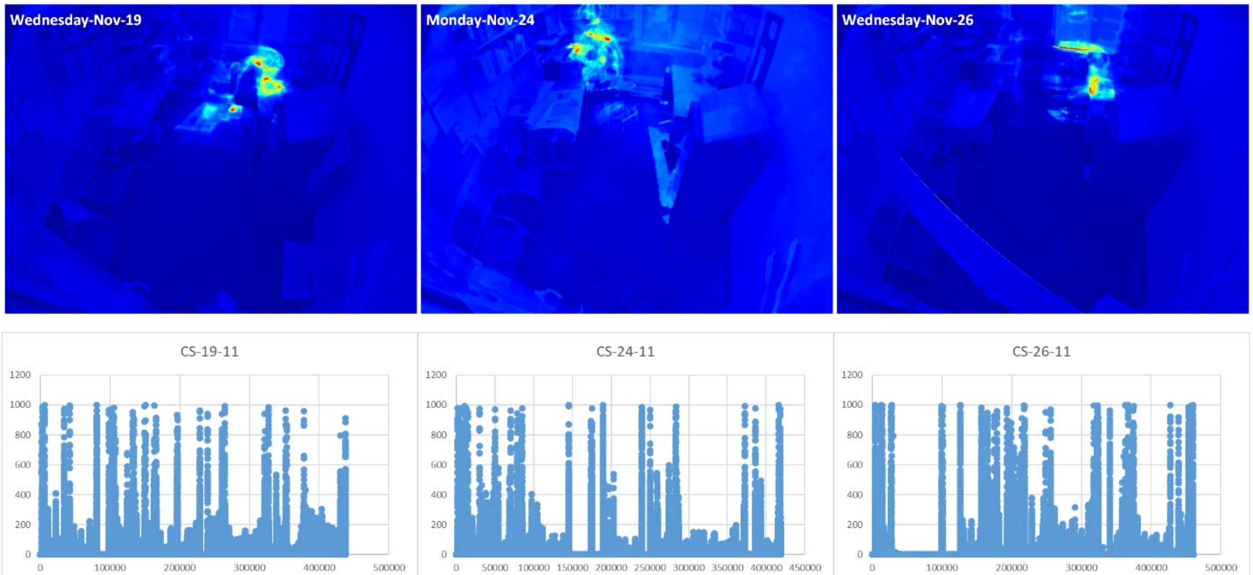
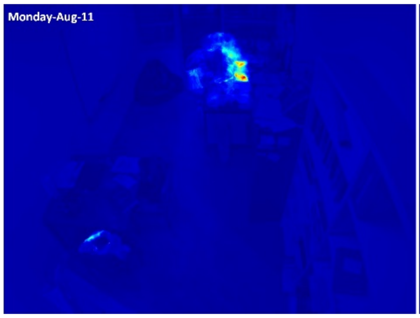
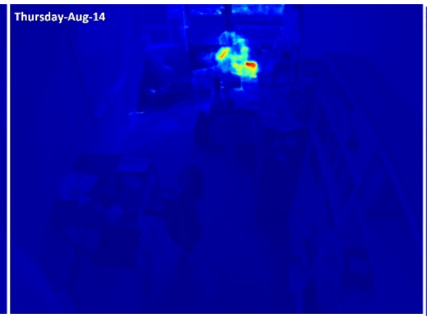


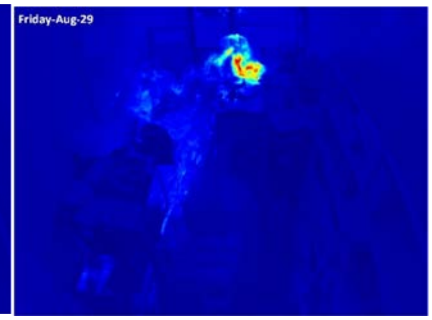
Figure 55. Heatmap showing density values associated with spatial location and corresponding graph of pixel change frequencies identifying the level of physical movement for participant CS. The x-axis represents time (FPS) and y-axis the number of pixels changed.

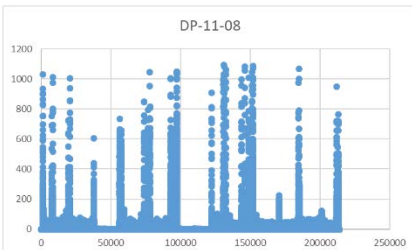
DP generated 78 hours of footage from the 12 sample days. Unlike AC, CH or CS, DP's heatmap data, Figure 56 shows the total centrality of a single desk to daily work practice. This was supported through Rapid Scan Analysis that located DP in this area throughout their time in the office. The frequency measures greater than 600 capture an irregular but repetitive practice that Rapid Scan Analysis revealed were caused by frequent, but sporadic exiting and entering the office, with some of these exits resulting in extended periods of out of the office. As a result, DP's movement frequency graphs identify significant levels of movement (above 200) with a minimum of sustained desk work represented by values less than 200. Over the 12 days analysed, visitor times included seven colleague/student consultations and three family related visits (these are represented by thick density frequencies that rise above 200 on the frequency graphs). During these visits, DP was positioned at the computer desk, a further indication of the centrality of the desk area to their work practice. DP was the only case that exhibited a clear connection between work and family, with three visits from partner and child (Rapid Scan Analysis). On two occasions, their child stayed for an extended period. It is worth noting this connection between work and family is a common trait of millennials, and that it represented one of the few generational markers found in the data.

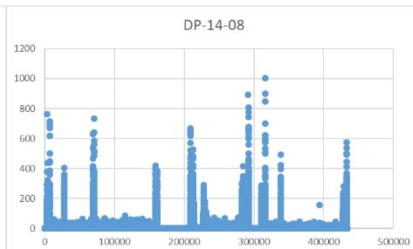
DP – Health Science

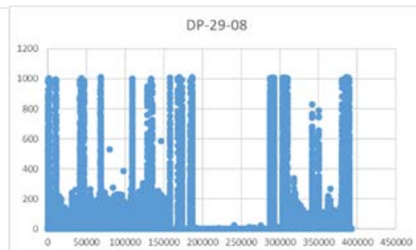


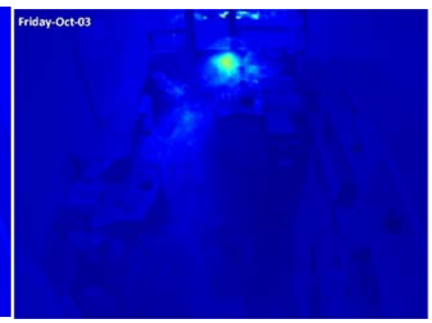


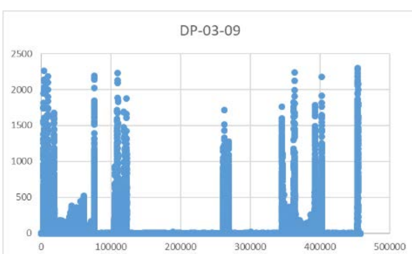


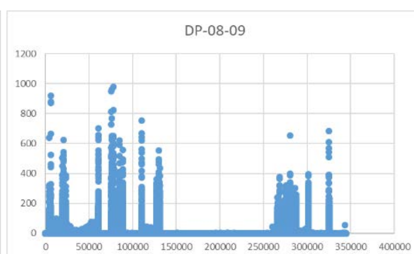


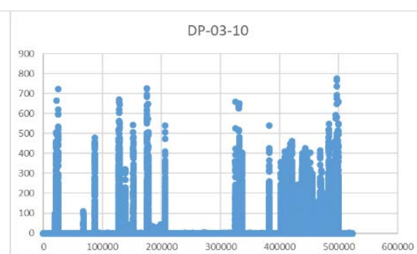












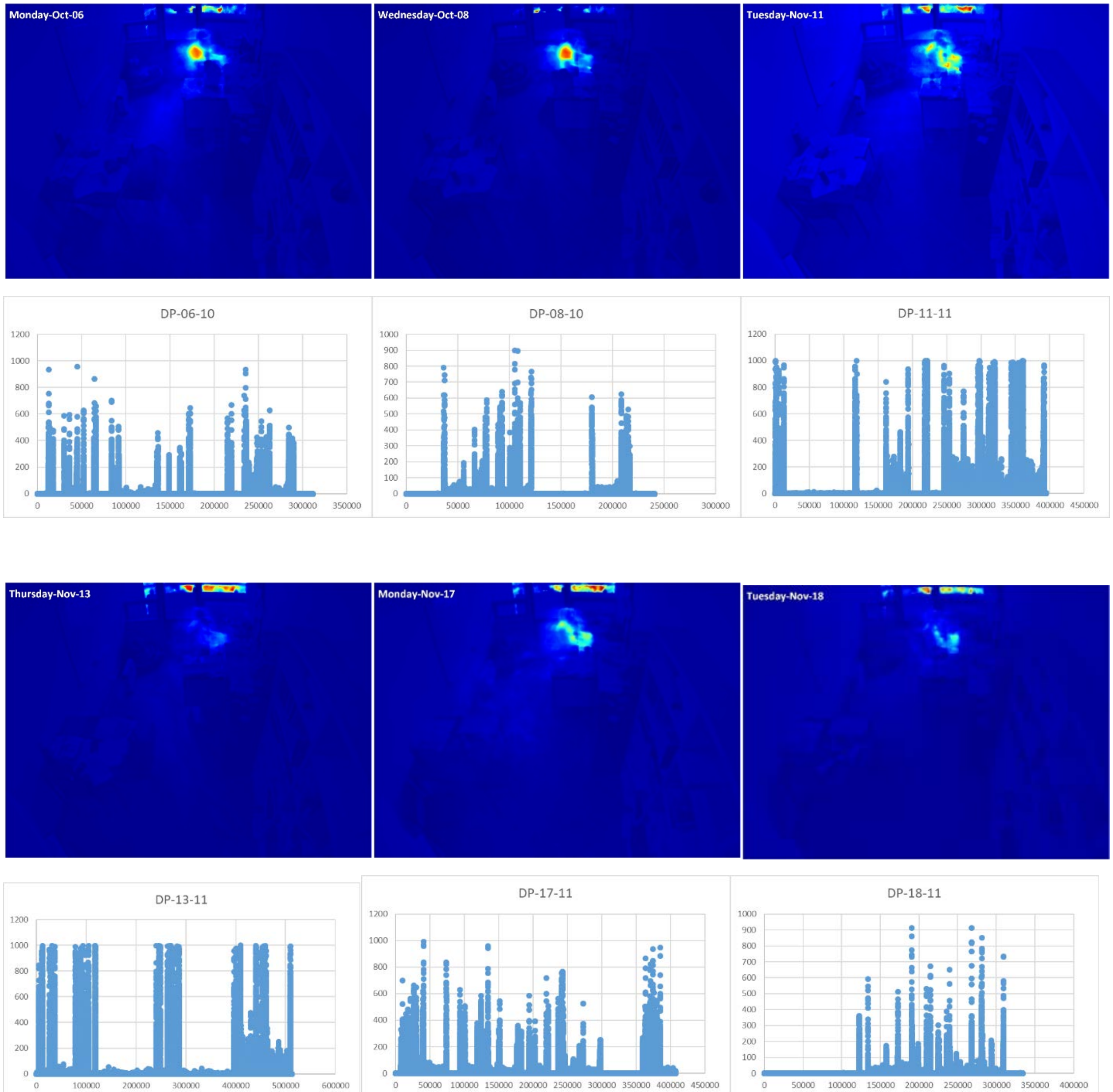
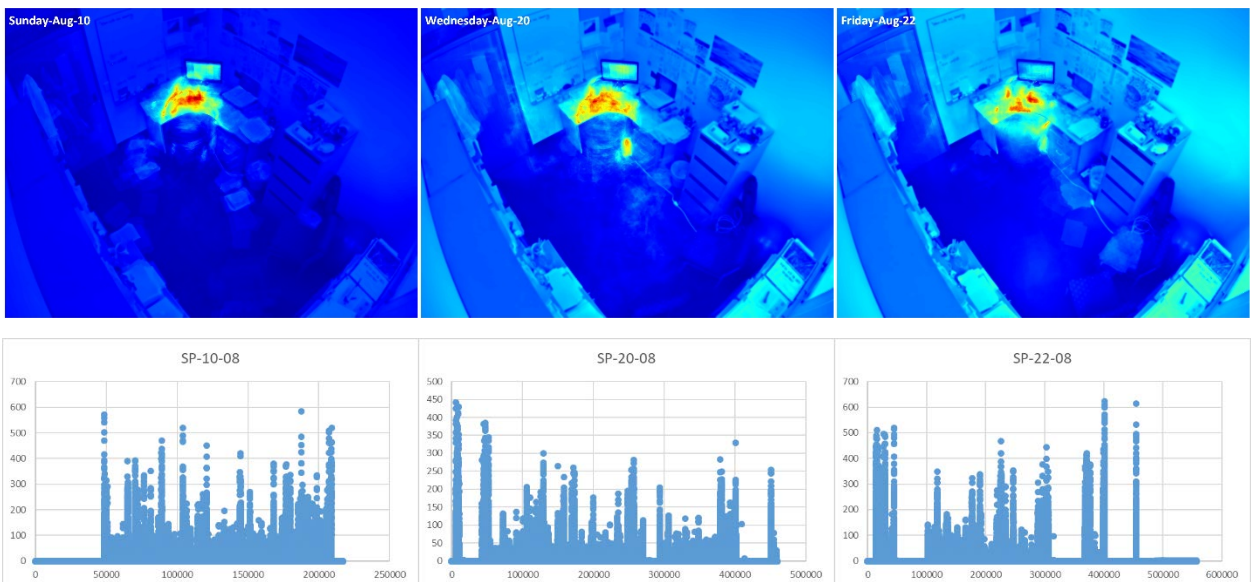


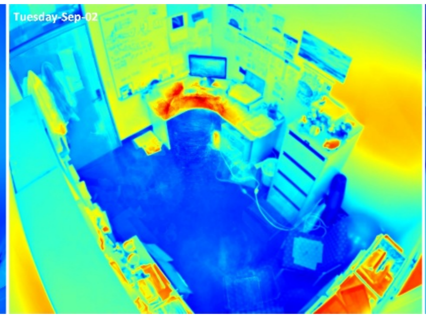
Figure 56. Heatmap showing density values associated with spatial location and corresponding graph of pixel change frequencies identifying the level of physical movement for participant DP. The x-axis represents time (FPS) and y-axis the number of pixels changed.

SP generated the highest office work time, recording in excess of 110 hours over the sampled twelve days. Like DP, SP's heatmap data shows the total centrality of a single desk to daily work practice (*Figure 57*). In fact, SP was the only participant who did not include a second desk as part of their office configuration. While SP's work time was punctuated with periods of entry/exit, there were a significant number of sustained deskwork periods (less than 200) and periods out of the office (0 rated, straight line) as shown on the movement frequency graphs. As with the others, SP generated repetitive and sporadic movement data above 200. The Rapid Scan Analysis revealed that the primary source of movement frequency data was people and door movement at the entrance of the office. This was caused by visitors (students or colleagues) engaging in short interactions within this entrance zone. Similar to CS, CP's office was not configured for consultations. The position of the desk meant interaction with a person at the door was easy and convenient. Of the 10 or so consultations, only three occurred within the room (area C), with the rest occurring within the door zone (20/08, 18/09, 17/11). As revealed in a number of the heatmaps, there was also density data associated with the area adjacent to SP's desk. During the Rapid Scan Analysis, this was identified as a coffee making area.

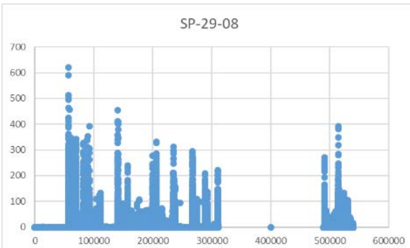
SP-Science




Friday-Aug-29


Tuesday-Sep-02


Thursday-Sep-18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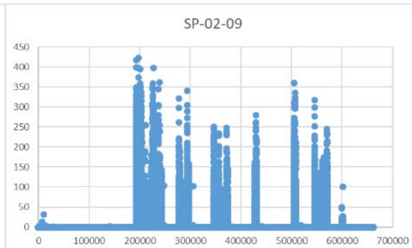
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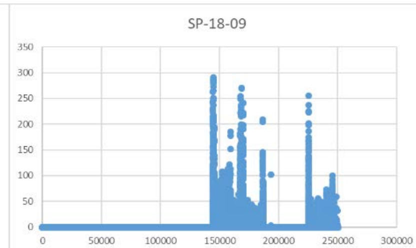
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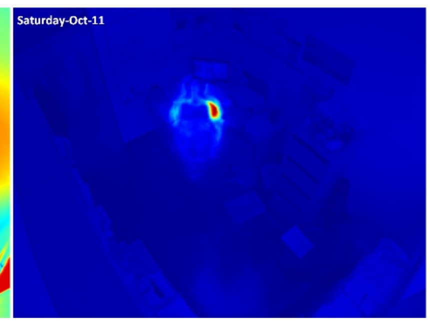
Friday-Sep-26


Wednesday-Oct-08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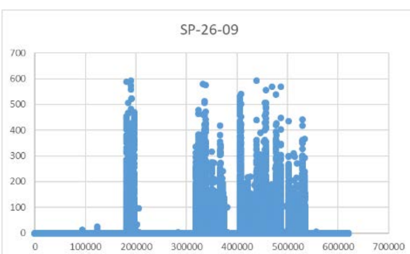
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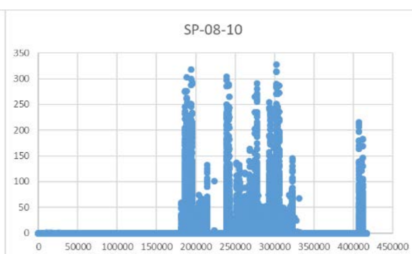
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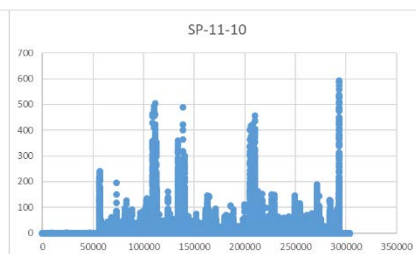
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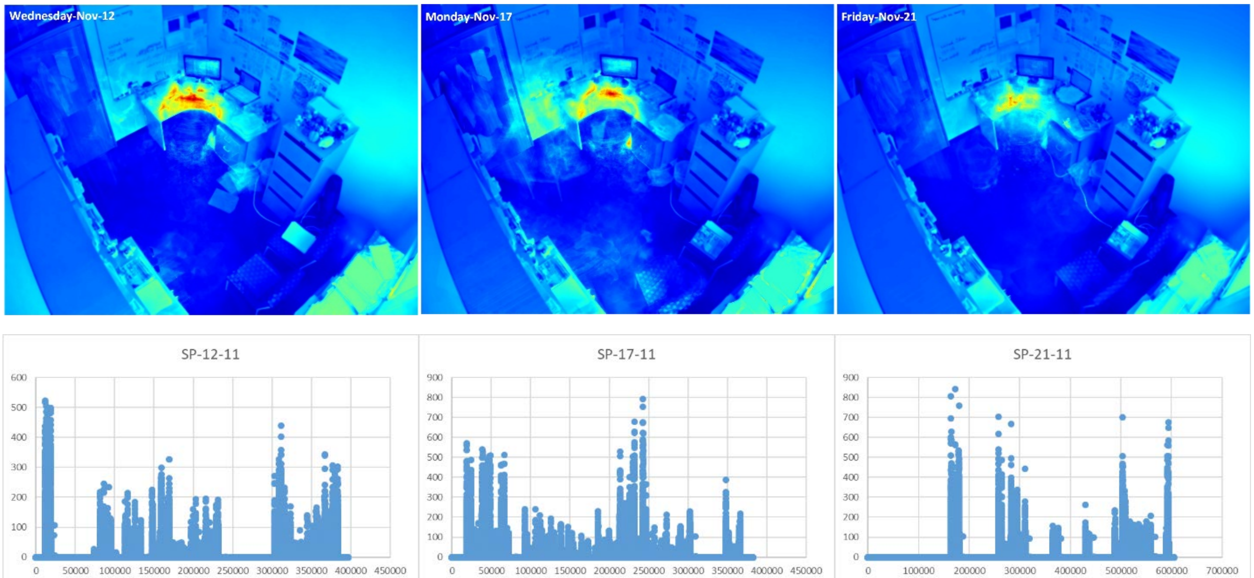

Figure 57. Heatmap showing density values associated with spatial location and corresponding graph of pixel change frequencies identifying the level of physical movement for participant SP. The x-axis represents time (FPS) and y-axis the number of pixels changed.

Discussion

A core purpose of the analysis was to 1) to determine office activity of the five early career academics and whether this reflected behaviours associated with New Ways of Working, and 2) to ascertain the merits of deploying continuous data capture techniques within natural settings for the appraisal of activity as a useful unit of analysis.

Regarding ways of working, the first piece of critical evidence concerned work style. In three of the five cases, the work orientation incorporated a computer and non-computer desk configuration. This juxtaposition of two desks reflects a work process that has its roots in the advent of the typewriter. These devices were positioned on a second supporting desk. This created a switching routine between non-typing and typing practices. This configuration continued with the introduction of the computer through the 1990s with computer desks manufactured specifically designed for situating the computer. The use of two desks by AC, CH and CS results in a physical switching between the computer desk and the non-computer desk. This separation is predicated on a split between digital and paper-based work methods and reflects the hybrid work processes typified in the information age of the early part of this century. New Ways of Working reflects the next stage where paper-based methods have been succeeded by digital-centric, networked processes. Paper-based work practices represent individual, non-networked approaches to production that contravene the core principles of collaboration and transparency that underpin New Ways of Working.

The second piece of critical evidence concerns the use of digital devices and mobility. While computers played an important role in daily office practice, it is important to note that the measure of New Ways of Working concerns how devices are used rather than whether they are used. A core measure is the level of computer work mobility and in some cases, the mix of device types (tablets laptops and phones) in supporting this mobility. There was no sign of tablets or phones playing a role in daily work practice, but four participants had laptop computers and one a desktop computer. The daily practice for the laptop users was to 'dock' these devices at the start of each day, replicating a desktop configuration (associated keyboards and screens). In all cases, the laptops remained in this state throughout the office day. As a result, there was no indication of mobility of devices. Throughout the 12 days sampled, there were regular points of office departure, which were never accompanied by a laptop. In all cases, the computer was bound to the office for the entire period of the office day.

The third piece of critical evidence concerns the apparent primacy of the physical office. In all cases, bar one (CH), the physical office played an important role in defining the start and end of the formal workday. While there were out-of-office occurrences (likely because of teaching activities), considerable time was spent in the office. This represents the common, more traditional view of the individual physical office as the catalyst for work, unlike New Ways of Working, where the concept of the office has morphed from the physical to the virtual. This represents a subtle but powerful shift from physical work presence to virtual work presence. This shift in presence is best illustrated through the rise of networked mobility, where virtual work, undertaken in a variety of distributed, shared, collaborative spaces replaces the traditional, individual physical office space.

The fourth piece of critical evidence concerns collaboration. A central theme of New Ways of Working is the capacity of teams to drive innovation and productivity, displacing the idea of the isolated individuals working independently. In all five cases, the dominant format was independent work. Colleague interactions were typically short and student consultations followed conventional one-on-one formats. Office configurations were not structured for team collaboration. In cases where there was ‘shared’ space, this was limited to one or two people (AC, CH, DP). In the cases of CS and SP, the room configuration indicated no commitment to incorporate space for others. Based on the analysis of the 12 days observed, the findings indicated that for these five academics, the structure of work practice comprised independent work punctuated with individual student meetings and short colleague interchanges. There was no indication in office configuration or work behaviours that suggested team collaboration was practiced.

There were a number of less tangible outcomes that were not critical to New Ways of Working, but are nevertheless important in light of the study and therefore worth mentioning. The level of activity observed by all of the participants was high. Work was continuous, with no observed periods of relaxation, casual reading, or any sign of time-out. Apart from the consultations, the high level of time spent in independent work reflected a solitary work state.

Finally, a note/comment about the research method. The analysis employed a sample set of the total data repository and included a reduced set of analytical methods than was originally planned. Nonetheless, the heatmaps offer a surprisingly powerful static synopsis of the participants’ primary daily work patterns, while the movement frequency graphs illustrate the dynamic nature of these patterns. The outcome offers a glimpse into the potential of this approach. It renders an objective and rich set of data that strengthens the research process of evidence forming and implication creating. By adopting an open exploratory approach, it is possible to appreciate the relevance of these emerging, intelligent and analytical methods in rendering new objective insights into lived experience. The preliminary types of analysis used here in the form of heatmaps and movement frequencies are just two of many algorithm-driven forms that can be deployed to analyse these types of data and signal a new frontier for observational research.

