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Learning in Contract Work: An Actor-Network Theory Study of the Solar Photovoltaic Industry

by Anne Nguyen

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Certificate of Original Authorship

I, Anne Nguyen, declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Arts and Social Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abstract

With the extensive prevalence of contract work and the intense demand for solar energy, understanding the relations between learning and contract work is vital for addressing dynamic and unanticipated challenges emerging in everyday practice. However, much of the existing research on learning and contract work explores learning as individual acquisition or sociocultural participation. Few studies have investigated learning as enacted in practice; far fewer still have paid attention to learning in electrical contract work in the solar PV industry. Recent research in workplace learning has adopted practice-based approaches, including actor-network theory (ANT), to reconceptualise learning as emergence. Through ANT's distinctive sensibility, this research deployed the key concepts of human and non-human actors as well as network effects to generate a substantial dataset. Based upon evidence from 12 solar installations, four solar electrical contractors, 303 hours of observations, 24 interviews, and document review, this thesis contributes new knowledge on learning as emergence in practice.

In so doing, the study critically examines contracts, contracting practices and installing practices, to address the central research question, "How is learning in contract work enacted in solar PV installations?", and two subordinate questions, "How are contracts enacted in practice?" and "How is learning enacted in solar PV installing practices?" On the first subordinate question, the study found that contracts unfold as both matters of fact and matters of concern, and five salient contracting practices enacted the contract. On the second subordinate question, the evidence indicated that learning is enacted in different connection efforts in re-forming, mutating, and persisting networks. To answer the central research question, this thesis argues that learning is enacted as crafting-forward in contract work. This novel conceptualisation has three components: 1) entwined contracting and installing practices oriented towards completing the current contract, building reputation, and fostering future referrals, 2) four conditions of learning in contracting practices, attuning to contracts as matters of fact and matters of concern, that they a) matter, b) are liked, c) are populated, and d) are durable, and 3) learning in tinkering in installing practices, enacted in different connection efforts in re-forming, mutating, and persisting networks. This research contributes an empirical study that attunes closely to the dynamics of everyday work and contributes new conceptualisations that are of interest to researchers, solar installers, individual contractors, and organisations working with and for contractors.

1 INTRODUCTION

1.1 Introduction

This thesis examines the relationship between learning and contract work as enacted in electrical contract work in the solar PV industry. The learning integral to this study does not refer to prevalent notions of individual learners acquiring knowledge, such as attending training programs or participating in sociocultural processes. Essential to this research is the concept of learning as emergence, which expands the research focus and attends to learning as enacted in practice. Approaching learning as emergence, from an actor-network theory (ANT) perspective, affords a more comprehensive gaze, featuring prominently the sociomaterial and unanticipated dynamics of network effects as enacted in everyday contract work.

While existing studies on learning in contract work have paid scant attention to the learning enacted in practice, far fewer still have investigated learning in everyday electrical contract work in the solar PV industry. Contract work, at a distance, may appear marginal; however, this perception has been challenged increasingly and insistently. For instance, the OECD annual report on jobs and employment in 2019 assigns its full attention to non-standard forms of work, emphasising that these are no longer peripheral forms of work. The proportion of self-employed workers is one in seven, and one in nine workers is on a temporary contract (OECD, 2019). In highlighting this fundamental observation, the report also identifies a significant neglect: "Workers in non-standard forms of employment also have more difficulties accessing job-related training. This is the case for temporary, part-time and, in particular, own-account workers (i.e., self-employed without employees)" (OECD, 2019, p. 17). By underlining access to training as a pressing issue, the report brings attention to the importance of learning in contract work, although to the extent allowed by approaches equating learning with training, overlooking the pervasive learning enacted in practice.

Of crucial importance to this thesis is the conceptualisation of learning as crafting-forward in contract work in everyday practice. To conceptualise crafting is to insist on a quality that sustains reputation and future work. Within the notion of crafting, learning is viewed as enacted in the contract work crafted in entwined contracting and installing practices. To be more precise, installing practices are the practices related to the technical specifications of the product. In this study, they refer to the technical ways the solar PV systems were built, for example, the ways the mounting systems were anchored to the roof. One way this research conceptualises crafting is the tinkering in installing practices, which unfolds in three different ways relating to the connection efforts in re-forming, mutating, and persisting networks. Entangled with installing practices are five significant contract practices, identified in this research. They include establishing contracts based on trusted networks of connections, appraising sociomaterial requirements connected to the customer and the work site, arranging sociomaterial resources needed as the work unfolds, connecting the customer to significant sociomaterial changes arising as the work unfolds, and enacting sociomaterial assemblages as services additional to those contracted.

Further, based on an analysis of the contracts, the idea of crafting demands attunement to the unfolding of contracts, not simply as matters of fact that are agreed to between the contractors and the customers. Crafting attunes to the matters of concern that are the compositions of the matters of fact. Essential to such attunement are four conditions of learning in contracting practices, attuning to contracts as both matters of fact and matters of concern, that they matter, are liked, are populated, and are durable. With the conceptualisation of learning as crafting-forward, the notion of forward focuses on another central argument, considering the orientation in contract work towards completing the current contract, building reputation, and fostering future referrals.

The above main arguments of this thesis are drawn upon an empirical research that critically examines how learning in contract work is enacted in practice, particularly in electrical contract work in the solar PV industry in Australia. The overarching research question this study pursues is “How is learning in contract work enacted in solar PV installations?” In the current literature – on workplace learning, on learning in contract work, and on learning in the solar and construction industries – explorations largely lean on psychological theories to inspect learning as acquisition or, more increasingly, on sociocultural theories to consider learning as participation. While this study does not seek to dismiss these two approaches, by viewing learning as emergence, this research contributes new insights that make visible the previously invisible learning in contract work. Through the lens of ANT, the central conceptualisation advanced by this investigation in the solar PV industry is learning as crafting-forward in contract work is supported by the arguments elucidated in the seven chapters of this thesis.

Chapter overview

This chapter situates the study in the broader contexts of demands in contract work and the solar industry, as well as provides an overview of the significant arguments of the thesis. Following this introductory section, Sections 1.2 and 1.3 introduce the study within the context of the prevalence of contract work and the growing demands for solar energy, focusing on the dynamic challenges facing the solar PV industry in Australia. Sections 1.4 to 1.7 survey the thesis in a broad sense, beginning with Section 1.4, which provides a brief overview of the existing literature on workplace learning, on learning in contract work and on learning in the solar and construction industries, Section 1.5 then presents the research questions and aims before Section 1.6 moves to the ANT conceptual and methodological framework. Section 1.7 summarises the main findings and knowledge contributions and their implications for further research. Following a brief discussion on the impetus of the study briefly in Section 1.8, this chapter closes with Section 1.9, a structural overview of the seven chapters of the thesis.

1.2 Context: The prevalence of contract work

1.2.1 The prevalence of contract work

In recent decades, the number of contractors and other non-standard workers has increased in most countries worldwide, including Australia, leading to concerns about employment arrangements (Balliester & Elsheikhi, 2018; ILO, 2016a). In Australia, non-standard employment has increased from 24% in 1971 to 34% in 1984 and has continued to rise, particularly since 2008 (Laß & Wooden, 2020). Based on statistics for the 12 months to August 2018 – of the 12.6 million workers – close to 40% engaged in non-standard employment arrangements: 24.6% were casual workers, 8% were independent contractors, 5.2% were on fix-term contracts, and 1% were paid by employment agencies (Australia, 2018). According to the Australian Small Business and Family Enterprise Ombudsman (2020), based on the number of businesses, small businesses (having 0-19 employees) account for 97.4% (or more than

2.3 million firms) of all Australian businesses. Of these small businesses, 62.8% have no employees, and 25.7% have 1-4 employees.

Where contract work also includes the work conducted by small businesses, such prevalence is no longer peripheral (Leighton & McKeown, 2015); the view of contractors as a disposable, temporary part of the workforce is no longer sufficient (Coates et al., 2009; Morgan et al., 2013). However, the significance of contract work does not correspond with adequate knowledge of this form of work. McKeown argues that further studies into self-employed contractors

> necessarily, have to be different from those for managing employees. The focal point is on the self-employed as individuals who earn their income via a commercial contract, who are the business and whose personal and business lives are intimately intertwined.… Self-employment may not (yet) be a dominant means of work, but it is fundamentally changing the world of work. (Mckeown, 2016, p. 793)

The decline of standard work and the rise of non-standard forms of work, such as contract work (Laß & Wooden, 2020), drive significant concerns as work regulations remain primarily designed for standard work (OECD, 2019c). Despite the recognition that the standard model of being employed with one company for decades is in decline (World Bank, 2019), labour laws tend to centre on standard employment (ILO, 2016c). Echoing earlier findings that many organisations had not developed systems and processes to address the contractor workforce (Fenwick, 2004) and that the employment system is outdated (Cappelli & Keller, 2013), recent research highlights several issues relating to contract work, such as career management and the reward system (Leighton & McKeown, 2015). The knowledge to understand and manage contractors remains impoverished, a significant challenge in HR practices

(Cross & Swart, 2021); the "individual experience of working as contractor still remains largely unexplored" (McKeown & Pichault, 2021, p. 315).

Research in contract work also highlights the prevalence of approaches directed at employed workers in research, policy, and management (Leighton & McKeown, 2015). The challenges of non-standard work were brought into sharp relief during the health and economic crises of the COVID-19 pandemic (OECD, 2020). As the dynamic nature of contract work is increasingly being examined, a critical gap in the knowledge of learning in contract work remains.

1.2.2 The broader context of fragmentation

The prevalence of contract work forms part of broader social changes that drive the decline of traditional, stable forms of standard work (U. Beck, 2000; Campbell & Brosnan, 1999; Reich, 2008; Spies-Butcher, 2014). Research on the changing world of contract work intersects with a broad range of research that investigates non-standard forms of work alternatives to the standard, full-time employment. Non-standard employment refers to forms of work that depart from standard employment (ILO, 2020; Rodgers, 1989) where workers do not earn a salary for permanent and full-time work (Laß & Wooden, 2020; Osnowitz, 2010; Polivka & Nardone, 1989). The Fordist paradigm of the 20th century – the paradigm of structured work processes – and the post-Fordist forms of neoliberal organisations have gradually emerged as the dominant, yet relatively recent, social norms of full-time employment arrangements in developed countries (Hager & Beckett, 2019; Reich, 2002). By the beginning of the 21st century, full-time employment was referred to as standard work, as opposed to non-standard work (Kalleberg et al., 2000).

Even though non-standard forms of work have always existed throughout history and alongside standard work, the marked rise of non-standard work since the 1970s is contrasted with the decline of Fordism and standard work (U. Beck, 2000). In a seminal account of neoliberalisation, Harvey (2005) identifies major economies from the end of the 70s – under the influence of Deng Xiaoping, Thatcher Reagan, and Volcker – as instrumental in pushing neoliberalism into a global hegemony. Harvey (2005) sees the individual and temporary contracts as the keystones of neoliberal political and economic practices, which centre on "liberating individual entrepreneurial freedoms and skills" (p.2), where "temporary contract supplants 'permanent institutions'" (p. 3). While neoliberalism is an umbrella term for a range of contesting ideas (Fine & Saad-Filho, 2017), one of the effects of destabilising permanent institutions is the erosion of standard work, coinciding with the rise of non-standard work, including self-employed contract work. The literature on contract work and other non-standard work came to be defined in comparison to standard work conditions. Rodgers' (1989) influential work identified four dimensions of stability of standard work: time (extent of job security), organisation (employment consistency), economic (remuneration and progression), and social (protection from unfair treatment). Where full-time work provides standards of the stability of time, organisation, economic and social, non-standard work is also defined in terms of those standards, but crucially, in diminished forms of such standards.

The rise of self-employed contract work and other forms of non-standard work coincides with widespread social changes such as the increasing deregulation, privatisation, limitation of the welfare state (Harvey, 2005; Reich, 2008; Spies-Butcher, 2014), market specialisation and expansion of market size (Eccles, 1981a, 1981b; Troiani & Dutson, 2021). In the workplace, these factors have resulted in agile responses such as just-in-time labour supply, minimised labour costs, externalised risk, instrumentality, and individualism (Bal & Dóci, 2018; M. Johnson, 2008; Quinlan, 2012; Wilson & Ebert, 2013). In Beck's (2000) thesis, insecurity is the hallmark of contemporary society, where fragmentation of time and space is observed in employment trends, where the number of standard jobs is declining, replacing an increasing demand for non-standard labour and the growing number of temporary jobs. Technological developments coupled with neoliberalism have gradually surpassed state boundaries and work regulations, entrenching transnational capitalism within open, risk-filled labour markets. With challenges intensifying, new and empirically founded knowledge is paramount to effective responses to escalating demands for a flexible labour supply, such as contract work.

1.2.3 Approaches in contract work literature

This study is situated within the literature on contract work, where much research focuses on adverse work conditions. The rise of contract work and self-employment gears towards precarious work (Caraher & Reuter, 2019). Compared to unemployment, contract work provides employment (OECD, 2021) and better health outcomes for individuals (Gebel & Voßemer, 2014). However, compared to standard employment, the lower income in contract work further aggravates precarious working conditions (Holley & Rainnie, 2012; Pfeifer, 2014). EU contract workers face isolation and exploitation, where labour rights are often neglected (Heindlmaier & Kobler, 2022). In the UK, contractors, such as those working as freelance interpreters, endure conflicting invisible work: one as the embedded yet contracted, unprotected outsiders; another as the skilled workers capable of blending in the organisations while masking mistakes; furthermore, as the team collaborators and competitors who sabotage colleagues for the next contracts (Giustini, 2022). Social network structures reduce labour precarity among contractors working in creative industries (Farr-Wharton et al., 2015). However, within self-employed social networks, work-family synergy and conflict affect experiences of engagement and strains (Beutell et al., 2019). Along with precariousness, low income, and labour protection (Arrizabalo et al., 2019; Burrows, 2013; Farr-Wharton et al., 2015; Marín-Sanchiz et al., 2021; Wall, 2015), key concerns include social isolation, job insecurity and inadequate support.

The continuing issues of job insecurity and income (Arrizabalo et al., 2019; ILO, 2016b, 2016a; Quinlan, 2012; Rasmussen et al., 2019; Standing, 2011; Wall, 2015) are common issues in contract work. Job insecurity is associated with low incomes and the lack of social security or unemployment compensation (Arrizabalo et al., 2019), and it also correlates with declined industrial protections (OECD, 2019b). Self-employed workers face higher job and income insecurity than permanent employees, particularly during economic downturns (Ingelsrud, 2021). Due to the COVID-19 pandemic, workers on fixed-term contracts suffered more significant loss of work hours and joblessness than other groups (OECD, 2021). Income insecurity is ongoing for self-employed contractors, particularly those unable to obtain other work (Tammelin, 2019). Perceived job insecurity over extended periods is associated with a higher experience of stress and poorer health (Fehrenbacher, 2016; Virtanen et al., 2011). High emotional exhaustion in self-employed workers increases work exit (Shahid & Kundi, 2021). However, higher psychological capital – such as efficacy, optimism, hope and resilience – could reduce job insecurity in contract work (Chiesa et al., 2018). Beyond psychological capital, questions remain about other aspects of contract work in securing further contracts and facilitating job performance and income security.

Experience of isolation is common in contract work (McKeown & Pichault, 2021). Social connections in contract work are affected by social segregation and marginalisation (Gundert & Hohendanner, 2013), the perception of being a second-class citizen (Boswell et al., 2012), and social conflict associated with insomnia (Sakurai et al., 2014). Irregular workweeks adversely impact contractors' ability to arrange social engagements (Woodman, 2013). Some workers position themselves positively as experts, associated with being free agents, but share the experience of being outsiders or strangers (Bryant & McKeown, 2016; McKeown & Pichault, 2021; Nieminen & Hytti, 2016). In a quantitative study drawing on data collected from 19,859 individuals, Gundert and Hohendanne (2013) conclude that temporary workers experience lower levels of social affiliation than permanent workers. Contractors from ethnic minority groups face racialised challenges in gaining access to networks that can generate contracts (Fenwick, 2012). Connections to networks, such as social connections, are essential to successful outcomes for the contracted work and to improving safe work conditions (Agnello et al., 2015). Under such constrained work conditions, how contractors make the necessary connections to various networks and be successful remains to be more thoroughly examined.

Not all contractors' experiences are negative. Compared to workers employed by organisations, self-employed workers report higher job control and well-being levels, and better engagement when presented with increased learning opportunities; however, they face more challenges in attending events (Bujacz et al., 2017). Contractors who highlight motivation and choice in being pulled – rather than pushed – into contract work, report more positive experiences, such as flexibility and higher income (McKeown & Hanley, 2009). Australian self-employed workers, aged 50 and above, were motivated by pull factors such as available opportunities and social identity (Perenyi et al., 2018). The sense of freedom, recognition, and learning are highlighted in self-employed nursing work in Canada (Wall, 2015). Non-standard workers who value autonomy (Rossetti & Heeger, 2019) in producing cultural works experience freedom in self-determination and self-expression (Banks, 2017; Cnossen et al., 2019). Personality traits – such as goal setting, social networking, emotional resilience, and work drive – correlate to the success of self-employed small business owners (Owens et al., 2013). Talent management practices are applied to standard and non-standard workers to "produce superior outcomes for all" (McKeown & Pichault, 2021, p. 313). As much of the literature on contract work highlights several challenges and some opportunities for contractors, further research is needed to facilitate practices appropriate to the growing prevalence of contract work in different contexts.

The literature further notes contentious issues and constraints relating to learning and contract work. Several constraints relate to training in contract work, including financial constraints (Pauli, 2020), resource scarcity (Coetzer et al., 2012; Nolan et al., 2020; O'Connor & Kelly, 2017), and time limitations (Cedefop, 2019). With contradictions concerning the use of training programs in contract work, existing research overwhelmingly emphasises the importance of learning, approached as training, in contract work. According to the OECD Employment Outlook 2019, the future of work, in particular of non-standard work, is reliant on adult learning where "a major overhaul of adult learning programmes to increase their coverage and promote quality is essential to harness the benefits of the changing world of work" (OECD, 2019d, para. 5).

1.2.4 Definition: contract work and contractors

Several terms are used in the current literature to examine forms of work related to contract work and contractors. Earlier research finds the "terminology denoting self-employed types of boundaryless work becomes blurry: 'freelance', 'contract', 'non-traditional work' and 'self-employment'... Self-employment is a broad category, including business owners/employers as well as independent entrepreneurs producing and selling goods" (Fenwick, 2008a, p. 13). Subsequent research continues to observe that these blurry boundaries have persisted, as McKeown and Pichault (2021) identified that "much of the research in this area provides a confusing conflation of working arrangements" (p. 314). The literature refers to various terms: contracting (Mckeown, 2016), subcontracting (Tang et al., 2018), self-employed (García-Fernández et al., 2020), vulnerable (ILO, 2016c), entrepreneurial (Yin & Jahanshahi, 2018), agency work (Cochrane & McKeown, 2015), consulting (Wye et al., 2015), flexible (Garsten & Haunschild, 2014), boundaryless contract work (Fenwick, 2008a), casual (Nicholas & Wells, 2017), seasonal (Wilson & Ebert, 2013), precarious (Michael, 2015), temporary (Chambel et al., 2015), freelance (Marín-Sanchiz et al., 2021), and contingent (Ekmekci, 2010).

Some challenges with defining the terms "contract work" and "contractor", and subsequently conceptualising learning in contract work, relate to geopolitical differences resulting from various industrial systems and different definitions of contractors. While recognising that terminologies have specific usages within the particular research contexts, some research foci overlap. The International Labour Organisation groups part-time work in the same category as temporary work (ILO, 2014). However, in Australia's highly regulated industrial system, full-time and part-time work are differentiated from casual and contract work. Full-time and part-time workers in Australia are permanent employees, entitled to sick leave, annual leave, superannuation, and benefits that are not available to casual workers or contractors (Ombudsman, 2016b).

Recent literature on contract work includes various strands of research on non-standard work, located within ongoing debates about employment status and how different work arrangements are defined (Bögenhold & Klinglmair, 2016; K. M. Kuhn, 2016; McKeown, 2015; McKeown & Pichault, 2021; OECD, 2019a; Petrescu, 2016). The pervasiveness of the standard employer-employee status, the basis of much of employment law and labour law, is no longer as dominant in labour markets as in the past (Shamir, 2016). According to the OECD (2019c), standard employment is full-time, open-ended employment. Sham contracting or false self-employment hides the nature of the work: full-time, standard employment, yet it is labelled as non-standard, self-employed work. In doing so, such practices avoid regulations associated with employees (ATO, 2017; Ombudsman, 2016a; V. Smith, 2016; Theodore et al., 2006). By 2021, several court cases have been heard in Australia to determine whether workers, such as food delivery riders (Zhou, 2021) and car-share drivers (Patty, 2021), were employees or contractors. The importance of debates clarifying employment status conveys how employment status affects work conditions, labour protections and conceptualisations of such work conditions, including access and responsibility for learning and skills development (Koranyi et al., 2018; OECD, 2019c).

In this study, the term "contract work" is defined as work relating to a self-employed individual "who earns his or her income through the commercial or civil contract and not the employment contract" (Mckeown, 2016). This study defines the term "contract work" as work relating to a self-employed individual "who earns his or her income through the commercial or civil contract and not the employment contract" (Mckeown, 2016, p. 781). Following McKeown (2016), this research defines the

contractor/micro business owner/self-employed person important in terms of

- workers: who work for a living but are not employees.
- businesses: in that they engage in business but are qualitatively as well as quantitatively different to a large or even medium-sized business.
- consumers: in that they buy, use and consume products and services but they are different to other consumers in that they also produce products/services. (Mckeown, 2016, p. 784)

In the Australian context, this definition also aligns with the Australian Taxation Office (ATO) definition, which delineates the dichotomy between employees and independent contractors. The ATO definition clarifies six fundamental tests that differentiate a contractor from an employee where a contractor 1) can subcontract or delegate the work, 2) receives payments based on quotations, 3) provides most of the tools and equipment required for the work, 4) takes commercial risks and is being legally responsible for the work and defects, 5) has control over how the work is done, subject to contract requirements, and 6) operates an independent business and is free to accept or reject work in addition to the contract (ATO, 2020).

1.3 Context: Growth of the solar industry in Australia

1.3.1 Growth of the solar industry

In the context of the worsening climate crisis, the renewable energy sector, particularly Australia's booming and dynamic solar industry, is chosen for this study. By 2020, the electricity generation from renewable energy held 28% globally (IEA, 2020a), a share of electricity generation closely mirrored in Australia at 27% (Clean Energy Council, 2021). By 2025, solar PV is set to grow to 60% of all renewable capacity additions (IEA, 2020b). The importance of conducting research in the solar industry is accentuated by the continuing strong growth of the industry, where a new solar panel is installed every six minutes (Australian Renewable Energy Agency, 2018). As the fastest-growing renewable energy industry in the world (IRENA & ILO, 2023), the solar industry has grown 15 times between 2010 and 2019 (IEA, 2020c). In Australia, over the same period of ten years, the production capacity grew 26.5 times (IEA, 2020c). By 2020, 27% of suitable residential dwellings in Australia had rooftop solar PV (ABS, 2020). Such growth coincided with the declining cost of solar energy (Watt et al., 2018), a saving of 82% between 2010-2019 (IRENA, 2020b), the result of fundamental changes such as government policy and technological development (Kavlak et al., 2018).

1.3.2 Politics of uncertainty

The remarkable growth of this industry emerged amid multitudes of challenges, from government policies to technological advancement. In 2020, Australia placed last on the Climate Change Performance Index for climate policy, along with the United States (Climate Change Performance Index, 2020). This poor record formed part of the politics of uncertainty linked to climate policy paralysis in Australia (Ali et al., 2020). The solar electrical contractors in this study worked with uncertain policies, particularly surrounding the Renewable Energy Target (RET) established in 2001. After lengthy periods of contention and uncertainty in trying to abolish the target (Clean Energy Council, 2020b; Clean Energy Regulator, 2016; Tomaras, 2016), uncertainty remained in the absence of a policy to replace the RET (Clean Energy

Council, 2018a). Amid the lack of a national policy, states and territories administered different renewable energy targets, ranging from having no target in New South Wales to 100% renewable by 2022 in Tasmania (Bourne et al., 2019). Though the Reserve Bank of Australia expected long-term growth of investment in renewable energy, it highlighted that uncertainty placed limitations on investment (de Atholia et al., 2020). As the demands for renewable energy continue to soar, the solar industry leads the sector's growth while facing the dynamic challenges of a relatively new industry (Clean Energy Council, 2021).

1.3.3 Rapid technological advancement

Further, the solar industry has advanced with rapid technological developments, emerging in highly challenging and dynamic contexts (Bibas et al., 2015; Bosetti et al., 2012; Schelly, 2015; A. Smith et al., 2014). Technological advancement involved electrical, mechanical, and chemical micro-technology innovations that affected different aspects of solar PV technologies, from solar cells to energy storage to monitoring devices (Shubbak, 2019). To gauge the rate of technological development, and hence the challenges facing solar electrical contractors in learning to deploy these technologies, patent applications provide a significant indicator of new technological development. The Worldwide Patent Statistical Database 2016b (PATSTAT) recorded exponential growth of technological innovations between 1950 and 2011, when more than 112,000 patent applications related to PV technologies were documented (Shubbak, 2019). During this period, 95% of the innovations were generated outside of Australia, in major Asian economies – Japan, Korea, China, and Taiwan – as well as in the USA, Germany, and France (Shubbak, 2019). Sourcing materials from international networks, Australian solar companies – such as those owned by the electrical contractors participating in this study – mainly utilised imported solar panels, building their business on sales and installation activities (Johnston & Egan, 2015). Australian solar installers faced growing learning demands in responding to technological encounters, many of which were produced overseas.

By 2021, an array of new solar panel technologies competing to increase the efficiency of electricity output had emerged, accompanied by numerous issues (Australian National Audit Office, 2018; Clean Energy Regulator, 2020; M. Green et al., 2021). From the early days of 1873, when the photoelectric effect was discovered, the speed of technological development has been driven by the growing demand for sustainable development, critical technological discoveries, and industry competition (Luan et al., 2020). However, technological improvement engenders technical issues, and industry regulations evolve to adapt to changes in the industry. In Australia, such changes were exemplified in November 2016 when the Clean Energy Council (Clean Energy Council, 2016) removed almost 7000 types of solar panels from the approved products list. By December 2018, about half of the remaining panels had also been removed (Clean Energy Council, 2018b).

The context of this research is embedded in further ongoing contentions. Multiple audits and reports across various Australian states have highlighted persistent work quality concerns since 2011. The Australian National Audit Office reported that about one in five panels installed between 2011 and 2018 was sub-standard, posing high risks due to issues such as faulty wiring and unsecured panels (Australian National Audit Office, 2018). The audit found that of the installers inspected, "768 (45.8 per cent) had at least one of their inspected installations rated as "sub-standard" or "unsafe'" (Australian National Audit Office, 2018, sec. 4.32). The Clean Energy

Regulator (2020) reported inadequate maintenance of installed solar systems and the deficiency of annual service inspections as one of its central concerns. Not only were there technical issues, but there were safety issues relating to educating customers, as consumers were unfamiliar with maintenance requirements.

Technological development demands skilled workers in both the solar and the electrotechnology industries. Innovations assert vital implications on skill demands in the related industries (Australian Industry Standards, 2020). Some of the advancements are concentrated in areas such as renewable energy technologies (particularly battery and energy storage solutions), the Internet of Things (growing with smart buildings, from 25 billion connected devices in 2020 to 75 billion in 2025), digital competence (computer technology, customer-service platforms, and cloud computing) (Australian Industry Standards, 2020). Technological development presents challenges for both licensed and novice electricians (Australian Industry Standards, 2019b, 2020).

1.3.4 Skill shortages and employment in the industry

The solar solar photovoltaic (PV) industry comprises more than one-third of the global green workforce (IRENA & ILO, 2023). This study of solar electrical contract work is located in Australia in an emerging solar PV industry experiencing intense demands for labour. The solar PV industry in Australia, specifically jobs in temporary construction and installation, holds 75% of the labour market for renewable energy (Briggs, Dominish, et al., 2020). Still, the solar industry faces significant skill shortages, particularly for work on small-scale rooftop solar (Briggs, Rutovitz, et al., 2020; Statistics, 2019). Much of the present study's fieldwork was conducted outside of the capital cities, where 70% of employment in renewable energy is projected by 2035 (Clean Energy Council, 2020a).

High demands for electricians have continued in the last decade. In the OECD and North America, electrician jobs are projected to increase by 456% between 2015 and 2025 (Dominish et al., 2019). In Europe alone, one million jobs in solar design and installation are expected to be created by 2025 (SolarPower Europe, 2023). Electricians, as an occupation, are ranked among the top ten occupations in terms of the total number of jobs in Australia (Labour Market Information Portal, 2018). The industry had a large electrical contractor workforce, consisting of micro businesses (< 5 employees) that provide twice the number of jobs per megawatt of residential solar systems compared to larger firms (> 20 employees) (Briggs, Rutovitz, et al., 2020). Demands for electricians and electrical trade assistants remain the highest in the renewable energy industry (Clean Energy Council, 2020a). A significant part of the growth in the solar industry is in small-scale, residential solar work, which is the context of this study.

Despite the strong growth, challenges continue in recruiting skilled workers in the solar industry, including workers working in regional areas similar to the electrical contractors who participated in this study. Summing up the demands for skilled workers in Australia's solar industry, "most small-scale solar businesses face difficulties recruiting accredited solar designers, electricians, electrical trade assistants and roofers, especially in regional areas, yet these are in high demand" (Clean Energy Council, 2020a, p. 27). However, analysing training trends and accreditations, the Australian Industry and Skills Committee (2020) reported only a 24% completion rate. Despite such pressing needs, discussions around solar electrical contractor learning or retraining workers from other industries – such as coal-based industries (Sinden & Leffler, 2016) – are primarily focused on formal training programs. For instance, in transitioning to carbon neutrality, the International Renewable Energy Agency considers the growth of required skills contingent upon additional training, improved curricula, better trainer training, and advancing technology for remote learning (IRENA, 2020a). Beyond training, the development of skilled workers for a green transition is affected by a limited understanding of the environment–skills nexus, adequate employment forecast and financial investments (ILO, 2018).

The relatively new Australian solar industry (Clean Energy Council, 2018a) is subjected to various learning demands concerning the need for renewable energy, technological innovations, safety, evolving policies, and complex global supply networks. Amid the deepening climate crisis and a skill shortage, "maintaining supply of trained personnel in key occupations is likely to remain a challenge whilst the industry continues to grow so strongly" (Briggs, Rutovitz, et al., 2020, p. 63). To complement such training of key workers, it is crucial to study how workplace practices emerge in such dynamic contexts within this demanding industry, a context of rapid growth, evolving participants, changing policy, and technological complexity, where consumers are adversely affected (Consumer Action Law Centre, 2019). The highlighted issues further warrant attention in this research area.

This research is situated within the context of the effects of the climate crisis, where the catastrophic 'Black Summer' fires of 2019-2020, the worst fire season on record, burned across 46 million acres in Australia, killing about three billion animals (WWF-Australia, 2020). The worsening economic crisis also disproportionately impacted insecure work (OECD, 2020), where Australia's COVID-19 pandemic caused about one million job losses (Farrer, 2020). To promote renewable energy in the context of the severe challenges of climate change, technological development should align with critical research in the social sciences to influence various research projects, policies, legislations, and the adoption of new technology (Shubbak, 2019).

In addressing the multitude of challenges, "learning is crucial for the cost declines [of low carbon technologies] and global deployment needed to address climate change" (Lewis & Nemet, 2021, p. 2). In particular, understanding the learning involved in non-hardware costs, which account for 60% of installation costs – such as installation labour, customer acquisition and supply chain – requires urgent attention (Gao et al., 2022). Growing demands for renewable energy and insecure work are highly relevant to the context of this study, as there is a need to explore how electrical contractors learn, where their work presents a multitude of changes and demands changing and adaptive practices. There is a clear scarcity of literature on learning and electrical contractor work in the rapidly expanding solar PV industry. This urgent gap in the knowledge will be discussed in Chapter 2, a review of the relevant literature. Addressing this knowledge gap in this study provides a timely and significant contribution to the fields of workplace learning, learning in contract work, and their position in the solar industry.

1.4 Key literature and existing knowledge gaps

Workplace learning debates, particularly since the 1990s, have evolved into a highly diverse field, drawing on various research fields such as psychology, sociology, and labour studies (Fenwick, 2006, 2010; Olsen & Tikkanen, 2018). The literature on workplace learning can be categorised based on three learning metaphors, corresponding to three categories of learning theories influenced by psychological, sociocultural, and postmodern theories (Hager, 2011; Hager & Beckett, 2019). Much of the current literature on learning in contract work and learning in the solar and construction industries examines learning as training and individual acquisition (Brooks & Urmee, 2014; Eggerth et al., 2018; Idris et al., 2020; McKeown, 2015; Ripamonti & Scaratti, 2015; T. D. Tsoutsos et al., 2013) or as sociocultural participation (Fenwick, 2012; Lefebvre et al., 2015; Neij et al., 2016; Nolan & Garavan, 2016; Vlachos, 2020). Instead of limiting learning to individual learnings or social groups, by approaching learning as emergence, a growing body of studies in workplace learning (Gherardi & Nicolini, 2000b; Scoles, 2018; Thompson, 2011, 2012) drawing on distinctive ontological and epistemological conceptualisations finds significant learning emerges in everyday practice. Much of the extant literature neglects the interconnection between contracts and learning in all three sets of literature. Despite the increasing prevalence of contract work, how contractors learn in the workplace remains poorly understood, limited by the dominant acquisition and participation metaphors of learning.

Operating in increasingly connected, global markets, contract work is no longer about discrete organisations requiring the service of independent, isolated contractors. With changing working conditions in many industries, accelerated by rapid technological development (Tarhini et al., 2015), contract work is inherently unstable, resulting in negative outputs where, for example, one in ten solar PV installation contracts in the US are cancelled (Cook et al., 2021). The dynamic nature of contract work produces unique, poorly understood learning challenges, individual contractors lack resources, and organisations have not provided adequate support for contractors (Brooks & Urmee, 2014; Johnstone et al., 2005; Ryan et al., 2013).

Education should, therefore, be reconceptualised, with the focus shifting from front-loaded education in institutions to a "system in which skills are continuously updated during the working life to match changing skills needs" (OECD, 2019c, p. 7). This research contributes new knowledge by examining how learning is enacted in the everyday practices of contract work beyond the dominant preference for training programs. This knowledge is essential in supporting contractors and organisations engaging in contractor work and is urgently needed to address learning challenges in practice to mitigate the climate crisis.

1.5 Research questions

As will be established in subsequent overview sections, this study aligns the research gaps identified in the literature with the theoretical framework, methodology and analysis (Chenail, 1997). The central research question to address the vital research gap is:

> How is learning in contract work enacted in solar PV installations?

In answering this central research question, the analysis also addresses the following subordinate questions:

> How are contracts enacted in practice?
>
> How is learning enacted in solar PV installing practices?

The aims of this study are, therefore, to:

1) illuminate how learning occurs in contract work,
2) use ANT to illuminate learning in practice, and
3) identify how electrical contractors learn while working in the solar industry.

The associated objectives are to:

1) generate new knowledge about workplace learning and learning in contract work,
2) articulate new knowledge about how electrical contractors learn in the solar industry, and
3) contribute practice recommendations for the industry.

1.6 Conceptual and methodological overview

This study is grounded firmly on a substantial body of research using ANT (C. Adams & Thompson, 2016; Bueger, 2013; Callon, 1999a, 2014; Fenwick et al., 2011a, 2011c; Fenwick & Edwards, 2013, 2018; Latour, 2005; Law, 1992, 1999; Michael, 2017a; Mol, 2010) which elucidates new insights into previously invisible, yet highly powerful aspects of work. Drawing on a well-established ANT ontology and epistemology, this study benefits from ANT's unique sensibility towards network effects and sociomaterial actors, including the powerful and mundane, in workplace learning, avoiding the dominance and limitations of human-centric foci in the existing literature. Through the lens of ANT, the qualitative methods of observation, interview, and document review are used to generate rich and detailed data on everyday practices across 12 solar installation sites in Australia, comprising 35 days of solar installation. The sites involve four solar electrical contractors working over a period of eight months. The fine data generated includes 395 typed pages of 303 hours of observation and 24 interviews, along with documents such as quotes, drawings, emails, manufacturing information, audit reports, industry publications, and media coverage. In drawing on ANT concepts of network effects, human and non-human actors, this study traced contracts and solar installing practices connected to the mounting systems. Thus, the research design featured rich accounts of workplace learning (Hopwood et al., 2014; Hyland, 2002). In investigating contract work and learning, this study enriches and extends the broader discussion about the nature of workplace learning, casting new light on the constantly changing interface between work and learning.

1.7 Significant findings, contributions, and implications

Significant findings

Based on the extensive database of empirical evidence, this thesis establishes several significant findings to answer the research questions. The findings that answer the first subordinate question are that, firstly, contracts are enacted as both matters of fact and matters of concern. Secondly, five salient contracting practices enact the contract: 1) establishing contracts based on trusted networks of connections, 2) appraising sociomaterial requirements connected to the customer and the work site, 3) arranging sociomaterial resources needed as the work unfolds, 4) connecting the customer to significant sociomaterial changes arising as the work unfolds, and 5) enacting sociomaterial assemblages as services additional to those contracted. To answer the second subordinate question, the study found that learning is enacted in different connection efforts in re-forming, mutating, and persisting networks. In answering the central research question, the thesis found evidence of learning as crafting-forward of contract work. This novel conceptualisation has three components: 1) entwined contracting and installing practices oriented towards completing the current contract, building reputation, and fostering future referrals, 2) four conditions of learning in contracting practices – related to matters of fact and matters of concern, that they a) matter, b) are liked, c) are populated, and d) are durable, and 3) learning in tinkering in installing practices, enacted in different connection efforts in re-forming, mutating, and persisting networks.

Empirical and conceptual contributions

The important contributions of this thesis are an extensive empirical study of learning in contract work and new knowledge of learning as crafting-forward in contract work. As an empirical study, this research generated an extensive dataset from everyday practices involving sociomaterial actors and contributes to the literature that is predominantly human-centric, focusing on learning as acquisition in training programs and social participation. Further, as contracts have been mostly neglected in the literature on workplace learning, this thesis offers an empirical examination of how they are enacted in relation to learning. This research enriches the literature by addressing the critical knowledge gap about "contract-appropriate practices" (Scheel et al., 2014, p. 750). This empirical study also contributes a study of contract workers, specifically solar electrical contractors, who are trade workers and have been given scant attention in the existing literature. As small business contractors, trade workers often operate without structured learning support and have limited resources for training (Idris et al., 2020; ILO, 2016). This study offers new knowledge that responds to the learning challenges facing contemporary industries that increasingly rely on trade workers. Considering the literature on workplace learning, this study contributes a unique empirical study of workplace learning specific to the context of contract work and solar PV installation.

This thesis contributes a new conceptualisation of learning as crafting-forward in contract work. This substantial contribution is built on several unique conceptual contributions. By conceptualising contracts as both matters of fact and matters of concern, this new knowledge contributes a new way to view contracts, not as multiplicity, but in terms of composition, a shift of the gaze from the stage to the theatre (Latour, 2005). This contributes to the ANT literature that examines the multiple ways actors are enacted (Law & Singleton, 2014; Mol, 2002; Stewart, 2014). This study also contributes to Latour's (2005) concept of four conditions for matters of concern, by extending it to refer also to matters of fact involving the four conditions of learning in contract work. Another original contribution of this thesis is conceptualising different ways learning occurs in re-forming, mutating, and persisting networks in relation to different connection efforts (Latour, 2005), and in doing so, this study offers a new way to understand the movements of actors beyond Callon's (1986) four moments of translation. Further, by conceptualising learning as being enacted in different connection efforts in re-forming, mutating, and persisting networks, this research adds new knowledge to conceptualising learning as emergence. By conceptualising learning as crafting-forward, this study contributes the concept of orientation to the existing conceptualisation of learning in practice in terms of the six strands (Reich & Hager, 2014).

Before this study, knowledge of learning in contract work was articulated dominantly in terms of acquiring training or the skills and ability of the owner or participating in social connections. In advancing the field, this thesis contributes the theorisation that learning in contract work involves a reconceptualisation of learning as crafting-forward.

Implications

This study has several implications for future research, individual self-employed contractors, and organisations. Future research can use the conceptualisation of learning as crafting-forward to study other types of contract work and solar installation work, as well as a broader range of demographics – for instance, contractors working in installations larger than 100kW, sub-contractors, contractors in the mining and solar disposal sectors, female contractors, minority workers, and workers with specific needs. Individual self-employed contractors such as solar installers can expand their understanding of learning beyond attending training programs and connecting to people, to being attentive to the different ways learning as emergence occurs in everyday contract work in re-forming, mutating, and persisting networks. By approaching contracts as more than rigid agreements, contractors can consider the emerging changes and educate their customers on how contract unfolds. In viewing learning as crafting-forward, contractors can use the knowledge that future contracts rely on reputations shaped by quality work, completed not only by the careful enactment of installing or technical practices but also by the attentive performance of the five key contracting practices directed towards agreements that are malleable as the work progresses. Organisations working with and for contractors may use the findings of this study to firstly question the dominance of learning as acquisition in training programs and consider that training does not equate to learning. Secondly, the findings of this study have implications for how organisations articulate how the learning that occurs in everyday practice as crafting-forward in contract work, being attentive to how contracts are enacted and to different ways of learning is enacted as network effects in connection to changes at work sites, in organisations or industries.

1.8 The researcher and the research

The impetus of this research began with my professional experience as an employee and a contractor working in developing organisational learning. It is also inspired by my master's degree research into workplace learning and a nine-month internship at a major solar installation company. Furthermore, with six years of experience working as a contractor in sectors such as energy and construction, I can relate my experience to the issues discussed in the literature from the perspectives of both contractors and organisations. My master's degree provided insightful theoretical frameworks for reflection on my professional experience. With the realisation that there is a significant gap in knowledge on contract work and living in a climate crisis, I recognised a pressing need for further research to investigate learning in contract work in renewable energy industries such as the solar industry.

1.9 Structure of the thesis

Each of the seven chapters of this thesis advances the central arguments of this research, following the sequence commonly deployed in PhD dissertations: introduction, literature review, conceptual and methodological framework, findings (two chapters), discussions, and conclusions. Following this Introduction Chapter, Chapter 2 situates the thesis within three sets of literature: workplace learning, learning in contract work, and learning in the solar and construction industries. Three metaphors are drawn upon to conceptualise workplace learning in the literature: acquisition, participation, and emergence. The chapter develops the argument that it is critical to investigate learning as emergence in contract work beyond the predominant focus on acquisition and participation approaches in the literature.

Chapter 3 concentrates on ANT as a conceptual and methodological framework and positions this thesis in the broad debates on ontology and epistemology related to ANT. As ANT is considered a sensibility or a method, the traditionally separated chapters on theory and methods are combined here. An overview of ANT in this chapter is followed by an explanation of three key concepts: 1) humans and non-human actors, 2) network effects, and 3) matters of fact and matters of concern, followed by a description of how learning is defined in this ANT research. Details of praxiography and fieldwork are presented, and the chapter closes with descriptions of the induction analysis process and ethical considerations.

Two chapters are devoted to the major findings of this empirical study. Chapter 4 engages with the findings that answer the first subordinate question, "How are contracts enacted in practice?" By tracing contracts, this chapter discusses in rich detail the evidence underlining the central argument that contracts are enacted as both matters of fact and matters of concern. The analysis of each contract further reveals five salient contracting practices. Chapter 5 answers the second subordinate question, "How is learning enacted in solar PV installing practices?" Focusing on installing practices, this chapter analyses the mounting systems as tracers. The chapter argues that learning is enacted in different connection efforts in re-forming, mutating, and persisting networks.

With the detailed descriptions of the empirical evidence in the previous two chapters, the thesis progresses to the discussions in Chapter 6 to answer the central research question, "How is learning in contract work enacted in solar PV installations?" This chapter draws on the two findings chapters to establish a new conceptualisation called learning as crafting-forward in contract work. The chapter opens with a discussion around crafting in terms of quality work and the forward orientation of contract work. Chapter 6 then expands the concept of crafting in terms of learning in contracting and installing practices before bringing them together to concentrate on learning in entwined practices.

Chapter 7 concludes the thesis, gathering the insights developed throughout the previous three chapters in a summary of the answers to the research questions. The chapter then highlights the empirical and conceptual contributions of this thesis before discussing accountabilities, trustworthiness, and quality of research. After acknowledging the study's limitations, the chapter considers the implications of this research and offers final reflections.

The next chapter, Chapter 2, reviews the existing research in three sets of literature: workplace learning, learning in contract work, and learning in the solar and construction industries.

2 LITERATURE REVIEW

2.1 Introduction

This chapter situates the thesis within three sets of literature: workplace learning, learning in contract work, and learning in the solar and construction industries. The literature on solar and construction industries is included in this review since solar PV installation work in Australia is subject to the standards and codes of conduct required for solar PV installation and building construction. Considering the terrains of the extant literature, this chapter argues that there are significant and critical knowledge gaps about how learning is enacted in contract work in solar PV installations. Three metaphors are drawn upon to conceptualise workplace learning in the literature: acquisition, participation, and emergence (Hager, 2011). The chapter develops an argument for the focus of this study: an investigation beyond the substantial concentration of acquisition and participation approaches in the literature on learning in contract work and on the solar and construction industries, addressing a significant neglect of how the contract is conceptualised in relation to workplace learning.

Chapter overview

This chapter begins with Section 2.1, which presents the scope of the literature and the deployed search strategies, followed by three major sections. Section 2.2 discusses the literature on workplace learning using the three metaphors. Section 2.3 considers learning in contract work, and Section 2.4 focuses more specifically on learning in the solar and construction industries. The chapter closes by returning to Hager's (2011) metaphors of workplace learning in Section 2.5 to discuss significant gaps in the literature on contract work and the literature on learning in the solar and construction industries. This final section summarises the major approaches to learning in contract work in the literature. It reviews significant aspects of learning in contract work that remain unaddressed, highlighting the critical oversight of how the contract relates to workplace learning.

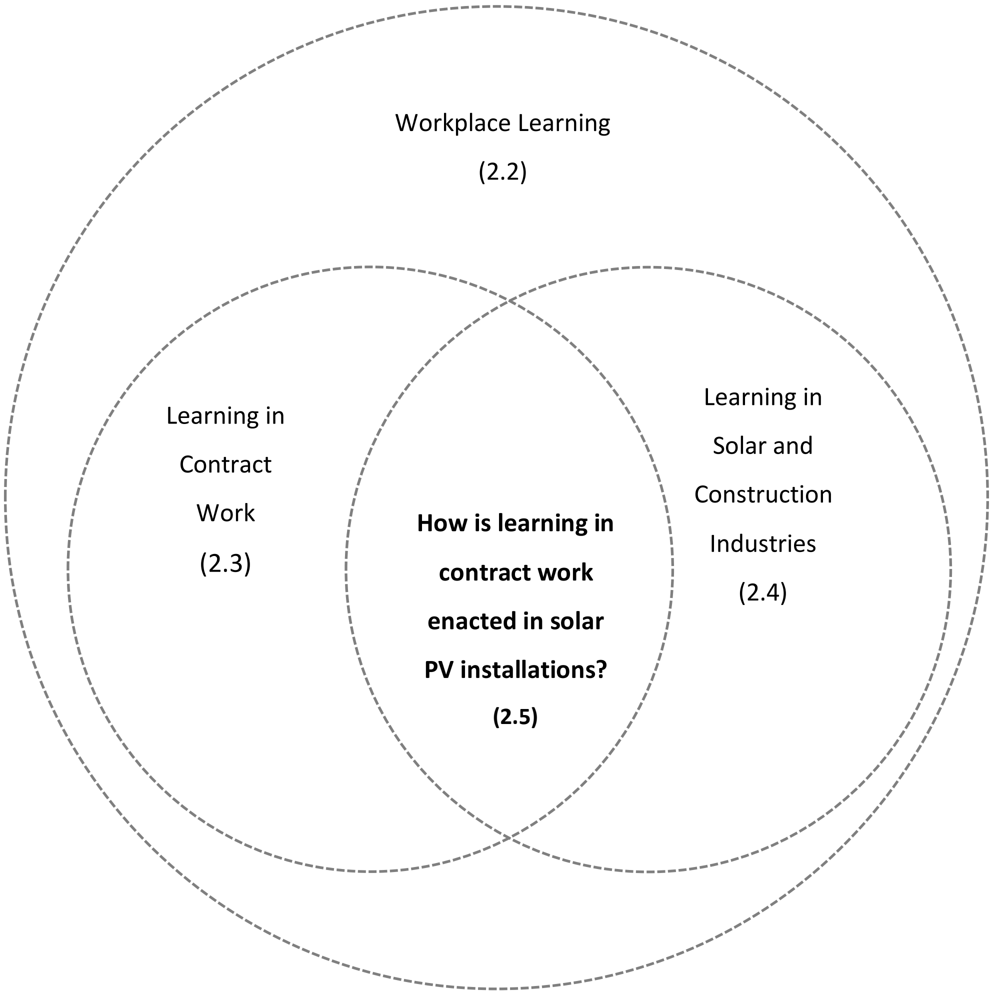
2.1.1 Search strategies

The literature in this review – written in English and published mostly between 2012 and 2022 – is drawn from peer-reviewed journal articles, books, book chapters, reports, and theses. The databases searched include ProQuest Central, Springer, SAGE, Wiley, and JSTOR, as well as Google Scholar, the OECD Library, and VOCEDplus (a database produced by the Australia-based National Centre for Vocational Education Research – NCVER). Highly relevant journals such as the *Journal of Workplace Learning* and *Studies in Continuing Education were also specifically targeted and accessed.* Further, reference lists were also mined for any relevant articles.

2.1.2 Scoping the literature

The scope of this review involves field-based and definitional aspects. The topics covering the field-based aspects include 1) the literature on workplace learning, 2) the literature on learning in contract work, and 3) the literature on learning in the solar and construction industries, emphasising the contract work in these industries. Figure 2.1 visualises the relationships between the three fields of literature.

Figure 2.1 The Literature Sets and Structure of Chapter 2



The following discussion outlines the scope of each of these fields. First, the literature on workplace learning draws from remarkably diverse research fields in the humanities and social sciences. These fields include adult education, labour studies, human resource development, psychology, philosophy, and sociology (Fenwick, 2006, 2008b; Illeris, 2003; Reich & Hager, 2014; Tynjala, 2008; Tynjälä, 2013). This chapter includes the literature on these fields, focusing specifically on work and learning.

A short note on whether training programs should be included in a review of workplace learning as there are two approaches to consider. Informal learning, for example, can be defined as "a phenomenon that is *not* the result of some planned and structured educational or training activity" (Boud & Rooney, 2018, p. 135). However, there are other conceptualisations which include studies that approach workplace learning as formal training opportunities *and* informal learning (Brandi & Iannone, 2020; Hemmler et al., 2023; Tynjala, 2008). Including the full range of training programs in this review on workplace learning allows for an examination of a dominant approach in the literature on learning in contract work.

Second, on the definitional aspects of scoping, within the literature on learning in contract work, its scope is bounded by how contract work is defined. One significant challenge in selecting and reviewing the literature is how contract work is defined and studied. As discussed in Chapter 1, for more than a decade, many studies have noted that the field of contract work has not had clear boundaries and unified definitions (Fenwick, 2008a; ILO, 2016a; Laß & Wooden, 2020; Leighton & McKeown, 2015; Mckeown, 2016; McKeown & Pichault, 2021). Given the complexity of work arrangements related to contract work, a clear definition is needed to demarcate the scope of the literature relating to contract work.

Contract work in this study is defined in relation to a self-employed individual "who earns his or her income through the commercial or civil contract and not the employment contract" (Mckeown, 2016, p. 781). Following McKeown's (2016) definition, the present study also defines the:

> contractor/micro business owner/self-employed person important in terms of them being:
>
> - workers: who work for a living but are not employees.
> - businesses: in that they engage in business but are qualitatively as well as quantitatively different to a large or even medium-sized business.
> - consumers: in that they buy, use and consume products and services but they are different to other consumers in that they also produce products/services. (Mckeown, 2016, p. 784)

This definition aligns with how contract work is defined in Australia, where the data for this research was gathered: solar electrical contractors who worked as both individuals, self-employed contractors, and small businesses. This definition is applicable here because it clarifies that contract work involves commercial contracts; it further sets the size boundary in that these businesses are not large or medium-sized; it allows the scope to include individual contractors who are also businesses; and it highlights that contractors are also consumers who can rely on networks of suppliers for their tools and equipment – an aspect that applies to the solar electrical contractors participating in this study's Australian context.

Based on this definition, the scope of the literature review of this research includes studies that refer to the contract work performed by individuals or businesses – micro businesses and small businesses, as well as small-medium enterprises (SMEs). Unlike some studies that consider only solo self-employment (e.g., Olazabal & Avila, 2022; Rossetti & Heeger, 2019; Tammelin, 2019; Vries et al., 2019), the studies included here also examine self-employed contractors and contractors who employ staff as well as engage subcontractors (ATO, 2018, 2020). To summarise, this thesis examines self-employed contract workers and the literature on micro, small businesses, and small-medium enterprises (SMEs), where most participants are from small businesses.

Due to the variety of the terminologies deployed in the literature on contract work, this review is inclusive of research identified using the keywords "contract work" and "contractors", as well as studies that do not use these keywords but instead centre on "self-employed", "micro-business owner", "sole traders", "contingent workers", "entrepreneurs", "consultants", "freelancers", and "temporary workers". Also integrated in this review are studies whose participants are self-employed owner-managers working in micro-businesses, small businesses, and SMEs.

Third, apart from searching the literature for studies using keywords such as "workplace learning", "work and learning", "learning", "training", and "knowledge", the search also involved keywords related to the relevant industries solar industries, such as "solar", "solar installer", "trade work", "tradesmen", "tradeswomen", "electrician", "electrical" and "construction".

The literature search scope also involved exclusions. These were studies of learning in large organisations, as well as studies of medium and small businesses that do not gather data from a majority of participants who work as contractors, self-employed people, owner-managers, or participants who perform one of the other forms of contract work. Also excluded are studies on contract work in the three fields (workplace learning, learning in contract work and the relevant industries) that draw data from schools, e.g., entrepreneurship education in schools (Ruskovaara &

Pihkala, 2015), and university settings, e.g., undergraduate small business schools (J. E. Johnson & Jordan, 2019).

2.2 Learning as acquisition, participation, and emergence

2.2.1 Three metaphors of learning

This chapter draws on Hager's (2011) conceptualisation of the literature on workplace learning, delineating three categories of learning theories. Without implying mutual exclusivity, these categories correspond to three metaphors of learning, influenced by psychological, sociocultural, and postmodern theories. Writing at the end of the 90s, in a highly influential paper, Sfard (1998) observed the literature offered a range of competing learning theories, lacking an overarching perspective. She advocated for using metaphors to provide an overview of the learning theories of the time. Instead of the traditional and common account of learning as a product – centring individuals who process knowledge as a stable thing in instructional contexts classroom – and the later view of learning as process, the account of learning metaphors is valuable because carefully chosen metaphors reveal significant assumptions and differences underlying a range of learning theories, enabling this research to advance knowledge beyond common and uncritical approaches to learning.

Extending Sfard's work, Hager emphasises the importance of metaphors for understanding workplace learning, where metaphors are "unavoidable" (Hager, 2005, p. 842), a significance carrying a sense of "inescapability" (Hager & Beckett, 2019, p. 118). Specifically valuable to the present study, the three metaphors offer a way to critically evaluate the existing literature, revealing the dominant use of the first two metaphors in the existing research on learning in contract work, and illuminating a significant gap of knowledge that is the limited research using the third metaphor in learning in contract work in the solar industry. Considering the importance of such use of metaphors, in this chapter, the three metaphors are applied as one significant organising principle: the metaphors of learning as acquisition, learning as participation, and learning as emergence, with "no claim on exclusivity of the metaphors" (Sfard, 1998, p. 6).

The three metaphors of learning correspond to psychological, sociocultural, and postmodern theories. The acquisition metaphor denotes psychological theories' influence on workplace learning conceptualisations (Bandura, 1977; Maslow, 1943; Schön, 1983; Skinner, 1953). In contrast, challenging psychological theories by approaching learning as participation, sociocultural theories (J. S. Brown et al., 1989; Chaiklin & Lave, 1996; Lave & Wenger, 1991) situate learning within cultural and historical contexts. The latest approach – referred to as post-modernist in Hager's categories – relates to post-Cartesian theories (B. Green, 2009) and also recently referred to as practice-based and sociomaterial theories (Edwards & Fenwick, 2015; Reich & Hager, 2014). The present research is established upon the foundations of this third category of learning theories, which approaches "workplace learning as emergent" (Hager, 2011, p. 27). That emergence is a metaphor appropriate to Hager's categorisation and is valuable because, as he argues:

> if emergence becomes an accepted feature of learning then we will require new metaphors to advance our understanding. The two most influential metaphors of learning, acquisition and participation, that Sfard (1998) argues underpin most educational thought, are clearly limited once the temporal dimension is

> acknowledged. If metaphors such as engagement, (re)construction, emergence or becoming, all look to be more promising. (Hager, 2011, p. 27)

Where metaphors are necessary for deliberations on learning, the three metaphors feature the fundamental contestations for definitions of learning, specifically workplace learning. Hager's (2011) conceptualisation traverses the literature on workplace learning, where the concept of learning is "extremely slippery in meaning and enactment" (Fenwick & Edwards, 2013, p. 54). The following three sections examine learning as acquisition, participation, and emergence. As mentioned, the last section of this chapter will revisit this conceptualisation to examine the assumptions underlying the literature on learning in contract work and on learning in the solar and construction industries.

2.2.2 Learning as acquisition

In Hager's (2011) overview, since the industrial revolution, approaches to workplace learning as acquisition have been influenced by psychological theories such as behaviourism and cognitive theory (Argyris & Schön, 1978; Bandura, 1977; H. L. Dreyfus et al., 1986; Maslow, 1943; Pavlov & Gantt, 1941; Skinner, 1953; J. B. Watson, 1928). Learning is viewed as thinking, as mental acts of knowledge acquisition. Focusing on the individuals' acquisition, formal training rooms are highlighted as the sites of learning for work (Hager, 2011). Sfard (1998) identified the acquisition metaphor as a metaphor where "the language of 'knowledge acquisition' and 'concept development' makes us think about the human mind as a container to be filled with certain materials and about the learning as becoming an owner of these materials" (p. 5). As will be shown in subsequent sections, the particular attention on training courses remains dominant in the literature on learning in contract work and learning in the solar and construction industries.

The acquisition metaphor is prominent in learning theories such as competency-based training (Hodge, 2014; E. Smith & Keating, 1997), the reflective learner (Schön, 1983, 1987), and single and double-loop learning (Argyris & Schön, 1978; Pedler & BurgoyneT., 1997). With the underlying assumption common across these psychological-based approaches that learning is located in the individual learners, knowledge is then acquired by the individual endowed with behavioural expressions or cognitive abilities. For instance, Dreyfus et al. (1986; 2004) approached learning as a five-stage model of adult skill acquisition – novice, advanced beginner, competent, proficient, and expert. Each of the stages includes a component of learning that is context-free. More recently, the acquisition approach has been used to examine, for example, the effectiveness of training programs on safety (Eggerth et al., 2018).

Hager (2011) notes the literature that approaches learning as acquisition attracts criticism based on three common assumptions. These assumptions are about 1) the individuals as learners and as the units of analysis, 2) learning as an enduring product, and 3) learning as independent of contexts. In locating learning in the individual learner, a sub-assumption is that learning is in the mind or the body of the learner, leading to another assumption that learning, as mental propositions, can be acquired and transferred. As learning can be acquired, learning is also assumed to be a product, separate from the contexts of learning. Detached from the learning environment, learning such as generic knowledge can be deemed to be universally acquired and applied in diverse geographical contexts. From the individual learner to viewing learning as a product, independent of contexts, these assumptions rely on the

Cartesian dualism of the separation of the mind from the body. Many of these assumptions are challenged when learning is conceptualised as participation and emergence. Approaching learning as acquisition overlooks broader social and cultural contexts of learning that are featured when learning is conceptualised using the metaphor of participation.