Limitations

The method of analysis employed, while innovative and informative, reflects a condensed version of what was planned. Failures in the initial data capture system (as discussed in Chapter 4) meant forgoing data analysis across the entire datasets (15 TB). The necessity to engage in a number of manual processes meant the dataset had to be reduced to 227 GB of data representing 425 hours of footage. This diminished the number of data layers that could be investigated, such as gregarious behaviour, analytics on specific movements between zones within the room, analytics on interactions with objects within the room, analytics on entry/exist frequencies, including time cycles and examination of pattern analysis to identify repetitive routine behaviours. It also precluded the generation of rich quantitative data valuable for pattern recognition. Notwithstanding these limitations, as an exploratory study, the visualisations produced here offer insight into the capability of automated algorithmic visual recognition systems for observational research. They presented rich activity data that disclosed critical evidence associated with office work practice.

A very different, but notable limitation concerns the centrality of the office to the study. The data in this study reflects academic behaviour within the office. While four of the five spent considerable periods in the office space, the periods of out-of-office time were not captured, and therefore the work practices during these times is unknown.

Conclusion

This study represents an observational approach guided by the principles and practices associated with Reality Mining for the acquisition of naturally occurring lived experience. The aim was to ascertain the degree to which office practice had been influenced by New Ways of Working that are emerging in response to the digital revolution through the deployment of Reality Mining techniques associated with continuous data capture.

This study offers evidence that the use of intelligent digital camera devices afford new types of data capable of producing analyses and representations not typically associated with video data. An auxiliary to this is the veiled, continuous and non-intrusive manner in which capture is achieved, reducing the likelihood of participant performance. However, as discovered, the capture, handling and analysis of this type of data comes with numerous practical challenges. The most difficult of these was the volume of data produced. This makes the handling of raw static video footage slow and time consuming. The solution to this problem is to append metadata to footage on the fly. In this way, footage becomes immediately searchable and filterable as it is captured. In these cases, it would be possible to continuously gather and analyse data, with no need to stop the data capturing process.

Due to failures caused in the configuration of the data capture system outlined in Chapter 4, a hybrid method employing some manual and some Artificial Intelligence automation was adopted. While this approach minimised the range of analyses possible, it offered a starting point for exploring the potential of automated, algorithm-based video analysis. This is particularly germane given the absence of previous office space studies employing continuous, naturally occurring video monitoring techniques. As a result, the experimentation of various approaches and procedures became a significant element in formulating methods for these types of observational studies.

The behavioural data analysed revealed work practices that were typical of the hybrid (digital-paper) forms associated with the information age that was dominant at the turn of the century. There was no appearance of variations that might imply integration or adoption of practices concerning collaboration, mobility or device and space use. Rather, there was an obvious absence of any of the tenets of New Ways of Working.

While the analysis did not reveal any of the attributes of New Ways of Working outside of the traditional work practices, it is worth noting that the analysis revealed each participant approached their office work in different ways, albeit within a dated paradigm. This ability to capture personal work profiles is perhaps the most useful in terms of pioneering new educational practices. In depth observational data, capable of rendering an objective image of the self that is both fast to acquire and targeted in its capture, may well form a new frontier in academic development. This new approach is based not on self-reflection, but on the capture and feedback of routine activity patterns that reinforce the tangible adaptive and maladaptive elements that often elude us.

Chapter 7

Computer Usage

The impact of the digital revolution on the daily computer practices of early career academics

Like the industrial era before it, the digital revolution is affecting every aspect of life. While the degree to which social institutions are affected varies, it is fair to say there is an inevitability about technological progress that is ignored at one's peril. This is particularly true regarding the growing digital intensification associated with the process of work. The accumulating mass of intelligent software applications, the dynamic elements afforded by cloud services and the diversity of devices for increasing personal and organisational productivity and efficiency make it difficult to ignore the importance digital literacy plays in the changing practice of work.

Since the rise of micro computing in the 1980s, research into the use and influence of personal computers has flourished. Although the primary attention has been on industry, a number of early studies investigated patterns of computer use amongst university faculty. One of these, a study by Jacobson and Weller (1987) of a small faculty cohort of early adopters of computers, found word processing and communication to be the primary use of personal computers by faculty members at this time. By the late 1990s, the adoption of personal computers had increased dramatically. A decade later and involving a much larger cohort, a similar survey undertaken by Rousseau and Rogers (1998) of 500 faculty members found that word processing and communication (email) continued to be dominant, but were now joined by a new application, the browser (World Wide Web). Word processing, email and browser use were also found to be the top applications in a survey undertaken at this time by Anderson, Varnhagen and Campbell (1998), of a similar number of faculty members from a research-intensive university. However, they also noted a level of alienation by many faculty members that was motivated by a deeply rooted suspicion of the culture of technology. It was the turn of the century; we were on the threshold of a new revolution, an era driven by radical advances in information technology. It was about change, from the industrial to a knowledge revolution fuelled by advances in technology (Chichilnisky, 2006). A level of scepticism and unease was natural; after all, we were at the dawn of a new millennium and faculty, like most of society, was betwixt and between the hope of technological efficiency and productivity and suspicion.

On entering this new era, it would be fair to say the digital age, as predicted, is producing unprecedented change across virtually every aspect of society. As a result, we are seeing accelerated computer innovation driven by productivity and efficiency that is irreversibly transforming the way we live and work (Brynjolfsson & McAfee, 2011; de Kok, 2016; Heerwagen, 2010). The university is not immune, as higher education institutions are becoming more complex and competitive, driven by political, cultural, economic, and technological factors (Staley & Trinkle, 2011). This has created a state of uncertainty motivated by an increasing expectation for change (The Economist Intelligence Unit, 2008). Campaigns by governments and institutions regarding the need to embrace 'change' is a persistent message of the 21st century (Lee, 2016). While growing economic pressures (Guevara and Ord 1996), global competition (Cartwright & Holmes, 2006), increased performance expectations (Burke & Cooper, 2006), and demographic and cultural changes (Alvesson & Sveningsson, 2016) are all influential drivers, it is the technological advancements that present the strongest and clearest message in regard to change: either progress or be left behind.

Such a situation is developing into a gulf flanked by those who embrace the digital age and those who do not. On the digital side, new networks are allowing different channels of communication that necessitate new attitudes concerning openness and transparency, and new sharing and networking behaviours. As a result, traditional role-based hierarchies are levelled through anyone, anytime, anywhere access across boundaries that were traditionally governed through various control mechanisms. While simple in their action, these new communication technologies are also driving the phenomenon of personal profiling, global recognition and web presence: seen-to-be-seen. Similarly, the shift from the desktop to the 'cloud' represents a move to a more connected dynamic environment. Virtually every collaboration platform today has a cloud-based deployment option allowing many to work from anywhere, anytime, and on any device. This ability to 'connect to work' rather than 'be at work' is changing the way work is defined and signals a shift toward increasing flexibility in where, when and how we work.

A number of studies looking at the growing dependency on technology and its impact on the way we work have suggested a key indicator may be generational. While generational differences are well documented, they are often overlooked in research that investigates the impact of change. This is unusual given the evidence that generations are significantly different in terms of beliefs, values and practices concerning technology and work (Napoli, 2015). For instance, Gen-X companies drove the technology boom of the 1990s and the formation of Silicon Valley. Their technological innovations and work cultures have influenced the way many of us currently think about and engage in work. It is therefore not surprising that the following generation, referred to as Gen-Y or Net-Gen or Millennials, are already re-defining technological innovation, values and practices. A good example of this is the phenomenon known as the New Way of Working. It consists of three distinct elements referred to as bricks, bytes and behaviour. Bricks represents the physical dimension of work environments; Bytes represents the technological dimension, concerned with virtual spaces and devices, and Behaviour represents the activity dimension, concerned with the way we work.

Evolving work paradigms like New Ways of Working are emerging in response to the rise of knowledge-intensive organisations (de Kok, 2016; de Kok, van Zwieten, & Helms, 2016). They offer a vision for making work more effective, efficient, pleasurable and valuable for both the organisation and the individual, giving workers space and freedom to determine how they work, where they work, when they work, what they work with and with whom they work (Bijl, 2011). Computers aid this process by progressing knowledge productivity, networking and flexibility (Ahuja and Shankar, 2009; Rodrıguez Casal et al., 2005; Sigala, 2003) through new forms of action in response to the knowledge worker’s non-routine, ill-structured, problem-driven environment (Reinhardt et al., 2011).

While the affordances of the digital revolution in academia are obvious, the impact these changes are having on the work practices of academics is still unclear. For this reason, this study investigated the degree to which a group of early career academics were employing computers to facilitate new forms of work in response to the ‘new work’ paradigms of the 21st century.

Given the vital role that computers play in developing practices of knowledge workers, an understanding of the degree to which Millennial (Gen-Y) academics are leveraging computers to facilitate 'new work' practices in response to the digital revolution would certainly be beneficial to the sector. Unlike process work, the work habits of knowledge workers can appear chaotic due to the absence of process or flow (Drucker, 1999; Haas and Hansen, 2007; Bosch-Sijtsema et al., 2009). It is precisely this issue that makes self-report data problematic. Any study wanting to ascertain computer usage patterns will need to focus on practice as opposed to perceptions (Butson & Sim, 2013). Unfortunately, the independent, self-governing nature of academic work means capturing practice and measuring efficiency and productivity is fraught with difficulties.

The intention of this study was to determine an accurate picture of computer usage for the purpose of examining the degree to which these participants had adopted New Ways of Working that have resulted with the rise of the digital revolution. Specifically, the study was interested in identifying shifts from the traditional use of computers indicative of the information age to those associated with the cloud computing that has spawned the New Ways of Working movement.

To address these questions requires an understanding of the degree to which work practices have transformed from technology use that is personal, computer-centric and application poor to collaborative, transparent approaches that are cloud-centric, mobile and application rich. A second, less known indicator of change is the shift from multitasking to the new 'focused tasking'. By the early 2000s the ability to simultaneously divide ones attention across multiple tasks became a desired work skill. Computer multitasking was setting new standards for productivity and efficiency, and as progressive humans, we were eager to follow. However, by 2010 this idea was under attack. Studies started to reveal that multitasking was overwhelming brain function and resulting in lower productivity, causing workers to feel out of control (Hunter & Scherer, 2009). There was a growing sense that multitasking lead to mass inefficiencies. While initial attempts to break the cycle/culture of multitasking focused on the cognitive overload that resulted from excessive information channels/processing, a number of researchers argued that it was not so much the issue of information overload, as one of attention switching (Crenshaw, 2008; Rosen, Mark Carrier, & Cheever, 2013).

It seems that the configuration of a physical desk where you are able to simultaneously manage multiple texts, take notes, write articles, write letters, prepare presentations, create and manage reference cards, listen to audio or watch videos while simultaneously engaging in punctuated live conversations, would have been seen as physically and cognitively irrational in the pre-digital era. In the computer age, this type of configuration is not only possible, but also relatively common. So pervasive is the drive to 'do more on our computers' that many have extended their screen realty to incorporate multiple virtual and physical screens so they can run more applications. In essence, the more apps there are available, the more people are likely to multitask.

In situations where people are juggling various tasks, extra capacity is needed in order to refocus attention. This process, known as 'switchtasking' (Crenshaw, 2008; Rosen, Mark Carrier, & Cheever, 2013), has been found to reduce attention and consume valuable time as a consequence of the act of switching. As a result, there is a growing trend in the knowledge worker sector to reduce switchtasking through various work practices that act to firewall time through focused work sessions void of distractions and targeted time chunking and priority setting. By plotting the level of multitasking, it would be possible to measure the degree to which a person's work practices were indicative of multitasking or monotasking. This distinction was used in the study as a further indicator of work practice transformation.

Methodology | Method

There are numerous survey-based studies dating back to the 1980s that have investigated academic computer use, and to date they still rely on post-event recollection via self-reports to recall computer practices. While not always stated, such self-reporting methods are measuring perceptions of practice rather than actual practice. In order to secure an accurate measure of practices, this investigation adopted a relatively new research methodology known as Reality Mining (Eagle & Pentland, 2006), a process of collecting and analysing sensor-based data associated with human behaviour in order to identify patterns of action.

The methodology and methods required to analyse the volumes and complexities of data generated from continuous data capture are, to some extent, still naïve. For this reason, and given the study was exploratory in nature, a within-individual variability (intra-individual variability) or idiographic design was adopted as an effective way to identify patterns of computer usage behaviour within the person across a range of purposes. Individual-centric approaches such as this are ideally suited to studies that capture data in real-time, in natural settings and over long periods of time. They offer a narrow but deep set of data, as opposed to the more common broad but shallow approaches of large-scale grouped population data. The study, therefore, does not claim generalisability, but aligns with transferability, inviting readers to develop valuable insights through making connections between aspects of this study and its findings with their own experience. Each person's results have been reported separately and identified by the symbols CH (humanities), AC (commerce), CS (science), DP (health science) and SP (health science).

Participants

Given the idiographic nature of the study, there was no requirement to employ formal sampling. Instead, a 'first-in' selection process based on 'convenience' was used to recruit five Gen-Y early career academics involved in research and teaching from across various academic disciplines. Five early-career academics (two females identified as SP and CH and three males identified as AC, CS and DP) from a range of disciplines (science, health science, humanities, commerce) who were participating in a broader study on academic practice at the time, volunteered to take part in the study.

Data Collection

In order to address the extent of computer use and for what purposes, personal time management software (RescueTime) was installed on participants' primary work computers. In all cases, except for CH, the computer was a laptop (often taken home). CH was the only participant who employed a desktop and for that reason, their data was only captured during time in the office. In all cases, participants' academic work was undertaken on a single computer (the one being tracked); smartphones were not used as part of their academic work. The software recorded, at 5 second intervals, the date, time, duration of access and the activities undertaken and applications used. A core analytical capacity of the software was the capture of document titles and web URLs (the content of documents, websites or emails was not captured). This afforded a deeper analysis that went beyond simply identifying software applications to one where applications could be associated with particular purposes.

The ubiquitous nature of the data capture software meant participants were not required to take any action, they simply carried on with their daily activities. They were, however, able to access the software dashboard at any time to review data captured. The data capture was maintained over the second part of the academic year (n = 25 weeks) from August 2014 to November 2014.

Each participant was given an orientation session on how the software worked, what was collected, how to access it and read the screens and how to turn the software off and on. An added function was included within the software to capture participants' non-computer activities. This was achieved through the activation of an onscreen 'where have you been' dialogue box. When participants were away from their computers for more than 30 minutes they would be presented with this dialogue box asking them to define the purpose of their absence from a drop-down selection that included Research, Teaching, Service or Break. The software then calculated the subsequent time allocation for each selection.

Data Analysis

Given the nature and volume of the data, it was appropriate to undertake multivariate data analysis based on frequencies. Contingency tables (crosstabs) were generated using the statistical package RStudio and presented as visualisations using plots across five core categories: computer usage, non-computer activity, computer applications, computer activities and multitasking. From these contingency tables and visualisations, a comprehensive understanding of the degree of computer use and the various software applications emerged. Finally, a series of heatmaps that simultaneously display all application use across date and time were created in order to identify patterns that may not be apparent through traditional visualisation techniques.

Findings

All five participants reported that accessing their computer was their first and last work activity of each day. As a result, it was possible to calculate the participants' total daily time spent on their computers. The caveat regarding this method is that while the computer time was accurate, the reliance on self-reporting of non-computer activity via the onscreen 'where have you been' dialogue box was likely to be less so. The total hours captured were compared to the institution's expected total work hours over the 25-week study period: 25 weeks x 37.5 hours per week = 938 hours. As shown in Table 4, the hours recorded for computer | non-computer data for SP (+69) and CS (+18) exceed the expected institutional rate, while AC (-12) was similar, DP (-154) below and CH (-638) significantly lower. It is important to note that while time on the computer is accurate, the record of non-computer represents a composite of system tracking and self-reporting. In this way, the non-computer time is less accurate. In the case of SP, CS and AC the total time equated closely to the expected total work time. In the case DP and CH, the lower times are likely to relate to less time on the computer.

Analysis of computer usage

In the case of actual computer usage, over half of the recorded time for SP (55%), CS (61%), AC (69%) and DP(69%) was shown to be related to time spent working on their computers (Table 4). In the case of CH, it was difficult to equate to total work time given the portion of unknown hours, but even in this case, 47% of the work time recorded was spent on the computer.

Table 4

Breakdown by total hours of computer and non-computer time captured over the study period

	SP Health Science		CS Science		AC Commerce		DP Health Science		CH Humanities	
Computer	554	55%	581	61%	638	69%	538	69%	140	47%
Non-Computer	453	45%	375	39%	288	31%	247	31%	160	53%
Total hours	1007		956		926		784		300	

Note. All figures are rounded to the nearest whole number. Non-computer measures generated from participant self-reports in response to the computer prompt 'where have you been'.

Non-computer activity

While non-computer time was not the primary focus of the study, it seemed reasonable to include it, given the low effort required for capture. Table 5 depicts the total time by participants across the 25 week study period for each of the four non-computer related categories. This data represents each academic's selections from the onscreen dialogue box 'where have you been' that appeared whenever the academic was away from the computer for more than 30 minutes.

Table 5

Individual breakdown of self-reported non-computer time – 25-week study period

	SP Health Science		CS Science		AC Commerce		DP Health Science		CH Humanities		Avg. Totals
Research	106	23%	30	08%	88	31%	50	20%	08	05%	19%
Teaching	119	26%	228	61%	121	42%	81	33%	68	45%	41%
Service	66	14%	42	11%	41	14%	49	20%	62	41%	17%
Break	163	36%	76	20%	37	13%	66	27%	15	10%	24%
Total hours	453		375		288		247		152		

Note. All figures are rounded to the nearest whole number. Non-computer measures generated from participant self-reports in response to the computer prompt 'where have you been'.

The data showed that teaching was the core non-computer activity undertaken. This was expected given that the institutional workload model for teaching was 40% and that teaching practice was predominantly theatre/classroom based. However, it was a surprise to find that the individual variability across the three core roles of Research, Teaching and Service was considerable. Accepting that any talk of why this might be the case was going to be speculative, it was still worth outlining plausible reasons for the finding. While it was possible that the variability was due to different time allocations associated with particular departments, this was regarded as unlikely given the low level of departmental control over individual workload. Instead, it was more plausible that it reflected academic autonomy by way of the personal workload choices made by each academic.

Also noteworthy were the low levels associated with non-computer time for research across all participants. This was expected for AC and CH given their research did not involve fieldwork or laboratory work. However, in the cases of SP (laboratory), DP (laboratory) and CS (fieldwork), it was expected that non-computer research would have been significantly higher. In the case of non-computer time allocated to teaching, a more consistent and higher percentage of time was recorded across all participants. These values shown suggest that significant portions of non-computer time involved teaching related activities.

Computer applications

A breakdown of software applications employed by the five participants show the spread to be relatively narrow. For example, Figure 58 shows that computer use by CH, DP and SP was dominated by email, word-processing and internet browsing. While computer use for AC and CS included a wider spread of applications, particularly in the case of CS, email, word-processing and internet browsing were still the primary applications used. It is also worth mentioning that these additional applications did not include newer collaborative or cloud-based applications (Web 2.0 & 3.0).

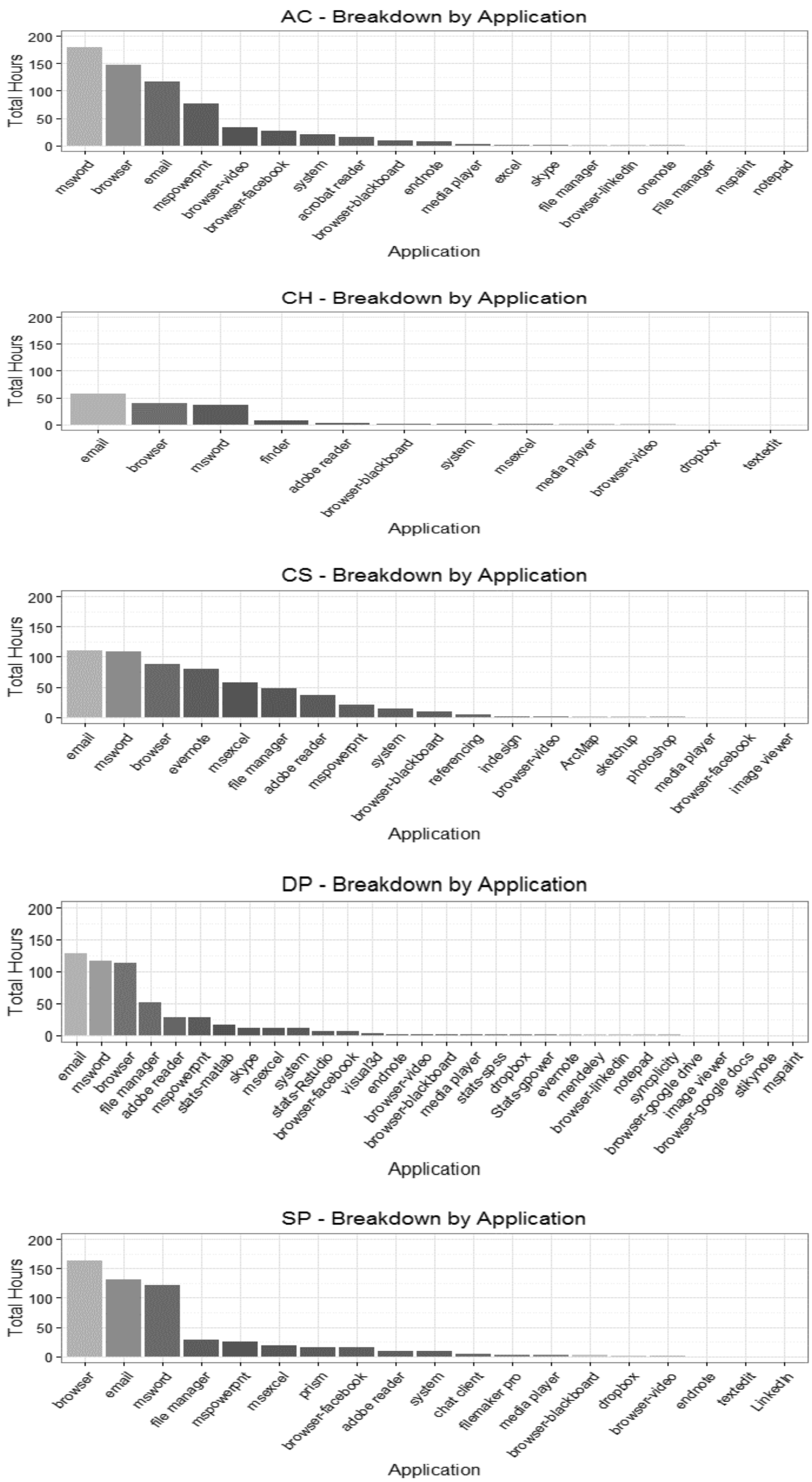

Figure 58. Individual breakdown by applications used over the 25-week period

It is worth noting that Web use included an assortment of various activities and a review of the site titles and URL addresses revealed the dominant practices were searching, reading and saving/printing. The Web category was partitioned when academic-orientated web applications were accessed, such as Blackboard (LMS), YouTube (video), Facebook, LinkedIn etc. Browser-based applications represented the emerging innovations in Web application use at this time and were therefore seen as significant. However, the mix of web-based applications used did not include any of the new and emerging collaborative applications. For this group, the use of word processing, email, and World Wide Web searches defined their computer practice. This portrays a mindset located within the early phase of computer use (Web 1.0) prior to the explosion of the collaborative turn associated with what is typically referred to as Web 2.0.

Computer activity

To gain a different perspective on daily practice, applications were then clustered by activity (Figure 59). For example, applications such as Gmail, Outlook, LinkedIn etc. were grouped under the title ‘interaction’. Drilling down by these application clusters showed that CH, DP, SP and AC primarily engaged in the three core activities of interacting, browsing and writing. Although similar to the others, CS also included, although to a lesser extent, a variety of other Web 1.0 applications.