2.2.3 Learning as participation

Challenging the three mainstream assumptions in viewing learning as acquisition, sociocultural approaches consider learning as participation. Since the 1980s, the literature on workplace learning has drawn on sociocultural theories to contextualise workplace learning, understood as the participation metaphor (Hager, 2011; Hager & Beckett, 2019). In questioning the notion of de-contextualised learners, sociocultural theories bring attention away from individual learning to highlight individual participation in social learning. Instead of the assumption of learning as acquiring a product, learning as participation is viewed as a process. Central to the participation metaphor is the fundamental view of learning as a process situated in conditions embedded in historical and cultural contexts.

By examining the learner in context, learning is conceptualised in several ways. The unit of analysis is no longer solely the individual but the individual as situated within the social (J. S. Brown et al., 1989; Chaiklin & Lave, 1996; Lave & Wenger, 1991). Approaching learning as participation also considers the social context of collaborative work and recognition of best practices (DiMaggio & Powell, 1983; Kraatz, 1998) and the socio-historical context of activity (Engeström, 2000; Engeström & Kerosuo, 2007). Moreover, learning is also understood as an expansive-restrictive continuum between context and participation (Fuller & Unwin, 2010). Sfard (1998) observes the sociocultural context as "rich and multifarious, and its importance is pronounced by talk about situatedness, contextuality, cultural embeddedness, and social mediation" (p. 6).

Notably, Jean Lave and Etienne Wenger (1991) continue to be the critical theorists who transformed research in workplace learning and examined learning beyond the learners' heads. Their seminal book examining learning as participation analysed five ethnography studies to challenge the acquisition approach, such as formal learning contexts or simply learning as acquiring facts. The authors argue for situated learning in communities of practice as legitimate peripheral participation. They make the critical contribution that learning is "to move toward full participation in communities of practitioners" (Lave & Wenger, 1991, p. 29).

Recent research has examined specific aspects of learning as participation, finding, for instance, that key members in an organisation, such as leaders and managers, are instrumental in facilitating learning in daily work (Wallo et al., 2022). However, learning also occurs among various members of communities through storytelling, for example, about safety knowledge (Goodbrand et al., 2021). Furthermore, learning happens in contexts, between partners such as professionals and their clients (Hopwood & Mäkitalo, 2019; Hopwood & Nerland, 2019). While learning occurs within sociocultural contexts, in workplaces, and involving team members and clients, emerging changes in the social, cultural, and material contexts and contractual agreements remain under-examined.

In considering the focus away from the individuals' acquisition and turning to social participation, Hager (2011) is contented that the metaphor of learning as participation also dismisses several related assumptions. Viewing learning as participation rejects the Cartesian dualism, and instead, learning is viewed as embodied. Research foci are also withdrawn from the view of learning as predominantly rational and propositional and bring learning contexts to the forefront. Learning beyond the individuals becomes possible in the collective learning of groups, teams, and organisations. Learning as acquisition is no longer assumed to be the de facto approach, and the associated assumptions, common and mainstream, are re-examined when the conceptualisation of learning is expanded to include the metaphors of participation and, subsequently, emergence.

2.2.4 Learning as emergence

For the literature on learning as acquisition and participation is substantial and widely influential, a growing body of research in workplace learning has offered radical challenges to these two approaches to learning. In this third metaphor of learning, analogous the participation metaphor, learning is no longer limited to an individual learner nor a product to be acquired but extended to the broader contexts. Underlined by emergence as the metaphor for learning, research interrogates learning in relation to changes and unpredictability in connection to not only humans but also non-humans. Hager (2011) understands that considering "workplace learning as emergent" means that "learning should be viewed as an ongoing process, i.e., it is characterised by temporal change. But as well, they view this change as not fully decidable in advance. Learning is emergent from its context in unanticipated and unpredictable ways" (p. 27).

Hager (2011) regards the third wave of learning theories as the postmodern theories of workplace learning, influenced by research on emergence, for instance, Bhaskar's work on educational philosophy (Scott & Bhaskar, 2015) and Hager and Beckett's (2019) more recent work on complexity theory and co-present groups. Influential in this third wave of theories is also Karen Barad's (2007) well-established work, which challenges the long-held tradition of assuming knowledge as the relationship between objects, representations, and the learners. Instead, Barad considers not only that "*practices of knowing are specific material engagements that participate in (re)configuring the world* [emphasis in original] (Barad, 2007, p. 91). Knowledge is not a pre-existing, separate entity waiting to be acquired or participated in, nor an object that can be reflected in the subjective learners but emerges in practice, in the entanglement of intra-action and diffraction (S. L. Brown et al., 2020; Murris, 2022).

This third wave of research in workplace learning, where this thesis is located, examines learning as practice-based within the complexity and changes emerging from the unfolding of everyday activities in the workplace (Hager, 2011; Hager & Beckett, 2019; Reich & Hager, 2014). Learning as emergence is not viewed as an objective, unchanging reality, external to work practices. One articulation shaped by the metaphor of learning as emergence, workplace learning arises in terms of six strands (Reich & Hager, 2014): knowing-in-practice (Gherardi, 2009a), social and material (T. R. Schatzki, 2012), embodied (Hopwood & Clerke, 2012), relational (Nicolini et al., 2018), situated in history and fluctuating contexts (T. R. Schatzki, 2006), and emergent (Hopwood, 2016). Among the leading scholars of practice-based research in workplace learning are Silvia Gherardi and Davide Nicolini. Their research, for example, includes observational data from several studies on safety practices (Gherardi & Nicolini, 2000b). The authors used ANT to argue that learning is situated in ongoing practices involving heterogeneous actors, such as concepts, artefacts, texts, persons, and norms. Learning, as Gherardi and Nicolini (2000a) phrase it succinctly, is "realized in practice" (p. 8).

Practice-based approaches are particularly advantageous for studies of learning in workplaces that face a growing prevalence of contract work, which is relevant to industries in Australia, such as the relatively new solar industry. As discussed in Chapter 1, the solar industry is fraught with contentions and unpredictability: political uncertainty, rocketing demands, and continual technological development. This thesis, therefore, addresses a critical knowledge gap in the literature by approaching learning as emergence in practice, focusing on how learning relates to contracts, specifically in the solar industry.

As discussed above, within the broad literature on workplace learning, three significant research trends, categorised using the metaphors of acquisition, participation, and emergence, have continued to challenge and advance our knowledge of learning in general and, more specifically, in workplace learning. The three metaphors remain powerful in shaping critiques of the literature on learning, and they will be revisited in the concluding section of this chapter to guide a critique of the literature on learning in contract work and learning in the solar and construction industries. Before then, as this thesis examines learning in contract work, the following section discusses the major themes identified in this literature.

2.3 Learning in contract work

This section analyses the literature on research conducted in the field of learning in contract work, establishing three significant approaches. First, the focus on training programs – of the studies that have examined learning in contract work, the majority have focused on training: the benefits and issues with training. Second, the importance of the self-employed owners' influence – this deals with the literature on the vital roles of self-employed owners, both in the accessibility of training programs and facilitating a learning environment, focusing on the owners' skills and strategies. Third, the significance of connecting networks – the relationship between learning and networks is explored in terms of the learning in networks that sustains work opportunities, learning within teams, extended networks, online networks, and managing contradictions.

2.3.1 Training programs

Positive effects of training

While much research in workplace learning has focused on employees – see, for example, Watson et al. (2018), Forssberg (2020), Yeo and Li (2022) – existing research on learning in contract work has focused on formal learning opportunities provided by training programs. Viewing learning as acquisition, several studies have established the positive effects of contract work training for workers and organisations working with contractors. For workers, outcomes include improvement in engagement and well-being. The self-employed workers who gained training opportunities while working in high-skilled creative jobs, reported higher engagement and well-being when compared to employees (Bujacz et al., 2017). The training programs provided by the Project GATE (Growing America Through Entrepreneurship) supported unemployed participants in gaining and sustaining self-employment (Michaelides & Benus, 2012). These two studies indicate that acquiring knowledge and skills from training programs can positively impact individual contractors' working experience and employment outcomes.

The literature has also highlighted positive effects related to training for organisations that work with contractors. For instance, while working for an insurance company, temporary staff who received training improved performance and revenue for their client organisation (Lyons, 2020). More specifically, since technical capabilities can improve outcomes for companies, Garcia-Fernandez et al. (2020) argued in support of investing in training programs to develop technical skills for self-employed and employed personal trainers working in fitness centres.

Further, the positive impacts of training on the performance of small businesses are linked to the types of training offered. Idris et al. (2020) found that combining off-the-job and on-the-job training provides more support than offering off-the-job training alone. This finding was based on 15,000 surveys of small business owner-managers conducted by the UK Department of Business, Innovation and Skills (BIS, 2016). The survey conceptualised learning as "training away from the individual's immediate work position, whether on your premises or elsewhere" (BIS, 2016, p. 82), where learning was viewed as the acquisition of knowledge from off-the-job training programs. Of particular interest is the specific exclusion of on-the-job training, or "learning by experience", which is "not the sort of learning by experience which could take place all the time" (BIS, 2016b, p. 82). Although relevant to a different purpose and methodology, such exclusion signals the bounded focus of this acquisition approach and raises questions about the learning by experience that has been excluded.

Issues with training

As the literature on contract work has robust evidence to support the positive impacts of training programs, the literature – while approaching learning as acquisition – also highlights many issues relating to training programs and contract work. According to the International Labor Organisation (2016a), non-standard work, which includes contract work, presents problems such as lower chances of participating in on-the-job training and lower quality of induction training. Fundamentally, considering the struggles faced by small businesses, for instance, in the UK, small businesses differ from large businesses in their approach to training, operating with reduced resources for training and often on an *ad hoc* basis, without specialist human resource support (Idris et al., 2020). Also, in a study conducted in the UK of 495 businesses, involving micro-businesses in rural areas that formed the majority of the participants – similar to some of the electrical contractors partaking in this study – the participants reported having less access to business support and voiced a need for training programs (Martin et al., 2013). Further, contractors identified with different labels, such as freelancers, in the theatre industry in Singapore, lacked access to professional development support, including training and learning opportunities, which can benefit contractors who want to build sustainable careers (Sahara et al., 2014).

While many studies have emphasised limited access to training programs as a significant issue, Ripamonti and Scaratti (2015) noted that the available training, which in their case is safety training, struggled to align with everyday safety practices. Their study sought to understand the contradictions between the demands of safety procedures and the demands of productivity, from the perspective of cultural-historical activity theory and approaching learning as participation. Based on observation and interview data of 30 dockworkers, half of whom were contractors, the study identified that some workers, including contractors, dealt with compliance requirements erratically when contradictions and challenges emerged, responding to conflicting demands in ways that did not always align with safety training and procedures. Therefore, the study suggests that human resource teams can involve contractors in developing safety prescriptions and training programs.

Several lines of evidence have maintained that contractors, as self-employed owners who view learning as acquisition, significantly influence the training being adopted. Recalling the definition in Section 2.1 at the beginning of this chapter, a contractor is both a business – micro or small business – and a self-employed worker "who earns his or her income through the commercial or civil contract and not the employment contract" (Mckeown, 2016, p. 781). The role of the self-employed owners is thus central to implementing HR practices such as offering training.

Atkinson et al. (2021) reported on a case study of 17 small businesses in the UK that the adoption of training programs is largely influenced internally by the self-employed owners, their understanding, confidence, and HR support, as well as external professional bodies, regulations, and legislation. Owner-managers' strategic decision-making overcomes resource limitations (time and financial constraints) to influence the implementation of training, based on surveys of 45 small firms (Kroon et al., 2013). Self-employed owners hold the crucial power that shapes the adoption of training programs, which can impact future contracts, as established by Saastamoinen et al. (2017). Their study found that positive attitudes toward training increase SMEs' participation in public procurement. In contrast, the lack of ongoing training opportunities reduced participation, based on 217 survey responses, 85% of which were completed by SME owners (Saastamoinen et al., 2017).

Most studies reviewed so far do not pay adequate attention to contracts. Few studies explicitly explore learning in relation to contracts. Instead of a general approach to contracts, a study of significant interest to this thesis was conducted by Scheel et al. (2014), who drew attention to aligning training with specific contracts. Their study – based on the analysis of 2,235 surveys in the food, education, and retail sectors in the Netherlands, Spain, and Sweden – investigated the training offered to permanent and temporary workers. The study demonstrated that the relationship between types of contracts, training, and performance is influenced by the economic and legislative contexts. The authors argue that "dealing effectively with contract diversity demands that a 'one-size-fits-all' approach to managing human resources be replaced with contract appropriate practices" (Scheel et al., 2014, pp. 749–750). The present research further extends this insight by examining the relationship between contracts and learning.

2.3.2 Self-employed owners

Learning environment

Besides influencing training programs within the business, as discussed in the above section, the contractors, as self-employed owners, are central to shaping the workplace as a learning environment; here, learning is approached as participation. A literature review of 17 articles on learning in small businesses focused on self-employed owners and defined learning as participating in everyday practice (Coetzer et al., 2019). The study highlighted small businesses as learning environments, noting the "central roles of owner-managers in shaping the learning environment" (Coetzer et al., 2019, p. 429). Similarly, subsequent research, such as a survey of 199 small businesses in Korea conducted by Lans et al. (2022), confirms the central role of the owners in facilitating workplace learning.

For Nolan and Garavan (2019), owners were vital to the informal learning processes within small businesses in the tourism industry in Ireland, acting as the "key agent in shaping HRD dimensions" (Nolan et al., 2020, p. 12). The study found that the owners are essential in providing informal learning processes of mentoring, on-the-job training, and guiding their staff. In addition to facilitating knowledge, previous research contended that owners participate in complex social activities where learning involves redefining boundaries, hence changing practices, as Higgins et al. (2013) argued in a conceptual paper on SME owners and social learning.

Owners' skills and strategies

Within the literature examining self-employed owners, several studies have focused on the owners' individual learning skills and strategies, conceptualising learning as acquisition. A study of owners of small firms in the agri-food sector in the Netherlands identified two domains of owner social skills that facilitate workplace learning: learning orientation and strategic relationships – based on 554 surveys and 13 interviews (Lans et al., 2016). In the first domain, owner-managers having a learning orientation engage with dialogues, handle criticism, and utilise feedback for improvement. In the second domain, social and emotional cues are used to build strategic relationships and social networks, contributing to learning and performance in the business.

A study of small businesses with no employees – based on datasets collected between 1994-2003 and 1600 surveys of potato growers found that the owners' motivation and self-regulated learning influence the learning experience and the quality of work outcomes (Faber et al., 2012). Owners' learning involves the use of information resources that are electronic, paper-based or obtained from social contacts. More recently, Margaryan (2019b) surveyed self-employed crowdworkers and found several self-regulated learning strategies. Among the 20 strategies examined, some included setting short and long-term learning goals, collecting information from various sources, and asking for help when faced with difficult tasks. Being self-employed, these workers were less likely to articulate formal learning goals, such as those required in standard employment. A conceptual paper also found that self-directed learning in small businesses includes a "just-in-time strategy that involved very little pre-planning" (Cormier-MacBurnie et al., 2017, p. 119).

In a recent study of the owners' dynamic capabilities, Olazabal and Avila (2022) acknowledged three critical mechanisms of dynamic capabilities: recognition, assimilation, and reconfiguration capabilities. Based on semi-structured interviews with 20 owners of sole proprietorships in the music industry on the American and European continents, Olazabal and Avila proposed a theoretical framework where the three capabilities are driven by a fourth capability – focus capability. Focusing on business goals, Olazabal and Avila suggested this ability involves three components: a) the passion that harnesses business efforts, b) the foundations comprised of the essential aspects of the business, and c) the self-confidence of believing in one's abilities.

The above literature has made explicitly clear the critical role of self-employed owners in the adoption of training programs and in facilitating a learning environment. The literature has also drawn attention to some owners' learning skills and strategies. However, this literature has not focused in much detail on how these types of learning respond to changes triggered by various actors in the work environment, such as the rapid technological changes discussed in Chapter 1. The role of the self-employed owners being perceived as critical is not the same as saying they are solely the vital facilitators of learning within their teams or disconnected from the external context. The following sub-section will consider the literature on how learning in contract work is enmeshed in different networks.

2.3.3 Connecting networks

Internal networks

Applying the participation metaphor, the literature reviewed here has highlighted learning in connecting to networks. Connecting to networks engages learning processes with the internal networks of team members and extended networks, such as suppliers and associations, online and in-person. More recent evidence from the literature features the links between learning as participation and the internal networks of team members. A study of the owners and employees of three small businesses in Australia, for example, showed that participation allowed by physical and social proximity (i.e., family-like culture) facilitates informal learning (Coetzer et al., 2022).

For Nolan and Garavan (2019), on-the-job learning from internal networks has been a vital factor in the success of three small professional service firms in Ireland. In this study, both the owners of the small businesses and the employees recognised on-the-job learning in working on projects as vital. Internally, they took advantage of networks connected to the owner-managers and employees. Engaging in "a dynamic learning environment was evident, whereby colleagues and owner-managers played a key role in facilitating the learning and skill acquisition of fellow employees" (Nolan et al., 2020, p. 11). More specifically, other research has shown that learning within internal networks is supported by the owners' self-promotion, not to advertise their achievements but to present the owners as potential learning partners (Lans et al., 2022).

Learning new knowledge and skills through participation also occurs by adding new members to the internal networks of the team. Sharafizad (2018) reported from interviews with 28 Australian women who were small business owners that the self-employed owners hired new workers who could offer the needed knowledge. In the context of limited resources, the emphasis on meeting the client's needs and working with social networks underlines the importance of interpersonal skills and the "interdependencies between employees" (Nolan & Garavan, 2019, p. 495). This thesis also examines how learning involving team members is enacted in practice.

Extended networks

Beyond learning from the internal networks of colleagues, learning occurs in a range of extended networks, including participation from clients, suppliers, and professional associations. Learning where the owners of small businesses consult external experts is linked to improved performance (Lans et al., 2022). For Nolan and Garavan (2019), learning is expected to occur while working on projects and beyond working hours, during extracurricular networking activities, and via activities that are encouraged and rewarded (Nolan & Garavan, 2019). In a study of three small businesses, they also found that owner-managers rely on external networks of clients, professional associations, universities, informal advisory networks, and personal contacts to access knowledge and expertise. Explicit use of resources includes access to policies, processes, certification, and professional bodies guidelines (Nolan & Garavan, 2019).

Similarly, a study of small businesses in Brazil found 38 actors connected to a network of professional associations that promoted workplace learning companies (Ipiranga & Aguiar, 2014). These actors were divided into seven types: small companies, suppliers, customers, consultants, universities, supporting organisations and district associations. Another study also found that the owners connect to networks to acquire new knowledge (Sharafizad, 2018). More specifically, Kitching (2016) observed that owners of micro and small businesses learn regulatory obligations from informal networks of family and friends, especially those with expertise in HR.

The literature also reveals that challenges are addressed in cooperation with communities of practice. Suryanti et al. (2021) reported that engaging with other community members involves learning processes that support cooperation. Gray and Jones (2016) noted that owners participating in peer learning communities reduce the likelihood of failures and increase confidence in securing contracts and team management. Owners or senior managers attending business advisory programs for small businesses reported increases in innovation and learning by observing other firms sharing their practical experiences of success and failure, including sharing relevant and valuable resources such as books and articles (Sawang et al., 2016).

Participating in formal sociocultural networks, away from the work sites, facilitates learning for small business owner-managers. Lefebvre, Lefebvre, and Simon (2015) found evidence for professional learning, identity formation, and social interaction from participation in a dynamic professional network. A learning community emerges from interaction with a professional community where learning practices are observed in role modelling and teamwork, as well as "knowledge sharing during meetings, explanation, advice and guidance, questioning, listening and providing feedback, encouragement and emotional support" (Lefebvre et al., 2015, p. 513). Connecting to networks of professional communities promotes learning for contractors. Studying work opportunities and ethnic contractors in Canada, Fenwick (2012) foregrounded the importance of connecting to networks to generate further contracts. These contractors invested significant effort in participating and developing diverse networks. Growing networks involve negotiating these networks where ethnic contractors learn to manage their position, power, and how they are perceived. Essentially, "they depend upon these networks for their employment and knowledge" (Fenwick, 2012, p. 609).

In addition to contractors' efforts, the literature has argued that for freelancers, in the theatre industry in Singapore, industry-wide changes such as building networks of professional recognition to acknowledge quality work, providing development opportunities, and fostering more creative jobs can benefit contractors in gaining work and developing careers (Sahara et al., 2014). Not only the contractors but also the networks in which the contractors are connected can influence the work outcomes for contractors. Understanding how such connections, with communities of practice, are enabled in practice, along with other types of networks, would further extend the field of workplace learning.

Digital networks

A relatively small stream of research has also examined learning in contract work and digital networks. Based on a study of online crowdworkers, learning from online networks involved self-study, taking free online courses, and note-taking (Margaryan, 2019b). Previous research also noted that self-employed owners, in Australian rural areas, who are already more willing to share knowledge in-person are more inclined to share knowledge online (Carr et al., 2013). Two studies of learning in digital networks applying the emergence metaphor warrant distinctive attention, given their close alignment to the theoretical approach taken in this thesis (i.e., ANT). In a study examining contractors' learning in online communities (Thompson, 2011, 2012), ANT and interviews were used to study 11 contractors and consultants who were self-employed workers, without staff (Thompson, 2011, 2012). An essential finding of this study was the tracing of "an immense array of online spaces" (Thompson, 2012, p. 193), as well as the recognition of the importance of the relationships that are in and between networks of cyberspaces and the importance of both the social and material factors involved in work practices.

In another study, seeking to understand how work-learn practices are changing in mobile digital device usage, Thompson (2018) also used ANT and interviews to study 23 contingent workers and found that mobile digital learning contributes to online work-learn practices. However, the study also reported that contractors' increasing fluencies do not coincide with greater awareness of the growing contribution of mobile technologies to learning practices and learning on the move. The contractors, without instructors or training managers, "seem to be sorting things out on their own. This could be expected given the contingent and precarious nature of their work and workspaces… what is being learned about mobilities of work-learning practices is crowdsourced from multiple teaching presences" (Thompson, 2018, p. 1043). Mobilised learning practices – such as learning to use a new phone, storing, and backing up information – are significant, yet mundane and distributed, and remain invisible (2018). In this study, one aim will be to apply an additional observation method to enhance data collection, in an attempt to make visible both the social and material dimensions as they emerge in everyday practice.

Contradictions and challenges

Learning by connecting to networks is not without its contradictions and challenges. Contractors face learning challenges in negotiating contradictions emerging across network boundaries in their everyday work. Fenwick (2008a) examined learning in boundaryless contract work, interviewing 31 self-employed female contractors in Canada. As one of the early and rare studies examining the relationships between networks and contracted work, this 2008 study is included in this literature review since it highlights essential aspects of the scope of work and contradictions involved in contract work, aspects that will be further explored in the discussion chapter, Chapter 6, of this thesis.

Contractors learn to negotiate contradictions, precisely contradictions at the boundaries between their daily work and perceptions of their work; they also learn to build a self-image and position their work (Fenwick, 2008a). Although faced with the need to clarify the terms and expectations of their work, such as access to equipment, space, and contracted outcomes, women contractors are often "absorbing the project overruns and myriad unanticipated details or problem-solving" (Fenwick, 2008a, p. 19). Learning to negotiate the contradictions – educating clients, hiding exhaustion, hiding the chaos of work while portraying control – involves "practices and labour that are not recognised, valued or rewarded on the market, even by the women contractors themselves" (Fenwick, 2008a, p. 24). This thesis will use praxiographic methods – observation, interviews, and document review – to clarify the learning enacted in other practices that are not recognised and under-valued in contract work.

In another early study – one of the few examining contract work using a practice-based theory – learning and innovation, as emergence, in contract work occur across different boundaries and communities of practice. Fenwick (2004) defined innovation as learning for and learning in innovative practices. Learning in contract work involves discerning and rendering innovation, mobilising support within the organisation, and anchoring the innovation in the organisation. A key finding, multiple communities of practice, was contrasted with Lave and Wenger's (1991) notion of sociocultural learning and boundaries within a community. Fenwick noted "a different set of relations and learning problems confronting those who move in and out of multiple communities of practice: negotiating many boundaries" (Fenwick, 2004, p. 243). The present research extends this insight to explore boundaries between multiple communities of practice, beyond narrated accounts, as they are enacted in everyday practice, exploring not just innovation but also other forms of learning.

At a more fundamental level, recent research has applied practice theory to explore the role of the senses in learning and participating in social practices. From interviewing 18 founders of entrepreneurial businesses that operated in areas such as human resources, market research, and education, Vogt, Bulgacov, and Elias (2022) argued that aesthetic and sensible knowledge, enacted in social practices, is essential to learning. The senses of sight, hearing (and speaking in conversations), smell, touch, and taste allow the entrepreneurs to connect to networks of practices, senses that are fundamental and "useful to create a venture, understand 'the rules of the game, and run a business" (Vogt et al., 2022, p. 300).

While many studies have shown the importance and value of participating and connecting with networks for learning, such connections also present challenges. Where communities of practice offer learning opportunities, peer support, and growing self-reliance to novice contractors, participating in the same community detracts from other work-related activities and from participating in other professional communities. Further, expert contractors perceive that participating in learning communities might diminish their reputation as experts. Kitching (2016) identified an important issue: "The burden of discovering regulation is a dynamic phenomenon, fluctuating over time, rather than a stable, permanent condition. Studies typically ignore the temporal specificity of regulatory burdens, implicitly treating them as invariant over time" (Kitching, 2016, p. 603). For Nolan and Garavan (2019), future research should seek to understand "how access to network actors changes over time, and their relative importance as the small PSF [professional service firms] grows. It is vital to understand when and how networks change over time" (p. 497). This thesis explores how learning is enacted in changing contexts, such as policy changes.

Section summary

The literature on learning in contract work has been primarily moulded in the metaphors of learning as acquisition and participation, with a limited approach to learning as emergence. This literature is significantly shaped by the focus on training programs, the role of self-employed owners in workplace learning, and increasingly on learning in connecting to networks. While the literature has identified the many benefits of training for the success of contract work, several issues related to training were also highlighted by the existing literature, such as access to training, training deliveries that do not align in practice, and the relevance of contracts. Along with the focus on training programs, the literature has paid significant attention to the self-employed owners of businesses. Self-employed owners are vital to the provision of training programs and the facilitation of a learning environment. The owners' learning skills and strategies have also attracted some attention in the literature. However, the learning of self-employed owners in relation to the contracts their firms have with the clients was under-explored. Further, knowledge of the relationship between the contract and workplace learning remains an important yet largely under-researched aspect of the literature.

2.4 Learning in the solar and construction industries

This section reviews the literature on learning in the solar and construction industries. The literature is relevant to this study as installations of solar PV systems in Australia are subject to standards and codes of conduct involving solar PV systems and construction work (Clean Energy Council, 2022; SafeWork NSW, 2019). The studies included in this section mostly drew data from contract work in the two industries, and the last sub-section focuses on studies that applied emergence approaches. These approaches are central to this research, including studies that do not specifically focus on small-business contract work. This section unfolds in four sub-sections: 1) technology and industry, 2) learning by doing and cost reduction, 3) local learning, and 4) practice-based learning. It is argued here that while much research in the industries has focused on technical knowledge and industry, approaching learning as acquisition and, to a lesser extent, as participation, the issue of how learning emerges in everyday practice is overlooked.

2.4.1 Technology and industry

As in the literature on learning in contract work, it is unsurprising that the literature on learning in the solar and construction industries is also keenly interested in examining training programs, predominantly approaching learning as acquisition. Analogous to the literature on contract work, training programs also influence work opportunities. However, unlike the literature on contract work, in this context, the literature focuses on how qualification frameworks and the provision of training can develop the industries, specifically zooming in on adapting to new technological knowledge and designing training programs.

Work opportunities

Several studies in the literature on learning in the solar and construction industries have also identified some advantages of training programs in expanding work opportunities. For Brooks and Urmee (2014), the knowledge acquired in technology transfer training programs, for both the installers and the owners of solar PV systems, supports the ongoing success of rural electrification, based on evidence from a case study of solar PV installations in the Philippines. In focusing on the "transfer of experience, knowledge, skills and practices in a process called 'capacity building'" (Brooks & Urmee, 2014, p. 177), this study examined learning in contract work in relation to participation in training programs, analysing data gathered from surveys and focus groups. Votteler et al. (2014) noted a similar finding that training provided the key value for the growth of solar PV businesses, based on interviews with 18 owners and general managers of solar service providers in the Western Cape. This work identified that customer service and training for customer service skills offer significant growth value and increase stakeholder satisfaction.

Having established the positive impacts of training programs, as in the contract work literature, technological changes – a far greater concern in this literature – hamper the positive impacts of training on growing work opportunities. While training supports business growth, the training of installers also brings work opportunities, with a critical caveat. Silwal and Bhatta (2017) reported that completing training increased employability, based on a case study of a training program for solar technicians in Nepal (Silwal & Bhatta, 2017). However, Hemson and Peek (2017), in a study of training for women in the solar PV industry in Bangladesh, critically identified the ways that rapid industry changes – including some technological changes similar to those in the context of this study, and already discussed in Chapter 1 – weaken the link between the knowledge acquired in training programs and employability.

Qualification frameworks, training provisions, and learning resources

Despite featuring the many advantages of training, the literature, using the acquisition metaphor, has underscored the need to examine qualification frameworks, training provisions, and learning resources. Unlike the literature on learning in contract work, the concern of this literature relates to the industry's growth as a whole, especially in promoting sustainability and safety. A study surveying the national framework for professional training, qualifications, and certifications of solar installers in Greece, Cyprus, Bulgaria, Romania, Croatia, and Spain documented that there was limited technical training on offer (T. Tsoutsos et al., 2013). The work raised the concern that the lack of suitable training and qualified installers can reduce the quality and credibility of the industry. The study reported that customers were willing to engage qualified installers even at higher prices, while, similar to the solar industry in Australia, the demand for solar PV systems overtook the supply of qualified installers.

Studying the relationship between training and safety in the construction industry, Mohammadi et al. (2018) found significant learning differences between company sizes and the provision of safety training. This literature review of 90 papers on safety in construction projects studied research on several types of learning and types of workers – training, competency, safety experience, safety information, hazard awareness, and the qualification for the safety of subcontractors and contractors. The study found that small contracting companies and sub-contractors in the construction industry do not perform as well on safety as large contractors on safety (Mohammadi et al., 2018). Also, in the construction industry, the lack of training programs and short courses from higher education institutions for construction contractors is identified as one of the key barriers to implementing sustainable and energy management strategies (Athapaththu & Karunasena, 2018; Enshassi et al., 2018).

In addition to training, research on solar PV installation work has also investigated learning in terms of the resources that are available to installers. Strupeit (2017) found that training offerings diversified and specialised over time. The author analysed data from 20 interviews and documents published in Germany since the early 1990s – documents relating to building legislation, technical guidelines, research reports, websites, as well as 188 issues of industry magazines. Workshops and short-term courses were offered by various actors: manufacturers, wholesalers, technical academies, solar associations, publishing houses, training institutes, in-house training, and on-the-job training. Such training complemented the professional, yet foundational, training received in the Germany vocational system.

Further, knowledge of technical systems and installation deployment has grown since the 1990s, distributed in printed publications and virtual products, including magazines, websites, and software that "provided comprehensive learning opportunities" (Strupeit, 2017, p. 279). This picture of comprehensive learning opportunities also included learning-on-the-job, where it was "relatively easy for small and medium-sized installers to try out and learn about PV technology at a low level of risk and subsequently benefit quickly from learning-on-the-job" (Strupeit, 2017, p. 279). However, the processes by which these types of learning, primarily learning-on-the job, remain a knowledge gap and will be addressed by this study.

Adapting to technological changes

Analogous to the literature on contract work, this literature shares the same established recognition of the importance of training programs; however, the literature focuses more notably on the effectiveness of technical training programs, in terms of knowledge acquisition. Considering the dynamic technological context of the solar PV industry in Australia, as discussed in Chapter 1, technological developments impact both licensed and novice electricians (Australian Industry Standards, 2019b). Some electricians completed recent qualifications, which are "falling behind industry advancements… a negative impact on workers' ability to adapt to technological advancement" (Australian Industry Standards, 2019b, p. 29). Hemson and Peek (2017) noted that training programs that focused on technological competency assumed that "the acquired skills would be durable over time" (p. 56).

However, the focus on technical competency did not align with the changing market, shaped by global networks of dynamic innovation, intense competition, and lowering prices. Strupeit (2017) observed that technological advancements in the solar PV industry "affected the type of deployment knowledge that is necessary to install these products" (p. 278). The present research will address the knowledge questions that arise as solar PV technologies are being deployed in practice, connected to networks of everyday technological deployment on installation sites.

Brooks and Urmeed (2014) questioned how learning content could be updated and become relevant to solar electrical contractors. Emphasis was placed on the importance of training programs that were available "to the right people at the right time" (Brooks & Urmee, 2014, p. 183). Urmee further (2016) showed that, facing the limited success of existing solar PV systems, one of "the main issues was that the guidelines that have been developed to date are insufficiently comprehensive or completed" (p. 12). This knowledge gap invites the publication of comprehensive guidelines, such as Urmee's book (2016) and the use of follow-up training, as well as monitoring and modifying the training programs (Hemson & Peek, 2017). Such concerns about aligning learning outcomes with industry changes should stimulate further research. This thesis is a response to that call; it will explore ways to unpack learning, beyond the confines of training programs and guidebooks, the learning that is updated and available when needed.

Designing training programs

Some literature has zoomed in to focus on considering the effectiveness of the details of the design of training programs. From reviewing 19 solar PV training manuals, published between 2003 and 2018, Sharma and Sengar (2022) found a gap between theoretical and practical training formats. The gap occurred during the field visit stage, where theoretical knowledge of components of solar PV systems could not be connected to important aspects of existing solar PV systems. The authors designed detailed checklists for trainees to gather information during field visits to address this gap. The information on the lists included, for example, the user's daily electricity needs, costs of installations, tilt angles of the solar PV panels, and thickness of electrical wires. In the Findings chapter of this thesis (Chapters 4 and 5), the learning enacted in practice, involving such fine details, will be comprehensively examined.

Eggerth et al. (2018) studied the design and effectiveness of a specific training program in the construction industry, finding that incorporating engagement activity in a training program was more effective than providing information alone. One example is toolbox talks or brief instructional sessions, of about 10-15 minutes, delivered on construction sites. The study developed and tested two versions of a toolbox talk on safety for small construction contractors. The standard version contained safety information only, and the variation version included narrative scenarios and discussion questions. The study found that including the narrative and discussion questions improved learning acquisition, "increased knowledge gain and led to increased training impact" (Eggerth et al., 2018, p. 997). Also, analysing the content of training programs, to improve customer service, Votteler et al. (2014) argue that training for installers should focus on delivering reliability, responsiveness, assurance, empathy, and tangible presentation.

Several studies have also examined the effectiveness of the design of online training programs. Observing the training for improving electrical safety, Zhao and Lucas (2014) proposed designs for a virtual simulated training program on safety for the construction industry in the US. In Australia, reviewing a national mandatory training program on health and safety provided to both employees and contractors working in the Australian construction industry, the Australian Skills Quality Authority (2013) found that online training programs are too short, lacking sufficient time in the workplace for developing skills, as well as facing concerns about the verification of student identity.

Previous research has established that technical knowledge is gained not only from the contents of training programs but also that training events can function as knowledge networks. For Merino and Hatakeyama (2015), training courses and events provided important socialisation within knowledge networks, expanding technical capabilities, based on surveys of seven small businesses in the solar industry in Brazil. Such learning involved “tacit knowledge and its incorporation in good practices during installation and maintenance of equipment” (Merino & Hatakeyama, 2015, p. 2246).

2.4.2 Learning-by-doing and cost reduction

Considerable attention has focused on how learning, as participation, can contribute to cost-reduction, chiefly learning by doing (A. L. Beck & Rai, 2019; Bollinger & Gillingham, 2019; Nemet et al., 2020). Beck and Rai (2019) reviewed key reports and 129 academic papers and found cost reduction in relation to several types of learning: external processes (learning by interacting, hiring, imitating, training, and alliance), internal processes (learning by doing, searching, and using), knowledge socialisation (learning by interacting, training, and observing), and codification processes (learning by writing and standardising). While each of these processes is further divided into several sub-processes, detailed explanations of each of the sub-processes of learning were not offered.

For Nemet et al. (2020), cost reduction is substantially attributed to learning-by-doing, and knowledge spillovers between solar installers are more prominent at local levels. From a dataset of 240,626 US residential solar PV systems (1kW-15kW), knowledge spillovers between local firms gained more considerable benefits than between firms across geographical borders. The study defined learning-by-doing as “knowledge gain through practice and experience with the technology” (Nemet et al., 2020, p. 2). Knowledge spillovers are seen to occur when “a developer’s innovation or new practice spreads to competitors, other industries or even other regions and countries, therefore involuntarily contributing to knowledge stocks and inspiring further change” (Nemet et al., 2020, p. 2). The study also found that learning occurs informally and frequently in smaller companies. While this thesis will not seek to isolate and specifically examine these types of learning, the learning enacted in practice, as discussed in the Findings chapters, will contribute to current understandings regarding some of these types of learning as they emerge.

Bollinger and Gillingham (2019) found that cost reduction relates to the learning-by-doing occurring internally within a firm and externally as spillovers between firms. Analysing a dataset of 76,838 installations in California, the study documented evidence of internal learning that increased as the competitor’s installation increased, indicating external learning between firms. Where experience accumulates, learning and time decrease the learning rate, as firms with a larger number of total installations can learn from their competitors. Learning "may occur from factors such as hiring employees from competitors or watching how competitors install systems” (Bollinger

& Gillingham, 2019, p. 38). This research helps open "the blackbox of learning-by-doing" (van Poeck et al., 2020, p. 298) and extends these fields by examining evidence of how learning occurs internally and externally in practice.

2.4.3 Suppliers and local learning networks

As with the literature on contract work, connecting to extended local networks also seems essential for learning; in this area, a prominent focus is on the suppliers and the proximity of local networks. Several recent studies in the solar industry have examined workplace learning within learning networks, focusing on actors such as suppliers and local business partners. To study the relationship between cost reduction and three types of learning – learning by doing, researching, and interacting – Gao, Rai and Nemet (2022) analysed data from patents and over 125,000 residential solar PV systems. They found that when learning by searching and interacting, predominantly when connecting with manufacturers, "the network-related variables reduce the coefficient of an installer's own cumulative installed capacity by about 43%" (Gao et al., 2022, p. 8). In this study, the cumulative installed capacity is also referred to as learning by doing.

In terms of local learning, or learning that occurs in relation to national boundaries, occurring within a country rather than from foreign sources such as ownership of overseas facilities, Lema and Lema (2016) found that training provided by suppliers is essential to local solar industries. This finding was based on their work analysing databases of solar PV projects in nine countries. The researchers noted that while the duration of the training programs is primarily short, focusing on operations, advanced knowledge of imported technologies is transferred and propagated after the installation. However, for Ulsrud et al. (2018), inter-local learning, defined as the learning of a project (e.g., a solar PV technology in different geographical contexts), is less the case of transferring stable technologies and more about the collaborative perspectives, the use, and the experiences of the technologies that provide the knowledge for adapting the technologies in new contexts. Inter-local learning across projects in different contexts can thus be shaped by trends in broader social and geographical contexts.

In addition to local learning involving suppliers and adapting knowledge across distant contexts, Neij et al. (2016) documented evidence for a type of participation in local learning, which occurs at sub-national levels and requires proximity. As identified by this study, local learning involves sharing tacit knowledge, sharing stories, social relationships, and inter-organisational networks. The authors argue that local learning processes rely on proximity embedded in the sites' historical, physical, and institutional networks. Then, with time, local knowledge is codified, joining knowledge at national and global levels.

In the construction industry, local learning is shaped by a number of factors. Several studies of contract work in the construction industry underline the importance of learning with business partners. These include early knowledge exchange (Hastie et al., 2017), learning based on feedback (Wong & Wong, 2014), foregrounding the importance of factors such as relationship management, leadership engagement, role clarity and empowerment in learning from failure (Gressgård & Hansen, 2015). Powers (2013) found that the owners' attitudes towards training influence how their teams learn and perform, noting important aspects of local learning in contract work: the variety of practices, teaching and working with team members. These studies reveal substantial interest in learning in the solar and construction industry. This thesis will contribute to this literature by further examining how, in everyday practice, such learning emerges in relation to suppliers and local networks.

2.4.4 Learning in everyday practice

This research and the studies reviewed in this sub-section have in common a diversion away from the acquisition and participation approaches, which are dominant in the literature. The literature here presents glimpses of how learning is conceptualised and studied as emergence in the construction and solar industries, including one PhD study that drew data from a larger organisation with about 120 staff (Scoles, 2017). This research will join an increasing number of practice-based studies in the solar and construction industries that offer fresh insights into learning as emergence in contract work.

The fundamental understanding of learning as emerging in daily work is well established in practice-based research; hence, examining practices features in several important studies in the construction industry. Foremost among leading practice studies is a major study of learning and safety in construction work in Italy in which Gherardi and Nicolini (2000) sought to understand how safety learning was enacted on construction sites. Across the various projects, they found that "a safety culture is a process, not a content or an object, and as such, it must be constantly sustained by appropriate organizational practices" (Gherardi & Nicolini, 2000, p. 9). The authors challenged the rigid, technical approach to safety, narrowing organisational safety to technologies, artefacts, rules, and regulations.

Also, in studying learning in practice, Strati (2007) observed the learning that is sensible knowledge of tradespeople, working as roof removers, and stripping roofs from buildings. As an earlier study, this influential paper is included in this review because it traces a form of sense-based knowledge critical to solar PV installation work, especially when it involves working from height and moving heavy materials. Sensible knowledge extends beyond the senses; it is "the mere direct, physical and objectively observable relation; instead, it accounts for the subject's intimate, personal and corporeal relation with the experience of the world" (Strati, 2007, p. 62). Examples of this form of sensible knowledge are learning "by 'feeling with the feet' or by 'leaning with the body' or by 'listening to noises'" (Strati, 2007, p. 70).

Closely related to the aims of this thesis is a practice-based study that used ANT to examine engineers' learning in a large company (120 staff) in the wind energy industry in Scotland (Scoles, 2017). Scoles' study focused on three areas: tensions and negotiations in engineering practice, knowing-in-practices and learning strategies, and practice-based pedagogical implications. In using ANT and the methods of observation, interview, and document review, this study traced the practices of 13 engineers; they were employees of the wind energy organisation, not contractors. The contract – central to the engineers' practices – and the use of ANT to explore learning directly inform the present study on learning in contract work. Scoles' analysis revealed three key insights: dynamic stability sensibility, the use of sociomaterial processes to negotiate tensions, and the patching of different knowledge practices.

The term "dynamic stability", coined by Scoles, describes a knowing-in-practice sensibility. Responding to the volatile wind industry, engineers innovate, tinker, and attune. A dynamic stability sensibility invites questions about "working in uncertain, opaque and unstable spaces, rather than striving for certainty and order" (Scoles, 2017, p. 231). Sociomaterial processes, rather than just the individual human, also negotiate tensions in everyday practices. Engineers facing volatile challenges must engage with various forms of expertise and resources, using "patching" to collaborate on solutions. Patching transfers attention from a fixed body of engineers' knowledge to an interdependent, yet patchy, knowledge in practice. These findings support this research's aims: to examine contractors' everyday practices to understand how learning in contract work relates to the dynamic uncertainty, tensions, and diverse range of patching.

Also investigating the renewable energy industry, an MA thesis focusing on practices in cultural resource management in the Mojave Desert in California (Gorrie, 2014). The research used ANT to study a solar PV installation project within its local context as it unfolds in practice. The study aimed to examine matters of concern relating to the management of cultural resources. As a case study, the research gathered data from document research, site visits, and interviewing nine informants, analysing the networks of actors such as government agencies, corporate owners, construction contractors, indigenous peoples, and archaeologists. While the complete and thorough knowledge of each actor's concerns was not possible, the study emphasised the importance of understanding practices, an approach that makes "ongoing and situated efforts to understand how we take action in relation to other humans and non-human actors", beyond the limits of matters of fact of "the 'legal' as a boundary informing just knowledge practices" (Gorrie, 2014, p. 81).

Section summary

Compared to the literature on contract work, the literature on learning in the solar and construction industries also bears the heftier dominance of the focus on training programs. Similarly, the benefits of training programs are noted, influencing work opportunities. The literature also raises concerns about qualification frameworks and the provision of training programs. Critically, unlike the literature on learning in contract work, in the literature relating to the industries, several studies have underlined issues of learning that do not respond sufficiently to the rapid rate of technological advancement. Some studies have sought to pinpoint how cost reduction occurs in relation to learning-by-doing. Recent research in the solar industry has also begun to examine local learning, while the construction industry has identified local factors that contribute to learning. A number of studies in both industries have applied practice-based approaches to explore learning about safety and sensory feedback on construction sites and the construction of wind energy and solar plants. However, how solar installers learn in practice remains an under-explored area. As in the literature on learning in contract work, how learning unfolds in relation to contracts remains neglected. A more nuanced understanding of how learning unfolds in practice is needed, beyond the broad understanding of learning as occurring at the local level or the general terms of learning-by-doing. This thesis also seeks to address this gap to understand how such learning occurs, in practice, in the daily work of solar electrical contractors, and in relation to the contract.

2.5 Critical synthesis

This section offers a critical synthesis of the literature reviewed and a summary of the arguments discussed throughout this chapter. Over the past decade, increased attention has focused on learning in the workplace (Reich & Hager, 2014). Instead of the conventional view of knowledge as isolated, representational structures, approaching learning as emergence has reconceptualised knowledge and practice on distinctive ontological and epistemological bases (Hopwood et al., 2014; Reich & Hager, 2014). Approaching learning as emergence means recognising that learning requirements based on traditional acquisition models cannot adequately respond to dynamic workplaces. As mentioned earlier in this chapter, this section returns to Hager's (2011) overview of the field of workplace learning, drawing on the three metaphors of acquisition, participation, and emergence, as the basis upon which to unpick prevailing assumptions and to offer novel research questions that advance the literature on the matter.

2.5.1 Limited knowledge of learning as emergence in solar electrical contract work

While the above literature consists of various perspectives, current scholarship converges in recognising the importance of learning and development opportunities in contract work and the solar and construction industries. However, many studies rely on the metaphor of individual acquisition, exploring learning as individuals' psychological activities, where sociocultural contexts are overlooked or underestimated. Recent research has highlighted the importance of training, predominantly approaching training programs as opportunities for knowledge acquisition. While the term "training" is often used but not defined (Nolan &

Garavan, 2016), research in workplace learning questions the dominant view that workplace learning is encapsulated in structured training programs (Boud & Hager, 2012; Fenwick & Nerland, 2014). Training does not equate to learning (Antonacopoulou, 1999), as "formalized training either tends to be provided too late, or the knowledge and skills acquired are not sufficient to support the continuous learning that is taking place" (Antonacopoulou, 2001, p. 341). In contexts of dynamic technological changes, such as that of the Australian solar industry, the focus on learning as acquisition and training programs limit the scope of learning. Further research is needed to expand the scope and understand how contractors learn beyond training programs.

Extending the literature beyond the individual learners, studies using the participation metaphors focus on human activities in communities of practice and highlight the importance of sociocultural context (Lave & Wenger, 1991). Learning is a continuing process of participation, connecting to networks within sociocultural contexts. However, in the literature reviewed above, there is little sense of how changes in the context of participation in workplace learning are addressed. As with the acquisition metaphor, the participation metaphor attracts criticism for the assumption of stable individuals and contexts.

One way of rendering the important, yet under-explored learning that occurs in everyday contract work, is the use of emergence as a metaphor, approaching learning in everyday practice. The emergence approach has established increasing recognition in the literature; accordingly, this research will draw inspiration from this third metaphor. Learning will be analysed as emergence, building upon the limited number of practice-based studies that have approached learning as emergence in the construction and solar industries.

Considering methodology, much of the research based on the acquisition approach used surveys (Brooks & Urmee, 2014; Bujacz et al., 2017; García-Fernández et al., 2020; Idris et al., 2020) and datasets (A. L. Beck & Rai, 2019; Gressgård & Hansen, 2015; Strupeit, 2017). In the long shadows cast by Lave and Wager's work on communities of practice, many studies applying participation approaches deployed interviews (Fenwick, 2012; Sawang et al., 2016; Sharafizad, 2018; Vlachos, 2020), and some combined observation and survey (Lefebvre et al., 2015; Nieminen & Hytti, 2016; Ripamonti & Scaratti, 2015) as well as focus groups. Within the emergence approaches, some studies used interviews (Fenwick, 2008a; Thompson, 2012, 2018) or combined interviews and observation (Gherardi & Nicolini, 2000a), adding document review (Scoles, 2017). Approaches resembling the emergence metaphor have often treated social and material entities as ontologically separate, presenting non-human actors as relatively invisible. There is scant research that uses not only interviews and document review but also observation to scrutinise learning as emergence, practice-based, and specifically the learning of those electrical contractors in the solar industry. This study will attempt to do just that.

It is essential to clarify that this discussion does not imply that it is outdated to approach workplace learning as acquisition and participation. These approaches continue to thrive in the literature. At the same time, criticisms of these have advanced research frontiers towards emergence approaches. Nor is it suggested here that these approaches are inaccurate. The literature on learning in contract work, especially in the solar industry, can extend beyond these two metaphors. The argument here is that these two fields of literature can benefit from the literature on workplace learning, the recent, yet well-established conceptual and methodological framework of the emergence approach, using it principally to examine learning in practice.

2.5.2 Limited attention to contracts

Crucially, in the extant literature, there are insufficient accounts of contracts in learning, with little evidence of the role of learning in the success of contracts. Although there are valuable studies of the role of contracts in contract work, their links with workplace learning remain little explored. Therefore, this research will address this significant knowledge gap by examining how learning is enacted in relation to contracts.

2.5.3 Limited research on electrical contractors

Further, while several studies have focused on the experience of precarious, educated and skilled professional, self-employed workers (Marín-Sanchiz et al., 2021; McKeown & Leighton, 2016; McKeown & Pichault, 2021), there is little sense of the learning in practice of contractors who are not knowledge workers, such as trade workers. Contractors working as small businesses often work without structured learning support and have limited resources for training (Idris et al., 2020; ILO, 2016). There is scant research on the learning of electrical contractors, particularly those in the solar PV industry. Of the literature on solar installers, the focus has been on reducing costs and how learning contributes to cost reduction. This study addresses this knowledge gap in trade work, mainly contract-based work.

2.5.4 Research questions

As shown in the above literature review, most existing research has scrutinised learning in contract work as acquisition. A small number have applied the participation metaphor. However, very few have used the emergence approach. Underwriting much of the literature is the assumption of relatively stable entities: individuals acquiring knowledge or stable communities that participate in the learning activities. Knowledge of the learning that occurs in contract work in the solar industry, applying the emergence metaphor, is urgently needed in the context of the current and growing climate emergency.

In drawing on research across the three areas of the literature, the above review offered insights into important and urgent research gaps concerning:

- how learning is enacted in everyday practice beyond training programs;
- how practices – beyond sets of soft and technical skills – and learning emerge;
- how learning emerges in relation to contracts; and
- how to engage with a more comprehensive approach to the learning that emerges in connection with highly dynamic aspects of contract work.

This research asks a new and urgent research question that addresses the significant gaps identified in the literature review above:

- How is learning in contract work enacted in solar PV installations?

In developing this overarching question, the literature review above has also revealed other significant gaps that lead to more questions concerning the oversight of the relationship between learning and contracts and the learning that occurs in the everyday work of installing solar panels. Two subordinate questions arise in relation to these gaps:

- How are contracts enacted in practice?
- How is learning enacted in solar PV installing practices?

2.6 Summary

Overall, two parallel research trends are prevalent in the literature on learning in contract work and learning in the solar and construction industries. On the one hand, both fields of literature have focused on examining training programs and taking the acquisition approach. Much of the literature tends to privilege the use of surveys and datasets. On the other hand, recent research has increasingly recognised the importance of the link between connecting to networks and taking the participation approach. Notably, however, neither of the sets of literature on contract work and learning in the solar and construction industries have paid much attention to integrating the methods of interview, observation, and document review. However, the literature on learning in contract work has further extended the field with substantial research that applies the lens of emergence approaches. Turning to the literature on the solar and construction industries, much research is still needed to unpack the learning referred to in the literature as local learning and learning-by-doing. Significantly, the existing literatures have also overlooked the relationships between learning and contracts.

The next chapter on the conceptual and methodological framework begins by tracing the development of a well-established alternative ontological and epistemological approach to learning as emergence, known as the practice turn. Practice approaches have emerged within the workplace learning literature as a powerful tool, providing a perspective for articulating concepts where learning is seen as emerging in social and material connections. These well-established theories are contemporary responses that are appropriate for understanding the relationships between work and learning and reveal influential factors that have been previously ignored (Hopwood, 2013). The chapter then zooms in on ANT, featuring its key concepts of sociomaterial actors and network effects, along with a focus on how learning is defined in ANT studies. The next chapter also discusses details of praxiography, study settings, data generation methods, analysis process and ethical considerations.

3 CONCEPTUAL AND METHODOLOGICAL FRAMEWORK

3.1 Introduction

As examined in Chapter 2, with the predominant focus on learning as acquisition and participation, the extant literature on contract work and learning in the solar and construction industries has overlooked emergence as a metaphor for learning, a metaphor well-established in the literature on workplace learning. Chapter 2 identified the assumptions and limitations in the existing literature and formulated the research questions.

This chapter details the conceptual and methodological groundwork of this thesis, arguing that ANT offers an original framework highly valuable for investigating learning as emergence in the rapidly evolving solar PV industry. The arguments in this chapter locate the study within ANT research (Fenwick et al., 2011a; Latour, 2005; Mol, 2002), and praxiographic methods. The focus on ANT will illuminate in rich detail the relations between human and non-human actors in the dynamics of network effects enacting work practices.

Chapter overview

Following this introduction, Section 3.2 introduces ANT as a sensibility particularly suitable for the present study. Section 3.3 discusses the key concepts of human and non-human actors and of network effects, as well as the concepts of matters of fact and matters of concern that emerged from the inductive analysis process and will help elucidate the main findings in Chapter 4. Section 3.4 considers how learning is approached in this ANT research. Sections 3.5 to 3.8 discuss praxiography, the study setting, methods, and the analysis process. Ethical considerations are detailed in Section 3.9, and the chapter concludes with a summary in Section 3.10.

Unlike traditional PhD theses, this thesis combines the conceptual framework and the methods chapters, often typically presented as two separate chapters. The combined chapter reflects an ANT approach to theories and methodology. Key ANT thinkers do not regard ANT as a theory but as a sensibility, a set of tools, or a methodology (Latour, 2005; Law, 1999; Mol, 2010).

3.2 Adopting ANT in this study

As a conceptual and methodological framework, ANT will be utilised to address the research gaps highlighted in Chapter 2. The previous chapter demonstrated how the existing research in learning in contract work is dominated by the metaphors of learning as acquisition and participation. However, the limited research that conceptualise learning as emergence in contract work poses a critical lack of knowledge, particularly how contracts are enacted and how contract work in everyday practice is enacted. This thesis examines this knowledge gap through the well-established conceptual and methodological framework of actor-network theory, a practice-based approach to examining everyday contracting practices. This approach illuminates in rich detail the social and material in everyday dynamics of work practices, dynamics that are becoming increasingly the effects of the contemporary, globalised workplaces.

The overarching research question, “How is learning in contract work enacted in solar PV installations?” is also anchored in the third wave of workplace learning theories, which approaches learning as emergence. Approaching learning as emergence affords new ways to investigating the learning that unfolds in everyday practice.

3.2.1 Questioning traditional ontologies and epistemologies

This thesis benefits from ANT, a practice-based approach well-informed by an alternative ontology and epistemology. Originated in science and technology studies (STS), ANT joins a growing interest in STS and other fields such as anthropology and philosophy (see, for example, Jensen et al., 2017) to challenge persistent assertions of traditional realism and constructivism (Barad, 2007; Law, 2008a, 2016; Law & Lien, 2013; Mertens, 2019). Before examining in detail ANT's relational approach, the following traces some of the history of the contentions, drawing on the ontological and epistemological analyses as outlined by John Law (2016), one of the pioneers of ANT, and Karen Barad (2007), a prominent STS feminist. Their evaluations involve four central ideas relevant to this study: realism, constructivism, representationalism, and practice-based research.

Traditional realism and social constructivism

Law succinctly summarises two major traditional ontological and epistemological assumptions that STS has contested since the 1950s, and subsequently by ANT, as follows:

> Most Western philosophers assume that the stuff of reality is constant, that we share the same reality-world, and that we disagree about reality because we have different perspectives on it. But recent STS is pushing back against this… it is saying that ontologies are relational effects that arise in practices (Barad 2007; Law 2002) and that since practices vary, so too do objects. (Law, 2016, p. 43)

As Law suggests, the well-debated "binarism" between the structured singular world of traditional realism and the scattered pluralism of social constructions has been increasingly contested by relational ontology and practice-based approaches (Law, 2002, p. 3). Further, Law acknowledges the importance of Barad (2007) who also rejects these two profoundly held ontological and epistemological conventions.

Traditional realism – differentiated from other versions of realism, for instance, agential realism (Barad, 2007) – insists on ontological separations between individual entities as well as between the external empirical world and the internal world of mental representations. For instance, following Niel Bohr's lead, Barad also questions prominent Western ontological and epistemological philosophies contesting traditional realist philosophies such as Democritus's atomic theory, Descartes' mental representations, and Newton's mechanics of independent objects. For Law (2016), significant criticisms of traditional ontological and epistemological assumptions also include the realist ontology that formed the foundation of Boyle's scientific method of the 1660s. Shapin and Schaffer's (1985) significant historical account examines Boyle's belief in the scientific procedures that study constant matters as the foundation of certainty in factual knowledge. To the philosopher Thomas Hobbes, Boyle's assumptions were unsatisfactory, an objection continued by Shapin and Schaffer (1985), who argue that "neither the acceptance of the experimental programme nor the epistemological status of the matter of fact ought to appear self-evident" (p. 22).

This thesis benefits from ANT, a practice-based approach well-informed by an alternative ontology and epistemology. Originated in science and technology studies (STS), ANT joins a growing interest in STS and other fields such as anthropology and philosophy (see, for example, Jensen et al., 2017) to challenge persistent assertions of traditional realism and constructivism (Barad, 2007; Law, 2008a, 2016; Law & Lien, 2013; Mertens, 2019). Before examining in detail ANT's relational approach, the following traces some of the history of the contentions, drawing on the ontological and epistemological analyses as outlined by John Law (2016), one of the pioneers of ANT, and Karen Barad (2007), a prominent STS feminist. Their evaluations involve four central ideas relevant to this study: realism, constructivism, representationalism, and practice-based research.

Instead of science's assertion of objectivity as impartiality, Donna Haraway's (1988) influential research regards such notion of objectivity as an illusion, deriding the assumption as a "god trick". She argues that scientific knowledges are situated knowledges. Then, for her, without claims of universality, the notion of objectivity can be redefined, and hence retained, as alternative "epistemologies of location, positioning, and situating" (p. 589). Law observes that in questioning positivism, "STS came into being by reacting against it" (Law, 2016, p. 33). In STS, works such as Haraway's in the 1980s invited ontological re-examinations, and one of the explicit articulations of an ontological turn can be traced to a 2002 workshop on "new ontologies" organised by Andrew Pickering (Jensen et al., 2017). In place of the positivist claim of objective scientific knowledge and logical generalisation, STS highlighted social divisions entrenched in the enactment of scientific methods in practice (Law, 2016).