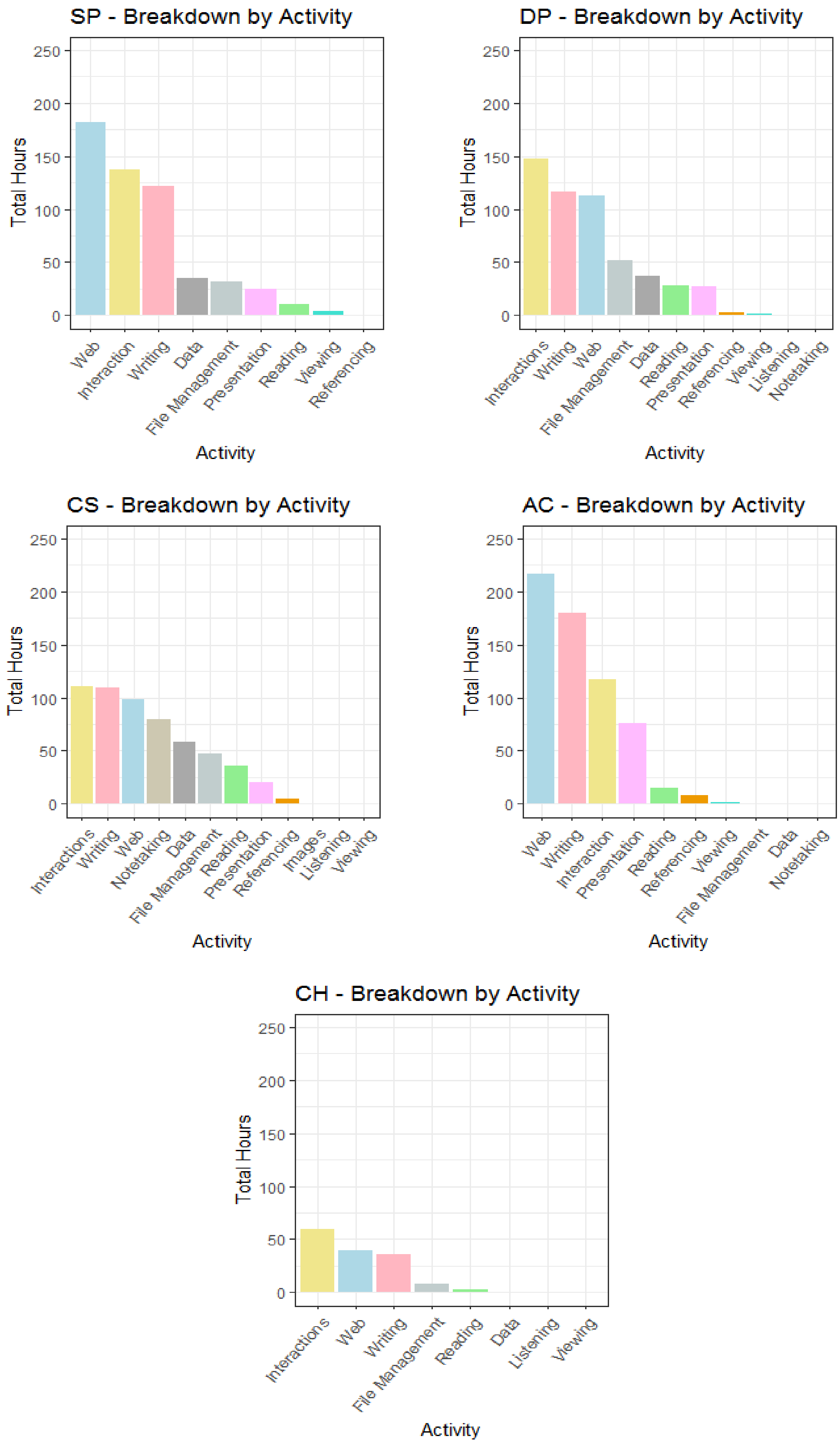

Figure 59. Individual breakdown of captured activity for the 25 week period

Further clustering of this data was inspired by the idea of the three distinctive scholarly practices of consumption, production and networking. These could offer yet another perspective by slicing academic practice in order to gain insight into the patterns of computer use. This involved filtering the data by high-use applications that were predominantly ‘academic related’. For example, Microsoft Outlook, Google Gmail, and LinkedIn etc. were associated with networking; Microsoft Word, Excel and PowerPoint etc. with production; and Adobe Reader, academic publishing websites, Word articles and various academic blogs with consumption. The clustering process, while obvious in the case of some applications, was not clear in all situations. Word documents can be both consumption and production. In these cases, application alone was not enough to warrant classification. An appraisal of the purpose of the document was required in order to ascertain if the document was being edited, or if it represented a downloaded academic article (the most common consumption document). The same process was employed for websites, PowerPoint files and Excel files. As a result, the completed clusters represented a judicious interpretation.

There are no baselines or standards for these categories established in the literature and therefore any attempt to ascertain meaning is of course going to be highly speculative in nature. Nevertheless, the method of aggregating various activities under these three behaviours seems reasonable, given the relevance of these behaviours as processes within the profession.

Table 6

Individual breakdown of participant activity by consumption – production – networking

	SP Health Science		CS Science		AC Commerce		DP Health Science		CH Humanities		Avg. Totals
Production	163	33%	275	53%	266	43%	184	39%	37	27%	41%
Consumption	195	39%	135	26%	233	38%	144	30%	43	31%	33%
Networking	137	28%	110	21%	118	19%	147	31%	59	42%	25%

Note. All figures are rounded to the nearest whole number.

As shown in Table 6, the average values show production activities generating the greater percentage of computer work time. Individually, the mix is very different. While CS, AC and DP followed this trend, SP engaged in higher levels of consumption. While the individual values are interesting and offer some insight into the personal foci of the academics, a more useful way to read the data is by the alignment of the categories. For instance, AC and DP follow a PCN configuration. That is, highest percentage of time is invested in Production, followed by Consumption and then by Networking. SP, on the other hand aligned with a CPN configuration and CH reversed the stack with an NCP configuration. In the cases of SP and DP, the range was minimal (less than 10%). In the cases of CS, AC and CH, the differences were far greater. Over the study period, CS was clearly engaged in high levels of production-orientated behaviours (53%), supported by some consumption activities, but invested very little time in computer networking. In terms of the digital revolution, it would be fair to say that information technology, while increasing access to information, offers methods and applications that make the search and capture of targeted information much faster and efficient, thereby reducing the time for search activities and increasing the time production activities. There was no use of innovative advance search applications. In all cases, the primary information gathering application was Google. Likewise, the growing notion of diminishing borders associated with globalisation is creating a new 'collaborative' dimension driven by dynamic (synchronised and non-synchronised) networking via new cloud-based messaging applications that maintain links to various workflows (documents/files). However, there was no evidence that these types of applications were being used. Instead, networking mirrored the traditional, non-dynamic format offered through traditional email channels, with file sharing via attachments.

Given the rise of cloud-based applications where production- and knowledge-sharing work practices are infused within digital collaborative networks, it is plausible that we will see a shift from the traditional Production – Consumption – Networking format to one predominantly focused on Networking. This is exemplified in many of the newer knowledge-based tech companies that have embraced cloud computing with cloud-based environments such as the Google suite of collaborative applications. This represents a shift (that began in 2010) from the traditional client-orientated application (Web 1.0) to the more collaborative and advanced systems offered through cloud computing (Web 3.0). For the academics in this study, computer use reflected a more traditional approach that relied on non-collaborative practice.

Multitasking

Multitasking is a commonly discussed topic in computer use, firstly because it underpins the very nature of the practice of using computers, and secondly, because of its status in the quest for increased productivity and efficiency at the centre of organisational growth frameworks of the 21st century.

An analysis of application usage across given time periods revealed high degrees of multitasking; this was not unexpected given the ease with which computers support/create multitasking practice behaviours. In this way, computer technologies have been a catalyst in driving multitasking to an entirely new level. The non-digital era of books, typewriters, visitors and the phone has changed exponentially as a result of the rich and complex environments associated with multiple simultaneous activities afforded by computers, smartphones and tablets. To gain an appreciation of the levels of computer multitasking, an analysis of the percentage of applications running per hour across the entire study period are presented in Table 7.

Table 7

The degree of multitasking by application per hour across the 25 week study period.

Application Use per hour	SP Heath Science		CS Science		AC Commerce		DP Heath Science		CH Humanities		Avg. Totals
2 or less	215	19%	162	15%	274	21%	123	11%	89	23%	18%
3 to 5	436	39%	523	48%	347	27%	333	31%	233	60%	41%
5 to 8	421	38%	376	35%	525	41%	488	45%	67	17%	35%
More than 8	37	3%	27	2%	130	10%	136	13%	1	0%	6%

Note. All figures are rounded to the nearest whole number.

As shown, multitasking in the range of 3-8 applications running at any given time was typical. To gain a more realistic understanding of what this means in practice, randomly selected days were analysed by hourly intervals. Figure 60 shows a breakdown of weighted values of the various applications used within selected one hour morning periods. In all cases, email and browser are present. It is also noticeable that in each case, there are one or two dominant activities. These represent the primary activity the person is undertaking during this hour period. The other applications can be defined as companion or dependency applications and are associated with the primary action e.g., Word-browser, Word-Endnote, browser-Endnote, file manager-PowerPoint, Word-Evernote. However, in all cases there is a collection of applications that are commonly described as distracting, either because they are interactive in nature, such as Facebook (browser), LinkedIn, Skype and email, or static but visually present, e.g., News (browser), Adobe Reader, YouTube etc.

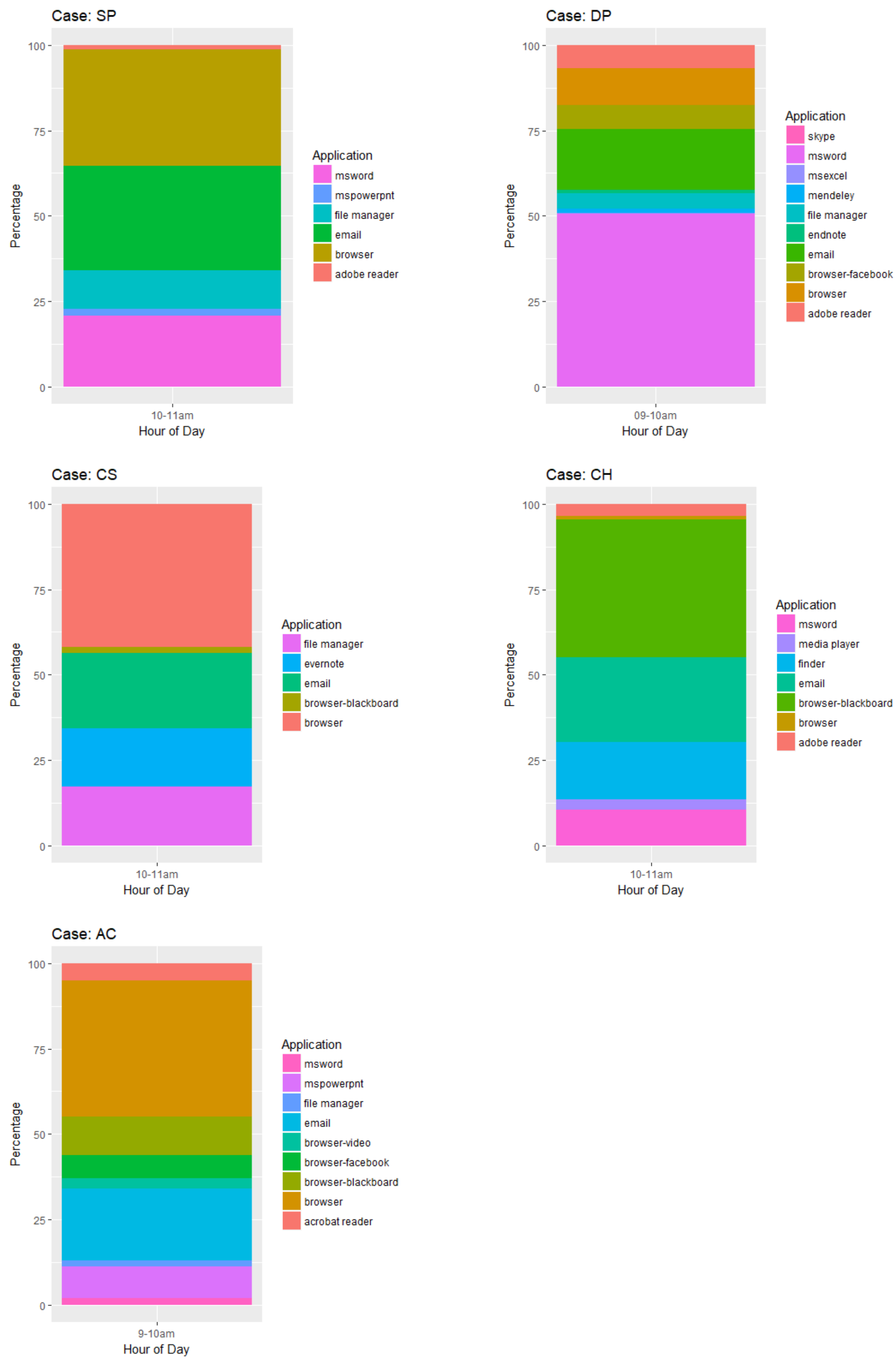

Figure 60. Breakdown of applications over a 1-hour period showing the degree of multitasking across various applications.

The difficultly with analysing multitasking is that data capture needs to be aligned with useful timeframes. Measuring multitasking by week or even per day does not offer a realistic picture. In this study, application metrics were captured at 5-minute intervals. While this afforded analysis at the level of minutes across the entire 25 weeks, it also meant managing extremely large volumes of data. Rather than manage this through aggregate data values, it was decided that heatmaps would allow all data values to be used, offering an effective visualisation of date-time.

Heatmaps allow dense packing of data into grid forms that are ideal for visually showing the relative intensity of values within an array. This would also render a deeper understanding of the patterns of multitasking. In Figure 61, the lighter the area, the greater the degree of multitasking. These resulting patterns show the levels of multitasking (the number of applications running at that time) across 24 hours over the period of the study. The frequencies define the number of applications, with AC and DP going as high as 12. The black areas represent no use. Areas of no action resulted when faculty were sick or on leave, or attending courses and conferences.

The use of density measures (heatmaps) offered a valuable way of illustrating personal usage patterns across 24 hour periods over the entire study. The arbitrary partitions of morning, day and evening reveal the personal work styles across the academics, with SP and DP engaging considerably more in evening work than the others did. As mentioned earlier, CH employed a desktop computer, which meant their data was specific to the time they spent in the office. AC and DP had the greatest range of work hours across the 24-hour periods, with some early starts going well into the night and sometimes into early morning. In both cases, the overall active work range included the full 24-hour period. SP shows a reasonable investment of evening time over and above the 8:30 a.m. – 5.00 p.m. cycle. CS, on the other hand, showed a more controlled work schema of 8:00 a.m. – 5:30 p.m. CH presented the greatest variance of activity within the 9:00 a.m. – 5:00 p.m. periods with a number of short computer sessions. The density of multitasking is the strongest in CS. The level of light shading is greater for CS than any of the others.

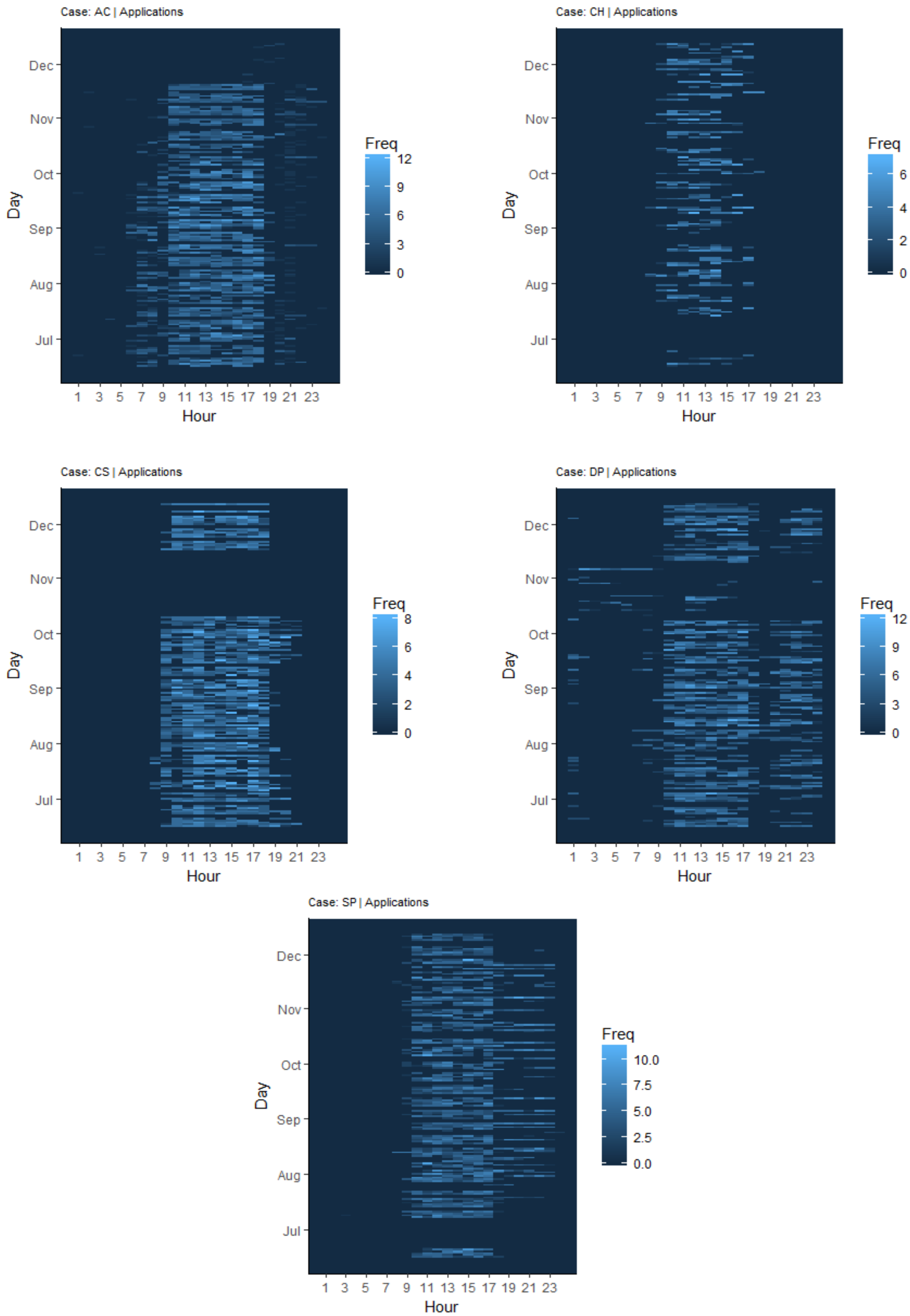

Figure 61. Heatmap graphs showing all application use by participants across the entire study period. The lighter the area the greater the degree of multitasking.

The dark blue section that shows no data represent periods when the academic was away. In all cases, these away states related to leaving the campus to attend academic conferences or conventions. It is interesting to note that the laptop was not used during these instances. This represents a very traditional approach where the academic adopts an 'out-of-office' approach. This idea of having little to no digital presence is somewhat at odds with the flexible, mobile connected state of New Ways of Working.

The data was then broken down further by selecting only the top three applications—word processor, email and browser use (Figure 62). On first glance, it is difficult to notice any significant difference in usage patterns to the large dataset represented in Figure 61. This suggests that Word, email and browser usage was significant across the entire work period; the density of light blue areas confirms the significant degree of dependence (multitasking) between these applications.

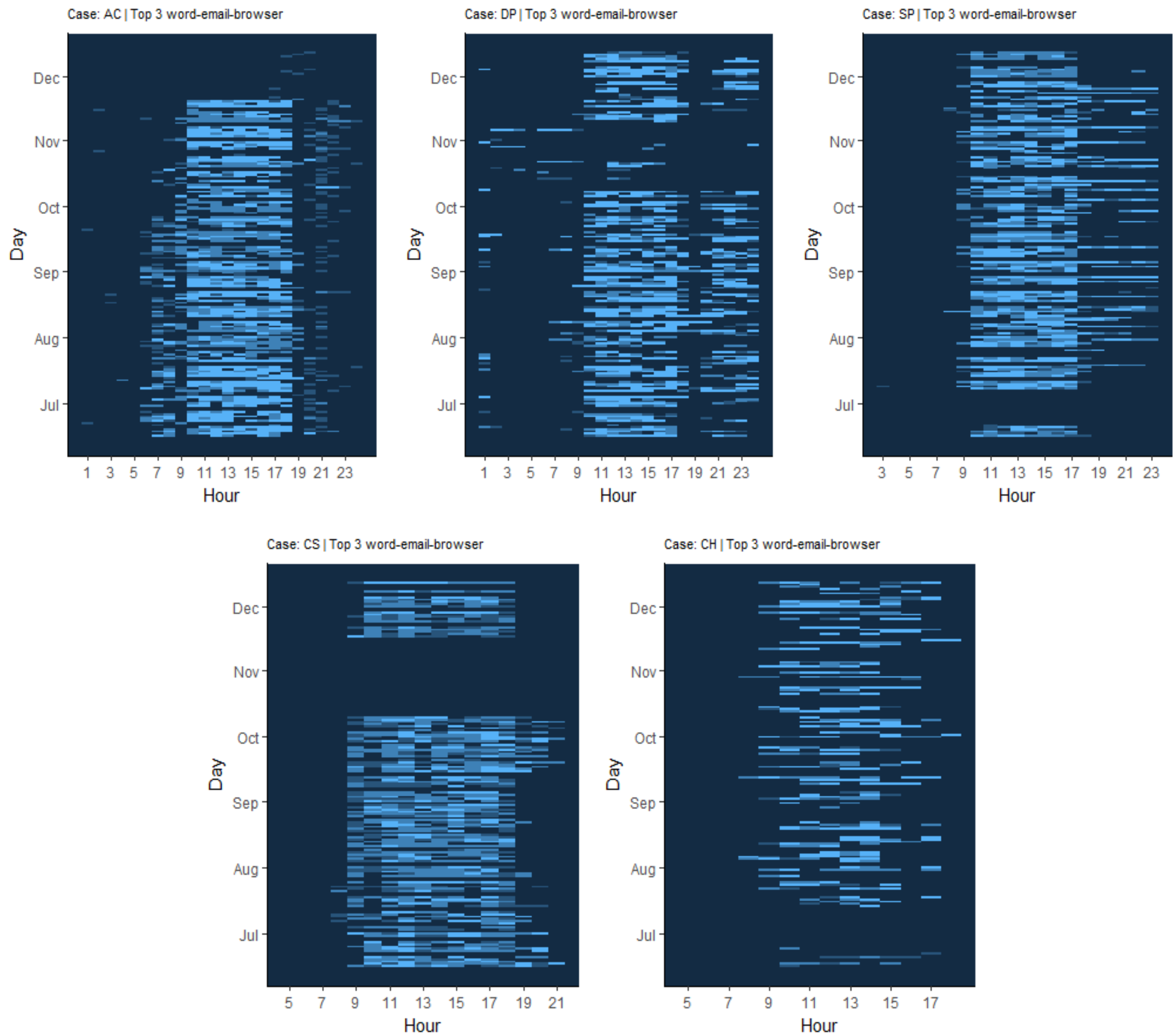

Figure 62. Heatmap graphs showing distribution of Microsoft Word, email and browser usage per-participants across the entire study period.

In order to gain some clarity regarding the relationship between these three applications, a further level of filtering and extraction was performed. Figure 63 demonstrates the individual makeup of the density values presented in single heatmap form. While word processing, email and browser applications dominated computer usage across all five academics, the configuration of use varied across the participants. The preferences of each of these three applications by participants was previously shown in Figure 59. Figure 63 illustrates is the measure of temporal spread. For AC, the distribution shows Word use during office hours, with some early morning use during the July to September period. Email use outside office time shows routine early morning use, with some sporadic evening access. Browser use for AC shows the greatest use of the three outside of office time, with regular use early morning and late into the evening. The overall measure of temporal spread shows a strong usage pattern associated with office time (9:00 a.m. to 6:30 p.m.). CH, on the other hand, is more restricted in both the volume of data and the time range. The mix of Word, email and browser use is relatively even, with no visible usage pattern from the overall temporal spread; variable usage limited to office time (9:00 a.m. to 5:00 p.m.) due to CH's use of a desktop as opposed to a laptop. In the case of CS, email was the primary application, followed by the browser and then Word. The measure of temporal spread shows the typical usage pattern associated with office hours (8:30 a.m. to 6:00 p.m.). There is evidence of some evening work, most noticeably during the October period. As with AC and CH, the graphs show all three applications were running simultaneously.

DP and SP present very different usage patterns. In both cases, as with the others, the measure of temporal spread reveals a defined usage pattern associated with office time (9:00 a.m. to 5:30 p.m.). DP presented the greatest spread of computer usage, with considerable evening usage of all three applications between the hours of 8:00 p.m. to midnight. In some cases, usage continues into the next day (3:00 a.m.). There is also some sporadic use in the early morning hours (6:00 a.m. to 9:00 a.m.). Email and browser use show similar usage patterns, with Word less so during out-of-office time. In the case of SP, there is a regular pattern of evening work extending, in many cases without an obvious break, through to midnight.

In all cases, it is evident that computer usage is associated with Word, email and browser use and that these three applications are running simultaneous during participants' time on the computer. This also indicates that while switching between these three applications was frequent, the co-dependency between these three applications is low. By this I mean that while there is a high co-dependency between word processing and browser use, the level of co-dependency between email and browser use is much lower, and even more so for word processing and email. Nevertheless, the fact that these applications are always running suggests their purpose for running is not based on dependencies but more likely on convenience.

In addition, it is worth considering the benefits of this type of data dissection to academics as a form of feedback regarding their patterns of computer use. It may be that live access to such analytics would be advantageous for self-monitoring and regulation of work practices.