On the one hand, while Boyle's faith in the scientific method persists in positivism and postpositivism (Hammersley, 2019; Shapin & Schaffer, 1985), on the other hand, in examining knowledges and scientific methods, the significant works of philosophers such as Husserl, Dilthey (see Mertens, 2019), and Thomas Kuhn (1962) highlighted the social construction of scientific knowledge. In place of the singular reality of traditional realism, constructivism – one label among many, including phenomenology – posits multiple realities constructed in social and cultural contexts. Barad considers various positions of traditional realism and constructivism and encapsulates her dispute using the metaphor of the mirror. She rejects both the realism that assumes "science as the mirror of nature" and the strong constructivist position that "science mirrors culture" (Barad, 2007, p. 40). Scientific knowledge represents either nature or culture, and in rejecting this deeply held traditional assumption, Barad, among many others in STS and ANT, launches an alternative concept of ontology and epistemology. For instance, Barad (2007) advances the idea of "ethico-onto-epistemo-logy" to erase the traditional separation of the three fields of study. One of the critical challenges from STS and ANT against the ontologies and epistemologies of both traditional realism and social constructivism centres on the mirror reflection or representationalism that greatly influences positivism and constructivism in research.

Representationalism

As Barad (2007) observes, the mirror metaphor is a common metaphor for representationalism. The metaphor denotes the traditional assumption of knowledge as the mirror reflecting either nature of culture. ANT joins STS to challenge the postpositivist insistence on the ontology of singular reality and the status of scientific knowledge as a reflection of nature (Law, 2016; Mertens, 2019). The challenge aims at the ontological assumption of a reality outside the individual, the postpositivist epistemology of objectivity, and the mentalistic representationism of the stable reality. Learning as acquisition – the metaphor underlying much of the existing research, as discussed in the previous chapter – assumes knowledge is representative of an empirical nature. Consequentially, postpositivist methodology depends mostly on de-contextualised quantitative data collected from surveys and existing data sets, viewing the role of the researchers as independent of the participants. Most of the quantitative studies identified in the literature review in Chapter 2 use surveys. A postpositivist approach to researching learning in contract work relies on structured quantitative data that overlooks data related to the practices enacted at work sites. Even though a large sample size of a survey provides a greater pool of data for analysis, surveys and structured interviews presuppose the isolated and independent ontological status of the variables being surveyed or questioned. Using an alternative ontology such as ANT avoids the ontological assumptions that this study could be a mirror reflection of a few pre-determined natural structures that would be pre-existing and waiting for the researcher to discover. Such a traditional realist approach would limit the possibility of illuminating other answers to the research questions.

ANT also offers an alternative to the social determinism of constructivism by questioning the reliance on the social ontological foundation. Rejecting postpositivism, constructivism rests on an ontology whereby reality is not assumed to be singular or objective but is multifold and socially constructed (Mertens, 2019); knowledge is a representation of different social structures. This ontological and epistemological approach forms the foundations of the metaphor of learning as participation, as commonly used in the literature discussed in Chapter 2. By questioning the de-contextualised subjects presumed by postpositivist research, constructivist epistemology examines social patterns based on the individuals' lived experiences. An advantage of this approach is that contextual factors can be described using qualitative data such as interviews, observations, and document reviews. Here, knowledge is a representation of the socially constructed and emerges not only due to the rich description of participants' experience but also due to the interaction between participants and researchers. A significant supposition in the constructivist literature leans heavily on representing the social in the "privileging of epistemological issues over ontological ones" (Barad, 2007, p. 41).

ANT relational ontology

ANT gathers robust critiques of ontological and epistemological assumptions of stable entities waiting to be grasped and represented by research. Especially since the 1980s, early writers of ANT (Callon, 1986; Latour, 1988; Latour & Woolgar, 1986; Law, 1986) offered critiques of traditional realism and social constructivism assumptions. ANT rejects explanations that suggest some essential reality behind concepts such as law and psychology (Latour, 2005). It also explicitly keeps a distance from any attempt to equate ANT with constructivism because such an attempt is regarded as a proliferation of realism (Latour, 2005) or seeing ANT as the tool to construct reality out of social relations (Law & Singleton, 2014).

In rejecting the epistemological assumption of multiple social perspectives and the ontological assumption of a singular or multiple constant realities, ANT's relational ontology rejects notions of separate realities that underpin representationalism and the inadequacies of the traditional dichotomies of nature/culture, representation/practice, and human/non-human, (Latour, 1991/1993, 2005; Law, 2016). Latour's discussions of the dichotomy of critique delineate the distinction between the ANT approach and other approaches. Each positivist and constructivist perspective focuses on representing elements of such dichotomies as ontologically innate and hierarchical, whereby culture, the mind, and theory are often privileged over the non-human, the physical body, and practice. With such presupposition, these traditional approaches exclude from research other aspects that could prove robust and influential.

ANT commits to a relational ontology that views "everything in the social and natural worlds as a continuously generated effect of the webs of relations within which they are located. It assumes that nothing has reality or form outside the enactment of those relations" (Law, 2008a, p. 141). In ANT, all actors are not pre-determined entities but unfold in relations, between the social, the material, and the animal as distributed network effects, and therefore, there is no privileging of human actors over non-human actors (see Section 3.3). Recognising the limitations of positivist and constructivist approaches, as discussed above, this study examines learning in contract work in practice, beyond restrictive traditional ontological and epistemological foundations.

Practice-based approaches

As a branch of STS, the present ANT study is located among practice-based approaches. Practice-based approaches form a large and growing body of research in workplace learning, exploring the complex and changing nature of learning (Hager et al., 2012). Practice-based theory includes contemporary approaches to research, such as actor-network theory, activity theory, and workplace studies (Gherardi, 2012a), suitable for investigating learning in the complexity of everyday practice. Common across these theories is the interest in the non-human world. The interests in the material world are extensively examined in prominent Western philosophies, for instance, in the works of thinkers such as Epicurus and Lucretius, through to Hobbes and Spinoza, and including Diderot, Nietzsche, Thoreau, Darwin, Adorno, and Deleuze – all of whom Jane Bennett (2010) listed as significant to her influential work *Vibrant Matter*.

More recently, these approaches have been influenced by the "practice turn" in the humanities and social sciences (T. R. Schatzki et al., 2001), tracing its roots back to the works of philosophers such as Heidegger and Wittgenstein. Knowledge – instead of being separated from matter, as one part of the mind/matter dualism – is reconceptualised: practices come to underlie the traditional dichotomy of subject/object, activity/representation, and human/non-human (T. R. Schatzki et al., 2001). ANT joins other practice approaches to reject traditional dualisms, such as between mind and matter, individual and social, and process and product (Hodkinson, 2005). Knowledge changes in everyday practice are conceptualised as emergent and extended in interconnected textures (Gherardi, 2016). Rather than viewing agency as an exclusive feature of human beings, agency is also in the non-human world (Latour, 2014; Latour & Woolgar, 1986; Mol, 2002). From this perspective, both human and non-human worlds are crucial in the enactment of everyday practice.

The word "practice" might be too general to offer helpful meaning, as Green observes (2009); however, this study is established within practice-based approaches, where practice is understood in terms of six major threads: knowing-in-practice, sociomaterial, embodied, relationality, historical and emergent (Reich & Hager, 2014). First, workplace learning is no longer about the transference of cognitive knowledge but is regarded as a form of knowing-in-practice which, in everyday practice, is renewed and transformed (Gherardi, 2009a; Manidis & Scheeres, 2013). Second, anthropocentric views of knowledge are replaced by a recognition that foregrounds two types of actors: social and material (Kilminster et al., 2011; T. R. Schatzki, 2012). Third, practice perspectives emphasise practice as embodied, observable in bodies and voices, rather than hidden in mental operations (Hopwood & Clerke, 2012). Fourth, practices are not isolated entities; they are understood in terms of relationality, a range of relations between human and non-human (Fenwick, 2008b). Fifth, practices are situated in historical and social contexts (Reich & Girdwood, 2012; T. R. Schatzki, 2006). Sixth, workplace practices are emergent, not prescribed in advance, emerging in times, spaces, bodies, and materiality (Hopwood, 2016). A practice-based approach recognises that traditional realism and constructivism cannot adequately respond to dynamic workplaces, where in everyday practice, people and materials are connected, yet dispersed, and disruptions generate learning problems in multitudes.

3.2.2 Why ANT?

ANT is a distinct approach amongst practice-based theories for its unique sensibility to both humans and non-humans. The turn to practice-based research addresses the neglect of the material world and explores the relations between the material and social. Along with ANT, various approaches are suitable for investigating learning in everyday practice, including activity theory, situated learning theory, cultural perspectives, workplace studies (Gherardi, 2000, 2019), complexity theories, cultural-historical activity theory, and spatial theory (Fenwick et al., 2011c). Each approach embraces different foci, such as thesis and anti-thesis in CHAT and non-linear emergence in complexity theory. Unlike ANT, in other practice-based approaches, for instance, complexity theory and its application in educational research, "the material dimensions seem to shrink" (Fenwick et al., 2011a, p. 55). With ANT, the privileged focus assigned to human actors is challenged. The choice of ANT allows this study to overcome the limitations set by the narrow focus on human activities, enabling non-human activities to be examined and allowing new possibilities in understanding learning in contract work.

Not only are humans decentred in ANT, but both human and non-human actors are approached in the relational ontology of distributed network effects. The ANT methodology asks, “How might we catch some of the realities we are currently missing?” (Law, 2004, p. 2). Instead of focusing on a few pre-determined actors, ANT traces relations in assemblages of humans and non-humans. ANT is a methodology that transfers the traditional obsession with centralised foci into examining the configuration and re-configuration of assemblages of actors. ANT offers a toolbox for tracing changes enacted in practice where networks are connected and disconnected (Fenwick et al., 2011c). As discussed in Chapter 1, in the context of the solar industry, changes, including rapid technological developments, assert significant demands on learning. ANT not only sidesteps the narrow focus of the prescribed actors but also allows previously invisible actors across multiple assemblages to be illuminated and analysed. The ability to study new and complex relations makes ANT a robust conceptual and methodological framework for investigating learning in the dynamic solar industry.

The ANT sensibility that insists on rich details and even mundane actors is another reason ANT is a suitable choice for this study. Education researchers have long been drawn to ANT’s conceptualisation of tracing the material and social, paying attention to mundane matters in everyday practices (Fenwick et al., 2011c). Indeed, ANT engages more completely in practice as a “study of the ephemeral, the indefinite and the irregular" (Law, 2004, p. 4). ANT allows this study to generate data on both human and non-human actors, both established and newly invented, however seemingly powerful, or mundane. The analysis of such rich data expands the scope of this study to examine actors that might be neglected or even dismissed as mundane. ANT not only addresses the neglect of the material world, but it also strives to understand relations in their fuller complexity without pre-excluding some seemingly insignificant matters. In compassing a rich range of data, ANT broadens the possibilities of significant entry points for analysis and understanding of how relations are made or omitted.

ANT offers the most suitable framework to address the crucial learning demands discussed in Chapter 2: the need for studying learning in contract work as it emerges in practice, the importance of both the social and material actors, and the dynamic, complex, unanticipated relations in contract work and solar installation work, and the possibility of a more comprehensive understanding based on a richer gathering of data. The three central ANT concepts deployed in this research – human and non-human actors, network effects, and matters of fact and matters of concern human – are carefully selected to target the answers to the research questions. Before examining these concepts in detail in Section 3.3, this section further explores the unique feature of ANT as a suitable sensibility that is both the conceptual and methodological framework for the present study.

3.2.3 ANT as a sensibility

Actor-network theory, contrary to its name, is not a theory. ANT is not to be taken as another theory of the structure of reality. Whereas a theory is usually defined as the overarching structure with explanatory and predictive laws, ANT theorists seek to avoid this understanding of theory (Latour, 2005). The publication of *Actor-Network Theory and After* (Law, 1999) firmly established what came to be known as "post-ANT" or "after-ANT". Here, John Law (1999) rejected the rigid perception of ANT as a theory where theory in the conventional sense is a contradiction to ANT's rejection of the dichotomy of structure and agency as, for instance, in notions such as solidified actors and networks. Unlike other approaches, ANT does not assume macro-structures are the foundations for explaining micropatterns. This study follows Edwards and Fenwick's approach (2015) and uses the term ANT to refer to concepts within both types of ANT approaches, early ANT and post-ANT.

Instead of a theory, ANT is viewed as a sensibility, a lens, a set of tools or a methodology (Farias et al., 2020; Latour, 2005; Law, 1999), a method assemblage (Law, 2004), or as interchangeable with assemblages (Fenwick & Edwards, 2018). It is utilised as a guide of views and methods, both conceptualising the world as well as offering methods, such as the famous instruction to "follow the actors" (Latour, 2005, p. 68) to describe – rather than explain – "'how' relations assemble or don't" (Law, 2008a, p. 141) in practice. From the earliest works, ANT does not assume that:

> aggregates are mainly made of (x). It makes no difference if (x) stands for "individual agent", "organizations", "races", "small bands", "states", "persons", "members", "will power", "libido", "biographies", "fields", etc. ANT simply doesn't take as its job to stabilize the social on behalf of the people it studies; such a duty is to be left entirely to the "actors themselves". (Latour, 2005, pp. 30–31)

ANT does not view its tasks as explaining the subjects of its study: ANT examines everyday practices, seeking to understand the actors in action and their relations (Law, 1999). Central to this study is the conceptualisation of ANT as descriptive. Rather than offering explanations, ANT seeks to provide descriptions. Law (2008a) stresses that while theories search for reasons underlying the occurrence of phenomena, "actor network theory is descriptive rather than foundational in explanatory terms" (p. 141).

Considering the dynamic emergence of contract work in the solar industry, where changes such as technological development cannot be prescribed in advance, the ANT sensibility avoids a premature focus on predetermined factors. Instead, ANT offers fitting methods to follow actors in its web of relations, bearing in mind the globalised networks of the solar industry. ANT offers this study a sensibility that illuminates how everyday practices emerge and how they are held together within assemblages of social and material actors, enabling the gathering of fine empirical data as the basis of rich descriptions as new knowledge.

3.2.4 Challenges to ANT

While ANT offers valuable concepts and methods, ANT is not free from criticism; however, these criticisms have been defended by ANT scholars, and these defences inform how ANT is deployed in this study. Criticism of ANT generally falls into four categories: symmetry of human and non-human actors, the problem of description, lack of social structures, and amoral stand (S. Jackson, 2015; Walsham, 1997). In terms of ANT's notion of symmetry between human and non-human actors, a major criticism is that by suggesting that ANT researchers approach social and material actors symmetrically without privileging human actors, ANT is creating a flat ontology that dehumanises human actors (Vandenberghe, 2002), and is erasing social accountability networks (Collins & Yearley, 1992). The ANT approach is challenged for committing either symmetrical absence or symmetrical absurdity where the research either fails to present an analytical symmetry or leads down an infinite regressing loop of networks created within networks (McLean & Hassard, 2004).

In responding to this criticism, Callon (1999b) argues that the concept of symmetry is an analytical symmetry, not an ontological symmetry; actors are not predetermined since ANT "assumes the radical indeterminacy of the actor. For example, the actor's size, its psychological make-up, and the motivations behind its actions" (p. 181). Actors are viewed as indeterminate, and the "effects" of other actors are also deemed indeterminate. Criticisms of symmetry are misguided because they refer to the ontological status of human and non-human actors. In this study, the symmetry of actors as effects – not of actors as *a prior* entities – was a helpful concept to challenge the entrenched ontology of innate and isolated entities.

With the ANT approach that traces practices as they emerge in rich detail, a significant concern for researchers is the large volumes of data generated and how to make decisions on what to include, exclude, and describe (S. Jackson, 2015; McLean & Hassard, 2004; Walsham, 1997). In following the actors, Latour proposes that among the masses of entities that emerge in practice, these are connected in some ways, and the crucial point is to resist the urge to prematurely collapse the data to concepts or narrow the trajectories of actors and their connections (Latour, 1996). This study generated a large volume of data, including 395 typed pages of observation and interview data. As much as possible, data on the seemingly important and mundane actors was generated without predetermined foci. In doing so, this study avoided limitations set by predetermined foci and allowed an extensive examination of the emergence of connections without settling for premature explanations.

ANT's emphasis on the fine details of practice leads to the criticism that this approach fails to account for broader social structures adequately. In focusing on how practices are accomplished, the influences of social institutions on practices are ignored, and what remains are the local and indeterminate (Reed, 1997). Latour anticipated such criticism in 1991 when he emphasised that the "macro-structure of society is made of the same stuff as the micro-structure" (Latour, 1991, p. 118). However, where researchers are unconvinced of the validity of the claim that links the micro to the macro, additional theories of social structures can complement the use of an ANT approach (Walsham, 1997). In this study, actors at the local level, such as the local installation site, are directly shaped by actors at different locations, such as the federal government. ANT's key concept of network effects – to be discussed in the next section – is a powerful tool to examine the relationship between actors in assemblages without resorting to ontological assumptions of structures and hierarchy.

3.3 Key ANT concepts in this study

Three of the most important ANT concepts used in this research will be discussed in this section, focusing on human and non-human actors, network effects, and matters of fact and matters of concern.

3.3.1 Human and non-human actors

Given the arrays of material connections required for the successful installations of solar PV systems, the foremost reason for using ANT in addressing the research questions is the ANT conceptualisations of actors. While ANT recognises the importance of human actors, it rejects traditional anthropocentric models. ANT questions the preoccupation with knowledge residing in the human mind, a cognitive-based inheritance still dominant today in the literature, as discussed in Chapter 2.

In ANT, the term "actor" does not hold a human-centric preference. Actors are defined as "what is made to act" (Latour, 2005, p. 218). The term refers to a multitude of actors, both human and non-human. A key feature of ANT is its sensitivity to non-human actors, refusing to take the material world for granted. The material world is not simply a postscript of human activities. ANT takes account of the ongoing dynamics of actors and the dynamics of the material, connecting and disconnecting with humans and animals (Fenwick et al., 2011). Materiality acts and is acted upon, emerging as actors in sociomaterial relations, void of relationships of hierarchical levels (Latour, 1999). Therefore, in ANT, preference is not given to either human or non-human actors. The ANT sensitivity insists on not ignoring seemingly mundane actors that are both human and non-human actors. These include, for example, the glue gun that enables children to create new designs (Roth, 1996) or a gentamycin form that invites assemblages of practices, such as where medical records are stored or the duration of an antibiotic prescription (Mitchell, 2019).

While ANT is sensitive to a multitude of human and non-human actors, the term "actor" is a label; it does not refer to an intrinsic reality. Actors, such as the contracts analysed in this study, connect or disconnect with other actors, forming a heterogeneous assemblage of agencies (Latour, 2005). Studying an actor, such as a contract or a solar system, is not about studying hermetically sealed contracts or discrete units of solar panels. In his earlier writing on ANT, Latour insists that an actor such as one denoted by the term "science" does not exist in isolation but in connection to other actors (Latour, 1988). Similarly, an actor in a workplace, say Andrew-the-strategist, is a collective of human and non-human actors:

> Andrew + fax + fellow managers + secretary + head office + trains to London + his PC + the work of scientists and engineers + the memos that circulate + the time slips filled in by employees . . . So Andrew-the-strategist cannot be detached from this arrangement of materials. (Callon & Law, 1997, p. 177)

In the same way, an actor, such as a contract or a solar panel, cannot be detached from its heterogeneous collectivities (Callon & Law, 1997).

A heterogeneous collectivity or "what is made to act", such as Andrew-the-strategist, is defined by actions that are not restricted to just intentional actions. In ANT, actions are dislocal, enacted across different times and spaces. To offer an example of the dislocal agency, Latour reflects on a lecturer teaching in a lecture hall. There is an amphitheature, a chair, student seats, as well as the wood, the seeds of the trees, paint, and many other actors that cannot be all named. However, all were created at different times in the past and different locations. The lecturer teaching in that hall is a node of actions performed in the past and in various places.

Of both human and non-human actors, actors that are "made to act" (Latour, 2005, p. 218), and they are "entities that do things" (Latour, 1992, p. 241). Latour discusses two concepts, mediators and intermediaries, concepts that are defined in terms of actions that are inputs and outputs. Mediators are actors whose inputs have the effect of much greater outputs. They enact change, often requiring other mediators to transform and generate further actions. As for intermediaries, the input and output are more or less the same; they do not transform nor make any significant difference. Where mediators and intermediaries are concepts characterised by transformation and lack of transformation, ANT highlights the concept of the mediators in both human and non-human actors, actors that enact change and transformation, actors that generate differentiations (Mol, 2010).

Human and non-human actors are chosen as key concepts in this study to bring a methodological emphasis, firstly away from a humancentric gaze and secondly to focus on the actions that are transformative. Examining an actor involves investigating its actions in relation to networks, "for what really acts is heterogeneous networks" (Croce & Margoni, 2021, p. 1). For Czarniawska and Czarniawska-Joerges (2014), it is crucial to understand an ANT actor to explore how an actor and the various connected actors in the heterogeneous networks are presented as one actor. In other words, actors are enacted as network effects, the second key concept central to this thesis.

3.3.2 Network effects

The concept of network effects is a key concept in this study as it is central to how learning is defined in ANT studies. ANT in education research approaches learning as network effects (Fenwick & Edwards, 2010). In ANT's relational ontology (Law, 2008a), interactions between actors enact "relations are more foundational than components" (Haavik, 2021, p. 88). Actors form relations in networks that allow them to act (Mol, 2010). For example, a fish as an actor depends on other actors, such as the water and plankton, for its survival and swimming ability (Mol, 2010). Similarly, a functioning solar panel depends on actors such as the manufacturer's factory, the supplier's inventory, and sunlight. To understand the focus of the central research question, "How is learning in contract work enacted in solar PV installations?" is to seek a nuanced understanding within a relational ontology of how learning unfolds as network effects, in the relations enacted between actors connected to solar electrical contract work.

Without taking a foundational stance, the ANT concept of network effects focuses on effects rather than causes of human and non-human assemblages in solar contract work. Mol (2010) notes that the idea of causality applies a rigid determinism where the action is withheld from the object being caused. Causes assume certainty and confine possibilities for action. Similarly, Latour (2005) argues that in causes, the outputs are predictable and already contained in the inputs. For him, if everything is already in the cause, it is futile to study its effect. Effects are central in ANT: it is not the causes of activities but where the activities go (Mol, 2010).

With the ANT sensibility, in this study, actors are viewed as network effects, capable of generating actions that are dislocal, actors that do not solidify to any site, acting fully in everyday practice. For example, the activity of pressing a power button can turn on a computer (Latour, 2005), or turning on a solar system on a rooftop can have the effect of electricity being generated; here, the actors are intermediaries. The same action can have complex effects – when the same computer malfunctions due to hardware or software issues, or the owner of the solar PV system can be fined for using electricity before acquiring the necessary approval, or blames can be raised between different actors. The actors – the computer or the solar PV system – can undergo transformation as mediators. The emphasis is not on the reasons or causes for a particular action but on the effects of such action (Winthereik, 2020).

Latour emphasises the importance of *not* considering ANT as a theory about fixed networks. Post-ANT challenges the limits of networks being bounded within limits and homogenous forms (Law, 1999). Rejecting the rigid connotations and confusion implied by the word "network", Latour emphasises the activity, the forming of the networks, as enacted in practice, in the actions of the work, the actions that, when traced, form the networks (Latour, 2005). Hence, when applied to a study of contract work and solar PV installations, the ANT follows the actors in the mundane connections to make the previously invisible relations visible.

Latour cautions that the ANT networks are not local or global contexts. ANT is used to trace networks as they emerge by following connections. Focusing on the relations, Latour (2005) emphasises that "an actor-network is traced whenever, in the course of a study, the decision is made to replace actors of whatever size by local and connected sites instead of ranking them into micro and macro. The two parts are essential, hence the hyphen." (p. 179). Consider, for example, the connections related to an organisation, which involve materials such as documents, products, and even passion that are more securely connected. Latour rejects comparisons between a more expansive network with the macro or a smaller one with the micro. However, such secure connection effort does not automatically equate to notions of global/local, wider/smaller, higher/lower, and micro/macro networks. Instead, following Tarde's lead, Latour (2005) suggests the ANT networks are "made of a proliferation of incommensurable entities" (p. 243), and the emphasis is always on the continuous connections:

> it's not that there is no hierarchy, no ups and downs, no rifts, no deep canyons, no high spots. It is simply that if you wish to go from one site to another, then you have to pay the full cost of relation, connection, displacement, and information. (p. 176)

In following the actors and their connections, however seemingly mundane, network effects can be traced. Instead of taking shortcuts to discuss structures such as capitalism and society, ANT emphasises the detailed and laborious task of describing more connections across different times and spaces, such as the computer connections between a Wall Street trading room and Bloomberg trading screens (Latour, 2005). An ANT approach is attentive to the negotiations at the connections (Fenwick, Edwards, & Sawchuk, 2011a). Connections can zigzag between the social-social or material-material or social-material (Latour, 2005) and in ANT, "it's the work, and the movement, and the flow, and the changes that should be stressed" (p. 143).

Connection efforts

The view where learning is conceptualised as network effects of struggles, tensions, and negotiation at nodes of connections (2011) remains prominent in ANT research. Rather than considering learning as network effects with the rigidity of fishnets, network effects are better understood as the actions of connections and disconnections being carried out in everyday practices. While conceding that "network" is not the most suitable word choice, as it denotes rigidity, the term is still a workable choice since, for Latour, it highlights the importance of nodes of connections.

> There exists no good word anyway, only sensible usage; in addition, the original material metaphor still retains the three important features I wish to induce with this expression

> a) a point-to-point connection is being established which is physically traceable and thus can be recorded empirically;
> b) such a connection leaves *empty* most of what is *not* connected, as any fisherman knows when throwing his net in the sea;
> c) this connection is not made for free; it requires effort as any fisherman knows when repairing it on the deck. (Latour, 2005, p. 132)

Requiring effort, learning as network effects is enacted in the negotiation of connections and disconnections that vary. Latour (2005) sees the nodes of connections as "longer, faster, and more intense connections" (p. 179) or "far safer connections with many more places than others" (p. 176) or the multiplying "number of connections" (p. 215) or "some sort of more or less durable connection" (p. 221). Latour refers to William James, arguing that "to liberate" an actor such as a marionette is not to reduce the number of connections by cutting the strings connecting them to the puppeteer but to multiply the connections. The agency or enslavement of actors correlates to various connection assemblages or connection efforts. This concept of connection effort invites the ANT researchers to examine actors closely "the *ways they are connected* to one another" (Latour, 2005, p. 22). Defined as such, in studying learning, ANT explores how the connections emerge in struggles and negotiations, what the network effects are and how these effects serve and influence other connected actors and networks. The importance of "connection" continues to feature in ANT research on workplace learning.

3.3.3 Matters of fact and matters of concern

Two ANT concepts central to the analysis of this study are matters of fact and matters of concern. The analysis of the data gathered for this study revealed these concepts as significant to the study. Using the key concepts of actors and network effects, practices relating to contracts were identified as important actors in two critical ways: contracts as an approved quotation and contracts as an emergence composed of changes in everyday work. These two approaches to contracts are best understood using the concepts of matters of fact and matters of concern. These two concepts were used in the study and are discussed in this section as they are essential to the discussion in Chapter 4 on the findings related to the two ways of understanding contracts.

To understand the matter of fact of a contract is to understand its matters of concern. The term "concern" here does not simply mean a cause to worry; it refers to the composition of the matters of fact. These concepts address questions pertinent to this study's changing context, exploring the process of how matters of fact and matters of concern are enacted (Michael, 2017b). While the ANT relational ontology does not advocate for an ontologically separate reality that is a fact, matters of fact are matters, in *conventional* everyday practices, taken to have an objective reality. The emphasis here is on the conventional view. These matters are seen conventionally as isolated and fixed, matters that are approached with limited consideration of their relational composition. In ANT, the conventional view of matter of fact is discussed in contrast to another way of viewing matters, which is matters of concern. Matters of concern analyse the same matters of fact but with extended scope. An analysis examining matters of concern does not dismiss or ignore matters of fact, but it is an analysis that gathers the web of relations in the composition of such matters of fact. Matters of concern "detect *how many participants* are gathered in a *thing* to make it exist and to maintain its existence" (Latour, 2004, p. 246).

The two approaches rely on different ontological accounts. Since the 17th century – in Newton's theory of light and sound and Locke's theory of primary and secondary qualities – the matter of fact approach assumes an objective world, separate from the social world (Latour, 2008; Whitehead, 1920). This objective world provides the facts that can be uncovered or discovered. Matters of concern, on the other hand, seek to listen to matters that are connected, yet remain invisible and silent. To use these two concepts is "to shift from a nature always already there to an assemblage to be slowly composed" (Latour, 2010, p. 477). These concepts consider the matter's compositions and map how matters negotiate to reach some forms of stabilising consensus.

Latour follows Whitehead's lead in adding matters to the analysis. One of the highlights of Whitehead's philosophy for Latour lies in the idea of considering different types of data, the red sunset, as well as its electric waves; between them, there is no privileged consideration (Whitehead, 1920). The critical method is *not* to choose in advance of the investigation. It is *not* to eliminate the sunset right from the start of the matters being examined. The method is to follow the actors to understand it beyond predetermined facts.

Matters of concern, as a critical method, add to matters of fact, not debunking matters of fact. Matters of fact – useful as they are since the Enlightenment in debunking misinformation such as superstitions and fake news – are only parts of "reality" (Latour, 2010). Here, "reality is not defined by matters of fact. Matters of fact are . . . renderings of matters of concern and only a subset of what could also be called *states of affairs*" (Latour, 2004, p. 232). To understand how states of affairs are enacted is to gather matters of concern. In order words, ANT seeks to examine matters of fact as matters of concern. Describing how an entity emerges is not the same as saying that the entity does not exist. Matters of concern do not diminish the matters of fact but engage extensively with the matters of fact (Latour, 2004). For example, describing how solar panels are manufactured and how the components are sourced does not mean that solar panels do not exist. It is also a mistake to think this analysis moves away from facts.

Analysing the gathering of matters of concern is analogous to "shifting your attention from the stage to the whole machinery of a theatre" (Latour, 2008, p. 39). ANT does not try to determine whether a matter is real or fabricated; the key to understanding the difference between matters of fact and matters of concern is that matters of concern look closely instead at how matters of fact are assembled (Latour, 2005). Actors are analysed as matters of concern when the ANT sensibility opens actors taken for granted as undisputed facts (Latour, 2005). Facts regarded as solid, isolated, taken-for-granted, rely on a range of matters of concern to exist (Latour, 2004). A fey ANT methodological approach is to explore actors, those taken as matters of fact, and examine them as matters of concern.