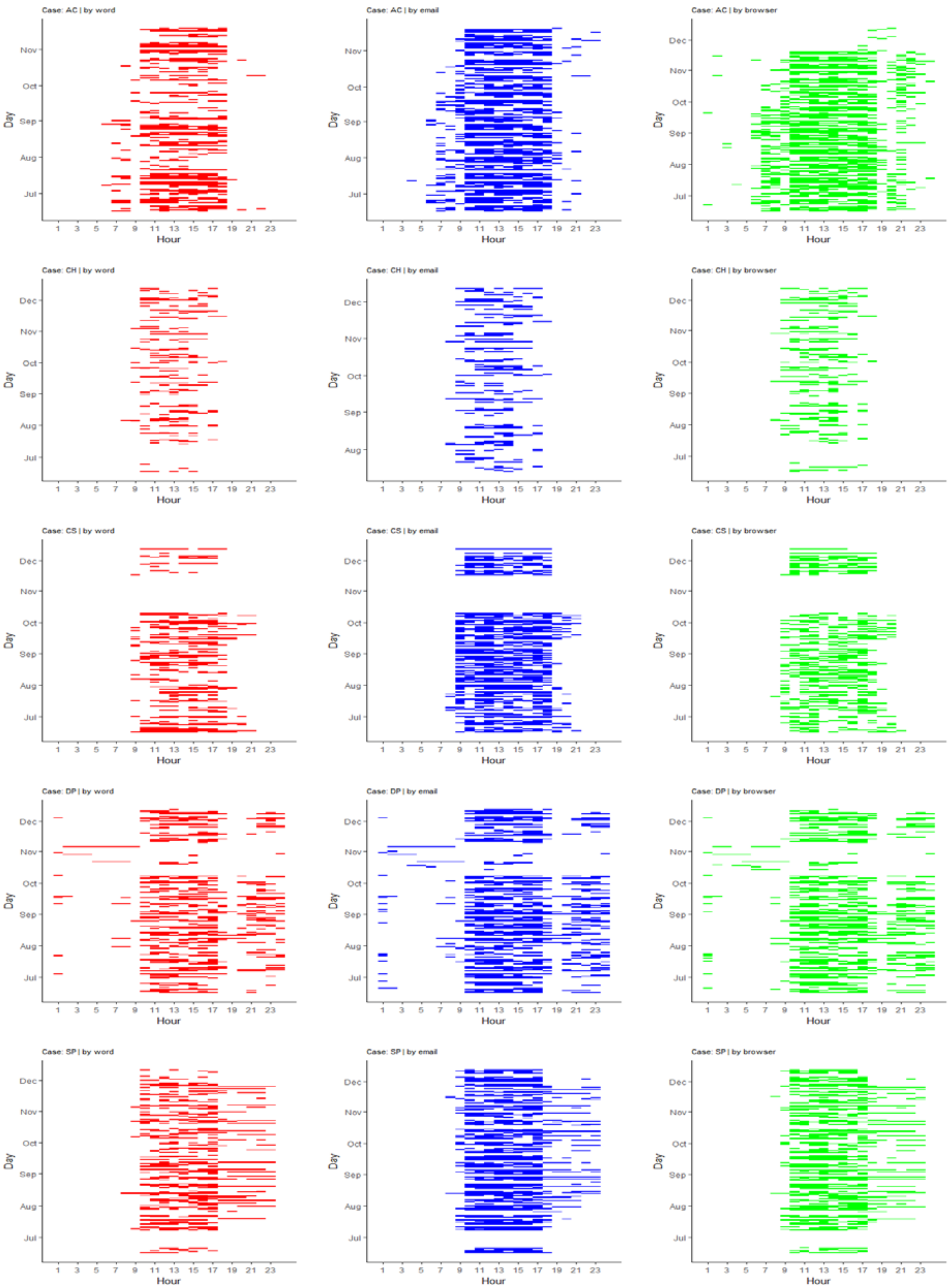

Figure 63. Heatmap dissection graphs showing separate distribution of Microsoft Word, email and browser usage per-participants across the entire study period.

The hallmark of New Ways of Working in the digital era is the deployment of cloud-based services. These services are typically browser-based applications. To ascertain the degree to which browser use was associated with cloud-based services meant extracting non-academic use, and search and information retrieval use. The result was a limited set of applications that consisted of Facebook, LinkedIn, Blackboard (LMS) and Video (YouTube, Vimeo etc.). A dissection of these browser-based activities was performed and is shown in a series of graphs representing each individual (Figure 64). Facebook and video represent applications that support academic and private use, while Blackboard and LinkedIn are solely academic.

In the case of AC, Facebook and video were more dominant than LinkedIn and LMS. However, their use was mainly limited to traditional work hours (9:00 a.m. to 5:30 p.m.). For instance, in the case of Facebook, usage was predominantly between 6:00 a.m. and 6:00 p.m., evenly spread across the entire 25 weeks. Conversely, CH's computer usage across these four browser applications was extremely low, with Facebook and LinkedIn not used, and video use marginal. While there are sporadic access points to the LMS system, these too were minimal. In the case of CS, it is curious to see three isolated uses of Facebook. CS's most used application was the institutional LMS. LinkedIn was not used and video only minimally. For SP, Facebook was the prevailing pick of the four applications. Like AC and DP, Facebook access was punctuated throughout the day, starting around 8am through to the end of the day at 11:00 p.m. For SP, an increase in Facebook use was identified during the December period.

While the computer data revealed variation of use between participants and aspects associated with multitasking, there were no incidences of the newer cloud-based applications that are emerging as part of the digital era. In all cases, computer usage reflects the information era, where the browser's dominant use is for search and retrieval, while networking is supported by email. The use of LinkedIn by AC and DP, while minor, was a positive sign regarding the importance of a Web presence. While not a major indicator of New Ways of Working, it does show an appreciation of the importance of a digital presence in a global environment.

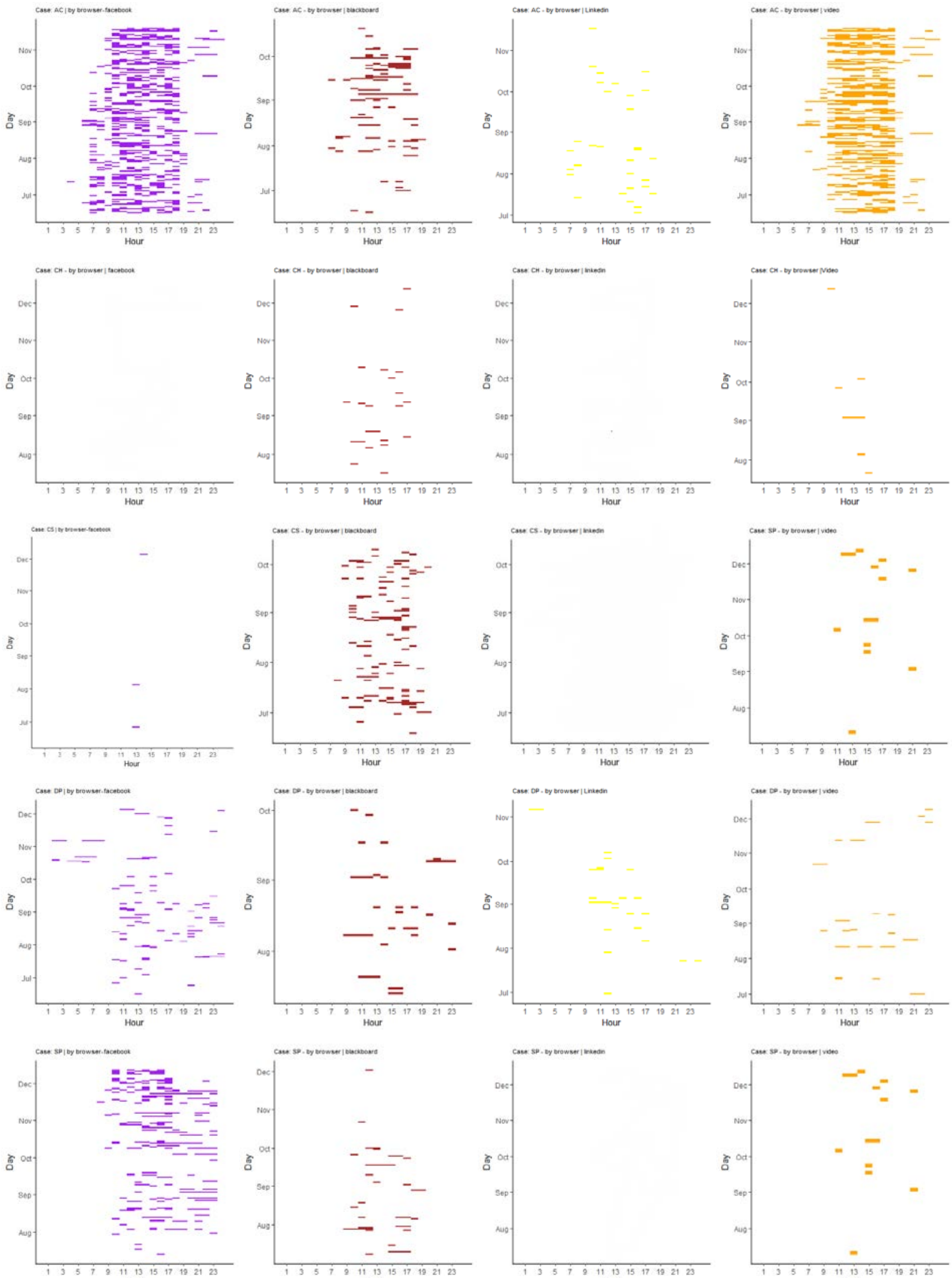

Figure 64. Heatmap dissection graphs showing distribution of browser usage per-participants across the entire study period for Facebook – Blackboard – LinkedIn and video (YouTube, Vimeo etc.)

Discussion

The aim of this study was to investigate the degree to which the computer practices of early career academics had altered in response to the digital revolution through new digital methods that might reveal insights not previously known. Specifically, this meant determining the presence of shifts in practices from the computer work patterns of the late 1990s to the core characteristics that define the emerging digital frontier of today (flexibility, mobility, connectivity and transparency). This required a clear understanding of the computer usage behaviours of each of the academics. It was therefore vital to adopt a method that could render rich, practice-based data that offered an improvement over the conventional approach of questionnaires.

In the 1990s, generating measures of computer use was achieved through questionnaires. These questionnaires quantified computer usage by gauging the time at the computer by hour-range per week: 1-5, 5-10 or more than 10 hours per week. In this study, computer usage times have moved way beyond these rather low values. This reflects a significant change and bears witness to the essential presence of computers as a core part of academic work, both, as shown in this study, in the office and time at home. While these findings reveal that time spent on computers has risen dramatically since 1990s, the shift in the range of applications is limited. For example, in all cases, the core applications were email, word processing and the World Wide Web. This gamut is the stock application trilogy that dominated academic use of computers in the Web 1.0 phase of the late 1990s. The more collaborative and cloud-based applications and practices indicative of the Web 2.0/3.0 era were not present.

This is demonstrated through browser use by these academics, where use was limited to non-collaborative use and focused on individual academic tasks such as searching, YouTube, Facebook, LinkedIn and Blackboard (LMS). There was no indication of the advanced cloud-based services that are indicative of New Ways of Working that leverage the dynamic realm of mobile, transparent, collaborative and distributive attributes of all things digital. There was also a notable absence of the growing online academic services that are reshaping research practices and education, such as the Microsoft and Google cloud suites of applications, nor evidence of sustained use of the emerging services supporting academic research services.

A second aspect indicative of change is the level of multitasking. The act of computer multitasking is very appealing when there is an extensive array of applications that are only a click away. The ability to quickly and easily manage multiple activities simultaneously is what makes computers so appealing. So pervasive is the drive to 'do more on our computers' that many of us have extended our screen realty to incorporate multiple virtual and physical screens in order to run more applications. In essence, the more apps there are available, the more we are likely to multitask. To operate contrary to this requires a degree of pro-active behaviour. As discussed earlier, multitasking, while encouraged in the late 1990s and early 2000s, has since been called into question. Knowledge workers adopting new ways of working will be actively engaged in practices aimed at controlling distractions by promoting focused work sessions in an effort to reduce levels of unfocused multitasking (Crenshaw, 2008; Junco & Cotten, 2012; Rosen et al., 2013). So powerful has this move been that device operating systems and many applications are now available to help or enforce these states. In this study, multitasking was a dominant feature across all participants. There was really no indication that any of the participants were employing some of the more aggressive anti-multitasking techniques such as dedicated 'focused sessions' or running applications aimed at monitoring, controlling and reducing unfocused multitasking. There was also no sign of the more common, mild technique of dedicated app use, where distracting applications such as email, Facebook, LinkedIn, and messaging apps are typically turned off and only activated at set times throughout the day. Instead, these dynamic applications were persistently open.

Finally, an unexpected finding was the amount of time these academics spent on their computers, including the range of time, for some, from early morning to late evening. It was surprising to see that four of the five spent considerable amounts of their daily work time on their computers. During early conversations with the participants regarding perceived use and flexibility of computer use, each informed me that the office was the exclusive place where they were engaged in computer activity. If this were the case, then this would suggest they spent considerable periods of the day in their offices. This too was unexpected. The 'academic office' is hardly a space that has attracted research attention. In fact, it would be fair to say it has been generally overlooked in studies on academic work. Given the considerable time these academics spent in their office suggests that this inattention is ill-founded and that the office should be deemed a critical element in any research aimed at understanding academic work/life.

Overall, the findings allude to a digital divide between the level of digital literacy of the academics in this study with those following the more mobile, connected, transparent and progressive approaches afforded by cloud computing. This is not to say these academics were uninterested or unwilling to engage in a more immersive web experience, on the contrary, ad hoc discussions over the study period revealed they were keen to advance and were very concerned they were being 'left-behind'. I have no doubt that if time and resources were available for orientation and training in new ways of working, they would have certainly accepted. Notwithstanding, it makes one reflect on the importance of academic development to be instilled as a condition of work rather than a consequence of work. By this, I mean a more sustained targeted approach to address the need for change in a rapidly progressing environment, as opposed to a laissez faire option that assumes development occurs as a result of time and practice. Nevertheless, it would be naïve to assume this situation is solely the result of development alone. The formidable academic resistance to technology found by Anderson and colleagues (1998) in the 1990s is a reminder that it may be as much a mistake to ignore the role of ideology as it would be to overlook the role of the environment in this matter.

Theoretical implications

More theoretically, given the growth of digital technology and the rise of New Ways of Working, these findings are concerning. They reveal a situation of early career academics 'stuck' in traditional computer-based work practices, striving to be more efficient and productive against the backdrop of 'smart' ideology. As a conclusion, it seems too simple and deterministic, even demoralising, to suggest that many will be 'left behind' in the surge of progress. The findings beg the question; in an age driven by efficiency and productivity, and powered by digital technologies, why, in all five cases, were these young, early career academics entrenched in computer practices of a previous era? As the industrial era gives way to the digital, both individuals and organisations must be cognisant of the increased need for education during times of rapid, unpredictable change that engulfs not only practice, but also theory and ideology.

The perplexing relationship we have with tools is at the heart of ideologies, theories and practices associated with progress. In some respects, human advancement is the history of toolmaking and tool use and while this is commonly accepted, there is the not so widely known view that tools also make humans. This proposition implies that the tools we create also influence us. In support of this position, the British primatologist, Richard Wrangham (2009) argues that humans, unlike other species, have evolved due to technology and as such are the evolutionary result of the pressure of change inherent in technology. This reciprocating juxtaposition of 'humans as toolmakers' and 'tools as making humans' is, to some extent, cybernetic in nature. While the topic of cybernetics is beyond the scope of this study, it is worth noting the enduring view of cybernetics—the fusion of human and tool (machine) —reflects this entanglement. However, recent thinking is starting to question this position. Rather than a fusion of human as tool and tool as human (cyborg), there is evidence that humans and the machines we create (no matter how intelligent and sophisticated) are always going to be different in nature (Brynjolfsson & McAfee, 2011). As a result, in the short term, theories of technological progress seem less likely to merge with humans (cyborgs), and more likely to develop along a different trajectory, separate from human development. This raises important implications for professional development within the digital revolution. For instance, the technological quarantining experienced by the participants of this study and the feelings of being 'left behind' may be less important than they suppose. While it is clear we inhabit, supportive or not, an era branded as 'smart'—smart cars, phones, houses, appliances, machines, processes etc. —the assumption that humans too must be 'smart' in order to increase outputs through productivity and efficiency may be a misnomer.

Future implications

The rise of robotics and artificial intelligence (AI) has undoubtedly pushed the concept of efficiency and productivity to new levels, not through any fusion with humans (cyborgs), but independently. It is now well established that work requiring high levels of productivity and efficiency are the target of the growing domains of AI and robotics (Phan et al., 2017; Siau, Lacity, & Sauter, 2018). The drive for automation is turning out to be a fundamental design feature with devices capable of interacting more freely (Internet of Things). Automation is no longer the domain of factories and robotics, but is spreading through intelligent devices and intelligent apps that can manage low value, time consuming repetitive practices from appointment scheduling, to finances, to home heating.

You could say that humans appear rather inefficient and unproductive in comparison. Putting aside the commonly cited human flaws of volatile states of energy and emotion and the dubious practices of self-regulatory failure such as procrastination and daydreaming, humans excel at creativity and innovation, attributes that sit outside the current drive for efficiency and productivity. In some respects, creativity and innovation are typically inefficient and unproductive in that they are considerably time-consuming and often fail to produce an outcome.

By associating creativity and innovation as essential drivers of knowledge work, we partition knowledge work with its reliance on creativity and innovation from process. Process work is work that is applicable to the automated, efficient operations possible through Artificial Intelligence and robotics: from the management and production of goods or factory work, to more sophisticated, analytical tasks such as scanning the internet for extremist and illicit content.

The dominant impact of the rapid advances in computer technologies has been the adoption of attitudes and ideals associated with working smarter in order to be more efficient and more productive. This has resulted in longer hours and higher levels of multitasking in order to do more in less time. The participants in this study appear to be located within this phase. More recently, with the progress of Artificial Intelligence, robotics and the Internet of Things, it means technology can undertake work independently, shifting our perception of technology from a tool to a colleague. This independence that intelligent automation brings allows us to step away from process work and instead focus on innovation and creativity. We are already seeing an emphasis on focused thinking and time management, core elements in the rise of knowledge workers.

Conclusion

In this study, I have compared the computer usage practices of five early career academics to ‘new ways of working’ characteristic of the 21st century knowledge era. I make the case that these academics are stuck in a hybrid state influenced greatly by the computer usage behaviours of the late part of the last century and the seemingly, new SMART thinking of the early part of this century. Due to the rapid shifts that occur as a result of the developments and impacts of technological progress, both of these representations of work were beginning to be questioned as early as 2010.

The new space, captured in recent trends in Artificial Intelligence and machine learning are re-defining automation of repetitive tasks. This will have a profound impact on the way we work. Laborious, mechanical aspects associated with academic work will be automated, reducing the workload on respective tasks and increasing time for innovation and creativity. Ingrained in rapid progress is the formation of new theoretical frameworks that add meaning and purpose to the present and impending future. Given these changes in practice, ideology, theory and futures, the degree to which one can engage will be dependent on the extent to which institutions and individuals are willing to embrace the significance of extreme or rapid learning.

Finally, on the topic of methods, this study has shown that access to continuous, live, naturally occurring data, while voluminous, afforded datasets that have the potential to catapult our understanding of computer activity into an entirely new dimension. The merits of this method for higher education lie not only in the forms and accuracy of the data, but also in the ability to use this data in active feedback loops via intelligent device dashboards. In this way, the method used here has the power to couple research with impact (education) by augmenting individual, dynamic, closed loop feedback structures for immediate access by the respondent. This represents an entirely new level of education that incorporates a focus on patterns of action.

Chapter 8

Discussion

Introduction

I began this thesis by stating that the study was about a revolution and that revolutions concern shifts in the way we think and behave. I suggested that revolutions have a lifespan and that we are currently witnessing the death of one such revolution (industrial) and the birth of another (digital). I then located this study within the cusp of these two paradigms, a hybrid state that incorporates the overlap of the death and birth of paradigms (Figure 65). Like the process of subduction that takes place at the boundaries of tectonic plates, the convergence of these colossal paradigms forms a collision zone of intellectual and behavioural terrains where battles rage over a form of ideological hegemony.

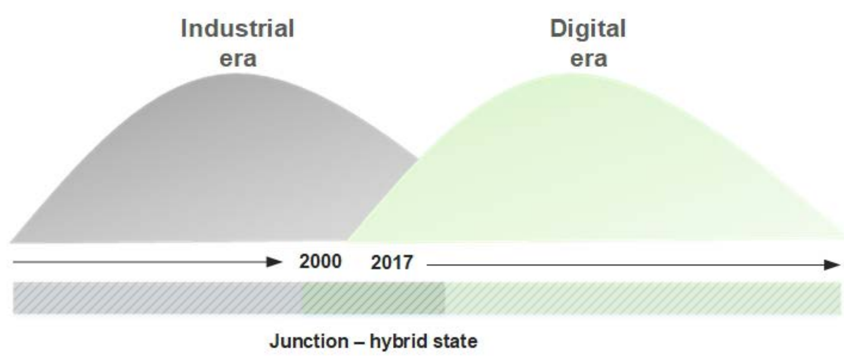

Figure 65. Schematic illustrating the clash of the industrial and digital revolutions.

I proposed that at the core of this perspective was the need to address the shift from linear processing synonymous with the industrial revolution to the more lateral, sometimes chaotic, innovative thinking that is spawning the digital revolution. The industrial revolution created ontologies rooted in process. The concept of mechanical automation dominated organisations from factories to offices, creating a fixation on production (by process) grounded in a symbiotic relationship between humans and machines. These are of course gross accounts and ignore the variability of multifaceted transformations that occur during such periods of rapid progress.

The mission of this study was not to be methodical nor decisive; it was simply to investigate the convergent terrain for signs of eruptions (or in my case disruptions) in the form of hot spots, rifts valleys and ridges. The journey, on the other hand, was arduous and multidimensional. The terrain, still in the process of change, meant that the evolving landscape, shrouded in haze, was obscured from view. Notwithstanding, below the miasma of colliding ideologies there was an abundance of phenomena available for examination.

Before discussing the contributions of this thesis, it is important to note the interlacing of three dimensions that underpin this work. Firstly, the examination of the potential of digital devices to drive a new form of higher educational research focused on the addition of activity (reality), as opposed to relying only on question asking (perception). Secondly, the development of a new methodology focused on 'precision research' grounded in the above method. Thirdly, the empirical dimension where the objective was to apply this new approach to the study of activity as it relates to academic office practice in order to gain an understanding of the degree to which these early career academics had adopted New Ways of Working conducive with the changing digital era. Finally, in reference to the nature of the study, it invokes the mysterious art of postulation and speculation synonymous with exploratory work that aims to invoke insight and deliberate meaning that is at the heart of social science. In this respect, there are no universal truths, no grand theories and no concrete findings. It embodies a rather fuzzy account, in writing, of my exploration and resulting conclusions of these three dimensions.

Caveat: Progress or Regress

As with any topic under study within academia, there are scholars for and scholars against; and this topic was no exception. However, much of the theoretical debate concerning the core threads that underpinned this study, in terms of both research method and the digital revolutions, can be reduced to the ideology of 'progress'. Whether progress is good or bad, desirable or undesirable, was not relevant to this study, only that change is occurring because of the rapid growth of technological developments. I did not engage with the ethical, political and economic arguments concerning change/progress that inundates the literature from anti-progressives and anti-technologists. This is not a limitation, but a conscious decision to maintain a pragmatic approach to a study grounded in understanding practice. Too often, empirical studies become imbued with theoretical arguments and dense literature reviews that detract from the empirical nature of the study, a path I was cautious not to follow. I propose the need for new ways of doing research, new types of data, new ways of collecting, new ways of analysing and most importantly, a deeper understanding of the connection between data and evidence.

Precision Research – A new research methodology & practice

As argued, higher education research is well known for its method of asking participants questions. As this method measures perception rather than practice, it can only offer partial insight. The rapid advancement of digital technology is changing this, with the development of sensor-based devices that are well suited to supporting the harvesting of multimodal data aimed at quantifying and qualifying our lived experience. This has significantly increased our capabilities of drawing data, not only on a person's perceptions (psychological state), but also from various layers of their environment and even their body voice (physiological state) (Figure 66).

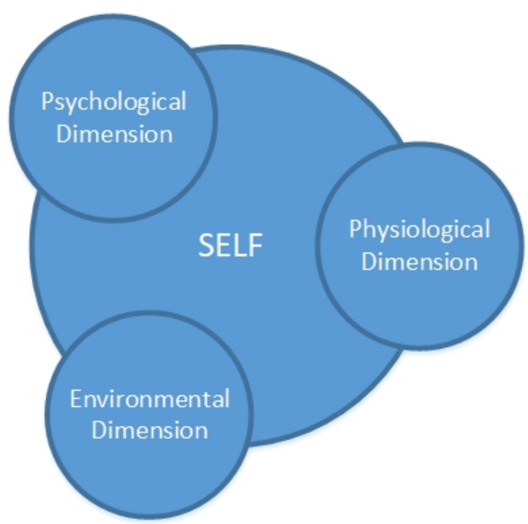

Figure 66. Schema illustrating the three dimensions

The significance of this approach for this thesis rests on the exploratory fusion of reality mining, idiographic science, and individual transformative action. It is this combination of rich, live and continuous data, sought exclusively for the benefits of enriching a person's life, which could raise applied educational research to a new level. The purpose of this approach is the necessity for better ways of 'seeing' by bringing new lenses to the practice of higher education research. As discussed in Chapter 3, it will require a methodological turn that incorporates a more multimodal approache capable of addressing psychological, environmental and physiological evidences. It represents an entirely new way of conceptualising and practicing applied research (Figure 67), requiring us to re-imagine the process of higher education research in light of the affordances offered by new and emerging technologies.