The essential difference between matters of fact and matters of concern is how the matters are conceptualised and studied. Latour (2005) discusses several examples. When viewed as matters of fact, matters such as genes and topsoil are treated as objective reality, silent, and undisputed. On the other hand, as matters of concern, to geneticists, genes are seen engaging in dispute, whether they transport information or compete for food. In another example, as a matter of concern, to pedologists, topsoil can either be a layer of coloured soil or the ecosystems of several micro-organisms.

The key ANT concepts discussed in this section are crucial to the study as they shape 1) the type of data being generated – human and non-human actors, including the seemingly mundane – 2) the conceptualisation of the actors not as isolated units but as network effects, 3) the study's resistance to predetermined focus and premature explanations, and 4) the findings related to the contracts to be discussed as matters of fact and matters of concern in Chapter 4.

While the key concepts used in this research are carefully selected and no single PhD study has the scope to deploy the full range of ANT concepts, some clarifications are needed regarding some seemingly analogous concepts. Translation is an ANT concept that appears to be comparable to the concepts of matters of fact and matters of concern. However, there are substantial differences. While the ANT concepts of matters of fact and matters of concern are ways of seeing, a sensibility of broadening the gaze from the stage to the theatre, translation tracks power processes and narrows the research gaze onto segments of the processes. For Callon (1986), translation is a process that involves four moments: problematisation, interessement, enrolment and mobilization, respectively accounting for 1) how problems are redefined to include the actor leading the translation, 2) how allies are established, 3) how allies are assigned roles, and 4) how allies are represented. The translation process could be used to answer the first sub-ordinate question, "How are contracts enacted in practice?" However, doing so would prematurely impose the structure of the four moments onto the present study. This approach would be contrary to the ANT tenet of following the actor. As already discussed above, Latour insists that "ANT simply doesn't take as its job to stabilize the social on behalf of the people it studies; such a duty is to be left entirely to the "actors themselves" (Latour, 2005, pp. 30–31).

As mentioned earlier in this sub-section, the concepts of matters of fact and matters of concern are discussed in this section on ANT concepts, not because they are pre-selected concepts to filter the data. These concepts arose out of the analysis stage of this study. By deploying the ANT methodology of following the actors, contracts emerged as significant actors for close analysis. An important outcome of the analysis is that the two concepts of matters of fact and matters of concern are most suitable for understanding contracts in their webs of relations in practice.

3.4 Learning and ANT in this research

ANT offers an alternative to the metaphors of learning as acquisition and participation, as discussed in Chapter 2. Fenwick and Edward (2010) succinctly summarise ANT's response to the foremost contestations in approaches to learning: "learning is not simply an individual or cognitive process. Nor is it simply a social achievement. Learning itself becomes enacted as a network effect" (p. 4). To explore learning as emergence in practice, this section on the ANT conceptualisation of learning draws on an established ANT definition of learning.

For Fenwick, Edwards, and Sawchuck (2011), "learning through an ANT analysis, therefore, can be viewed as a distributed effect, something that continually emerges through negotiations and struggles at myriad nodes of possible connections between human and non-human elements" (p.117). This ANT definition advances learning as emergence and relational connections; learning is not a fixed, isolated thing to be acquired in the learner's head or a social reality available for participation. To be clear, by following Fenwick, Edwards, and Sawchuck's lead to define learning as a distributed effect, I am not suggesting that learning is the same as any change.

Specifically, learning is the network effect (see Section 3.3.2) of negotiations and struggles generating differences and transformation. The negotiations and struggles occur at nodes of connections involving sociomaterial actors.

3.4.1 Nodes of connections

In ANT, learning occurs in actions at the nodes of possible connections of various actors and networks. The nodes of connections are nodes of actions. According to Latour (2005), "action is not done under the full control of consciousness; action should rather be felt as a node, a knot, and a conglomerate of many surprising sets of agencies that have to be slowly disentangled" (p. 44). Latour (2005) argues that actions and agency pertain to humans as well as to those seemingly inert, non-intentional non-humans, such as an amphitheatre built several years before the moment a lecturer teaches: "just because some material element of the place does not 'determine' an action doesn't mean you can conclude that they do nothing" (p. 195). Learning at the nodes of possible connection is enacted in action as distributed network effects. Latour even considers the term "work-net" as it connotes the actions, that "work-nets could allow one to see the labour that goes on laying down net-works" (Latour, 2005, p. 132).

Using ANT to study online work-learn practices, Thompson (2018) guided her study with a similar approach to workplace learning. Her work attends to "how negotiations between knotty tangles of actors end up enacting multiple practices and spaces as they become, move, mix and mobilize" (Thompson, 2018, p. 1032). In ANT research, learning is the enactment of the social and material worlds, including the mundane, be it a pen, tablet, or office. Even though these objects might seem mundane and perhaps pointless and unsettling in a general discussion, where the mundane is taken for granted, the effects of their actions on practices and learning are also taken for granted. These definitions of learning challenge the conventional hold that assigns to knowledge the ideas of acquisition and participation.

The ANT approach to learning questions entrenched understandings of what is involved in learning. As discussed in Chapter 2, the view of learning as emergence eschews learning being conceptualised as a purely cognitive activity or constructed in the social world. Conceptualising learning is more than assuming that learning is about acquisition and participation; that at the centre of learning are just human actions. With ANT, questioning these assumptions invites us to consider instead that learning is an enactment of connections, involving materials and humans. This study, therefore, explores how these connections and disconnections are assembled and enacted and to what effects, both in the human and non-human worlds.

3.4.2 ANT research questions

ANT research involves particular kinds of research questions. The research questions that guide this thesis consider the effects of "how and in what forms people, representations and artefacts move, how they are combined, where they get accumulated, and what happens when they are hooked up with other networks already in motion" (Nespor, 2002, p. 376). As in Thompson's study (2012) of contractor online learning, the use of ANT as a sensibility is a suitable approach to understanding uncertainties and messiness in ways of learning in the context of contract work in the solar industry in Australia. This provides the focused site of practice that Thompson emphasised: analysing learning in contract work from a perspective that accounts for the complexity of changing practices. In this thesis, the research questions align with the central ANT approach of asking the "how" questions instead of asking the "why" or "how many" questions – How is learning in contract work enacted in solar PV installations? How are contracts enacted in practice? How is learning enacted in solar PV installing practices? The research questions are carefully designed to address knowledge gaps in the existing literature, as identified in Chapter 2.

The word "enacted" in this study's research questions is a key ANT concept in understanding how learning is enacted in emerging networks. The term grounds this research in the ANT sensibility. Mol (2002) defines "enact" as follows: "in practices, objects are enacted. This suggests that activities take place – but leaves the actors vague. It also suggests that in the act, and only then and there, something is – being enacted" (Mol, 2002, p. 33). To avoid unintended connotations of words such as "construct" or "perform", following Mol's usage, this thesis limits the focus of the word "enact" to the action, the doing in everyday practice. In ANT, rather than separate entities, actors are connected to other actors and are formed as enacted networks that include some actors and exclude others (Latour, 2005).

In the dynamic context of contract work, particularly in the complex material world of solar PV, technologies change rapidly. As a practice-based approach, ANT offers conceptualisations of workplace learning that examine not only the social but also the material world in assembling learning. ANT examines the enactment of practice, which is entwined in negotiations and struggles connecting the human and non-human world. Attention is focused on both the material and social actors; it is a difference and a strength that sets ANT apart from other practice-based perspectives

(Fenwick & Edwards, 2012). Such an emphasis on researching sociomaterial actors makes visible a fuller range of the effects of the connections occurring between the social and material worlds.

3.5 Praxiography

The empirical groundwork of this study rested on praxiography. In a seminal work, *The Body Multiple*, Annemarie Mol (2002) offers the concept of praxiography instead of ethnography. Both approaches use well-known methods, such as observation, interview, and document reviews (Bueger, 2014), where the researcher conducts extensive observation on-site (Buscatto, 2018). Different ontologies establish crucial differences. Traditional ethnographic studies are founded on "ontological pyramids", where reality can be singular, plural, and real; another approach is based on practice, on ontology-in-practice (Mol, 2002). While "-graphy" refers to the acts of writing and recording, compared to ethnography, the "ethno-" indicates more interest in culture than the prefix "praxio-" where praxiography is more interested in practice(Bueger, 2014). As practice is messy, the data generation and data analyses in this study aimed to capture the richness of the practice. This was achieved with the praxiographic approach, which considers a variety of objects and events (Mol, 2002). The following sections present how this research generated data on actors, where they can be seen as mundane, even seemingly counter-intuitive (Latour, 2005).

In terms of the importance of practice in praxiography, by using the practice-based approach of ANT, this study profited from recent developments of alternative ontology, epistemology, and methodology, challenging both postpositivism and constructivism, as discussed in Section 3.2. These approaches challenge the postpositivist theories of quantifiable, unchanging realities, and de-contextualised subjects (Mertens, 2019), as well as questioning constructivism and the basis of an ontology whereby reality was argued to be multiple, subjective, socially constructed based on the individuals' interpretations of their experiences (Mertens, 2019). In contrast with postpositivist perspectives, constructivist approaches can make explicit various aspects that influence learning in contract work. Reflection and interpretation reveal features of learning, conceived as socially constructed. The advantage of a practice-based approach such as ANT is the use of interviews, observations, and document reviews, which also allow contextual factors to be described.

Unlike ANT, each positivist and constructivist approach focuses on certain learning features. An ANT study moves away from these reductionistic foci and engages with actors that seem ephemeral or irregular (Law, 2004). Such engagement is especially appropriate for this study, which is located in a changing work context, fluctuating with increasing learning demands, new technologies, new materials, and new stakeholders – as discussed earlier in Chapter 1, on the context of the solar industry in Australia. This methodology explores "How might we catch some of the realities we are currently missing?" (Law, 2004, p. 2). A practice-based approach such as ANT engages conceptualisations and methodologies designed to examine the complexity of workplace practice and is capable of revealing factors that are invisible where networks are connected and disconnected (Fenwick et al., 2011). This study sought to understand learning in contract work beyond restricted factors and addresses a significant gap in knowledge from a broader perspective that considers the complexity of changing everyday practice.

3.6 Study setting and the electrical contractors

This section discusses how the study was conducted. In this study, the ANT conceptual and methodological framework aligns with the research design and praxiographic methods – observation, interview, and document review. This section provides the rationale for how the study was conducted in terms of decisions regarding ethical concerns, participant selection, data generation methods, data analysis, and the writing up of an ANT thesis.

3.6.1 Overview of fieldwork

The fieldwork began in April 2018 and was completed in December 2018. Over a period of eight months, data were generated from 12 solar installations. Across 35 days of installation, the research generated data on the practices of four electrical contractors. While the complete cycles of installations could vary and overlap, each installation typically took place over two to three days. To generate data, this study used three methods: observation (303 hours in 35 days – 290 typed pages), follow-up interview (24 interviews – 105 typed pages), and documentary data (quotations, drawings, emails, manufacturer information, audit reports, industry publications, media coverage etc.).

During observation of the installation days, handwritten notes recorded the emerging actions, noting both human and non-human actors. Interviews were conducted, and voice-recorded, face-to-face on installation days, during breaks, while driving, or over the phone after the installation. The electrical contractors provided documents such as quotations, drawings, and emails. Documents also include publicly available websites and brochures. Table 3.1 presents an overview of fieldwork.

Table 3.1 Overview of the Fieldwork

Fieldwork Apr-Dec 2018	Solar PV Installations	Installation days	Electrical contractors	Data
8 months	12 installations	35 days	4 contractors	Observation: 303 hours in 35 days (290 typed pages) Interview: 24 interviews (105 typed pages) Document review: quotations, drawings, emails, manufacturer information, audit reports, industry publications, media coverage, etc.

The data gathered for this study involved not only the human actors who worked as electrical contractors. As discussed in Section 3.4, an ANT study follows the actors in action at the nodes of connecting to other actors. Latour (2005) considers the nodes of connections to be more or less intense, more or less connected to other nodes, or having various numbers of connections. In the gathered data, there were several actors and actions that frequently appeared in higher numbers. The word clouds of Figures 3.1 and 3.2 rank the recorded words based on the number of times they occur in the data, with the highest frequencies appearing the largest. Figure 3.1 shows that the observation data had many words for non-humans and actions. The material actors included “panels”, “roof”, “cable”, “isolator”, and “ladder”. The data also contained words that describe actions such as “drills”, “looks”, “walks”, “up”, “down”, “talks”, “talk”, “tells”, “asks”, and “explains”. The observation data recorded the mundane activities of actors such as panels, cables, and ladders, connecting with the electrical contractors and other actors.

Figure 3.1 Frequently Occurring Words in Observation Data

In Figure 3.2, the interview data had more conceptual words like “what”, “when”, “job”, “but”, and “know”. This frequency indicates that interview data often engage with cognitive activities such as connecting time, space, people, comparisons, and differences. Compared to the observational data, the interview data has more words that relate to humans, such as “I’m”, “you’ve”, “he’s”, “people”, and “know”. The observational data complements the interview data, offering a richer dataset referring to human and non-human actors. Without this observation data, a significant part of the actors, related connections, and actions involved in practice in solar electrical contract work cannot be illuminated.

Figure 3.2 Frequently Occurring Words in Interview Data

3.6.2 Recruitment

In preparation for this study, I negotiated an internship with a solar PV company to understand the industry and make connections to recruit participants. Over the first nine months of the candidature, I spent one day a week working on the internship. The experience helped me understand some work processes and gain valuable insight into the solar and renewable energy industry. However, the internship did not lead to the recruitment of participants.

Recruitment of participants occurred at a major conference and exhibition in Sydney, with the support of industry leaders who, at their events, extended the invitation to their attendees to participate in the research. With each potential participant who approached me at these events, I asked their permission to contact them via email or phone after the event. Using arms-length recruitment, this research enabled the potential participants' choice to ignore the invitation to participate without having to communicate the refusal directly to the researcher (Staller et al., 2010). The four solar installers recruited for the study were the only four who volunteered to participate.

Informed consent began at the initial contact with the electrical contractors. To obtain and maintain consent throughout the fieldwork, relevant information such as the research purpose, methods and implications were provided at the beginning and when requested by the participants. I also clearly communicated the importance of participants' confidentiality and anonymity. As this study aims to analyse everyday practices, there is neither deception nor concealment in the methodology; hence, the research involves no limited disclosure. All participants received the Participant Information Sheets and the Consent Form (See Appendices 1 – 6). Participants signed the Consent Form, and before the audio recording, I asked for permission and obtained verbal consent before turning on the recording device.

The study did not purposely include or exclude vulnerable groups such as participants who were pregnant women, participants with a disability or intellectual impairment, or participants of Aboriginal and Torres Strait Islanders heritage.

3.6.3 The electrical contractors

Four electrical contractors, working separately on 12 solar installations, participated in the study – see Table 3.2. Four participants and 12 solar installations allowed sufficient data to be gathered across various practices associated with different contractors and installation sites, within the time allocated to a PhD study.

Qualifications and accreditation

The participants were licenced electricians and accredited solar installers. To hold an electrical licence, an individual must complete the requirements of one of the seven qualification pathways (NSW Fair Trading, 2021). These pathways involved different requirements, such as a minimum of 12 months of relevant experience and relevant Certificate III (recognised within the Australian Qualifications Framework, starting from Level 1, Certificate I, to Level 10, doctoral degree). Electrical work in New South Wales (NSW), Australia, where the research sites were located, was regulated by the Home Building Act 1989 and the Electricity (Consumer Safety) Act 2004. Both Acts define electrical wiring work as the actual physical work of installing, repairing, altering, removing, or adding to an electrical installation or the supervision of that work. Electrical installation was defined as “any fixed appliances, wires, fittings, apparatus or other electrical equipment used for (or for purposes incidental to) the conveyance, control and use of electricity in a particular place” (NSW Fair Trading, 2016). Electrical wire rules complied with AS/NZS 3000-2018 standard.

Accredited solar installers

To ensure that the installed solar panels are eligible for claiming government financial incentives, the electrical contractor is an individual – rather than an organisation – who is accredited by the Clean Energy Council (Clean Energy Council, 2020c). To be an accredited solar installer, the electrical contractor is required to obtain a provisional accreditation by submitting the following:

- training certificates
- public liability insurance (at least $5 million)
- electrical licence (if applying for grid-connect install or battery storage install)
- working safely at heights certificate completed within six years (if applying for grid-connect install or SPS install)

The electrical contractor is then required to:

- complete online assessments

- practical installation assessment for Install Accreditation

There are different types of accreditations (Clean Energy Council, 2020e). These are divided into three categories of accreditation: solar, battery storage, and stand-alone (off-grid) solar systems. To obtain an annual renewal of the Clean Energy Council (Clean Energy Council, 2020d) accreditation, the installer must complete 100 credit points for continuous professional development (CDP). The installer earns the points by attending webinars, installer nights held across the country, and other training courses.

Table 3.2 Participants and Installation Sites

Solar Installer	Number of installation sites
Barrie	6
Charlie	2
Matthew	3
Patrick	1

The solar installers – Barrie, Charlie, Matthew, and Patrick – participating in this study were above 40 years of age. The specific ages of the participants are omitted to protect the anonymity of the participants, considering the small number of solar installers working in the state of New South Wales in Australia; smaller still was the number of installers whose high standards of expertise enable confidence in being examined in the research.

All the installers had multiple jobs, ranging from two to seven jobs, wide-ranging across various industries – some plan to move into a new sector.

Barrie – 6 sites

Barrie had worked as a licenced electrician for about a decade before joining the solar industry. In the solar industry, he had worked for about a decade, starting his career by working as a side job for a solar installer before completing the required accreditations to install solar systems. After a few years of working without profit, he built his solar business. His assistant, Bryan, worked for him as a contractor. Bryan had about three decades of experience in electrical work.

With Barrie, data was generated from six solar installation contracts.

Charlie – 2 sites

Charlie had been in the industry for multiple decades. He was accredited to install solar PV systems and batteries not connected to the electrical grid, also known as the off-grid or stand-alone power system. Clinton, his assistant, was familiar with trade work before working for Charlie. He was of a similar age as Charlie. They were good friends who often shared stories of their personal lives during work.

With Charlie, data was generated from two solar installation contracts.

Matthew – 3 sites

Matthew had about a decade of experience in the solar industry. He worked as an apprentice for an electrician and then pursued opportunities in the solar industry.

Morgan was Matthew's apprentice. They were part of an extended network of friends. Matthew reflected that, unlike his apprentice, who gained most of his skills from Matthew, Matthew had cultivated his knowledge by doing research and making phone calls to people in his networks, including suppliers, other electricians, and friends. At the time of the fieldwork, Matthew had started to research IT systems to support human resource management, looking forward to his apprentice finishing the final exams and taking on the responsibilities of a qualified electrician.

With Matthew, data was generated from three solar installation contracts.

Patrick – 1 site

Patrick had about a decade of experience working in the solar industry and two decades of experience as an electrician. He had three assistants. Patrick typically was on a site in the first half of the day and agreed on what to do with one of his assistants, who was also his site manager. Then, for half the day, he was off-site to work on sales, site inspection, design, and administration.

With Patrick, data was generated from one solar installation contract.

With all participants, during fieldwork, to avoid inconvenience, I called, texted, and emailed participants to maintain regular communication. Doing so ensured that scheduled research activities were responsive to participants' work schedules and demands. While the participants were free to vary the allocated time, for example, to respond to unexpected queries, in respecting the participant's time, I did not extend the research activity beyond the agreed schedule. Verbal and written confirmation for each observation and interview session was regularly reviewed to alleviate concerns about time away from work. I reminded participants that they could opt out without implications for my study. I discussed how the findings and conclusions would be used in presentations and publications. Attention was paid to signs of confusion and discomfort in the participants, which were addressed with clarification and assurance.

3.6.4 Solar installation locations

The fieldwork was conducted at installation locations on residential, farming, and commercial properties, across the state of NSW, Australia, in both regional NSW and Sydney. The geographical distance from major metropolitan areas presented additional challenges for regional sites. Most sites were accessible by standard sedan cars; a few required 4WD and regional air travel. The metropolitan properties were in densely populated suburbia of Sydney and newly built suburbs.

The electrical contractors selected the installation locations for observation. They provided the start dates of the installations and location information. Research locations were installation sites where electrical contractors completed the solar installation work. Where possible, I also shadowed the participants by travelling to sites connected to each installation. There were networks of locations such as the contractor's office and hardware stores where materials were procured.

3.7 Methods of data generation

3.7.1 Data generation

The phrase "data generation" rather than "data collection" aligns well with the ANT conceptual and methodological framework. Here, "data generation" is more epistemologically open, where the researchers construct knowledge compatible with their epistemological position (Mason, 2017). In the physical sciences, data collection refers to a positivist ontology of empirical objects that can be collected. In social sciences, the word "collection" continues to imply objective and stable knowledge nuggets that can be collected (Kvale & Brinkmann, 2009). In a study using ANT, such a conception of data collection contradicts an ANT sensibility. Data generation accounts for the researcher's reflexivity. Therefore, the term "data generation" in this thesis indicates my role in generating the data.

In ANT, data generation aims to "unpick the assembling processes" (Fenwick, 2016, p. 19) to answer the research question. This process is rooted in practice as the researcher witnesses the connecting activities of humans and non-humans (Latour, 2005). Data was generated at the selected installation sites, recording human and non-human enactments between the electrical contractors and emerging actors such as solar panels, design drawings, contracts, electrical contractors, and human actors, such as customers, team members, and suppliers.

While observing the installation works, handwritten notes recorded the emerging actions, noting both human and non-human actors. Interviews were conducted, and voice-recorded, either on installation days, during breaks, or after the installation over the phone. Interviews were transcribed using Microsoft Word and a desktop app to play audio files. Participants provided documents such as quotations, drawings, emails, and templates. Documents also include publicly available websites or brochures. Drawing on different data sources juxtaposes practices as observed and as told by the interviewees and actors, such as the literature and industry associations.

To explore different types of data is to be able to examine events by juxtaposing different stories from various sources (Law & Mol, 2008).

3.7.2 Observation

Observation is a key method in praxiographic research (Mitchell, 2017; Mol, 2002; Stewart, 2014) and ANT research (Czarniawska & Czarniawska-Joerges, 2014; Fenwick et al., 2011c). This study used shadowing and stationary observations (Czarniawska, 2007; Czarniawska & Czarniawska-Joerges, 2014). Using this method, the study focused on the daily practice of the electrical contractors working on installations and observing other actors involved. As work on installation sites unfolded, the method of sitting, shadowing, and watching practices, within their complexity, allowed the actor's movements across the research site to emerge. The ANT methodology does not narrow the research focus to a few factors; if the actors "are known from the beginning, there is no story to tell" (Czarniawska & Czarniawska-Joerges, 2014, p. 58). In this study, no preference was given to either human or non-human actors. Therefore, attention was given to details in recording actors and how connections and associations occur.

Observation is suitable for an ANT study because it can capture the mundane emergence of human and non-human assemblages. Law (2008a) argues that with observation, the researcher is not studying the construction of unchanged actors but is working with enactments that are variously precarious. What's essential in the ANT observation method is that it is a tool, similar to using a pencil to draw what is being observed. Latour suggests that drawing what is observed with a pencil is different from using the pencil to draw an image of a pencil, which is:

> the same with this ambiguous word: network. With Actor-Network you may describe something that doesn't at all look like a network – an individual state of mind, a piece of machinery, a fictional character; conversely, you may describe a network – subways, sewages, telephones – which is not all drawn in an "Actor-Networky" way. You are simply confusing the object with the method. ANT is a method. (Latour, 2005, p. 142)

Similarly, to say that ANT traces emerging networks of practice is not the same as saying that ANT traces solid, predefined networks. ANT is used like a pencil to draw the network, the connections that give rise to the learning practices.

Observation captures a fine level of attention to detail in ANT research. Seemingly mundane details are captured. Below is an extract from the observation field note, showing the details of ordinary activities noted in the observation.

> *Barrie walks along the roof with one arm stretched out in the air to keep balance; the other arm holds the drill.*
>
> *11.05am Barrie ties an orange string to the left of the rail on row 1, then walks over to the right to tie the string. He places a piece of wood under the string at both ends. Brandon walks to the middle section with a piece of wood. The middle section is too low, touching the orange string. Barrie un-drills the right end of the rail, lifts it up a bit, but it is still too low. The piece of wood touches the string.*
>
> *11.10am Barrie un-drills the rail on the left and lifts it up, still too low. Brandon uses a piece of wood to measure the gap between the string and the rail.*
>
> *Barrie: 'We can't go higher.'*
>
> *They move to the middle of the rail and start to lower this section.*
>
> (C3B3Obs 1, p. 6)

Across the 35 days of observation, the generated data attuned to the mundane activities that emerged. By attending to seemingly mundane details of activities, the 395 typed pages of observation transcript include fine data closely attuned to human and non-human actors.

While memos were written on the margins of the field notebooks to record my reflections, during observation, the data generation did not filter practice and did not decide in the generation whether what was being observed was relevant to learning or not. The study simply focused on the humans and non-humans of practice: carrying the rails, tearing the wrapping, and walking to the ute (utility vehicle). These were all relations that were seemingly mundane and yet were irrevocably parts of the practices of contract work. Attuning to such fine, mundane details made visible the essential evidence that informed the main findings of this study. Section 3.8, the analysis section of this chapter, further presents how the analysis processes attune to the sociomaterial worlds.

The observation occurred on installation sites – residential homes, farms, and businesses. Other locations – such as the local café, a patio for a lunch break, industry events and a home office – provided the contexts of the practice where the various actors connect to give rise to the network effects of practices.

Given safety concerns on construction sites, I used two types of observations: shadowing and stationary observation (Czarniawska & Czarniawska-Joerges, 2014). Based on the electrician's safety assessment, I either used shadowing to observe the electrician's work at locations judged to be safe, for example, where an inverter might be located on the ground floor – or used stationary observation to observe work being conducted on unsafe locations.

Further, the observation was unstructured rather than structured (Hammersley, 1998). The unstructured observation engaged with practices occurring across various spaces, where workplace learning also includes integrated development practices such as safety observation (Gherardi, 2019) and learning opportunities that are embedded in activities taking place in spaces such as the lunchroom and favourite café (Boud & Rooney, 2015; Reich & Hager, 2014; Rooney & Solomon, 2006). The research did not include covert observation, where the participants were not informed of the researcher's work (D. E. Gray, 2014). To avoid intruding on participants' work (Hyland, 2002), conducting observations did not interrupt or interfere with participants as they worked. While the main locations of observation were the installation sites, observations were conducted where related work practices occur, for instance, at a local café across the road or a professional development event.

Regarding the use of cameras, initially, my supervisor and I discussed inviting the electrical contractors to wear body cameras, such as GoPro, to record live-action. However, considering participants' privacy concerns, a zoom lens camera was proposed instead. I intended to use the zoom on cameras to gain a clearer view of activities occurring in the distance. However, being on-site, from participants' comments about not wanting to be photographed during certain types of work, I understood that using the camera and taking photos could hinder practices. With the electrical contractor's permission, a phone camera captured images of locations without capturing people, for use as reminders.

3.7.3 Interview

To clarify and follow up on the unfolding of events – identified during observations – follow-up interviews, in the form of narrative interviews (Czarniawska & Czarniawska-Joerges, 2014; Kvale & Brinkmann, 2009), were conducted with the electrical contractors. Unlike semi-structured interviews, which focus on data across several participants, narrative interviews focus on tracing a sequence of events that evolves across time (Czarniawska & Czarniawska-Joerges, 2014) or an event or chain of actions (Kvale & Brinkmann, 2009, p. 155).

During the interviews, questions were asked to follow actors and issues observed to be influential in making connections. Nods and prompting questions encouraged the narration to follow specific details of the chain of events, what the actors did, and what followed. I also asked about issues, particularly how the contractors addressed breakdowns. Tolerating silence, to allow thoughts to emerge (Seidman, 2015), I avoided speaking immediately after the participant and listened to the participant's comments until there was a definite pause before following up with the next question. The above interview strategies aligned with Kvale and Brinkmann's (2009) research, where the interviewer's principal function is that of a listener – using appropriate nods and silences (Kvale & Brinkmann, 2009).

Below is an example of how a special type of mounting system – a custom-made system built from two types of mounting systems, identified during observation – was traced in the interview.

> ***Researcher***: *With the two types of mounting systems, how did you learn to put them together?*
>
> ***Matthew***: *Just by reading the installation manual, from their website, which took a long time cos it's really hard to work out how to do something when you haven't got*

the pieces in front of you, to see how it goes and see how to pick the pieces. So, I spent a long time, days actually, going through all that and selecting the materials for that, putting in an order. There's a lot of time on it; nearly half of the time I spent was just on paperwork, and the half was installing it. So, a lot of time was spent on it, other than being on-site.

***Researcher**: Because this is a new system, and you had to teach yourself how to build it. Did you talk to anyone about combining the two systems?*

***Matthew**: Most of the information was off the manual and from one install before where I've done a similar thing, and so I learn just from doing it.* (C7M1Int2, p. 2)

From my observation of the construction of the mounting systems, the interview followed the mountain systems as actors. It made visible other sociomaterial networks, such as the installation manual, the website, and the components of the mounting system that were not available.

Before starting the interview, the participant gave permission to record the interview using a voice recorder. Handwritten notes also recorded the visual information, generating more nuanced details (Hesse-Biber, 2011). When an interview was off-record, handwritten notes were used during and immediately after.

Participants were encouraged to provide uninhibited responses rather than trying to give answers that were thought to be expected. To allay such concerns, I assured the participants that I was there to learn from their experience and knowledge and that I held no prior demands on what they would like to share. Another concern was that participants could withhold certain information for fear of negative repercussions. In anticipation of such situations, the participants were assured at the beginning of confidentiality and when I suspected possible hesitation.

I transcribed all interviews verbatim and loaded the transcripts to the MAXQDA software package (see Section 3.6.8 for a full discussion), along with observation notes, including details such as the physical appearance of the participants, where the interview was conducted and the details of the installation site. In transcribing the data myself, I closely engaged with the data, applying Mertens' analysis strategy as a researcher who, in transcribing, in transcribing the data, gains a closer familiarity with the data (Mertens, 2019).

3.7.4 Documentary data

The participants provided documents they thought relevant to the study, such as quotations and drawings. During fieldwork, when documents emerged during an event or a conversation, I asked if the participant was comfortable providing the relevant documents to me. Documents were also taken from the contractor's public websites and websites belonging to organisations connected with the electrical contractors' work, such as industry associations, suppliers, and energy distributors. These documents provided a printed/published inscription of the extended networks in the contractors' and related organisations' practices. The research also included reviews of documents provided by the contractors and sub-contractors, as well as suppliers whose networks extend beyond state and national borders. Photographs taken during fieldwork were used only as reminders of the installation sites. All photos used in this thesis are sourced from publicly available websites.