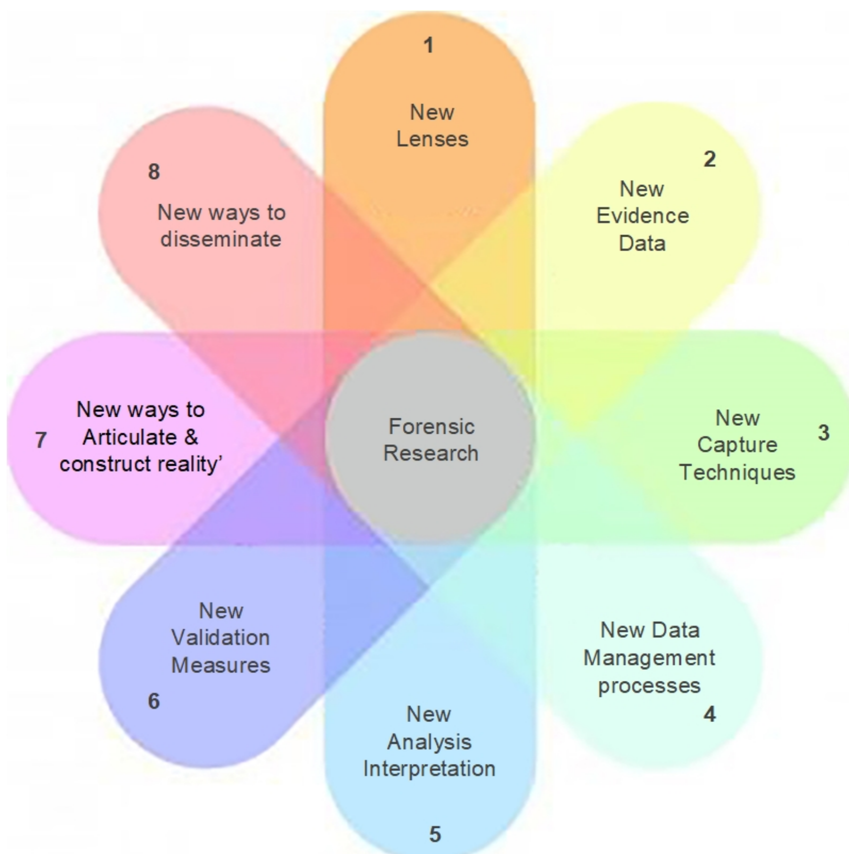

Figure 67. Methodology stack driven by sensor-based data that follows a generative design process.

Developed appropriately, this model has the ability to generate multimodal data (psychological, physiological and environmental) through the practice of teality mining, guided by ideographic science with the purpose of individual transformation. It presents an example of how educational research could promote new applied cycles that integrate multimodal data collections to identification of critical evidence, leading to action. As shown in *Figure 68*, a significant aspect of this new model is the ability to simultaneously capture, analyse and feed back meaningful responses, based on the continuous capture of multimodal data via digital devices across three dimensions. It signals a new level of self-research with the purpose of personal empowerment based on practices of quantifying and qualifying the self.

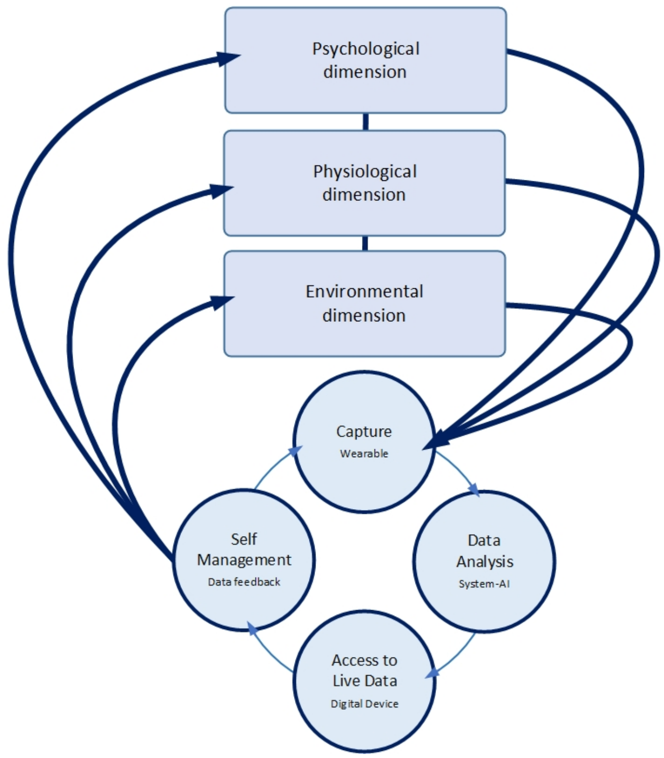

Figure 68. Closed-loop feedback system generated from personal analytics.

As presented in *Figure 68*, data is analysed synchronously and fed back to the individual via any digital mobile device such as a smartwatch, smartphone, tablet etc. This model represents a situation that is likely to give rise to a new awareness of the possibilities for a quantified and qualified self that could have profound implications for higher education practice and research. It offers a new frontier for those eager to embrace the possibilities and spoils of these technological advances for self-monitoring, self-education, self-development and ultimately self-confidence.

Old ways of working

The primary aim of the empirical sub-studies undertaken as part of this thesis was to understand the degree to which the digital revolution was influencing the work practices of early career academics. This was seen as pertinent given emerging trends in New Ways of Working (Baane et al., 2010; de Kok et al., 2016; Kok, Bellefroid, & Helms, 2013). These trends reveal a significant change in the practice of work from the rise of computers, where attention was bound to individual process work indicative of the industrial age, to the digital era characterised by the proliferation of knowledge workers operating in an advanced connected digital state with its rapid change, exemplified by creativity, innovation and disruption.

These changes are reflected in the growth of computer developments, from the introduction of the computer to the autonomous era driven by Artificial Intelligence (Figure 69). The sub-studies were undertaken in 2014—the era of cloud computing and the dawn of New Ways of Working. Cloud-based applications were changing the way many organisations were undertaking work. Rapid developments in cloud computing and increased connectivity meant continuous fast access that promoted stable networked environments, which promoted transparency through the use of shared, collaborative work practices. This represented a disruptive ethos that favoured teamwork over individual work, transparency over the unseen and virtual presence over physical presence. It was the dawn of open, networked, virtual work practices.

Collaborative cloud-based applications were replacing individual client-side applications, for example, Google Docs replacing Microsoft Word, various instant messengers and Google Hangouts replacing email. It has fortified the potential of team-based work, not through formal clustering of people within one physical space, but through a virtual act founded on autonomy and worker freedom. While a contradictory state under the older assembly-line process of production, New Ways of Working has promoted a worker ecosystem based on team participation that is fuelled by individual autonomy. It offers the perfect fusion of leveraging the knowledge productivity gains possible from multiple minds, while simultaneously feeding individual identity and empowerment and freedom. It represents a human-centric, self-organising culture well suited to the growing cohort of Millennial knowledge workers. Given the rise of the virtual to drive collaboration, transparency, mobility and flexibility, it seems credible to assume some of the practices would be exhibited by these Millennial academics.

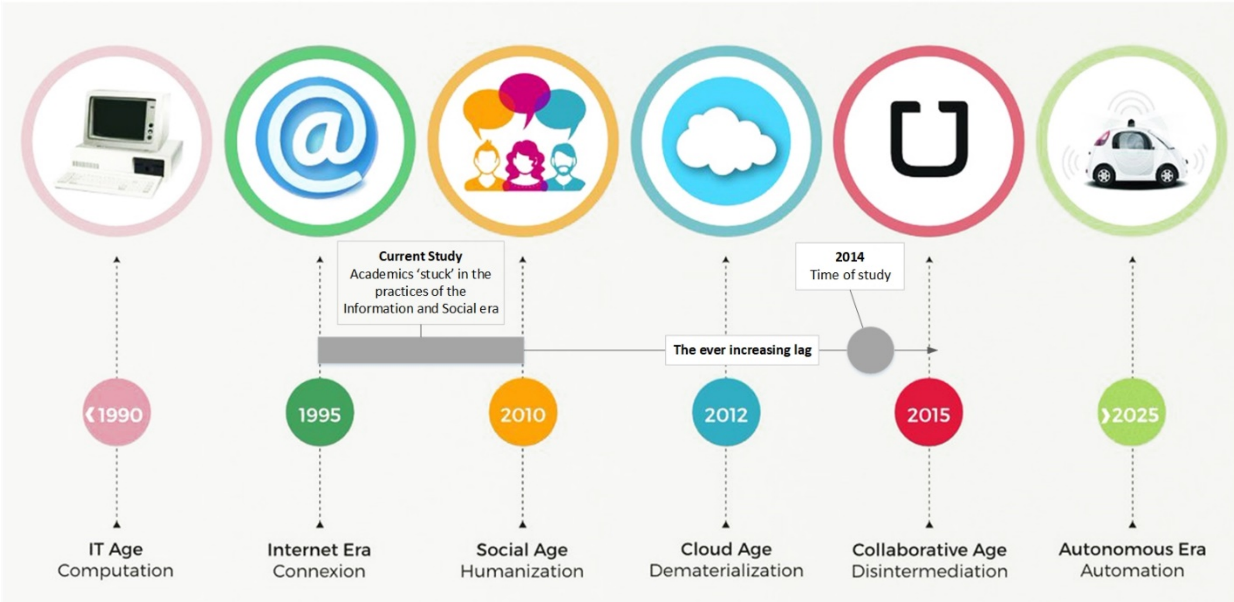

Figure 69. Infographic showing the commonly accepted stages of the digital age and the relation of the participants in the current study to these periods. Reprinted from Digital Transformation: a Pivotal Moment Entering the 4th Industrial Revolution, Blaise Reymondin Digital Marketing (2010). Retrieved, March 2017 from https://twitter.com/reymondin/status/699153820736233472

However, as the three studies independently show, the work practices of all five early career academics were more akin to the traditional ways of working associated with the traditional internet era (Figure 69). This was evident from the centrality of the office in both configuration and activities undertaken, and the types of software used. A further cross-section appraisal addressing the findings of each sub-study revealed a more accurate picture of office practice from the perspective of workspaces configuration (bricks), computer use (bytes), and office activity (behaviour).

Bricks: For each academic, the office represented a personal workspace where they were routinely located as part of daily work practice. This was evident from the way the office space had been designed for independent work and consultations. As revealed in the photographic comparison, the office layout in all cases reflected a particular format that was uncannily similar to the look and feel of academic offices from the 1950s until the 1990s. This was particularly observable in the three cases that incorporated two-desk configurations where one was designated for computer work and the other paper-based work. Over all, the layout of all five offices reflected work practices that supported a hybrid (paper-based – digital) model with the inclusion of bookcases, paper stacks, filing cabinets and a computer. These offices were significant places that defined the beginning and end of each workday.

Bytes: There was no indication of cloud-based services indicative of New Ways of Working. Instead, computer practice, while substantial, was limited to a narrow set of applications that included word processing, asynchronous communication via email and the use of the browser, primarily for information search and retrieval. These practices reflected computer usage bound to work processes and work flows typical of the internet age. The computer usage data reflected work practice as individual and solitary compared with the social and collaborative thrust of team-based work promoted through cloud computing. There was a clear sense that the data exhibited computer usage that had matured into routine work practices, despite the participants' awareness of rapid progress. The indications were that each was 'stuck' in a particular work style and therefore unlikely to change despite the shifting world around them.

Behaviour: Activities were predominantly individual and therefore reflected a process of tasks undertaken within a degree of isolation. There was no indication of collaborative work approaches within the physical space. In all cases, offices were littered with printed documents produced from computer activity. This dependency on creating paper-based reproductions from the digital is a typical symptom of work in the internet era, where printers acted as the conduit that connected computer practices with the physical environment. As the video footage showed, laptops were used as desktops, plugged into extended screens and keyboards, where they remained throughout the day, reinforcing the primacy of the office to daily practice and the significance of the desk to computer work.

In comparison, a New Ways of Working approach would situate worker presence within the virtual space, rendering the physical office less important. This reflects a shift from the physical office as the primary focus of work to the virtual or digital space as the foci of work process. In this situation, smart digital devices (smartphone, tablet or laptop) become the primary space in which work is managed. In this way, the office gives way to any space of choice where computer work can be undertaken, for instance, any of the various University's newly designed collaborative spaces, city spaces or home spaces. This highly mobile and flexible approach spawned by cloud computing has unleashed a new appreciation for collaboration, moving the practice of work from a somewhat static state to one that is highly dynamic. As a result, paper-based work practices and printers are being discarded. The new digital academic deploys cloud-based environments such as those offered by Google and Microsoft with collaborative applications and instant communication to manage and engage in research, supervision, teaching, service and continuing academic development. Research work is more likely to be team based and interdisciplinary. Out of office time would likely increase, with work being undertaken in a variety of spaces. For out of office time to increase, laptops would need to be undocked and be present during the academic's mobile periods. There would need to be less focus on the '9 to 5' and greater focus on work-life balance where (collaborative) work can be spread across longer periods and punctuated with important non-work activities.

This study reflects a growing gap between the traditional use of computer technologies that formed the internet era with those of the New Ways of Working that have become part of many of the new and emerging digital orientated, knowledge based organisations of the 21st century. How to address such problems was not part of this study, but it does highlight the need for action and action soon, given the persistent and rapid developments that are plunging us into the autonomous era driven by Artificial Intelligence, creating an even greater lag.

Limits and Alternatives

As in all research, limits must be set based on the aim and scope of the study. This was certainly an important element in this case, where the intention was to avoid recognised educational research frameworks and approaches. Adopting an investigative genre situated the work in the unknown, creating landscapes that were both limitless and restrictive. The forging of new ideas within unknown topographies is an arduous and painstaking task that, in many cases, boils down to time lost. In this respect, the desire to chase the 'new' was a major limitation regarding personal productivity and efficiency, which were sacrificed in favour of innovation and creativity. The ability to perceive anything in this often desert-like state presents limits that are difficult to articulate. It creates a condition where there is an awareness of structures, but all that is seen is sand. The limits of your cognition, of your perspective, of your experience and of your ability to forge insights are profound in these moments, periods that can last minutes, days or weeks. For empirical research, foresight can only go as far as practice allows, which means that of the routes covered, only a few led somewhere. For instance, some alternatives that arose from initial trials were not followed up due to the pragmatics of time. This does not represent a limitation, but rather highlighted pathways that were made obvious through probing and testing that afford research opportunities for another day.

Employing an exploratory approach compels the need to be upfront about what constitutes concrete limitations or restrictions. For instance, the exploratory aim and subsequent configuration of the thesis was fashioned on the quest to understand work practices and processes, and in so doing formulate new ways of researching and new ways of knowing. It is therefore important to acknowledge that there was no intention to produce a sound, well-developed set of propositions, frameworks or theories from this work.

There are, however, limitations in both concepts and practice to which much of this work was subject. These specifically relate to methods and analysis. Firstly, the use of sensor data required skills beyond those currently affiliated within the educational research community. For this reason, it is important to acknowledge that sensor-based research of the type employed in this thesis requires multidisciplinary involvement: skills and knowledge of advanced statistical applications, computer programming, video analysis and pattern recognition to name a few. It was difficult to secure expertise in these areas. This meant much of the work was achieved through upskilling in areas well beyond my initial research abilities. Limits were set on the degree to which the methodology could be developed, to which visual analytics could be employed, and to which data science and pattern recognition could be employed. Similarly, the categories of Production, Consumption and Networking employed in Chapter 8 were difficult to filter and therefore speculative. That is not to say the approaches used and analysis generated are defective, but rather that they were restricted to the knowledge and ability I was able to acquire within the period of the study.

Trial and error is simply that, many attempts with numerous errors. The assumption is that we access learning as a result of such errors. This was not the case in this study, as errors often resulted in dead ends with no clues about where to from here. They were termination points, not just of one approach or one idea, but from a chain of actions that had been forming as assemblages of elements that were coupled in various forms. An error in one part collapsed the entire assemblage, forcing a restart. This was especially evident with the video data, where gross configuration failures at the time of the initial setup set in motion a long and protracted hunt for applications and methods that could generate value from the spoilt dataset.

This study focused on a select group of academics employed in a particular university. The aim was to explore the office activity of these five academics and the merits of new research methods. It neither reflects an experiment nor aims to offer substantive or generalisable theories. Instead, it represents an exploratory analysis of a particular situation at this university for these academics, although it is likely that these findings are reflected in other institutions of a similar constitution. It also offers a kaleidoscope of intersecting ideas and evidences that established a particular set of lenses for discovering and understanding new phenomena rather than solving issues. Nevertheless, in both cases, it is limited to the spatial and temporal conditions on which this study was undertaken.

Finally, it must be acknowledged that this study spanned a period of five years. Consequently, the data reported from the sub-studies were captured in 2014. For this reason, the arguments developed in these sub-studies reflects the digital development of cloud based computing that were significant at that time. However, given the passing of time, it has become clear that the ideas and trends discussed cautiously in these sub-studies have since come to fruition.

Implications

For research methodology

The purpose of this discussion is to underscore the importance of engaging in new ways of undertaking educational research. As with many social science disciplines, educational research has no single or accepted 'way', but rather employs a range of various ontologies, epistemologies and methodologies, often unbeknown to the reader. It is therefore important to appreciate that educational research is guided by and contingent on the particular ontology, epistemology and methodology adhered to. In this way, not all educational research is equal, but rather the sector represents a collection of incompatible approaches such as positivism, feminism, critical theory and constructivism. However, while these research paradigms are dissimilar ontologically, much of social science research, illogically, has evolved to hold similar definitions of what evidence is and the methods used to acquire this evidence is typified in the practice of asking questions. In this question-asking method, various mechanisms are employed such as: focus groups, questionnaires, discussions, interviews etc. I do not see these as different methods, as is often implied, but as different mechanisms for collecting answers to questions. Whether a person responds to a question by a graded scale, sentence and verbal comment or within a group discussion, the method is to acquire the person's considered response to a question.

I have argued that this method is specific to perception data. While perception data is an important type of evidence, there is a danger in relying on single forms of evidence. Unfortunately, single forms of evidence are too often used to define features outside the evidence range. For example, it is not uncommon to find studies that have employed question-asking methods to make claims regarding practice. This may result in a misrepresentation of evidence. A study employing a question-based method to discover particular behaviours or practices is going to generate data that represents perception-based evidence. This data reflects 'perceptions of what occurred' or 'post-event recollections' of what is thought to have occurred. The danger arises when these perceptions become a surrogate for data on what actually occurred. Given this confusion, it was essential in this work to guard against such miscarriages of evidence and adhere to an iterative process of continual appraisal regarding the relationship between phenomenon, devices, data and subsequent generation of evidence claims.

I am acutely aware that the capability of digital sensors to harvest continuous streams of naturally occurring personal data is going to have a profound impact on social science in the same way the telescope did for astronomy and the microscope for science. Although it has created an ontological, epistemological and methodological minefield from acts of boundary crossing, trajectory plotting and juxtapositioning, traversing this route is vital in the fabrication of new lenses. As with the microscope and telescope, digital sensors mean we are now able to see activity patterns previously unseen. These lenses offer unprecedented access to a vast array of 'actual' rather than 'perceived' physiological and environmental data.

In some respects, the advent of sensors and subsequent new lenses recapitulates the shift that occurred within the legal system where eyewitness testimony (self-reports) has given way to digital forensics (mining reality) as the principal measure of evidence. It epitomises the desire for measures that offer a more accurate picture of what actually occurred. The legal system has downgraded the significance of self-reports as a reliable form of evidence on the grounds that eyewitness testimony is inconsistent and all too often wrong (Arkowitz & Lilienfeld, 2010; Buckhout, 1974). Of course, the miscarriages of evidence within the legal system result in devastating effects ranging from incarceration to death. What defines evidence is therefore ruthlessly scrutinised in courtroom judgements. Social science research, on the other hand does not generate significant consequences from miscarriages of evidence. This is not to say it does not occur, but more that the consequences are not regarded as critical and therefore evidence is treated as 'soft', aiming to imply rather than warrant a particular judgement. A blatant example of this appeared in the online magazine Quillette in 2017. Clay Routledge, Professor of Psychology at North Dakota State University, published a short but provocative article titled, "Why social scientists should not participate in the March for Science"[2] (Routledge, 2017). Routledge pulls no punches, arguing there is clear evidence that social science research is ideologically biased and methodologically sloppy, and therefore should be excluded as a science.

The business sector too has recently begun to question the validity of social science research, in fact any research operating outside of the technological data-intensive domain. In 2008, the then editor of the magazine Wired, Chris Andersen, published a scathing editorial title, "The End of Theory: The data deluge makes the scientific method obsolete", a phrase he borrowed from George Box (Box & Draper, 1987). Andersen goes on to state that,

> This is a world where massive amounts of data and applied mathematics replace every other tool that might be brought to bear. Out with every theory of human behavior, from linguistics to sociology. Forget taxonomy, ontology, and

[2] The March for Science represents a global initiative aimed at celebrating science and the role it plays in everyday lives.

> psychology. Who knows why people do what they do? The point is they do it, and we can track and measure it with unprecedented fidelity. With enough data, the numbers speak for themselves. (Andersen, 2008*)*

By 2009, the academic community had joined the debate with the publication titled, *The Fourth Paradigm: Data-Intensive Scientific Discovery* (Hey, Tansley, & Tolle, 2009). The main argument of this book is the need for new approaches founded on large datasets that afford data-intensive research.

> The world of science has changed, and there is no question about this. The new model is for the data to be captured by instruments or generated by simulations before being processed by software and for the resulting information or knowledge to be stored in computers. Scientists only get to look at their data fairly late in this pipeline. The techniques and technologies for such data-intensive science are so different that it is worth distinguishing data-intensive science from computational science as a new, fourth paradigm for scientific exploration. (Gray, 2009, p. xix)

The authors promote the way computers, software and new data is changing the way we understand and practice research. In so doing, it creates a clear disruption between old science and new science, between those eager to engage in technological advances and those that either reject or simply ignore the change. It echoes the continuing growth within the legal, business and science communities committed to embracing digital data practices. While it appears that higher education education research is late to the table, it is likely to be enticed by the growing proliferation of digital devices and harvesting techniques proficient at extracting rich, real lived experience. In time, the quantity and quality afforded by mining evidence directly from reality will also raise the standard of higher education research in the quality of the data, validity of evidence and soundness of judgements.

In this thesis, these ideas were realised in the development of precision-research methodology underpinned by a reality mining approach that focused on idiographic data. It represents a first step into the development of a data-intensive framework for research into lived experience. While the processes employed in this work reflect more trial and error than systematic procedures, they align well with the call to explore new ways of researching in digital-data-centric forms. Innovation never follows prescribed paths, but willingly wanders down twisted narrow tracks in search of a better point of view. The various wanderings in this work helped to forge a new methodological framework, core practices for handling diverse digital data types and the subsequent data-specific analyses needed to form new types of evidence. It shadows the nature of innovation, language, models and practices expected by the data-intensive advocates operating within the business and science research communities. For these reasons, I feel confident that the understandings and practices formed through this work have created a useful and relevant contribution to the need for a new approach to higher education research in the digital era and more generally within the greater domain of social science.

For academic office space

We perceive the function of something by its form. In the case of the offices examined in this study, the form or configuration signifies its function. In all cases, the dominant signifiers did not resemble new or trending forms. Instead, there was a recognisable lack of anything that resembled the novel or new. The layouts, artefacts and overall look and feel were firmly entrenched in traditional office forms. The danger of speaking of old and new, of past and future, is of course problematic without variation, i.e., relative to what? In the case of office spaces, the proliferation of office design over the past 10 years highlights a clear distinction between the emerging digital office and the non-digital office as shown in *Figure 70*. While the newer office spaces shown here illustrate a high degree of open plan, within these are smaller, private spaces. The core features, aside from the inclusion of mixed spaces, are the furnishings and the level of aesthetics.