3.8 Analysis

3.8.1 Overview of the analysis process

To answer the research questions, a rigorous inductive analysis process was followed. By detailing the analysis process, I am not suggesting that this is a linear process. Adam and Thompson observe that “the division between data generation and analysis often overlaps, interacts, and blurs” (p. 21). Further, it is important to note, as Bryman and Burgess (2002) do, that there are no sharp boundaries from designing the research to the writing stages. The following list provides an overview of the analysis process:

- applying iterative analysis framework (Srivastava & Hopwood, 2009);
- noting memos on thoughts on the margins of pages, during fieldwork observation and at the end of the day (Flick, 2018);
- regular debriefing with the academic supervisor to review the fieldwork, analysis process and findings (Leech & Onwuegbuzie, 2008, p. 200);
- I transcribe observational and interview data, engaging deeply with the data (Mertens, 2019);
- using data analysis software to identify and label texts referencing specific actors to follow them across 395 pages of data (Skjott Linneberg & Korsgaard, 2019);
- continual reading and re-reading each page line by line, adding labels such as learning, as already conceptualised in the literature, and contract matters, and adding memos next to the texts throughout the reading (Jones et al., 2013);
- reviewing photos (Tinkler, 2014);
- drawing and revising visual maps (Aurini et al., 2016); and
- identifying significant patterns refining the findings (Gherardi, 2016).

The analysis progressed from reading and writing memos to applying the powerful data visualisation and searches offered by the software, attuning to all the words in the data set.

The following questions guided the analysis:

- "Who-what is acting? What are they doing?... What is the sociality around the object? The materiality?" (C. Adams & Thompson, 2016, p. 33)
- "What if a particular object breaks or is unexpectedly missing? What happens? In the wake of a breakdown, accident, or anomaly, what practices and things become more visible?" (C. Adams & Thompson, 2016, p. 49)
- "What are the different kinds of connections and associations created among things? What different kinds and qualities of networks are produced through these connections? What are the different ends served through these networks?" (Fenwick & Edwards, 2012, p. x).

The analysis questions above were asked throughout the analysis process, from writing notes during the transcription, reading and re-reading the data, and using the data analysis software to understand the actors, to the writing and re-writing drafts. These questions are based on Adam and Thompson's (2016) two heuristics and Fenwick and Edwards' reflection. One heuristic followed the actors, asking: "Who-what is acting? What are they doing?" and "Choose an object of interest. What is the sociality around the object? The materiality?" (p. 33). The other heuristic examines the breakdowns, accidents, and anomalies. The data is being examined with the questions: "What if a particular object breaks or is unexpectedly missing? What happens? In the wake of a breakdown, accident, or anomaly, what practices and things become more visible?" (C. Adams & Thompson, 2016, p. 33). The questions also resonate with Fenwick and Edwards' reflection on ANT research in education, asking "What are the different kinds of connections and associations created among things? What different kinds and qualities of networks are produced through these connections? What different ends are served through these networks?" (Fenwick & Edwards, 2012, p. x). The analysis questions are grounded in questions that aim to closely examine the connections among actors and the ways they are connected (Latour, 2005).

3.8.2 Inductive research

Crucial to the analysis process in this research is inductive reasoning. The analysis begins with an extensive dataset and follows the many iterative processes discussed in this section to arrive at the findings to be discussed in Chapters 4 and 5. A possible criticism of the analysis process might refer to one of the three sets of key ANT concepts deployed in this study. For instance, the discussion of the key concepts of matters of fact and matters of concern in this chapter and the findings of contracts as matters of fact and matters of concern in the next chapter can indicate a deductive process was applied to the data. However, this research is not deductive research. Following the inductive analysis process described in this section, particularly following contracts as tracers, I found the ANT concepts of matters of fact and matters of concern as most insightful for understanding the generated data. To help the reader navigate these important concepts, they were then added to the key ANT concepts section above.

An ANT approach resists the narrow focus of a deductive process in analysing data. ANT also insists on refusing a premature grip on explanations (Latour, 2005). Instead, it seeks empirical data by incessantly following the actors, embracing uncertain, contradictory, and inconsistent data and exploring them further (Travers, 2006). After the data is generated, the analysis process can proceed to examine the orders; that is,

> to regain some sense of order, the best solution is to trace connections… the search for order, rigor, and pattern is by no means abandoned. It's simply

relocated one step further into abstraction so that actors are allowed to unfold their differing cosmos, no matter how counter-intuitive they appear. (Latour, 2005, p. 23).

To closely attune to the humans and non-humans in practice and to avoid premature categorisation, this study generated data as they were enacted, resisting a premature insistence on securing the findings. This strategy allowed the findings to emerge after the data was generated, during the analysis. In doing so, this study embraced data that seems uncertain, contradictory, and inconsistent, in both data generation and analysis.

Some of the key components of the analysis process are discussed below. These include iterative processes, following the tracers, memos, photos, visual maps, MAXQDA software, and the writing of ANT text.

3.8.3 Iterative process

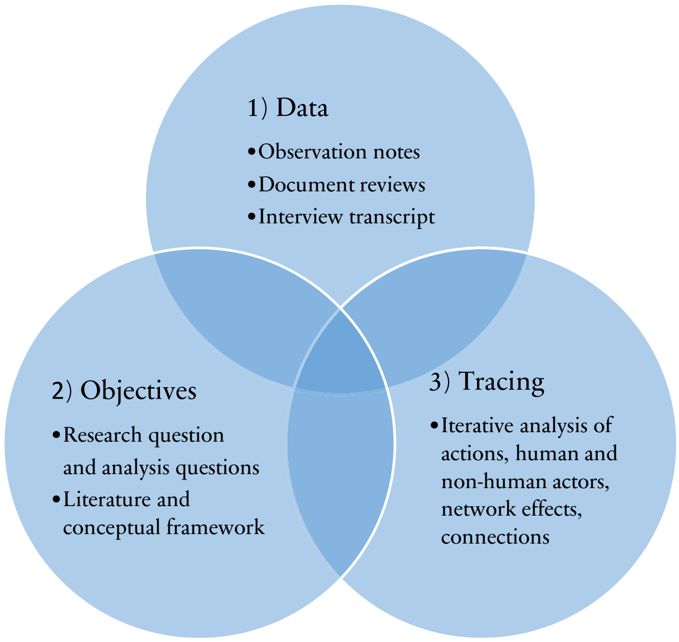
Data analysis was a continual process (Mertens, 2019). By attuning closely to human and non-human actors to answer the research questions, the analysis was based on a three-phase iterative framework (Srivastava & Hopwood, 2009) that asked three questions:

- Q1: What are the data telling me? (Explicitly engaging with theoretical, subjective, ontological, epistemological, and field understandings.)
- Q2: What is it I want to know? (According to research objectives, questions, and theoretical points of interest.)

- Q3: What is the dialectical relationship between what the data are telling me and what I want to know? (Refining the focus and linking back to research questions.) (p. 78)

This analysis process is captured in Figure 3.3.

Figure 3.3 Iterative Process of the Analysis Framework



The word "tracing" in Figure 3.1 refers to the iterative process of tracing actors and their networks across different data types. Tracing examines networks, connections, disconnections, and breakdowns. Tracing connects the patterns in different data types to the research objectives with discrepancies between data patterns reviewed and refined. A rationale of ANT's approach to tracing actors is to unpack the powerful and mundane, in fine detail, aiming "to trace more study relations and discover more revealing patterns by finding a way to register the links between unstable and shifting frames of reference rather than by trying to keep one frame stable" (Latour, 2005, p. 24).

One of the essential aspects of the iterative process in the analysis was careful and repeated reading of the data and notes (Jones et al., 2013). The field notes were read, and memos were added at the end of the fieldwork day or on the next day when the fieldwork was conducted past 6pm. I closely read the field notes throughout the transcription process, and memos were added as comments in the Word document, next to the notes. The transcriptions were uploaded to MAXQDA, and several readings of the transcriptions were conducted, line by line, while memos were written simultaneously. The memos from different stages of data generation – fieldwork, transcription in Microsoft Word, and reading in MAXQDA – were allocated different symbols to indicate when the memos were written. This technique allowed me to read and reflect on the progress of the insights recorded in memos. Writing of the findings was conducted with the reading. This is also an ANT analysis strategy, which involves writing and repeated readings of the data (Mitchell, 2017). This qualitative analysis technique consumed much time as it allowed me to immerse myself in the data, enacting a more robust analysis (Jones et al., 2013). Reading the data line by line several times facilitated my thinking and writing to engage extensively with the data.

3.8.4 Following the tracers

As highlighted in Chapter 1, the rapid changes occurring within the solar industry and the work of solar PV electrical contractors justified a distinctive practice-based approach. Education researchers, drawn to ANT's conceptualisation of tracing materials and humans, pay close attention to ordinary, mundane activities. In the dynamic context of the solar industry, this approach generated data on emerging actors, actors becoming visible beyond limited research foci. The ANT methodology made invisible actors visible and questioned the powerful actors that were taken for granted. It revealed possibilities of significant entry points for deconstruction and establishing connections in networks of practice beyond restrictive research foci.

To find the patterns, "to regain some sense of order, the best solution is to trace connections" (Latour, 2005, p. 23). There is a process of tracing closely the human and non-human actors, allowing the data to speak for themselves. The tracing of associations between actors – such as contracts and material components targeted by the two subordinate questions ("How are contracts enacted in practice?" and "How are solar PV systems installed in practice?") – is a fundamental concept, as well as a method to generate and analyse data. As an assemblage of views and methods, ANT is specifically good at tracing (Asdal, 2020). Latour highlights the importance of tracing associations in ANT, a sociology of association emphasising the tracing of associations to "follow the actors" (Latour, 2005, p. 68). An ANT study follows social and material actors to trace the nodes and networks to which they are connected. To make explicit the formation and transformation of practices and breakdowns, and to explore entry points for change, ANT research focuses on the micro connections where negotiations and alliances occur (Michael, 1996). To understand professional practices, ANT provides a valuable perspective to zoom in to examine fine details and trace the many types of actors that shape workplace practice.

The question then is how to use the method of tracing connections: with more time, slow and patient examinations (Law, 2004). For example, tracing a solar panel is not to seek an essential reality but to unveil "the possibility of seeing, hearing, sensing and then analysing the social life of things" (Mol, 2010, p. 255). In workplace learning research, tracing explores how connections between humans and non-humans are formed, how the relations are maintained, and the effects of their activities (Fenwick, 2016). Following a tracer is an essential method in the ANT approach. Tracing follows the trails of actions and notes how, in everyday actions, various connections, messy and mundane, assemble dynamic networks with other actors.

Selecting tracers: contracts and mounting systems

In following actors, ANT seeks to trace actors and their many connections without deciding in advance on some specific factors to focus on (Latour, 2005). Of the actors that ANT follows, tracers emerge in the data as powerful, yet possibly mundane, actors and for Latour, "depending on which tracer we decide to follow we will embark on very different sorts of travels" (p. 166). Using findings from the analysis discussed in this section, contracts and mounting systems emerge as powerful actors embroiled in controversies. Describing all actors enacted in contract work was not possible, as countless actors are enacted in the extended networks. Such indiscriminate descriptions also do not address the research questions about workplace learning. Recall the prominent conceptualisation of learning in ANT, discussed earlier, where learning is a "distributed effect, something that continually emerges through negotiations and struggles at myriad nodes of possible connections between human and non-human elements" (Fenwick et al., 2011, p. 117). The contracts and mounting systems sustained numerous connections and engaged in breakdowns that required negotiations and struggles, with widespread effects. These actors were suitable tracers, allowing deeper analysis that revealed new insights into learning in contract work. Connections were traced from actors at each installation site to the extended heterogeneous networks. Actors were followed to trace their activities and practices

(Law, 2008). Tracing examined the emerging practice in a way that "looked down" at the material world in detail rather than "looked up" to unifying concepts. The main idea in tracing was to account for existing and new actors.

3.8.5 Memos

Writing field notes involves writing memos (Flick, 2018) or "memoing", the process of reading, thinking, and writing notes (Mertens, 2019). While writing down the observations, as personal reflections emerged, I also recorded them next to the observation. At the end of the day, I took notes of my reflections on the fieldwork for the day. My personal reflection was also added to my observation and interview notes. While transcribing the data, I added comments to the Word documents, recorded ideas and reflections, and added memos to the relevant sentences. With the progress of the analysis and framework development, the memos were re-read, working in an iterative process. The memos from handwritten field notes and Microsoft Word files were then transferred to the software, and special marks separated the three types of memos.

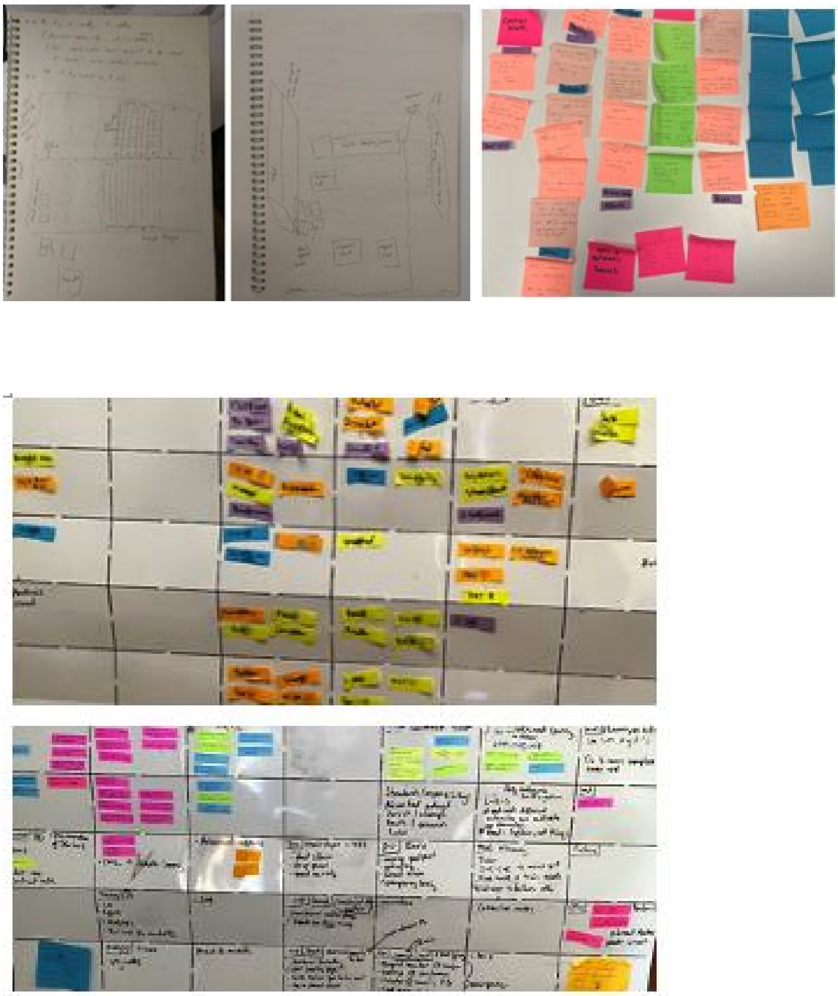
3.8.6 Photos

From fieldwork, photos without including people were taken from my choice of scene and, therefore, were constructed from my perspective (Tinkler, 2014). However, these records served as valuable reminders of the physicality of the installation sites, enriching the data being analysed. They were viewed as individual images and as collages to quickly gain a visual overview of the installation sites and related data (Grbich, 2012)

3.8.7 Visual maps

I used drawings of the installation sites, various iterations of simple mind maps and detailed conceptual maps (Aurini et al., 2016) to visualise different actors and trace their relationships (see Figure 3.4). For some maps, I used movable stickers to refine significant patterns emerging and changing throughout the iterative stages of the analysis.

Figure 3.4 Iterative Process of the Analysis Process



3.8.8 MAXQDA Software

This research used the data analysis software MAXQDA as a digital co-researcher. While a data analysis software is not a neutral tool – as its design can impose structural limitations on the data – it can be useful (Adams & Thompson, 2016). ANT strives to follow the actors, and in doing so, ANT research resits the impositions of restrictive foci at the beginning of the data generation stage and in the analysis stage. For instance, a data analysis software can be used to drive thematic analysis, which removes the data from the connected networks, a contradiction with the relational ontology of an ANT study. However, thematic analysis was *not* a function used in the present research. One possible objection to using analysis software in ANT studies is that discursive practices are entangled with their effects in contexts (Jackson & Mazzei, 2011). However, such a view assumes that data comprises only discussions or speech-act. The analysis in this study included observational data of both social and material actors, so the data analysed included both human and non-human enactments in the production of practice.

Data analysis software permits deep engagement in the data (Skjott Linneberg & Korsgaard, 2019), and several ANT studies have used qualitative data analysis software to analyse data (Alkhuraiji et al., 2016; Kurokawa et al., 2016; Nguyen et al., 2015; Thompson, 2010). In this study, the software was used as a sensitisation tool that allows me to attune at a granular level to an extensive and detailed range of actors, activities, and connections gathered across 395 typed pages of observation and interview data.

One of the ways MAXQDA was used as a sensitisation tool in the present research was simply to locate references to actors and label them, not for thematic analysis but for the identification and tracing of human and non-human actors in connections with other actors without severing them from their networks. Analogous to the use of posted-it notes on physical paper, to trace connections, this study used MAXQDA to label the actors across the different types of data. The use of material and digital co-researchers to label actors for tracing is also found in the ANT literature. For instance, Mitchell (2017) used physical Post-it notes and the comment function in PDF files to trace a medical form in her data. She recounted:

> My method for analysis was to look through my fieldnotes and use post-it notes to indicate where I had recorded information relating to gentamycin forms. I transferred these onto the PDFs of the notebooks as comments, so that I could search the notebooks. I also went through the transcripts to find references to the gentamycin form. (Mitchell, 2017, p. 92)

In the present study, the use of MAXQDA attuned efficiently and thoroughly to the actors in the generated data.

In the present study, MAXQDA quickly identified paragraphs containing the search word for an actor so that I could read each reference to the actor closely in tracing its connections to its recorded networks. The software had a function, lexical search, that tagged the label "mounting system" for words related to components of a mounting system such as "rail", "railing", or "rails". Not unlike Mitchell's use of a PDF (where comments linked to the tracer are examined together on a right-hand panel or below the document) in MAXQDA, all paragraphs containing the relevant words can be closely read in their contexts.

Use of software charts

The use of visualisation charts in MAXQDA in this study provided sensitisation tools to attune to the large dataset. They were not used to prune the dataset to fit the charts' featured patterns. Adams and Thompson (2016) caution that visualisation charts can transform the data into something else, losing track of the original data. None of the charts discussed in this section was used in the findings or the discussion chapters. The original data retains its full descriptions of actors, connections and networks in the subsequent chapters. In the early steps of the analysis stage, the charts below served as glimpses into the who-what is acting in the large dataset.

As discussed in Section 3.4, Latour (2005) sees the nodes of connections as "longer, faster, and more intense connections" (p. 179) or "far safer connections with many more places than others" (p. 176) or the multiplying "number of connections" (p. 215) or "some sort of more or less durable connection" (p. 221). Focusing on the connections and the who-what, the mounting systems emerged as a central actor that connects various actors. These connections were revealed in different co-occurrence models – see Figure 3.5 below for an example. The model visualised the frequencies where two actors co-occurred. It shows the connections between the mounting system and other actors across the 12 installation sites. The thicker lines showed where the labels for the actors overlap. The mounting systems invited being carried and walked around. They have thick connections with the drills, the roofs, and the panels.

Figure 3.5 Strengths of Connections Between Actors

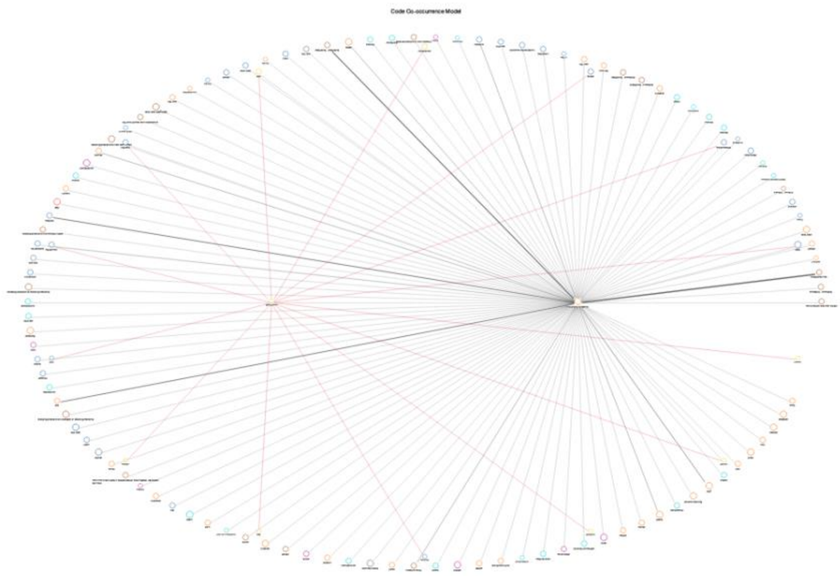
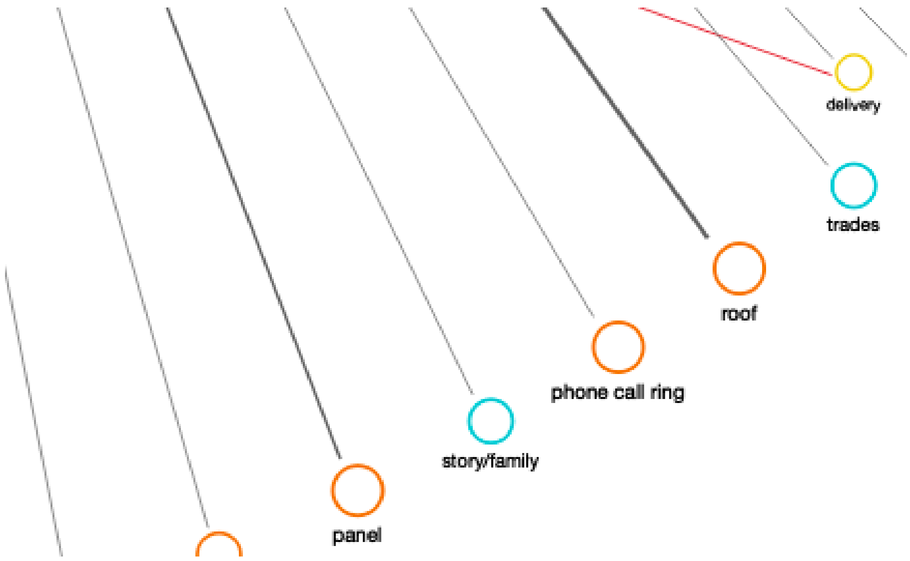


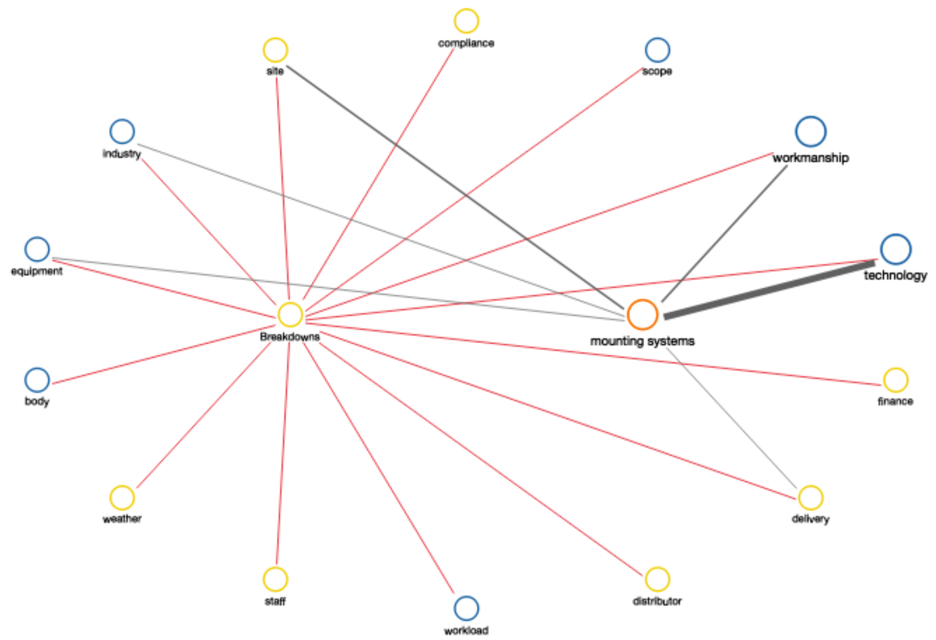
Figure 3.6 Thicker Connections to the Roof and Panels



The analysis revealed what can be observed about installing mounting systems: the use of panels, roofs, drills, etc. However, without using the ANT approach of generating detailed and mundane data, many actors would be precluded from the analysis. This visualisation brought the non-human actors to the forefront of the analysis, letting them show their connections with the human actors. The code co-occurrence models make powerful relationships, which had many connections indicating strong ties with the networks, visible. This model presented vivid visual evidence that guides the analysis away from assumptions, taken-for-granted relations, and from neglecting some seemingly mundane, yet powerful connections, to the background. This visual model provided the evidence to further explore the strong relationships between these actors in detail. The next chapter presents how analysing these powerful relationships contributes significant insights to learning in contract work.

The next analysis question focused on the mounting system and asked: What if a particular object breaks or is unexpectedly missing? What happens? What practices and things become more visible in the wake of a breakdown, accident, or anomaly? Who and/or what is excluded? The model below in Figure 3.7, also called the code co-occurrence model, visualised what was not connected or what had low connections to the tracer. Looking closely at the low connections, the mounting systems had no connection with some actors. This model showed that the breakdowns relating to the mounting system occur more frequently with certain types of breakdowns and not with others. Problems were related to the technology, the installation site, and the work quality. The data did not show connections to breakdowns in compliance with regulations, staff issues, or the body.

Figure 3.7 Connections between Mounting Systems and Breakdowns



3.8.9 Ordering the findings and writing an ANT text

The analysis processes discussed above are crucial to the ordering and reordering of data, resulting in the findings of Chapters 4 and 5. While the analysis processes I used for this research are well-established in the literature, the decisions I made to arrive at the findings are indeed interpretive. Solar electrical contract work in everyday practice is fluid and rich with a multitude of actors and connected networks, a richness that elides neatly ordered patterns. It is also not possible to follow and analyse all the actors connected in practice. By adhering to the above analysis process, I make the decisions to select and follow the two types of important tracers – contracts and mounting systems – to reach the significant findings of the subsequent chapters. I have already mentioned above, in ANT research, "to regain some sense of order, the best solution is to trace connections… the search for order, rigor, and pattern is by no means abandoned" (Latour, 2005, p. 23).

The above analysis processes allow me to take an ANT approach to analysis by iteratively immersing in the original data at a granular level through continually reading and reading transcripts, reading the referenced actors in MAXQDA, taking memos and notes, reviewing photos, maps, and charts. The processes discussed above afforded an open sensibility to allow an inductive process to engage with the data in order to allow salient actor-networks and patterns to emerge, informing the finding chapters. From the generated data, following inductive reasoning and the above analysis processes, Chapter 4 will discuss how contracts are enacted as both matters of fact and matters of concern and the findings on the five salient contracting practices. Chapter 5 will deliberate on the re-forming, mutating, and persisting networks, and build on those two chapters. Subsequently, Chapter 6 will examine learning as crafting-forward in contract work.

For Latour (2005), the writing of an ANT text, in this case as a thesis, seeks to describe in rich detail actor-networks of both humans and non-humans; it does not aim at providing explanations. This is a crucial point to note because a PhD thesis aims to elucidate new knowledge, and it is paramount to understand what this new knowledge entails from an ANT approach. An ANT thesis describing new knowledge is not about providing what a general reader would regard as explanations or correlations. This thesis does not seek to explain workplace learning, correlation, or imposing meta-structures. Expecting an ANT thesis to do so is, as Latour (2005) argues, the same as expecting the work to point to some forms floating above the everyday practice, or some frameworks, existing outside of practice and enclosing practice within it. The subsequent chapters on the findings and discussions, as well as the thesis as a whole, provide rich descriptions. The detailed descriptions are the hallmark of an ANT account (Thompson & Adams, 2020); the tiniest connections serve as the description of how actors are enacted in practice.

3.9 Ethical considerations

This study was conducted in accordance with the Australian Association for Research Education Code of Ethics (AARE, 2015), the National Statement on Ethical Conduct in Research Involving Humans (NHMRC, 2015), and the UTS Responsible Conduct of Research Policy (UTS, 2015b), the Ethical Conduct of Research Involving Human Participants Vice-Chancellor's Directive (UTS, 2015a) and Research Data Management Vice-Chancellor's Directive (UTS, 2014). Ethics approval was sought from and approved by the office of the UTS Human Research Ethics Committee.

Confidentiality and anonymity

Written agreements were used to establish confidentiality, and data related to individual participants were not to be disclosed to any other parties (UTS, 2014). Each participant received a copy of the Agreement Form. The importance of confidentiality was assured throughout the research, and it was ensured for all participants by using pseudonyms in records and writing (AARE, 2015). As solar PV systems were registered nationally for financial rebates, to protect the identity of the participants, this study did not refer to specific suburbs, installation dates or the exact size of the solar PV systems, providing approximations instead. Further, care was taken to ensure that the identities of the participants were protected in public presentations, publications, and social media networks, as well as in general discussions.

Managing possible risks and harms

The management of risks to participants, participating organisations, and the researcher was a core ethical feature of this research. Risks refer to harm and/or discomfort for participants and/or others (NHMRC, 2015). I reassured the participants of the importance of confidentiality and anonymity. I either emailed or handed the Participant Information Sheets to participants and asked them to sign the Consent Forms. I also informed participants that when they did not feel comfortable, they did not have to answer my questions, or supply documents or photographs. I was also mindful of participants' signs of distress and followed up by discussing concerns relating to the research.