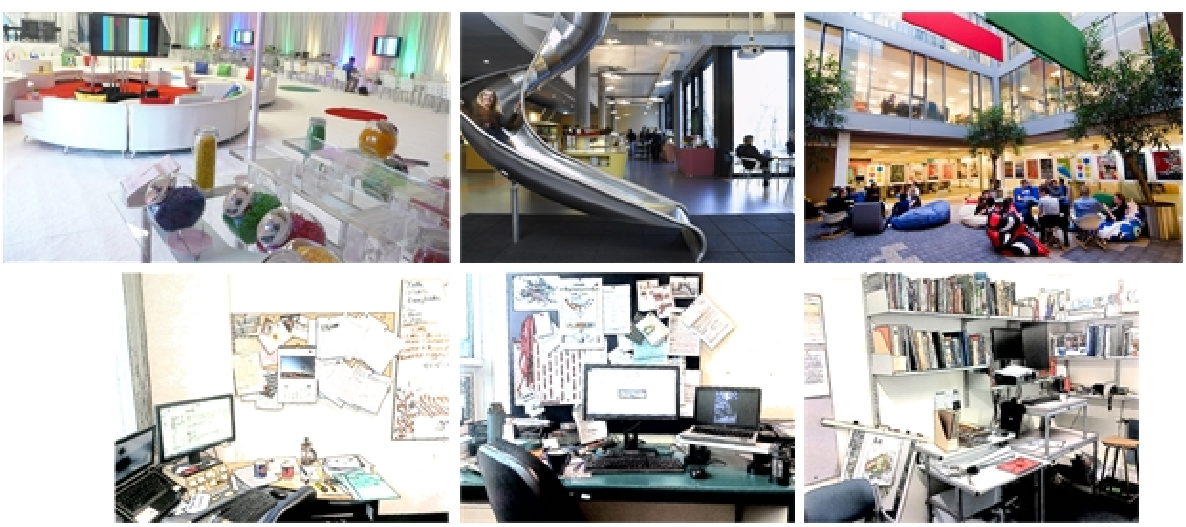

Figure 70. Comparison of knowledge worker workspaces between Google workspaces (top) and workspaces from this study (bottom).

The most obvious difference between these spaces is the degree of realty. In traditional privacy-centric offices where work is office-centric, room design is typically one size fits all, with offices designed to include one to two desks, a consultation area, one to two filing cabinets, a pinboard and a whiteboard. In New Ways of Working spaces, work is regarded as device-centric and collaborative, and as such, the space realty is less person-centric and more organisation-centric, incorporating a mix of spaces. The second difference is the level of design or aesthetics. Given the shift of work function to the virtual, it is now common for new workspaces to be driven by aesthetic rather than functional design. The common argument put forward is that the brain experiences pleasure when viewing beautiful things and therefore, the more people feel pleasure the more likely they are to have a 'good' attitude.

I once discussed the topic of aesthetically pleasing space design, as in Google-type workspaces, with a colleague who highlighted a view I had not considered. It went something like,

> Firstly, these staff are basically kids playing, it's all marketing propaganda… a publicised hoax driven by Google's need to align with the world of youth by being 'trendy', 'cool', 'hip'. No (mature) person could do serious work in these places. All this sitting around on sofas, drinking coffee and socialising it's just playing. Real work requires access to personal privacy and personal stuff.

This is no surprise given the academic in question went on to state that the obsession with aesthetics and beauty is a lower human trait and as an intellectual, they treat it with a degree of indifference: "As a scholar I have far more important things to consider than design and aesthetics".

Notwithstanding, we cannot deny that Google is extremely successful; ironically, they attribute this success, in large part, to the design of their workspaces that drive new ways of working. What my colleague's position alludes to is the presence of a perceptual divide between what they define as a real work environment as opposed to this 'other' thing. These types of spaces that Google employs are simply outside their way of thinking about work. The Google spaces incorporate aesthetics, design, transparency, collaboration and the digital. The spaces in this study had no inherent aesthetics, only the functional artefacts typical of a paper-based work space, albeit with a computer placed on the desk. It is private, isolated space, comprising mainly of paper-based systems and structures. The point I am raising here is that all spaces are designed. While this is obvious with the new contemporary office spaces, it is also true of the older ones. Their design is based on functions that are no longer necessary: the physical production, processing, archiving and retrieval of physical information in the form of books, articles, documents etc. As observed by Google, office configurations have a profound effect on the working practices of those who inhabit them; your environment is likely to alter the way you understand and perform work.

The traditional configurations of the offices in this study undoubtedly defined and reinforced dated work practices. I would speculate that each of the people in this study would have approached work very differently if they had occupied the newer types of workspaces. The inference is that these no longer fit-for-purpose office configurations enforce particular attitudes and ways of working that become internalised and ultimately influence an academic identity. While it is vital that office spaces are designed for contemporary work processes, it is important that they integrate design features that emphasise virtual and people centric configurations. Comparisons over time and with the development of New Ways of Working adopted by the business sector have highlighted that the office configuration of this university is out-of-date and consequently creating academics that are likely to feel left behind. What is required is a switch from paper thinking to pixel thinking. It is not just about flashy design, or change for the sake of change, but about our responsibility to nurture and develop new 21st century academic identities, founded on creative and innovative thinking grounded in the digital era rather than the dated process thinking of the industrial era.

For academic practice

The new digital era of technological types of work driven by science and technology is creating a new type of worker—the knowledge worker. Peter Drucker (1957) first coined this term when referring to universities that he depicted as human capital-intensive organisations, comprised of knowledge workers (academics) who were largely independent and self-governing. The key terms here are ‘independent’ and ‘self-governing’, in stark contrast to the dependent and managed worker that typified the industrial revolution. It was an idea that was taking hold back in the 1980s and 1990s during the early stages of personal computers and access to the internet. Global connections and the importance of knowledge as a commodity were seen to predict the arrival of a new world.

> We now live in a global economy characterized by rapid change, accelerating scientific and technological breakthroughs, and an unprecedented level of

> competitiveness. These developments create demand for higher levels of education and training than were required of previous generations. Everyone acquainted with business culture knows this. (Branden, 1995)

Branden was arguing, back in 1995 when the path was already forming, that these changes would require a greater capacity for innovation, self-management, personal responsibility and self-direction. To recognise the implications of this shift requires an understanding of the elements that underpin work: work technologies, work environments and the manner by which individuals leverage these to meet goals in purposeful and meaningful ways. In this sense, New Ways of Working is a response to rapid change in work technologies and workspaces that are demanding knowledge workers orchestrate meaningful and effective fusions.

The idea of working ‘smarter’ has driven the first round of this fusion. It comes from the developments associated with technologically driven processes that are powering the machine learning space of AI and robotics. The central objective of this space is productivity and efficiency. However, there is a growing awareness that the productivity and efficiency agenda is woefully inappropriate for humans (Ackerman, 2015; Frey & Osborne, 2016; Hong, 2000; Siau et al., 2018). As a consequence, the current wave of ‘new ways of work’ is switching from the productivity imperatives of multitasking and extended hours, to a goal orientated approach that is underpinned by mental and physical wellbeing, not just of the employer and employees, but also their lives outside the work place. It signals a broader focus on personal meaning and purpose, not simply outputs. The ability to create and innovate within a social milieu is key to this approach. This is only possible with the escalating practice of outsourcing efficiency and productivity features to technology (AI and robotics).

We are already seeing signs of a new consciousness regarding working. The talk of work-life balance is giving way to work-life life-work, as people’s life goals become bonded to the companies’ goals, ‘to live is to work and to work it to live’. Many businesses incorporate and promote ‘family’ models and family values. These progressive businesses are reinventing themselves by creating ecosystems in which people work and live. Technologies and spaces are redesigned around culture, rather than standardised practices or process. The picture is of flat organisational structures operating in ways that form and reform (the transformative processes of assimilation and accommodation that we define as ecosystems) as a result of the interplay of all involved, in meeting the triple bottom-line goals of social, environmental (or ecological) and financial. The upshot is that employee fulfilment has been added to the list of key performance indicators and staff wellbeing is common as an agenda item in many boardrooms (Easmon, 2014; Reid, Papalexi, & Slater, 2016). Company success is celebrated as a cooperative endeavour in meeting shared goals over profits to investors; hierarchies have given way to team expertise and contributions. It is important to note the rise of teams over the contribution of individuals in this new era. For the academics in this study, their ability to adopt or even appreciate new ways of working would be uncomfortable. The levels of social interaction in the office were extremely low, with much of their time spent engaged in isolated activities—continuous access to email likely acted as surrogate to the social.

I discussed this situation with a new academic who has recently left the business world to become an academic. She explained the tensions she was experiencing from the clash between her previous ways of working with those of the university. Her new academic colleagues had observed her attitude and approach as that of a misfit. The guidance she received was to go with the flow, to reshape herself within this new culture; to become an academic is to act as one. There was a sense that this culture was steadfast, separate from the progressive changes occurring in society—like a private society or old boys club. While she was attracted to the university's quaint historical side, she was aware that following such advice could destroy the progressive capital she had.

While the picture I have painted infers a degree of determinism, there is hope for the proactive. For many years now, universities have been leading the way in the design of working spaces for undergraduate learning. *Figure 71* demonstrates an example of student workspace design at the University of Otago. These spaces are equal to or surpass many found in the business sector. While the 'office' life of the academic is stuck in a bygone era, the students are enjoying the benefits of beautifully designed, collaborative workspaces. While on the surface there is an amusing inconsistency to this situation between faculty and student space, it shows a commitment by the institution to invest in such space. It also offers faculty, keen to exploit new ways of working, options to incorporate these spaces within their work practice; they do not need to stay isolated within the traditional office when these spaces are at their back door. Of course, this would require breaking the boundary between staff and student spaces—but this is a project for another day.

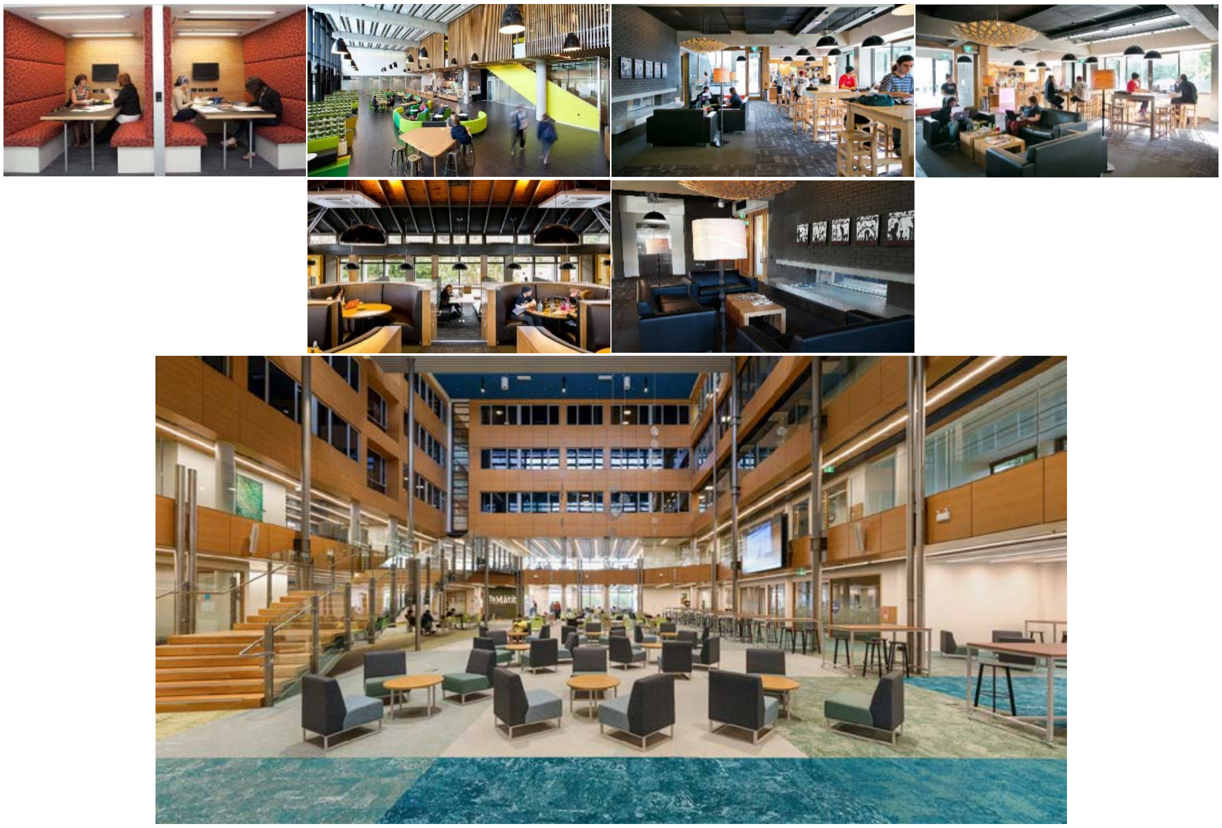

Figure 71. Examples of student designed learning spaces at the University of Otago. Images reprinted from University of Otago public collection.

This is not to say such spaces necessarily create innovative, creative thinking. They do not, but they do signify dramatic change and they align with new ways of understanding knowledge work as open, flexible, mobile and autonomous. I am guessing that faculty who exploit these spaces have different attitudes, principles and measures of success. Rather than institutional affirmation, they are more likely to quantify and qualify the self—I am who I am because I know myself, rather than I know who I am because the institution tells me so. I would speculate that this type of personal empowerment is likely to be a desirable attribute of this century.

For academic development

Frequently mentioned in this thesis is the significance of the times, as signified by the death of the industrial revolution and the rise of the digital. Within the overlap lies a turbulent and volatile state of change. Understanding these times is at the heart of 21st century academic development. As I have discussed in the opening sections of this thesis and concerning the tension between progress and regress, there are indications that the acceptance of this change has not been well received in higher education. This was evident in the empirical studies of this thesis that showed a group of Millennials engaging in what would be defined as practices from a previous era. This finding indicates an environment that is reproducing information age practices and attitudes within younger generations. This is an issue for higher education given the significance and influence of these traditional approaches on new and emerging academics. Appreciating the relentless pace of rapid change within the technological and commercial sectors, and continuing with the traditional modes of education practice is unlikely to be of any value, and may possibly be detrimental. To keep pace and take advantage of the current technological progressive cycles will require innovative and radical transformation of the sector. However, the first step is the recognition that it is a time for change.

Chapter 9

Conclusion

The dynamics involved in analysing a person's lived experience are challenging when a myriad of events are constantly occurring within an ever-changing spatial and temporal context. From the outset, this work was primarily concerned with the changing nature of academic work as it pertains to the rise of the digital revolution and the rise of New Ways of Working. The aim was to explore the impact this revolution was having on academic work practices, specifically office practices, of early career academics.

It was evident that this thesis should reflect principles of the digital era, particularly in the formation of new ways of researching. This required, in parallel, the appraisal of a new methodology and various methods that were both new to educational research and in some cases academic research in general. The need to forge new research methodologies and methods is evident if we wish to progress research at the pace of technology. The data captured and the subsequent evidence formed demonstrates 1) the potential for richer, thicker data as a result of employing precision research methodology and methods, and 2) the power of this approach to generate rich environmental evidence that can augment tradition question asking approaches.

Two key conclusions have arisen. Firstly, the study shows some merit in the use of a transformative orientated, idiographic focused, reality mining approach in educational research. It could signals a potential shift toward a more precision-based research methodology that is committed to having an impact on individuals' lives. It broadens our understanding of what data for 21st century research. Similar to the shift from eyewitness testimony to forensics, these preliminary trials reveal the potential of multimodal approaches to generate valuable evidence claims, based on behaviour or activity.

Secondly, it showed that for these five early career academics, the level of transformation in the form of physical workspace, activity of work and the use of technology, compared to their knowledge worker peers in non-academic organisations, was low. It revealed a situation where, for these academics, office practice was notably more akin to historic office practices than new and emerging ones. As alluded to earlier, the root cause of this dilemma is likely due to a lack of attentiveness by the organisation to the degree of change, and the importance of continuous learning. Fundamental to the success of many of our progressive and celebrated global organisations is their mindfulness toward policies, practices and attitudes in order to create the affirmative conditions for growth, learning and meaningful engagement. For the participants in this study, the lack of affirmative support in a rapidly changing era, placed sanctions on academic growth and left them reproducing historical process. The result is that young and emerging academics are inculcated into old ways of working through no fault of their own. The university, as a learning organisation, is responsible for addressing academic and professional progress in times of turbulent change and it is the institution that is best positioned to plan for and drive positive change. Universities that overlook or disregard these progressive, technological practices are unlikely to yield valuable knowledge or relevant knowledge workers. Like so many large commercial organisations already, universities too are in danger of being left-behind.

Finally, it is important to state that this thesis was not intended to be comprehensive nor complete. Instead, it denoted a foray into a state of critique that unpacked my assumptions and presuppositions concerning ontology, teleology, epistemology, methodology and practice. I experimented with bending and twisting my reality of research methodology, frameworks and practices. Accepting we are in a time of change, it seemed only reasonable and rational to push myself down the rabbit hole, to go where I had never been before, to break away from what was conventional, what was comfortable, what was routine, and above all, what was known. Cognisant of rapid technological progress and mindfulness of change, this endeavour reflects a chasing after the new, after states of eureka.

The result was an intense experience, not dissimilar to Alice[3], going down the rabbit hole, or Neo[4] swallowing the red pill. Reality as I had known it, disintegrated—what was once imagined was now visible and what was now visible was different to what was imagined. While thrilling, the great dilemma that I had failed to grasp was the price of harvesting colossal amounts of data. Continuous data capture at intervals of five minutes or less, even over set times, equated to a rich, unabridged portrait of a person's life. What I had neglected to appreciate was that this also included the time it took to produce this rich experience. Enthusiasm gave way to perplexity under the realisation that in order to liberate the data, it would require an act akin to the vicarious living of (in the case of this study) five lives over a period of 10 months. This was preposterous and completely undermined any plausible research potential. I had pushed the limits of operable data into the absurd.

So where to from here? Many aspects of the study warrant further exploration. For example, it is clear that more attention needs to be given to the investigation and development of new academic work practices that are able to keep pace with the rapidly changing world. This will requires a ruthless re-appraisal of the tenets that underpin academic development and the creation of innovative ways to stimulate meaningful change and growth. As I have argued, the prevailing narrow methods of higher education research are becoming less relevant in a technological world that continues to raise the standards on evidence-based research. The new research methodology and practices presented in this thesis represent a set of elements more suited to these new demands. The Precision Research approach outlined in this thesis has the potential to lift higher education research out of its preoccupation with perception-based evidence by embracing a more relevant, multimodal approach constructed on data mining across psychological, physiological and environmental dimensions. Rapid developments in sensor-based wearables devices designed to harvest continuous, naturally occurring lived experience offers higher education researchers a chance to embrace new approaches capable of rendering deeper, richer insights into how we learn and change in an increasingly progressive world. This thesis represents the first steps into this new future.

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[3] *Alice's Adventures in Wonderland*

[4] *The Matrix*

Chapter 10

Postscript

This thesis documents my exploration and discovery of ‘new ways’, an irrefutable feature of progress and a vital imperative in the process of change. History is punctuated with periods of accelerated change. These junctions reflect times of immense upheaval, where new ways replace old ways, where daily life is indelibly altered; times such as the pre-industrial to the industrial and the industrial to the digital. These transformations are depicted as intense shifts typically captured in the language and practices of revolution. They are tipping points where transformative action is accelerated and change is rapid. However, paradigm shifts of this size are to some extent like the dynamic, vibrant and extremely active reality of space, which appears to most of us as static and unchanging. In this way, we see progress like still photos—capturing specific differences over protracted periods, whereas revolution is moving images, illuminating detail that renders a portrayal of lively action. It is for this reason that many of us are unaware of the speed, significance and impact of change during these times. This state was the catalyst for the study. Primarily, I was interested in how the digital revolution was influencing the office practices of academics, and more specifically the degree to which new ways of working, promoted by progressive organisations, were impacting on the university environment.

The axiom “Neither do men put new wine into old bottles: else the bottles break, and the wine runneth out, and the bottles perish: but they put new wine into new bottles, and both are preserved” (Matthew 9:17, The New King James Version), stirred in me a series of thought experiments centred on two fulcra: 1) the scrutiny and deconstruction of current research paradigms, and 2) exploration of futuristic notions of research value and process. The outcome was a composite of hacks and adjuncts that constituted a grease that I was slowly smearing over my past ways of doing, thinking and progressing. If new ways of working presented new wine, the new wine skins represented a new ontology, epistemology and methodology. Pressed further, you soon appreciate the need for new ways of communicating. This thesis captures my progress, my hacks, as it were.

At its core, it represents questioning the status quo, of questioning my discipline, of questioning the practices of my colleagues—I was running the gauntlet. But it also represents an acknowledgement of the changing times and the intoxicating state that the new wine brings: new data, new evidence, new ways to address the maladies that affect learning in higher education. It is not about concepts or language, but about action, about having an impact on people's lives, of making a better world.

Following the outlook of Richard Feynman (Feynman, Leighton, & Hutchings, 1997), I think it is much more interesting to live not knowing than to have answers that might be wrong. Regarding this thesis, I now have approximate answers to some things, but still various degrees of uncertainty about others. It seems this is the nature of research: to acquire momentary assurance on particular things without absolutely surety of anything—a mutating fluctuating kind of state of knowing that is contingent on a continuous pursuit for clarity.

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Appendices

Appendix A

Information sheet for potential participants

Study Title: An investigation into the role of computer technology within the practice of research.

Invitation Paragraph

The nature of academic research is changing with new developments in information and communication technologies rapidly advancing research methods, particularly in the areas of networked repositories, joint analysis and co-authorship (Hey & Trefethen, 2008). Following international trends the New Zealand Government in collaboration with universities and crown research institutes has invested heavily in high speed research network, national authentication and a National eScience Infrastructure. In 2008 the NZ Government released its research agenda for the country. Within this document there is frequent reference to the need to engage in national and international collaboration and to adopt new technologies as the means of positioning New Zealand researchers within emerging models that require researchers to embrace computer technology...

"Science thrives on national and international collaboration, and new internet and digital technologies are making e-research not only a reality, but an expectation of top-performing teams. The latest generation of internet technology allows New Zealand to do the same: the challenge before us is to make full use of it. New skills are needed for the exchange of data and information and for doing science in virtual teams" (Moore, 1999; New Zealand Government, 2008, p. 8; Rogers, 2003).

Rationale for the Study

Although the adoption and assimilation of technology has always been fraught with great difficulty, there is a growing recognition that new computer technologies will benefit academic research to be more collaborative, productive and innovative, irrespective of geographical location. To better understand these asserted benefits will require a careful appraisal of the current level of computer technology use within the practice of academic research and researcher perceptions of its importance.

What is the purpose of the study?

I am interested in determining the role of computer technology in current research practices of academic researchers across the various elements of the research cycle. In particular, I am interested in determining the degree to which computer technologies have been assimilated into the research process. This will allow me to map out a picture of the hybrid and idiosyncratic nature of computer technology adoption. The aim is to gain a better understanding of the current state of play regarding the adoption and assimilation of computer technology as it pertains to the construction and distribution of new knowledge.

The best way to do this is to start with observing what it is you do. Rather than have a person with a note book shadowing, We will use technologies that will allow us to capture your daily office activities over a three month period.

What will Participants be asked to do

As a participant you will produce three datasets. The first dataset will be created from video data captured from a motion activated camera which will be situated in your work space for a three month period. The camera will capture visual data only; audio data will not be included. You will have live access to your video and computer log feeds. The second dataset will consist of analytics concerning core software applications used over the same period. Software will be loaded on to your computer that captures these analytics from pre-selected applications. This software will be under your control, both to visualise the captured data and to delete data. The third dataset will comprise a series of sketches/diagrams. You will be involved in a number of discussion sessions with me where you will be guided to develop a series of rough sketches/drawings of various aspects of your research processes.

Am I the Right Person?

Firstly, you are under no obligation to be involved, participation is voluntary. You might think that your use of technology is very low and therefore you wouldn't be of much use. Please don't feel this is the case. The study is aimed at getting a feel for what is currently the case. It is not aimed at studying advanced technology use.

Are There Any Benefits?

a) For those who are selected for the study, there will be a period of time post-data collection where you will be introduced to a range of new technologies that are currently being used within the national research space. This will involve the selection of a new computer-based technology to explore from across the broad areas of computation, data management and collaboration. Training and support will be offered for a period of time.

b) The power of video in training/development has long been recognised. You will have the opportunity to draw on my expertise to analysis and use the video data to improve aspects of your practice.

c) Your data will be made available for you to access at any time and to copy.

Protection of the Datasets

The video & computer analytics will be stored on a protected server within the University of Otago network. Data will be transferred directly to the server via the university network. The server will be stored in my office.

What will I do if I take part?

If you are interested then I would like to have a more detailed discussion with you. Simply reply to the email you have received from me, making sure you have added "I am interested" in the subject box. I will then arrange to meet with you to discuss aspects of the datasets in more detail.

Thank you for your support

Appendix B

RStudio scripts

```
##### R Code for Computer Logs Study - Individual Data #####
##### June 2016  ####
#============================================
##LOAD PACKAGES...
library(plyr)
library(dplyr)#tables
library(ggplot2)#plots
library(reshape2)
library(lubridate)
library(scales)
library(tibble)
#library(hexbin)
#library(xTable)#generates HTML code
#library(dygraphs)#time series
#library(DT)#tables
#library(diagrams)
#library(gdata)#reading excel data, actually we don't need this - too slow
#====================================================
##LOAD DATA...
data_Person <- read.csv("Person.csv")
##Convert Date from Factor to String
data_Person$Date <- as.character(data_Person$Date)
#=========================================================================
##ANALYSIS OF DATA
#=========================================================================
# A1= Person - Breakdown of Total Computers Hours by Week
# A2= Person - Breakdown of Computer & Non-Computer Time
# A3= Person - Breakdown of Non-Computer Activity
# A4= Person - Total Computer & Non-Computer Hours by Week Stacked bar
# A5= Person - Breakdown by Themes (CPN) by totals
# A6= Person - Breakdown by Themes (CPN) by week
# B1= Person - Breakdown of Computer Applications
# B2= Person - Breakdown of computer Activity
# C1= Person - Multitasking by hour across full Day
# C2= Person - Multitasking by min across hour of Day
# D1= Person - Multitasking table data - by application
# E1= Person - Heatmap
# E1= Person - Hex Plot
#A1----------------------------------------------------
#Person - Breakdown of Total Computers Hours by Week
#----------------------------------------------------
byLocation_Week <- group_by(data_Person, Location == "Computer", Week)
(Hours_by_Location_Week <- as.data.frame(summarise(byLocation_Week , Total_Hour = sum(Duration.Hour,
na.rm=TRUE))))
Hours_by_Location_Week <- Hours_by_Location_Week
ggplot(data=Hours_by_Location_Week, aes(x=Week, y= Total_Hour))+
  geom_bar(stat="identity")+xlab("Week")+ylab("Total Hours") + scale_y_continuous(limits = c(0,40)) +
  ggtitle("SP - Total Computer Hours by Week")+ scale_fill_grey()+theme_bw()
#A2----------------------------------------------------
```

```
#Person - Breakdown of Computer & Non-Computer Time
#-----------------------------------------------------
byLocation <- group_by(data_Person, Location)
(Hours_by_Location <- as.data.frame(summarise(byLocation , Total_Hour = sum(Duration.Hour, na.rm=TRUE))))
ggplot(data=Hours_by_Location, aes(x=factor(Location),y=Total_Hour, group=Location)) +
  geom_bar(stat="identity")+xlab("Location")+ylab("Total Hours") +
  ggtitle("SP - Breakdown of Computer & Non-Computer Time")+
  scale_fill_grey()+theme_bw()+guides(fill=FALSE)
#A3---------------------------------------------------
#Person - Breakdown of Non-Computer Activity
#-----------------------------------------------------
data_Person3 <- subset(data_Person, Activity == "NC-Research" | Activity == "NC-Teaching" | Activity == "NC-Service"
| Activity == "NC-Break" )
data_Person3$Activity <- droplevels(data_Person3$Activity)
byNCSet <- group_by(data_Person3,  Activity)
(Hours_by_NCSet <- as.data.frame(summarise(byNCSet , Total_Hour = sum(Duration.Hour, na.rm=TRUE))))
(Hours_by_NCSet$Activity <- factor(Hours_by_NCSet$Activity , levels=Hours_by_NCSet[order(-
Hours_by_NCSet$Total_Hour),"Activity"]))
ggplot(data=Hours_by_NCSet, aes(x=Activity,y=Total_Hour, group=Activity,  fill=Activity)) +
  geom_bar(stat="identity")+xlab("Activity")+ylab("Total Hours") +
  ggtitle("SP - Breakdown by Non-Computer Activity")+ theme_bw() + guides(fill=FALSE) +
  theme(axis.text.x=element_text(angle = 50, size = 15, vjust = 1, hjust = 1))
#A4---------------------------------------------------
#Person - Total Computer & Non-Computer Hours by Week Stacked bar
#-----------------------------------------------------
byLocation_Week <- group_by(data_Person, Location, Week)
(Hours_by_Location_Week <- as.data.frame(summarise(byLocation_Week , Total_Hour = sum(Duration.Hour,
na.rm=TRUE))))
ggplot(data=Hours_by_Location_Week, aes(x=Week, y= Total_Hour, group=Location, fill=Location)) +
  geom_bar(stat="identity")+xlab("Week")+ylab("Total Hours")+ scale_y_continuous(limits = c(0,55)) +
  scale_x_continuous(breaks = c(25,30,35,40,45,50)) +
  ggtitle("SP - Computer Hours by Week") +
  scale_fill_grey()+theme_bw() + theme(legend.position="top")
#A5---------------------------------------------------
#Person - Breakdown by Themes (CPN) by totals
#-----------------------------------------------------
data_Person <- subset(data_Person, Theme == "Consuming" | Theme == "Producing"| Theme == "Networking")
data_Person$Theme <- droplevels(data_Person$Theme)
byTheme <- group_by(data_Person, Theme)
(Hours_by_Theme <- as.data.frame(summarise(byTheme , Total_Hour = sum(Duration.Hour, na.rm=TRUE ))))
Hours_by_Theme$Theme <- factor(Hours_by_Theme$Theme, levels = c("Producing", "Consuming", "Networking"))
levels(Hours_by_Theme$Theme)
ggplot(data=Hours_by_Theme, aes(x=Theme,y=Total_Hour, group=Theme, fill=Theme)) +
  geom_bar(stat="identity")+xlab("Theme")+ylab("Total Hours") + scale_y_continuous(limits = c(0,300)) +
  ggtitle("SP - Breakdown by Theme")+
  theme_bw() + guides(fill=FALSE)
#A6---------------------------------------------------
#Person - Breakdown by Themes (CPN) by week
#-----------------------------------------------------
data_Person3 <- subset(data_Person, Theme == "Consuming" | Theme == "Producing"| Theme == "Networking")
data_Person3$Theme <- droplevels(data_Person3$Theme)
byThemeSet_Week <- group_by(data_Person3,  Week, Theme)
(Hours_by_ThemeSet_Week <- as.data.frame(summarise(byThemeSet_Week , Total_Hour = sum(Duration.Hour,
na.rm=TRUE))))
Hours_by_ThemeSet_Week$Theme3 <- droplevels(Hours_by_ThemeSet_Week$Theme)
Hours_by_ThemeSet_Week$Theme3c <- as.character(Hours_by_ThemeSet_Week$Theme3)
Hours_by_ThemeSet_Week$Theme3c[Hours_by_ThemeSet_Week$Theme3c == "Producing" ] <- "a_Producing"
Hours_by_ThemeSet_Week$Theme3c[Hours_by_ThemeSet_Week$Theme3c == "Consuming" ] <- "b_Consuming"
Hours_by_ThemeSet_Week$Theme3c[Hours_by_ThemeSet_Week$Theme3c == "Networking" ] <- "c_Networking"
Hours_by_ThemeSet_Week$Theme3c <- as.factor(Hours_by_ThemeSet_Week$Theme3c)
Hours_by_ThemeSet_Week2 <- Hours_by_ThemeSet_Week[order(Hours_by_ThemeSet_Week$Theme3c),]
ggplot(data=Hours_by_ThemeSet_Week2, aes(x=factor(Week),y=Total_Hour, group=Theme3c, fill=Theme3c)) +
```

```
  geom_bar(stat="identity") + xlab("Weeks")+ylab("Total Hours") + scale_y_continuous(limits = c(0,45)) +
  scale_fill_discrete(guide = guide_legend(reverse=FALSE),name="Theme", labels=c("Producing", "Consuming","Networking")) +
  ggtitle("SP - Breakdown of Consumption|Production|Network by Week")+ theme(legend.position="top")
#B1---------------------------------------------------
#Person - Breakdown of Computer Applications
#---------------------------------------------------
data_Person2 <- subset(data_Person,Application != "")
byApplication <- group_by(data_Person2, Application)
(Hours_by_Application <- as.data.frame(summarise(byApplication , Total_Hour = sum(Duration.Hour, na.rm=TRUE ))))
Hours_by_Application2 <- Hours_by_Application
(Hours_by_Application2$Application <- factor(Hours_by_Application2$Application , levels=Hours_by_Application2[order(-Hours_by_Application2$Total_Hour),"Application"]))
ggplot(data=Hours_by_Application2, aes(x=Application,y=Total_Hour, group=Application, fill = Application)) +
  geom_bar(stat="identity")+xlab("Application")+ylab("Total Hours")+ scale_y_continuous(limits = c(0,200)) +
  ggtitle("SP - Breakdown by Application") + guides(fill=FALSE) +
  theme(axis.text.x=element_text(angle = 50, size = 10, vjust = 1, hjust = 1))
#B2---------------------------------------------------
#Person - Breakdown of computer Activity
#---------------------------------------------------
#ADD FILTER TO REMOVE "system"  +  " empty values'
data_Person_no_NC <-  droplevels( subset(data_Person, Activity != "NC-Research" &  Activity != "NC-Teaching" & Activity != "NC-Service" &  Activity != "NC-Break" & Activity != "System" ))
byActivity <- group_by(data_Person_no_NC, Activity)
(Hours_by_Activity <- as.data.frame(summarise(byActivity , Total_Hour = sum(Duration.Hour, na.rm=TRUE ))))
Hours_by_Activity2 <- Hours_by_Activity
(Hours_by_Activity2$Activity <- factor(Hours_by_Activity2$Activity , levels=Hours_by_Activity2[order(-Hours_by_Activity2$Total_Hour),"Activity"]))
ggplot(data=Hours_by_Activity2, aes(x=Activity,y=Total_Hour, group=Activity,  fill = Activity)) +
  geom_bar(stat="identity")+xlab("Activity")+ylab("Total Hours")+  scale_y_continuous(limits = c(0,250)) +
    scale_fill_manual("legend", values = c("Web" = "light blue", "Writing" = "light pink", "Reading" = "light green", "Viewing" = "turquoise", "Interaction" = "khaki", "Presentation" = "plum1",
                                     "Data" = "dark grey","File Management" = "azure3", "Notetaking" = "cornsilk3", "Referencing" = "orange2", "image" = "gold2")) +
  ggtitle("SP - Breakdown by Activity")+theme_bw() + guides(fill=FALSE) +
  theme(axis.text.x=element_text(angle = 50, size = 10, vjust = 1, hjust = 1))
#C1-------------------------------------------------------------------------------------
#Person - Multitasking by hour across full Day
#-------------------------------------------------------------------------------------
# set data + set title date
#C2-------------------------------------------------------------------------------------------
#Person - Multitasking by min over an hour
#-------------------------------------------------------------------------------------------
# set data + set title date 08/10 11
data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
Select_AppSet_date <- subset(data_Personx, Date == "8/10/2014" & summary_hour == 11)
data_Person_no_NC <-  droplevels( subset(Select_AppSet_date, Application!= "system" &  Application != "" ))
byAppSet_Date <- group_by(data_Person_no_NC,  Application)
Hours_byApplication <- as.data.frame(summarise(byAppSet_Date , Total_Hour = sum(Duration.Sec, na.rm=TRUE ), summary_hour = 11))
Hours_by_Application2 <- Hours_byApplication
Hours_by_Application2$Percentage <- 100*Hours_by_Application2$Total_Hour/sum(Hours_by_Application2$Total_Hour)
Hours_by_Application2$summary_hour <- factor(Hours_by_Application2$summary_hour,labels="10-11am")
ggplot(data=Hours_by_Application2, aes(x=summary_hour,y=Percentage, group=Application, fill = Application)) +
  geom_bar(stat="identity")+xlab("Hour of Day")+ylab("Percentage")+
  ggtitle("Case: SP")+scale_fill_discrete(guide = guide_legend(reverse=TRUE))
#D1-------------------------------------------------------------------------------------------
#Person - Person - Multitasking table data - by application
#-------------------------------------------------------------------
##LOAD DATA for Personx...
```

```
data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
select_AppSet_date <- data_Personx
##Filter DATA for Person...
#data_Person_no_NC <-  data_Person <- read.csv("Person.csv")
#data_Person$Date <- as.character(data_Person$Date)
#data_Person_no_NC <-  droplevels( subset(Select_AppSet_date, Application!= "system" &  Application != "" ))
#byAppSet_Date <- group_by(data_Person_no_NC,  Application)
# Find the number of apps used in each hour and date---------------------
byAppSet_Date_hour <- group_by(select_AppSet_date, Date, Application, summary_hour)
Application_Date_Hour <- as.data.frame(summarise(byAppSet_Date_hour, NumApplication = n()))
Table_date_hour <- with(Application_Date_Hour, table(Date, summary_hour))
#Put the data in long format so each hour/date combo is a row--------------
Table_date_hour_long <- melt(Table_date_hour)
#create a table by counting the number of times each hour falls within the 4 conditions---------
#and then convert to percentage in each condition
maxApp <- max(Table_date_hour_long$value) #the highest number of apps used in an hour
(App_Table <- table( cut(Table_date_hour_long$value, breaks = c(0,2,5,7, maxApp)))) #raw counts
(Percent_App_Table <- round(prop.table(App_Table)*100,0))

#E1:Heatmap-ALL
Apps################################################################################
#Person - Heatmap - ALL Applications
hour_spacing <- 2
data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
select_AppSet_date <- data_Personx
unique(data_Personx$Application)
byAppSet_Date_hour <- group_by(select_AppSet_date, Date, Application, summary_hour)
Application_date_hour <- as.data.frame(summarise(byAppSet_Date_hour, NumApps = n()))
Table_date_hour <- with(Application_date_hour, table(Date, summary_hour))
Table_date_hour.df <- as.data.frame(Table_date_hour)
#Time format
Table_date_hour.df$Date2 <- Table_date_hour.df$Date
Table_date_hour.df$Date2 <- as.Date(Table_date_hour.df$Date2,format='%d/%m/%Y')
#make summary hour numeric
Table_date_hour.df$summary_hour_num <- as.numeric(paste(Table_date_hour.df$summary_hour))
Table_date_hour.df$summary_hour_num <- Table_date_hour.df$summary_hour_num + 1
#Check if any hours are missing
unique(Table_date_hour.df$summary_hour_num)
#hr 4 is missing
fill_in_1 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_2 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_4 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_5 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_6 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_7 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_1$summary_hour_num <- 1; fill_in_1$Freq <- 0
fill_in_2$summary_hour_num <- 2; fill_in_2$Freq <- 0
fill_in_4$summary_hour_num <- 4; fill_in_4$Freq <- 0
fill_in_5$summary_hour_num <- 5; fill_in_5$Freq <- 0
fill_in_6$summary_hour_num <- 6; fill_in_6$Freq <- 0
fill_in_7$summary_hour_num <- 7; fill_in_7$Freq <- 0
Table_date_hour.df.2 <- rbind(Table_date_hour.df,
                              fill_in_1,  fill_in_2,  fill_in_4,  fill_in_5,  fill_in_6, fill_in_7)
length(unique(Table_date_hour.df.2$summary_hour_num))#check that all hours are in data
maxhr <- max(as.numeric(Table_date_hour.df.2$summary_hour_num))
minhr <- min(as.numeric(Table_date_hour.df.2$summary_hour_num))
ggplot(data = Table_date_hour.df.2, aes(x = summary_hour_num, y = Date2)) +
  geom_tile(aes(fill = Freq)) +
  labs(x = "Hour", y = "Day") +
  scale_x_continuous(breaks = seq(minhr, maxhr, hour_spacing))+
```

```
  theme_classic()+
  theme(panel.background = element_rect(fill = '#132B43', colour = 'white')) +
  theme(plot.title = element_text(size = 8)) +
ggtitle("Case: SP | Applications")
#E2:Heatmap-Top                                                                                      x3
Apps###################################################################################
#Person - Heatmap - Top x3 Applications
hour_spacing <- 2
data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
select_AppSet_date <- data_Personx
unique(data_Personx$Application)
data_Personx$Application2 <- data_Personx$Application
data_Personx$Application2[data_Personx$Application == "browser-facebook"] <- "browser"
data_Personx$Application2[data_Personx$Application == "browser-blackboard"] <- "browser"
data_Personx$Application2[data_Personx$Application == "browser-linkedin"] <- "browser"
data_Personx$Application2[data_Personx$Application == "browser-video"] <- "browser"
data_Personx$Application2[data_Personx$Application == "browser"] <- "browser"
select_AppSet_date_MIX3 <- subset(data_Personx, Application2 == "msword" | Application2 == "email" |  Application2
== "browser")
unique(data_Personx$MIX3)
byAppSet_Date_hour_MIX3 <- group_by(select_AppSet_date_MIX3, Date, Application2, summary_hour)
Application_date_hour_MIX3 <- as.data.frame(summarise(byAppSet_Date_hour_MIX3, NumApps = n()))
Table_date_hour_MIX3 <- with(Application_date_hour_MIX3, table(Date, summary_hour))
Table_date_hour.df_MIX3 <- as.data.frame(Table_date_hour_MIX3)
#Time format
Table_date_hour.df_MIX3$Date2 <- Table_date_hour.df_MIX3$Date
Table_date_hour.df_MIX3$Date2 <- as.Date(Table_date_hour.df_MIX3$Date2,format='%d/%m/%Y')
#make summary hour numeric
Table_date_hour.df_MIX3$summary_hour_num <- as.numeric(paste(Table_date_hour.df_MIX3$summary_hour))
Table_date_hour.df_MIX3$summary_hour_num <- Table_date_hour.df_MIX3$summary_hour_num + 1
unique(Table_date_hour.df_MIX3$summary_hour_num)#hr 4 is missing
fill_in_1 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_2 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_4 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_5 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_6 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_7 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_24 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_1$summary_hour_num <- 1; fill_in_1$Freq <- 0
fill_in_2$summary_hour_num <- 2; fill_in_2$Freq <- 0
fill_in_4$summary_hour_num <- 4; fill_in_4$Freq <- 0
fill_in_5$summary_hour_num <- 5; fill_in_5$Freq <- 0
fill_in_6$summary_hour_num <- 6; fill_in_6$Freq <- 0
fill_in_7$summary_hour_num <- 7; fill_in_7$Freq <- 0
fill_in_24$summary_hour_num <- 24; fill_in_24$Freq <- 0
Table_date_hour.df.2 <- rbind(Table_date_hour.df_MIX3, fill_in_1, fill_in_2,fill_in_4,fill_in_5, fill_in_6,fill_in_7,fill_in_24)
length(unique(Table_date_hour.df.2$summary_hour_num))#check that all hours are in data
fill_in <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in$summary_hour_num <- 5; fill_in$Freq <- 0
Table_date_hour.df_MIX3.2 <- rbind(Table_date_hour.df_MIX3, fill_in)
maxhr <- max(as.numeric(Table_date_hour.df_MIX3.2$summary_hour_num))
minhr <- min(as.numeric(Table_date_hour.df_MIX3.2$summary_hour_num))
ggplot(data = Table_date_hour.df_MIX3.2, aes(x = summary_hour_num, y = Date2)) +
  geom_tile(aes(fill = Freq)) +
  labs(x = "Hour", y = "Day") +
  scale_x_continuous(breaks = seq(minhr, maxhr, hour_spacing))+
  theme_classic()+
  theme(panel.background = element_rect(fill = '#132B43', colour = 'white')) +
  theme(plot.title = element_text(size = 8)) +
ggtitle("Case: SP | Top 3 word-email-browser")
```

```
#E3a:Dissection-msword
####################################################################################
#Person - Heatmap - x1 Application breakdown - msword
hour_spacing <- 2
data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
select_AppSet_date <- data_Personx
unique(data_Personx$Application)
data_Personx$Application2 <- data_Personx$Application
select_AppSet_date <- subset(data_Personx, Application2 == "msword")

byAppSet_Date_hour <- group_by(select_AppSet_date, Date, Application2, summary_hour)
Application_date_hour <- as.data.frame(summarise(byAppSet_Date_hour, NumApps = n()))
Table_date_hour <- with(Application_date_hour, table(Date, summary_hour))
Table_date_hour.df <- as.data.frame(Table_date_hour)
Table_date_hour.df$Date2 <- Table_date_hour.df$Date
Table_date_hour.df$Date2 <- as.Date(Table_date_hour.df$Date2,format='%d/%m/%Y')
Table_date_hour.df$summary_hour_num <- as.numeric(paste(Table_date_hour.df$summary_hour))
Table_date_hour.df$summary_hour_num <- Table_date_hour.df$summary_hour_num + 1
unique(Table_date_hour.df$summary_hour_num)#hr 4 is missing
fill_in_1 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_2<- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_3 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_4 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_5 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_6 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_7 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_24 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_1$summary_hour_num <- 1; fill_in_1$Freq <- 0
fill_in_2$summary_hour_num <- 2; fill_in_2$Freq <- 0
fill_in_3$summary_hour_num <- 3; fill_in_3$Freq <- 0
fill_in_4$summary_hour_num <- 4; fill_in_4$Freq <- 0
fill_in_5$summary_hour_num <- 5; fill_in_5$Freq <- 0
fill_in_6$summary_hour_num <- 6; fill_in_6$Freq <- 0
fill_in_7$summary_hour_num <- 7; fill_in_7$Freq <- 0
fill_in_24$summary_hour_num <- 24; fill_in_24$Freq <- 0
Table_date_hour.df.2 <- rbind(Table_date_hour.df, fill_in_1, fill_in_2,fill_in_3,fill_in_4,fill_in_5,fill_in_6,
fill_in_7,fill_in_24)
length(unique(Table_date_hour.df.2$summary_hour_num))#check that all hours are in data
unique(Table_date_hour.df.2$summary_hour_num) #new list = 24
maxhr <- max(as.numeric(Table_date_hour.df.2$summary_hour_num))
minhr <- min(as.numeric(Table_date_hour.df.2$summary_hour_num))
Table_date_hour.df.2$Freq[Table_date_hour.df.2$summary_hour_num==2]
ggplot(data = Table_date_hour.df.2, aes(x = summary_hour_num, y = Date2)) +
  geom_tile(aes(fill = factor(Freq))) +
  scale_fill_manual("Applications",values = c("white","red"))+
  labs(x = "Hour", y = "Day") +
  scale_x_continuous(breaks = seq(minhr, maxhr, hour_spacing))+
  #theme_bw()+
  theme_classic()+
  theme(legend.position = "none")+
  theme(plot.title = element_text(size = 8)) +
  ggtitle("Case: SP | by word")
#E3b:Dissection-email
####################################################################################
#Person - Heatmap - x1 Application breakdown - email
hour_spacing <- 2
data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
select_AppSet_date <- data_Personx
unique(data_Personx$Application)
data_Personx$Application2 <- data_Personx$Application
```

```
select_AppSet_date <- subset(data_Personx, Application2 == "email")
byAppSet_Date_hour <- group_by(select_AppSet_date, Date, Application2, summary_hour)
Application_date_hour <- as.data.frame(summarise(byAppSet_Date_hour, NumApps = n()))
Table_date_hour <- with(Application_date_hour, table(Date, summary_hour))
Table_date_hour.df <- as.data.frame(Table_date_hour)
Table_date_hour.df$Date2 <- Table_date_hour.df$Date
Table_date_hour.df$Date2 <- as.Date(Table_date_hour.df$Date2,format='%d/%m/%Y')
Table_date_hour.df$summary_hour_num <- as.numeric(paste(Table_date_hour.df$summary_hour))
Table_date_hour.df$summary_hour_num <- Table_date_hour.df$summary_hour_num + 1
unique(Table_date_hour.df$summary_hour_num)#hr 4 is missing
fill_in_1 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_2<- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_3 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_4 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_5 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_6 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_7 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_24 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_1$summary_hour_num <- 1; fill_in_1$Freq <- 0
fill_in_2$summary_hour_num <- 2; fill_in_2$Freq <- 0
fill_in_3$summary_hour_num <- 3; fill_in_3$Freq <- 0
fill_in_4$summary_hour_num <- 4; fill_in_4$Freq <- 0
fill_in_5$summary_hour_num <- 5; fill_in_5$Freq <- 0
fill_in_6$summary_hour_num <- 6; fill_in_6$Freq <- 0
fill_in_7$summary_hour_num <- 7; fill_in_7$Freq <- 0
Table_date_hour.df.2 <- rbind(Table_date_hour.df, fill_in_1, fill_in_2,fill_in_3,fill_in_4,fill_in_5,fill_in_6,
fill_in_7,fill_in_24)
length(unique(Table_date_hour.df.2$summary_hour_num))#check that all hours are in data
unique(Table_date_hour.df.2$summary_hour_num) #new list = 24
maxhr <- max(as.numeric(Table_date_hour.df.2$summary_hour_num))
minhr <- min(as.numeric(Table_date_hour.df.2$summary_hour_num))
Table_date_hour.df.2$Freq[Table_date_hour.df.2$summary_hour_num==2]
ggplot(data = Table_date_hour.df.2, aes(x = summary_hour_num, y = Date2)) +
  geom_tile(aes(fill = factor(Freq))) +
  scale_fill_manual("Applications",values = c("white","blue"))+
  labs(x = "Hour", y = "Day") +
  scale_x_continuous(breaks = seq(minhr, maxhr, hour_spacing))+
  #theme_bw()+
  theme_classic()+
  theme(legend.position = "none")+
  theme(plot.title = element_text(size = 8)) +
  ggtitle("Case: SP | by email")
#E3c:Dissection-
browser#########################################################################################
#Person - Heatmap - x1 Application breakdown - browser
hour_spacing <- 2
data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
select_AppSet_date <- data_Personx
unique(data_Personx$Application)
data_Personx$Application2 <- data_Personx$Application
select_AppSet_date <- subset(data_Personx,
                             Application2 == "browser"|
                             Application2 == "browser-facebook" |
                             Application2 == "browser-blackboard" |
                             Application2 == "browser-video")
byAppSet_Date_hour <- group_by(select_AppSet_date, Date, Application2, summary_hour)
Application_date_hour <- as.data.frame(summarise(byAppSet_Date_hour, NumApps = n()))
Table_date_hour <- with(Application_date_hour, table(Date, summary_hour))
Table_date_hour.df <- as.data.frame(Table_date_hour)
Table_date_hour.df$Date2 <- Table_date_hour.df$Date
Table_date_hour.df$Date2 <- as.Date(Table_date_hour.df$Date2,format='%d/%m/%Y')
```

```
Table_date_hour.df$summary_hour_num <- as.numeric(paste(Table_date_hour.df$summary_hour))
Table_date_hour.df$summary_hour_num <- Table_date_hour.df$summary_hour_num + 1
unique(Table_date_hour.df$summary_hour_num)#hr 4 is missing
fill_in_1 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_2 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_3 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_4 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_5 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_6 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_7 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_24 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_1$summary_hour_num <- 1; fill_in_1$Freq <- 0
fill_in_2$summary_hour_num <- 2; fill_in_2$Freq <- 0
fill_in_3$summary_hour_num <- 3; fill_in_3$Freq <- 0
fill_in_4$summary_hour_num <- 4; fill_in_4$Freq <- 0
fill_in_5$summary_hour_num <- 5; fill_in_5$Freq <- 0
fill_in_6$summary_hour_num <- 6; fill_in_6$Freq <- 0
fill_in_7$summary_hour_num <- 7; fill_in_7$Freq <- 0
fill_in_24$summary_hour_num <- 24; fill_in_24$Freq <- 0
Table_date_hour.df.2 <- rbind(Table_date_hour.df, fill_in_1, fill_in_2,fill_in_3,fill_in_4,fill_in_5,fill_in_6,
fill_in_7,fill_in_24)
length(unique(Table_date_hour.df.2$summary_hour_num))#check that all hours are in data
unique(Table_date_hour.df.2$summary_hour_num) #new list = 24
maxhr <- max(as.numeric(Table_date_hour.df.2$summary_hour_num))
minhr <- min(as.numeric(Table_date_hour.df.2$summary_hour_num))
Table_date_hour.df.2$Freq[Table_date_hour.df.2$summary_hour_num==2]
ggplot(data = Table_date_hour.df.2, aes(x = summary_hour_num, y = Date2)) +
  geom_tile(aes(fill = factor(Freq))) +
  scale_fill_manual("Applications",values = c("white","green", "green", "green"))+
  labs(x = "Hour", y = "Day") +
  scale_x_continuous(breaks = seq(minhr, maxhr, hour_spacing))+
  #theme_bw()+
  theme_classic()+
  theme(legend.position = "none")+
  theme(plot.title = element_text(size = 8)) +
  ggtitle("Case: SP | by browser")

#E4:Heatmap-
Browser####################################################################################
#Person - Heatmap - Browser x5
hour_spacing <- 2
data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
select_AppSet_date <- data_Personx
unique(data_Personx$Application)
data_Personx$Application2 <- data_Personx$Application
select_AppSet_date_MIX3 <- subset(data_Personx,
                                  Application2 == "browser" |
                                    Application2 == "browser-facebook" |
                                    Application2 == "browser-blackboard" |
                                    Application2 == "browser-linkedin" |
                                    Application2 == "browser-video")
byAppSet_Date_hour_MIX3 <- group_by(select_AppSet_date_MIX3, Date, Application2, summary_hour)
Application_date_hour_MIX3 <- as.data.frame(summarise(byAppSet_Date_hour_MIX3, NumApps = n()))
Table_date_hour_MIX3 <- with(Application_date_hour_MIX3, table(Date, summary_hour))
Table_date_hour.df_MIX3 <- as.data.frame(Table_date_hour_MIX3)
#Time format
Table_date_hour.df_MIX3$Date2 <- Table_date_hour.df_MIX3$Date
Table_date_hour.df_MIX3$Date2 <- as.Date(Table_date_hour.df_MIX3$Date2,format='%d/%m/%Y')
#make summary hour numeric
Table_date_hour.df_MIX3$summary_hour_num <- as.numeric(paste(Table_date_hour.df_MIX3$summary_hour))
```

```
Table_date_hour.df_MIX3$summary_hour_num <- Table_date_hour.df_MIX3$summary_hour_num + 1
unique(Table_date_hour.df_MIX3$summary_hour_num)#hr 4 is missing
fill_in_1 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_2 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_4 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_5 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_6 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_7 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_24 <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in_1$summary_hour_num <- 1; fill_in_1$Freq <- 0
fill_in_2$summary_hour_num <- 2; fill_in_2$Freq <- 0
fill_in_4$summary_hour_num <- 4; fill_in_4$Freq <- 0
fill_in_5$summary_hour_num <- 5; fill_in_5$Freq <- 0
fill_in_6$summary_hour_num <- 6; fill_in_6$Freq <- 0
fill_in_7$summary_hour_num <- 7; fill_in_7$Freq <- 0
fill_in_24$summary_hour_num <- 24; fill_in_24$Freq <- 0
Table_date_hour.df.2 <- rbind(Table_date_hour.df_MIX3, fill_in_1, fill_in_2,fill_in_4,fill_in_5, fill_in_6,fill_in_7,fill_in_24)
length(unique(Table_date_hour.df.2$summary_hour_num))#check that all hours are in data
fill_in <- Table_date_hour.df_MIX3[Table_date_hour.df_MIX3$summary_hour == 13,]
fill_in$summary_hour_num <- 5; fill_in$Freq <- 0
Table_date_hour.df_MIX3.2 <- rbind(Table_date_hour.df_MIX3, fill_in)
maxhr <- max(as.numeric(Table_date_hour.df_MIX3.2$summary_hour_num))
minhr <- min(as.numeric(Table_date_hour.df_MIX3.2$summary_hour_num))
ggplot(data = Table_date_hour.df_MIX3.2, aes(x = summary_hour_num, y = Date2)) +
  geom_tile(aes(fill = Freq)) +
  labs(x = "Hour", y = "Day") +
  scale_x_continuous(breaks = seq(minhr, maxhr, hour_spacing))+
  theme_classic()+
  theme(panel.background = element_rect(fill = '#132B43', colour = 'white')) +
  theme(plot.title = element_text(size = 8)) +
  ggtitle("Case: SP | by multi-browser")
#E5a:Dissection-facebook
##################################################################################
#Person - Heatmap - x1 Browser breakdown - browser - facebook
hour_spacing <- 2
data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
select_AppSet_date <- data_Personx
unique(data_Personx$Application)
data_Personx$Application2 <- data_Personx$Application
#data_Personx$Application2[data_Personx$Application == "browser-facebook"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-blackboard"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-linkedin"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-video"] <- "browser"
select_AppSet_date <- subset(data_Personx, Application2 == "browser-facebook")
byAppSet_Date_hour <- group_by(select_AppSet_date, Date, Application2, summary_hour)
Application_date_hour <- as.data.frame(summarise(byAppSet_Date_hour, NumApps = n()))
Table_date_hour <- with(Application_date_hour, table(Date, summary_hour))
Table_date_hour.df <- as.data.frame(Table_date_hour)


#Time format
Table_date_hour.df$Date2 <- Table_date_hour.df$Date
Table_date_hour.df$Date2 <- as.Date(Table_date_hour.df$Date2,format='%d/%m/%Y')
#make summary hour numeric
Table_date_hour.df$summary_hour_num <- as.numeric(paste(Table_date_hour.df$summary_hour))
Table_date_hour.df$summary_hour_num <- Table_date_hour.df$summary_hour_num + 1
#Check if any hours are missing
unique(Table_date_hour.df$summary_hour_num)
#hr 4 is missing
fill_in_1 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_2<- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
```

```
fill_in_3 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_4 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_5 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_6 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_7 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_24 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_1$summary_hour_num <- 1; fill_in_1$Freq <- 0
fill_in_2$summary_hour_num <- 2; fill_in_2$Freq <- 0
fill_in_3$summary_hour_num <- 3; fill_in_3$Freq <- 0
fill_in_4$summary_hour_num <- 4; fill_in_4$Freq <- 0
fill_in_5$summary_hour_num <- 5; fill_in_5$Freq <- 0
fill_in_6$summary_hour_num <- 6; fill_in_6$Freq <- 0
fill_in_7$summary_hour_num <- 7; fill_in_7$Freq <- 0
fill_in_24$summary_hour_num <- 24; fill_in_24$Freq <- 0
Table_date_hour.df.2 <- rbind(Table_date_hour.df, fill_in_1, fill_in_2,fill_in_3,fill_in_4,fill_in_5,fill_in_6,
fill_in_7,fill_in_24)
length(unique(Table_date_hour.df.2$summary_hour_num))#check that all hours are in data
unique(Table_date_hour.df.2$summary_hour_num)
maxhr <- max(as.numeric(Table_date_hour.df.2$summary_hour_num))
minhr <- min(as.numeric(Table_date_hour.df.2$summary_hour_num))
ggplot(data = Table_date_hour.df.2, aes(x = summary_hour_num, y = Date2)) +
  geom_tile(aes(fill = factor(Freq))) +
  scale_fill_manual("Applications",values = c("white","purple"))+
  labs(x = "Hour", y = "Day") +
  scale_x_continuous(breaks = seq(minhr, maxhr, hour_spacing))+
  #theme_bw()+
  theme_classic()+
  theme(legend.position = "none")+
  theme(plot.title = element_text(size = 8)) +
  ggtitle("Case: SP | by browser-facebook")
#E5b:Dissection-blackboard
####################################################################################
#Person - Heatmap - x1 Browser breakdown - browser-blackboard
hour_spacing <- 2
data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
select_AppSet_date <- data_Personx
unique(data_Personx$Application)
data_Personx$Application2 <- data_Personx$Application
#data_Personx$Application2[data_Personx$Application == "browser-facebook"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-blackboard"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-linkedin"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-video"] <- "browser"
select_AppSet_date <- subset(data_Personx, Application2 == "browser-blackboard")
byAppSet_Date_hour <- group_by(select_AppSet_date, Date, Application2, summary_hour)
Application_date_hour <- as.data.frame(summarise(byAppSet_Date_hour, NumApps = n()))
Table_date_hour <- with(Application_date_hour, table(Date, summary_hour))
Table_date_hour.df <- as.data.frame(Table_date_hour)
#Time format
Table_date_hour.df$Date2 <- Table_date_hour.df$Date
Table_date_hour.df$Date2 <- as.Date(Table_date_hour.df$Date2,format='%d/%m/%Y')
#make summary hour numeric
Table_date_hour.df$summary_hour_num <- as.numeric(paste(Table_date_hour.df$summary_hour))
Table_date_hour.df$summary_hour_num <- Table_date_hour.df$summary_hour_num + 1
#Check if any hours are missing
unique(Table_date_hour.df$summary_hour_num)
#hr 4 is missing
fill_in_1 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_2<- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_3 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_4 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_5 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
```

```
fill_in_6 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_7 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_8 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_20 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_21 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_22 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_23 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_24 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_1$summary_hour_num <- 1; fill_in_1$Freq <- 0
fill_in_2$summary_hour_num <- 2; fill_in_2$Freq <- 0
fill_in_3$summary_hour_num <- 3; fill_in_3$Freq <- 0
fill_in_4$summary_hour_num <- 4; fill_in_4$Freq <- 0
fill_in_5$summary_hour_num <- 5; fill_in_5$Freq <- 0
fill_in_6$summary_hour_num <- 6; fill_in_6$Freq <- 0
fill_in_7$summary_hour_num <- 7; fill_in_7$Freq <- 0
fill_in_8$summary_hour_num <- 8; fill_in_8$Freq <- 0
fill_in_20$summary_hour_num <- 20; fill_in_20$Freq <- 0
fill_in_21$summary_hour_num <- 21; fill_in_21$Freq <- 0
fill_in_22$summary_hour_num <- 22; fill_in_22$Freq <- 0
fill_in_23$summary_hour_num <- 23; fill_in_23$Freq <- 0
fill_in_24$summary_hour_num <- 24; fill_in_24$Freq <- 0
Table_date_hour.df.2 <- rbind(Table_date_hour.df, fill_in_1, fill_in_2,fill_in_3,fill_in_4,fill_in_5,fill_in_6,
fill_in_7,fill_in_8,fill_in_20, fill_in_21, fill_in_22, fill_in_23, fill_in_24)
length(unique(Table_date_hour.df.2$summary_hour_num))#check that all hours are in data
unique(Table_date_hour.df.2$summary_hour_num)
maxhr <- max(as.numeric(Table_date_hour.df.2$summary_hour_num))
minhr <- min(as.numeric(Table_date_hour.df.2$summary_hour_num))
ggplot(data = Table_date_hour.df.2, aes(x = summary_hour_num, y = Date2)) +
  geom_tile(aes(fill = factor(Freq))) +
  scale_fill_manual("Applications",values = c("white","brown"))+
  labs(x = "Hour", y = "Day") +
  scale_x_continuous(breaks = seq(minhr, maxhr, hour_spacing))+
  #theme_bw()+
  theme_classic()+
  theme(legend.position = "none")+
  theme(plot.title = element_text(size = 8)) +
  ggtitle("Case: SP - by browser | blackboard")
#E5c:Dissection-linkedin
#######################################################################################
#Person - Heatmap - x1 Browser breakdown - browser-linkedin
hour_spacing <- 2

data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
select_AppSet_date <- data_Personx
unique(data_Personx$Application)
data_Personx$Application2 <- data_Personx$Application
#data_Personx$Application2[data_Personx$Application == "browser-facebook"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-blackboard"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-linkedin"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-video"] <- "browser"
select_AppSet_date <- subset(data_Personx, Application2 == "browser-linkedin")
byAppSet_Date_hour <- group_by(select_AppSet_date, Date, Application2, summary_hour)
Application_date_hour <- as.data.frame(summarise(byAppSet_Date_hour, NumApps = n()))
Table_date_hour <- with(Application_date_hour, table(Date, summary_hour))
Table_date_hour.df <- as.data.frame(Table_date_hour)
#Time format
Table_date_hour.df$Date2 <- Table_date_hour.df$Date
Table_date_hour.df$Date2 <- as.Date(Table_date_hour.df$Date2,format='%d/%m/%Y')
#make summary hour numeric
Table_date_hour.df$summary_hour_num <- as.numeric(paste(Table_date_hour.df$summary_hour))
Table_date_hour.df$summary_hour_num <- Table_date_hour.df$summary_hour_num + 1
```

```
#Check if any hours are missing
unique(Table_date_hour.df$summary_hour_num)
#hr 4 is missing
fill_in_1 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_2<- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_3 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_4 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_5 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_6 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_7 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_8 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_20 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_21 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_22 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_23 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_24 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_1$summary_hour_num <- 1; fill_in_1$Freq <- 0
fill_in_2$summary_hour_num <- 2; fill_in_2$Freq <- 0
fill_in_3$summary_hour_num <- 3; fill_in_3$Freq <- 0
fill_in_4$summary_hour_num <- 4; fill_in_4$Freq <- 0
fill_in_5$summary_hour_num <- 5; fill_in_5$Freq <- 0
fill_in_6$summary_hour_num <- 6; fill_in_6$Freq <- 0
fill_in_7$summary_hour_num <- 7; fill_in_7$Freq <- 0
fill_in_8$summary_hour_num <- 8; fill_in_8$Freq <- 0
fill_in_20$summary_hour_num <- 20; fill_in_20$Freq <- 0
fill_in_21$summary_hour_num <- 21; fill_in_21$Freq <- 0
fill_in_22$summary_hour_num <- 22; fill_in_22$Freq <- 0
fill_in_23$summary_hour_num <- 23; fill_in_23$Freq <- 0
fill_in_24$summary_hour_num <- 24; fill_in_24$Freq <- 0
Table_date_hour.df.2 <- rbind(Table_date_hour.df, fill_in_1, fill_in_2,fill_in_3,fill_in_4,fill_in_5,fill_in_6,
fill_in_7,fill_in_8,fill_in_20, fill_in_21, fill_in_22, fill_in_23, fill_in_24)
length(unique(Table_date_hour.df.2$summary_hour_num))#check that all hours are in data
unique(Table_date_hour.df.2$summary_hour_num)
maxhr <- max(as.numeric(Table_date_hour.df.2$summary_hour_num))
minhr <- min(as.numeric(Table_date_hour.df.2$summary_hour_num))
ggplot(data = Table_date_hour.df.2, aes(x = summary_hour_num, y = Date2)) +
  geom_tile(aes(fill = factor(Freq))) +
  scale_fill_manual("Applications",values = c("white","yellow"))+
  labs(x = "Hour", y = "Day") +
  scale_x_continuous(breaks = seq(minhr, maxhr, hour_spacing))+
  #theme_bw()+
  theme_classic()+
  theme(legend.position = "none")+
  theme(plot.title = element_text(size = 8)) +
  ggtitle("Case: SP - by browser | Linkedin")
#E5d:Dissection-Video
##########################################################################################
#Person - Heatmap - x1 Browser breakdown - browser-video
hour_spacing <- 2
data_Personx <- read.csv("Personx.csv")
data_Personx$Date <- as.character(data_Personx$Date)
select_AppSet_date <- data_Personx
unique(data_Personx$Application)
data_Personx$Application2 <- data_Personx$Application
#data_Personx$Application2[data_Personx$Application == "browser-facebook"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-blackboard"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-linkedin"] <- "browser"
#data_Personx$Application2[data_Personx$Application == "browser-video"] <- "browser"
select_AppSet_date <- subset(data_Personx, Application2 == "browser-video")
byAppSet_Date_hour <- group_by(select_AppSet_date, Date, Application2, summary_hour)
Application_date_hour <- as.data.frame(summarise(byAppSet_Date_hour, NumApps = n()))
Table_date_hour <- with(Application_date_hour, table(Date, summary_hour))
```

```
Table_date_hour.df <- as.data.frame(Table_date_hour)
#Time format
Table_date_hour.df$Date2 <- Table_date_hour.df$Date
Table_date_hour.df$Date2 <- as.Date(Table_date_hour.df$Date2,format='%d/%m/%Y')
#make summary hour numeric
Table_date_hour.df$summary_hour_num <- as.numeric(paste(Table_date_hour.df$summary_hour))
Table_date_hour.df$summary_hour_num <- Table_date_hour.df$summary_hour_num + 1
#Check if any hours are missing
unique(Table_date_hour.df$summary_hour_num)
#hr 4 is missing
fill_in_1 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_2<- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_3 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_4 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_5 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_6 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_7 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_8 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_9 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_10 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_18 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_19 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_20 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_22 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_23 <- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_24<- Table_date_hour.df[Table_date_hour.df$summary_hour == 13,]
fill_in_1$summary_hour_num <- 1; fill_in_1$Freq <- 0
fill_in_2$summary_hour_num <- 2; fill_in_2$Freq <- 0
fill_in_3$summary_hour_num <- 3; fill_in_3$Freq <- 0
fill_in_4$summary_hour_num <- 4; fill_in_4$Freq <- 0
fill_in_5$summary_hour_num <- 5; fill_in_5$Freq <- 0
fill_in_6$summary_hour_num <- 6; fill_in_6$Freq <- 0
fill_in_7$summary_hour_num <- 7; fill_in_7$Freq <- 0
fill_in_8$summary_hour_num <- 8; fill_in_8$Freq <- 0
fill_in_9$summary_hour_num <- 9; fill_in_9$Freq <- 0
fill_in_10$summary_hour_num <- 10; fill_in_10$Freq <- 0
fill_in_18$summary_hour_num <- 18; fill_in_18$Freq <- 0
fill_in_19$summary_hour_num <- 19; fill_in_19$Freq <- 0
fill_in_20$summary_hour_num <- 20; fill_in_20$Freq <- 0
fill_in_22$summary_hour_num <- 22; fill_in_22$Freq <- 0
fill_in_23$summary_hour_num <- 23; fill_in_23$Freq <- 0
fill_in_24$summary_hour_num <- 24; fill_in_24$Freq <- 0
Table_date_hour.df.2 <- rbind(Table_date_hour.df,
                              fill_in_1,  fill_in_2,  fill_in_3,  fill_in_4,  fill_in_5,  fill_in_6, fill_in_7, fill_in_8, fill_in_9, fill_in_10,
                              fill_in_18,fill_in_19,
                              fill_in_20, fill_in_22, fill_in_23, fill_in_24)
length(unique(Table_date_hour.df.2$summary_hour_num))#check that all hours are in data
unique(Table_date_hour.df.2$summary_hour_num)
maxhr <- max(as.numeric(Table_date_hour.df.2$summary_hour_num))
minhr <- min(as.numeric(Table_date_hour.df.2$summary_hour_num))
ggplot(data = Table_date_hour.df.2, aes(x = summary_hour_num, y = Date2)) +
  geom_tile(aes(fill = factor(Freq))) +
  scale_fill_manual("Applications",values = c("white","orange"))+
  labs(x = "Hour", y = "Day") +
  scale_x_continuous(breaks = seq(minhr, maxhr, hour_spacing))+
  #theme_bw()+
  theme_classic()+
  theme(legend.position = "none")+
  theme(plot.title = element_text(size = 8)) +
  ggtitle("Case: SP - by browser | video")
```

Appendix C

Heatmap Python Script

```
import numpy as np
import cv2
import argparse
import os
import time
import logging

# based on test.py from https://github.com/Muhamob/Simple-Python-heatmap

# use it if you wanna write video or ffmpeg
#from skvideo.io import FFmpegWriter

startTime = time.time()

FORMAT = '%(asctime)-15s %(levelname)-8s %(message)s'
logging.basicConfig(format=FORMAT)
logger = logging.getLogger('heatmap')
logger.setLevel(logging.DEBUG)
logger.debug('starting ...')

# construct the argument parse and parse the arguments
ap = argparse.ArgumentParser()
ap.add_argument("-v", "--video",
        help="path to the (optional) video file")
ap.add_argument("-r", "--rate",
        help="(optional) process rate")
args = vars(ap.parse_args())

# by default, use encode.mp4
file = "encode.mp4"
# by default, rate is 15
rate = 15

if args.get("video", False):
    file = args["video"]
if args.get("rate", False):
    rate = int(args["rate"])

cap = cv2.VideoCapture(file)

# get video information, like fps, width, height, etc.
fps = cap.get(cv2.CAP_PROP_FPS)
width = cap.get(cv2.CAP_PROP_FRAME_WIDTH)
height = cap.get(cv2.CAP_PROP_FRAME_HEIGHT)
frames = cap.get(cv2.CAP_PROP_FRAME_COUNT)
codec = cap.get(cv2.CAP_PROP_FOURCC)
total_time = frames/fps

# display message every display_per seconds, minimum is 100
display_per = int(total_time / 100)
if display_per < 100:
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    display_per = 100

logger.info("Video fps is (Tugui, 2004) resolution is {}x{}. There are total {} frames and {:.2f} seconds. Display process every {} seconds." \
            .format(int(fps), int(width), int(height), int(frames), total_time, display_per))

# output image file name (always output files on current path)
basename = os.path.basename(file)
img = os.path.splitext(basename)[0] + "-" + str(rate) + ".jpg"

logger.info("video file is {}, rate is {}, output image file is {}".format(file, rate, img))

start = 1
duration = 10

while True:
    try:
        (grabbed, f) = cap.read()
        f = cv2.cvtColor(f, cv2.COLOR_BGR2GRAY)
        f = cv2.GaussianBlur(f, (11, 11), 2, 2)
        cnt = 0
        res = 0.05 * f
        res = res.astype(np.float64)
        break
    except:
        print('s')

fgbg = cv2.createBackgroundSubtractorMOG2(history=1, varThreshold=100,
                                          detectShadows=True)

# writer = FFmpegWriter(outfile, outputdict={'-r': fps})
# writer = FFmpegWriter(outfile)

kernel = cv2.getStructuringElement(cv2.MORPH_ELLIPSE, (13, 13))
cnt = 0
sec = 0
while True:
    try:
        # if sec == duration: break
        cnt += 1
        if cnt % int(fps) == 0:
            sec += 1
            if sec % display_per == 0:
                total_process_time = (time.time() - startTime)*total_time/sec - (time.time() - startTime)
                logger.debug("Processing {} seconds, time remains {:.2f} seconds".format(sec, total_process_time))
        ret, frame = cap.read()
        if not ret: break
        if cnt % rate != 0:
            continue
        fgmask = fgbg.apply(frame, None, 0.01)
        gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
        # if cnt == 30: res
        gray = cv2.GaussianBlur(gray, (11, 11), 2, 2)
        gray = gray.astype(np.float64)
        fgmask = cv2.morphologyEx(fgmask, cv2.MORPH_CLOSE, kernel)
        fgmask = fgmask.astype(np.float64)
        res += (40 * fgmask + gray) * 0.01
        res_show = res / res.max()
        res_show = np.floor(res_show * 255)
        res_show = res_show.astype(np.uint8)
        res_show = cv2.applyColorMap(res_show, cv2.COLORMAP_JET)
        # cv2.imshow("video " + repr(sec), res_show)
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        # try:
        #     writer.writeFrame(res_show)
        # except:
        #     writer.close()
        #     break

        # k = cv2.waitKey(1) & 0xff
        # if k == 27:
        #     break
    except:
        logger.debug("exception happened")
        break

cv2.imwrite(img, res_show)
# writer.close()
cap.release()
cv2.destroyAllWindows()

endTime = time.time()
logger.debug("it took {:.2f} seconds".format(endTime - startTime))
```