Information about participants was not shared with their clients or other participants to maintain the participants' trust. When participants requested information about any of the other participants, I politely advised the participant that I could not comply with their request and reiterated the importance of protecting participants' confidentiality as well as that the use of the generated data remained solely for achieving the purpose of the study. Participants were not asked to change any parts of their daily work routines. When I became aware of negative behaviours, I did not share that information with other organisations or other participants, as this could cause harm to the participant's reputation and was beyond the scope of the research.

The loss of commercially sensitive information presents risks to the contractors. To address this risk, I accessed only the data the participants provided. I reassured the participants of the importance of confidentiality and anonymity to me, as well as the purpose of the research.

Regarding risks to the researcher, I was invited to join the participants for lunch or dinner, at a café or pub, as these are also parts of the networks of practice (Scheeres et al., 2010). During fieldwork, I notified a family member of my location and the estimated starting and finishing times.

Reflexivity

Reflexivity (Hammersley & Atkinson, 1995) speaks to my socio-historical position in conducting my research. Realism implies that research should be conducted in a sterile environment, independent of context, in the search for objective truth. On the one hand, I am a professional working in the field of organisational learning and development. On the other hand, I am also a researcher whose reflexivity involves my past experiences and understanding of my research. Based on methodological rigour, this work is thus integrated with my experience, my hinterland (Law, 2004; Rimpiläinen, 2015), which exists as the background and foreground of my work.

My professional background also includes my experience of nine months working on an internship for a solar PV company. The internship provided useful knowledge of the installation processes. It also provided opportunities for me to work with other women in the solar industry, many of whom had positions that did not involve the physical work of installing solar PV systems. As a woman conducting my fieldwork on installation sites, where men did the physically demanding work of installation, I did not feel isolated from the wider industry where there was more gender balance. Further, as many of the owners or relatives of the owners who were on site were also female, I did not feel that my gender was a concern to me. I gained trust with the participants by maintaining professional conduct such as responsive communication, punctuation, and dressing in line with the attires commonly seen on installation sites.

Data management

The management of collected data complied with the Research Data Management Vice-Chancellor's Directive (UTS, 2014). Data records were stored in the following formats: handwritten notes, photographs, voice recordings, transcripts of tapes/recordings and photocopies of documents. Data were saved on a university computer, locked with a password. A backup copy was saved in the university cloud storage system in accordance with the requirement of the university unit responsible for records (UTS, 2014). Data in storage were coded to remove participants' personal details from the data. Only my academic supervisors and I had access to the data. In 2021, within the last three months of my candidature (full-time equivalent), I relocated to another country. Per the University Records office's advice, I securely destroyed paper versions of my data as I already retained soft copies in my password-protected computer.

3.10 Summary

In Chapter 2, the literature review demonstrated how the existing approaches to learning in contract work are predominantly individual and sociocultural, limiting the lens of knowledge and the research focus. Understanding learning in the workplace as emergence allows the activities and practices in contract work in solar PV installation to be examined without predefined limiting foci. This chapter on conceptual and methodological aspects of the research discussed the reasons for using ANT as a conceptual and methodological framework. Key concepts are explained as to how they were used to answer the research questions. The chapter also describes the study's design, involving observation, interview, and document review methods.

It also includes detailed descriptions of the iterative analysis process and the ANT writing-up of research findings.

Through the ANT lens, the following three chapters discuss the significant findings of this study: Chapter 4 answers the two subordinate questions on contracting practices; Chapter 5 focuses on installing practices; and Chapter 6 discusses the answers to the overarching research question by weaving together the learning that occurs within contracting practices, installing practices, and at the intersections between them.

The next chapter, Chapter 4, follows contracts as tracers and discusses the answers to the first of the two subordinate questions, "How are contracts enacted in practice?"

4 CONTRACTS AS MATTERS OF FACT AND MATTERS OF CONCERN: KEY CONTRACTING PRACTICES

4.1 Introduction

The previous chapter discussed the ANT conceptual and methodological framework, identifying contracts and mounting systems as significant tracers. The findings chapters, Chapters 4 and 5, consider the answers to the two subordinate questions, and Chapter 6, the discussion chapter, will weave together the findings chapters to answer the central research question. The present chapter, above all, traces contracts as significant yet neglected actors, asking the first subordinate question: "How are contracts enacted in practice?" To answer this question, the main findings to emerge from the analysis are that A) contracts unfold as both matters of facts and matters of concern; B) five salient contracting practices enact contracts: 1) establishing contracts based on trusted networks of connections, 2) appraising sociomaterial requirements connected to the customer and the work site, 3) arranging sociomaterial resources needed as the work unfolds, 4) connecting the customer to significant sociomaterial changes arising as the work unfolds, and 5) enacting sociomaterial assemblages as services additional to those contracted.

Central to this chapter is the argument that in contract work, contracts are not just legally binding and rigid agreements. While the concepts of matters of fact and matters of concern are well-established ANT concepts, this chapter builds on the inductive analysis process discussed in Section 3.8 to present the evidence to support the findings that contracts unfolds dynamically as both matters of fact and matters of concern, being enacted by five central contracting practices.

Chapter overview

This chapter, the first of the two findings chapters, focuses on contracts. Section 4.1 offers a brief review of the theoretical underpinnings of this chapter, focusing on matters of fact and matters of concern, as already discussed in Chapter 3, and an overview of the empirical settings of this study. The main portion of this chapter is devoted to Section 4.2, which thoroughly investigates the significant findings resulting from tracing the contracts. This chapter closes with Section 4.3, summarising the main findings of the 12 contracts and the key arguments that contracts are both matters of fact and matters of concern, highlighting five central contracting practices.

4.1.1 A brief review of the theoretical underpinnings

As established in Chapter 3, the significant findings in this chapter emerged from the analysis process – an inductive process that began with a dataset of 395 typed pages and a range of documents, guided by analysis questions instead of being limited to an imposition of certain concepts. From the analysis process, the finding emerged that contracts are enacted as matters of fact and matters of concern. Having first identified these findings from the data, it became evident that the well-established ANT concepts of matter of fact and matter of concern are most suitable for conceptualising the findings to be discussed in this chapter.

The concepts of matter of fact and matter of concern, after all, have been widely studied in different fields, from the management of cultural resources concerning a solar installation project (Gorrie, 2014) to early childhood education (Iorio et al., 2017), and health policy (S. Adams et al., 2021). As Latour (2005, 2008, 2010) argues, matters of fact are taken to have an objective and stable reality. However, matters of facts, including signed contracts, are "achieved only by the slow process of composition" (Latour, 2010, p. 478), stabilised by the composition of matters of concern.

Approaching contracts as matters of concern is engaging with contracts in their extended scope beyond the matters of fact. As such, a matter of concern approach is analogous to shifting focus "from the stage to the whole machinery of a theatre" (Latour, 2008, p. 39). Therefore, matter of *concern* refers less to psychological worries and more to composition. The word *concern* in a matter of concern can promptly invoke the meaning of a cause for worry. Matters of concern may include matters relating to the motivation of significant actors (Gorrie, 2014) or feelings and thinking (Whitelaw, 2018); however, beyond these, matters of concern can be considered matters of composition. As mentioned above, matters of concern refer to the matters involved in the composition of matters of fact.

The discussions in this chapter frequently refer to the "machinery of a theatre" and the slow process of composition to highlight the compositions of matters of fact from matters of concern. Doing so is a way to underline the enactment of a contract, highlighting a "shift from a nature always already there to an assemblage to be slowly composed" (Latour, 2010, p. 477).

Analysis questions

To advance the key arguments, the remainder of this chapter frequently returns to the following analysis questions:

1. “Who-what is acting? What are they doing?... What is the sociality around the object? The materiality?” (Adams & Thompson, 2016, p. 33)
2. “What if a particular object breaks or is unexpectedly missing? What happens? In the wake of a breakdown, accident, or anomaly, what practices and things become more visible?” (Adams & Thompson, 2016, p. 49)
3. “What are the different kinds of connections and associations created among things? What different kinds and qualities of networks are produced through these connections? What are the different ends served through these networks?” (Fenwick & Edwards, 2012, p. x).

These questions guide the following discussion examining the contracts unfolding in everyday practice beyond limiting assumptions. These analysis questions scrutinise the seemingly mundane human and non-human actors, their interconnected networks, the breakdowns and the unexpected, emerging in everyday practice.

4.1.2 Empirical settings

The empirical groundwork of this chapter is founded on 303 hours of observing installation work, 24 interviews, and related documents. Below is an overview of the fieldwork and the three data types that informed the remainder of the thesis.

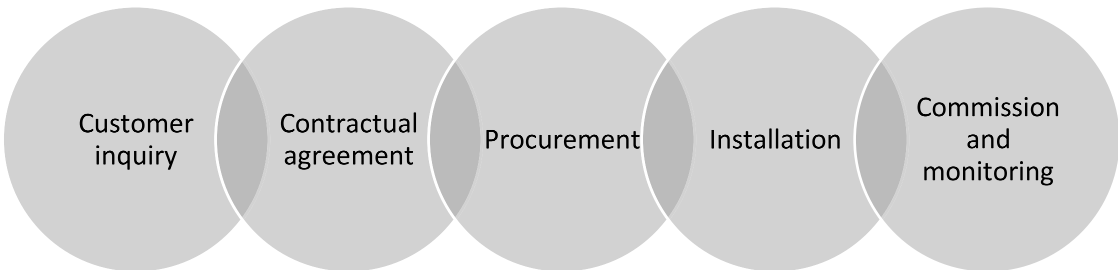
Table 4.1 Overview of the Fieldwork

Fieldwork Apr-Dec 2018	**Solar PV Installations**	**Installation days**	**Electrical contractors**	**Data**
8 months	12 installations	35 days	4 contractors	<u>**Observation**</u>: 303 hours in 35 days (290 typed pages)

				Interview: 24 interviews (105 typed pages) **Documents**: quotes, drawings, emails, manufacturer information, audit reports, industry publications, media coverage etc.

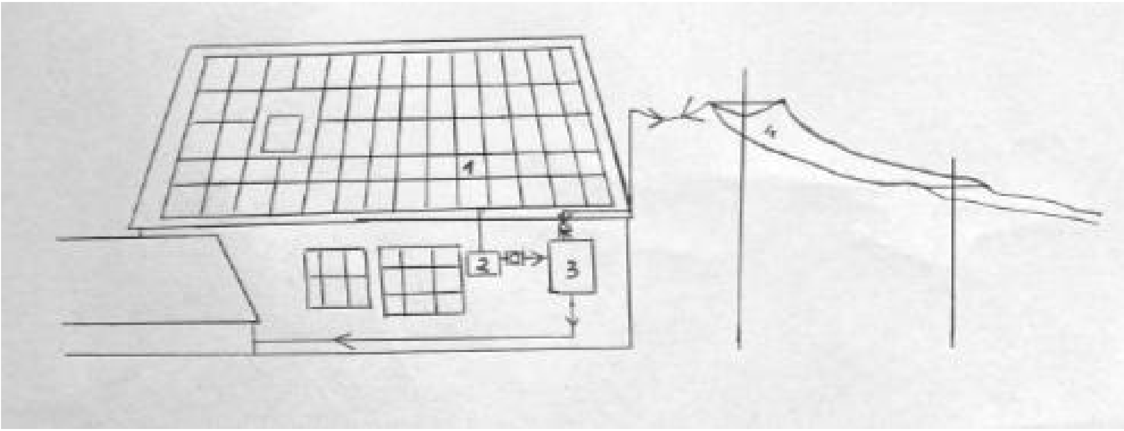
At a broad level of an overview, each installation typically took place over two to three days. While the full cycles of installations can vary, a contract to install a solar PV system includes several processes. Some of these processes in everyday practice overlapped without clear boundaries (see Figure 4.1).

Figure 4.1 Some Processes in Solar PV Contract Work



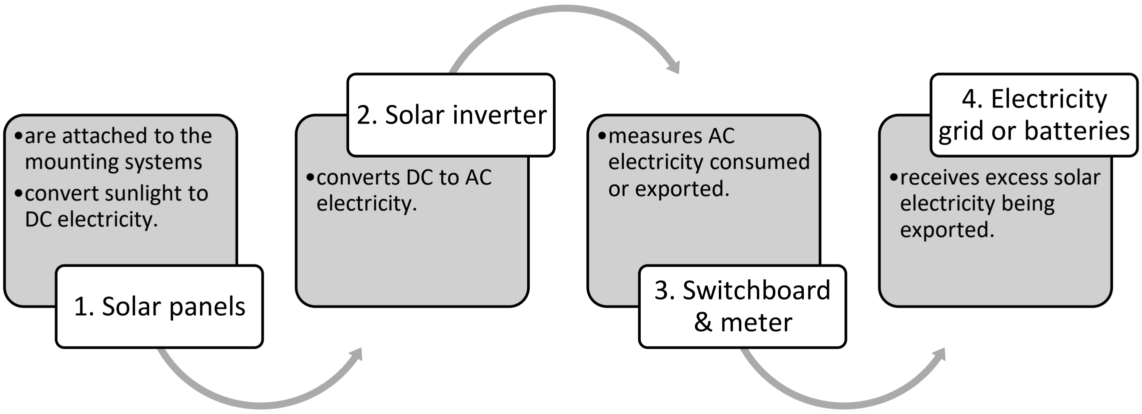
One of the early processes involved an inquiry from a customer. The electrical contractor then visited the property to inspect the site and emailed the contract – also referred to as a quote or quotation – to the customer. With the customer's agreement to enter the contract, materials were procured and delivered to the installation site. On installation days, the electrical contractor arrived with his assistants, who could be an apprentice or a sub-contractor. The major components installed were the solar panels, the inverter, and switchboard components (see Figure 4.2). The solar PV system was commissioned, a process that verified compliance with standards and requirements. The system was then monitored to ensure proper operations.

Figure 4.2 A Diagram of a Solar PV System



To help the reader understand the relationship between the various parts of the solar PV system, Figures 4.2 and 4.3 show major material components of a solar PV system discussed in this chapter. Sunlight reaching the 1) solar PV panels – attached to mounting systems securely attached to the roof – creates DC (direct current) electricity. This electricity reaches the 2) solar inverter and becomes AC (alternating current) electricity. The AC electricity then travels to the 3) switchboard before entering the 4) property for home appliances or being exported into the grid. A meter in the switchboard measures the amount of electricity consumed and exported. Excess solar energy is sent to the electricity grid or the batteries.

Figure 4.3 Major Components of a Solar PV System



Essential to this study is the protection of the anonymity of the participants and the carefully selected information related to the participants being presented in this thesis. Pseudonyms were used to refer to the electrical contractors. My photos and drawings were used in this thesis as cropped images to reveal only the typical material assemblages. I also refer to approximations of the electrical output, not the exact number of panels and energy output, as the precise quantities do not affect the arguments of this thesis. Instead, the following categories will be used: 5kW, 10kW, and 100kW. Figures 4.4 to 4.6 indicate the approximate sizes of the solar PV systems.

Figure 4.4 A Drawing of a 5kW Solar PV System

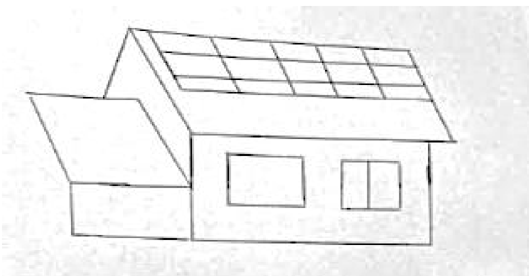


Figure 4.5 A Drawing of a 10kW Solar PV System

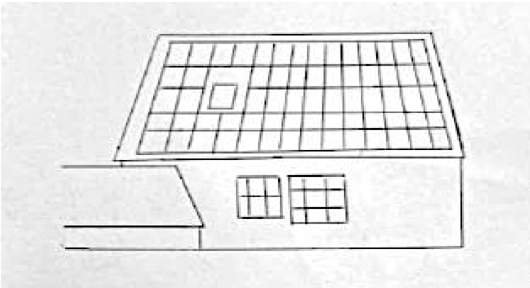
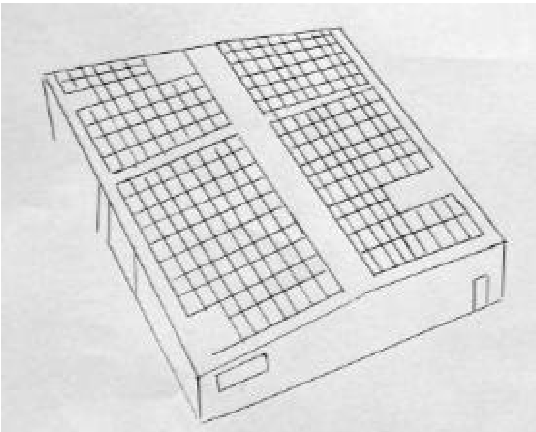


Figure 4.6 A Drawing of a 100kW Solar PV System



4.1.3 Defining the contract

An analysis of contracts requires a starting definition of contracts relevant to the Australian context of the study. The contract in this thesis refers to a commercial contract, not an employment contract (Mckeown, 2016). According to the Australian Competition and Consumer Commission (2021), a contract is "defined as a contract for a supply of goods or services"; more precisely,

> a contract is an agreement made between two or more parties that is legally enforceable. Contracts can be written or verbal. A contract arises when one party makes an offer and the other party communicates an intention to accept it. (paras. 1-3)

When a customer agrees to purchase a solar PV system, verbally or in writing, the customer enters into a contract. The essential element of a contract is the agreement between two parties, which is enforceable by law (Phillips, 2016). A contract can be a written document – even as informal as the back of an envelope – or a simple handshake, and the advice to the contractors and the customers in Australia is that:

> "whatever its form, if you agree to provide a service to a hirer for money, you have entered into a contract. You're promising to do a job for the hirer and the hirer is promising to pay you for it. The agreement may be enforced in court. (Australian Government Business, 2019)

The agreement can include details about the materials, timeframes, payment, and dispute procedure (Australian Government Business, 2019). All electrical contractors in the study used written forms of contract, including emails and formal agreements, often referred to as quotes or quotations.

In New South Wales, Australia, a contract to install solar panels can only be formed with a licenced electrical contractor or a licenced building contractor who has hired an electrical contractor (NSW Fair Trading, 2020). The licence is required to enter into a contract in NSW and some other states in Australia. In other states, a non-licensed seller can hire a licenced electrical contractor to install the solar system (Peacock, 2020).

The Clean Energy Council (2023) recommends that contracts for solar PV systems in Australia should include matters of fact such as the location of the installation, the size of the system, the cost, a proposed system design, and a list of key components to be installed (Clean Energy Council, 2023). To protect the anonymity and confidentiality of the participants, the exact amount of the costs, the specific layout of the system design, the brand and the quantities of the components are not included in this thesis. Only the central matters of facts are presented in detail: the type of region (metropolitan or regional), the type of building (a residential property, shed or factory), and the approximate size of the solar PV system. Other matters of fact of the contract are referred to in this thesis as types of fact: cost, system design, solar panels, and inverters.

4.2 Enacting contracts

As already emphasised, the findings presented in the subsequent sections and the following chapters are grounded in the gathered data and the analysis process. The aim here is to illuminate how, in practice, contracts are both matters of fact and matters of concern. Doing so further illuminates and identifies the practices enacting these contracts.

Before turning to the central part of this chapter, perhaps a remark is required to acknowledge that identifying certain matters or practices in some contracts – and not in other contracts – does not imply the absence of such matters or practices in the other contracts. For example, the reader will encounter in Contracts 3 and 8 discussions of matters of concern relating to compliance. Based on the data that could be gathered, compliance emerged in these two contracts as a salient matter of concern in response to specific breakdowns. The matters of fact, matters of concern, and contracting practices discussed in this chapter are based on the rich data that could be gathered during fieldwork. What is salient in some contracts does not deny compliance with policies and regulations in the work of the expert electrical contractors who participated in this study.

While the research examined 12 contracts, to avoid repeating similar findings, the data presented in this chapter refers to nine contracts; the remaining three are presented only in Table 4.2 in Section 4.2. In each of the contracts being discussed below, a summary of the particular details of the practices will refer back to these five practices:

P1 – establishing contracts based on trusted networks of connections,

P2 – appraising sociomaterial requirements connected to the customer and the work site,

P3 – arranging the sociomaterial resources needed as the work unfolds,

P4 – connecting the customer to significant sociomaterial changes arising as the work unfolds, and

P5 – enacting sociomaterial assemblages as services additional to those contracted.

4.2.1 Barrie

Contract 1

The central matter of fact of Contract 1 between Barrie and his customer Sami was to build a solar PV system, about 10kW, to be installed on the roofs of a residential property in a metropolitan area. Each panel was to operate with a power optimiser (a small device about the size of a hand attached to the rail at one end of a solar panel – see Figure 4.8). A range of important concerns arose regarding the use of the power optimiser. Contracting practices here involved much more than the simple matter of fact that specified a 10kW system – instead, reflecting, as Latour (2010) argues, "the slow process of composition" (p. 487), involving salient matters of concern, including trusted relationships, trees surrounding the site, the customer's aesthetic requirements, three-phase power property, and suitable technological development.

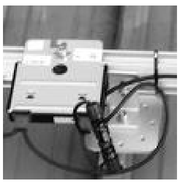
One aspect of matters of concern in the slow process of composition requires trust. The contractual agreement was entangled with the pre-existing relationship between the contractor and the customer. Since the customer was a friend of Barrie, a background of trust was already formed. Trust, as a matter of concern, will be shown across all the contracts being discussed in this chapter.

The matter of fact of the agreement to use the power optimisers to produce 10kW of solar energy involved several matters of concern. The matters of concern were negotiated several years earlier in conversations between the contractor and the customer about an assemblage of actors: the need for a solar PV system, the customer's aesthetic requirements, the impediments of a shaded site, surrounded by eucalyptus trees, and the lack of suitable technology for that site. Without suitable technological advancement, shadows from large trees on this site could prevent a row of solar panels from generating electricity. (See Figure 4.7 for an example of a node of connections of roof, trees, and shadows.)

Figure 4.7 An Assemblage of Roof, Trees, and Shadows

Sami requested that the solar panels be installed at a specific location, for aesthetic reasons. This request was one of the salient matters of concern in this contract. The seemingly simple analysis question "Who-what is acting?" (Adams & Thompson, 2016, p. 33) revealed an assemblage of connected actors. This request was connected to the materialities of the trees that cast shades on Sami's preferred location, requiring power optimisers. Connections to additional actors were made. Barrie used a Solar Pathfinder (a semi-spherical device, about the size of a palm, lined with markings indicating the average amount of sunlight for each month) and its software to calculate the energy that could be produced at the initially desired spot. The conclusion was that the energy would not be sufficient; therefore, other roof sections were tested. When the calculations indicated adequate energy requirements, Barrie and Sami agreed on where the solar panels should be installed. The negotiations here involved several sociomaterial actor-networks: the customer's preference, trees, shadows, roof, panels, power optimisers, Solar Pathfinder, software, and calculations. The contracting practices of the installation involved negotiating connections between the work site, the customer, and the contractors, connecting several human and non-human actors.

Figure 4.8 An Optimiser Connected to a Rail on a Roof



Also related to the matter of fact of using the power optimisers was a matter of concern regarding the suitability of the technology. The analysis question seeking to understand the qualities of networks (Fenwick & Edwards, 2012) revealed the slow process of connections and negotiations between humans and non-human actors, spanning several years. As technologies suitable for the site had not yet been invented, the contractor monitored technological developments in the industry and waited for the emergence of suitable technologies. Such new technologies depended on connections occurring in extensive networks of research, production, and distribution. With time, the ends of the research and production networks resulted in a suitable product that could be connected to this installation site. With this new technology, in a row of panels, when a shadow was cast on a solar panel, instead of turning off the rest of the panels in that row, the use of the power optimiser attached to each panel allowed sufficient energy generation in the remaining panels. Further, the distribution networks connected Barrie, the manufacturer of the power optimisers, and the wholesaler who sold the power optimisers. Barrie's connection to the distribution network was strengthened by attending two free training courses. By connecting to the "machinery" of power optimisers, the reputable manufacturer, and the wholesaler, the inclusion of the power optimisers in the contract was enacted as a matter of fact. The contracting practice was negotiating the connections to a technology needed to address a matter of concern of the installation site, negotiations that occurred over many years.

As components of the solar PV system were being built part by part, new matters of concern emerged, requiring the contracting practice of making explicit several connections between the material resources, the work site, the customer, and the contractor. The new matters of concern involved the customer's aesthetic requirements for installing the electrical conduit – a pipe that protects the electric cables from weather damage. (See Figure 4.9 for an example of a roll of electrical conduit.)

Figure 4.9 A Roll of Electrical Conduit Being Prepared for Installation

Seeing the conduits being prepared, the customer asked about the design of the conduit and wanted to modify the design so that the conduit could be installed along a different route. Barrie listened to the customer attentively as the customer explained his idea and agreed to the requested change, noting that the new route had a better aesthetic effect. Barrie recalled:

> *And you can't get those fine details when you do a site visit. There're too many things. You get a coarse understanding of where everything is gonna go, and then you develop that as you go. Because things change, you might think things go along well, but there might be things along the way, so you have to make another plan.* (C1B1Int1, p. 1)

Neither Barrie nor the customer could anticipate this matter of concern at earlier design stages. Only in practice, in the middle of the connections being made as the contracted work progressed, could such emerging matters of concern be made explicit.

The contracting practice here involved making explicit the connections and disconnections as the work was being completed. The second analysis question about breakdown and practices (Adams & Thompson, 2016) was used to examine the breakdown of the design of the conduit. Alongside the progression of the work on the solar PV system, many actors are connected: the solar panels are connected to the mounting system, which was connected to the roof; the customer noticed the conduit being prepared for connection; the customer's aesthetic judgement was used to examine the work at this stage of the work progression. As there was a disconnection between the customer's aesthetic judgement and the planned design of the conduit, a new matter of concern emerged. The contracting practice also included the contractor and the customer making explicit connections and disconnections before negotiating possible changes to the design of the conduit. The improved design of the conduit was enacted, not in advance as a matter of fact, but in practice, as an effect of making explicit connections and disconnection related to matters of concern.

In summary, the key contracting practices in this contract included the contractor and the customer being personal friends, expanding the friendship to a business relationship (P1); the shaded nature of the site and its effects on the power production of the solar PV system (P2); the customer's requirement for the panels to be installed at a specific location, appealing to his aesthetic judgment; attending manufacturer's training programs and procuring the power optimisers (P3); the customer's aesthetic preferences in changing the design of the conduit (P5). Seeing the contract enacted as matters of concern made visible the "ways of doing", i.e. the contracting practices that responded to the emerging matters of concern. In practice, Contract 1, as a list of matters of fact, is an assemblage of a number of matters of concern and a wide range of actors. For instance, the location where the panels were installed was considerably determined by the customer's aesthetic, the trees on the site, the path of the sun, and the technological development of the power optimisers. As the contract work progressed, new matters of concern emerged, and the key contracting practices above enacted the contract as both matters of fact and matters of concern.

Contract 2

The central matter of fact of Contract 2 between Barrie and his customers Saga and Shelley was installing a solar PV system, about 10kW, on the roofs of a residential property in a regional area. Barrie was referred by a mutual business acquaintance. The trust established between the customers and their business partner who recommended Barrie was a matter of concern that initiated this contract. Other matters of concern were enacted when Barrie visited the installation site for an inspection. He recalled:

> *I take the shade readings. I take the measurements on the roof. On that particular job, with the voltage rise calculation, and I worked out the biggest variable is 10kW. I measured for the string to make sure I could fit. I went inside and talked to them, and we can do straight 10kW... Explain to them the benefits. And you've got power spread across the whole array… which will work your air-conditioning loads, your cooking loads and things like that.* (C2B2Int1, p. 2)

Barrie assessed the customer's energy needs and the various measurements of the material assemblage at the installation location before proposing a contract that the customer accepted without change. At this initial stage of the contract, two contracting practices established the contract based on trusted connections and connecting to the requirements of the installation site and the customer.

As the solar PV system was being installed, a range of matters of concern emerged, revealing the "machinery" relating to the energy distributor, the company that managed the electricity grid. According to a policy enforced by the energy distributor, after a solar PV system is installed, a new smart meter must be installed by a technician working for the energy distributor before the solar PV system can be turned on to produce electricity for consumption. The smart meter recorded the energy consumed at the property and any surplus energy that could be exported to the electricity grid. Turning on the solar PV system without the new meter could reverse the old meter and reduce the amount of electricity recorded and billed. One of the contracting practices here was negotiating a resource, which was negotiating the logistics of installing the smart meter with the energy distributor.

Two matters of concern arose: compliance with the network of the energy distributor and maintaining a good relationship with the customer. To answer the analysis question about the ends or targets of networks (Fenwick & Edwards, 2012), the importance of connecting the customer to the policy emerged, which in turn served to cultivate a good relationship between the customer and the contractor. Without the customer's compliance, the relationship between Barrie and his customer could be jeopardised by the penalty from the energy distributor.

The composition of these two matters of concern included a matter of concern related to the effects of a past event. Barrie recounted the story of a previous customer who, despite warnings, turned on the solar PV system. In doing so, the meter was reversed, reducing the amount of electricity being recorded. When the energy distributor fined the customer, he placed the blame on Barrie. This incident reinforced the importance of matters of concern relating to compliance and approaches that maintain the contracting relationships.

In making explicit the two matters of concern at this installation site, a number of negotiations unfolded. Barrie explained to Shelley first that the energy distributor could impose a fine on the customer if the system was turned on before the new meter was installed. Following this conversation, during a lunch break, Barrie and his staff Bryan discussed how to explain the smart meter policy. They deliberated several approaches to explain the compliance issue. One of the options they explored was taping a label to the solar PV system power switch to remind the customer not to turn the system on. They made explicit connections and disconnections during the conversation by exploring options. They chose to use the analogy of a car pedometer: turning on the solar PV system had the same effect of reversing the number on the car pedometer. Barrie used this analogy to explain the issue – this time, to Shelly as well as to Sagar. The contract for this installation included not just the items agreed on in the signed contract. Instead, the agreement between the contractor and his customers included continual negotiations on what could be agreed upon and how to stabilise the new agreements in ways that addressed salient matters of concern.

The contracting practices here included negotiations that connected several human and non-human actors: customers, the contractor, the staff, the solar system being built, the energy distributor, the smart meter, the smart meter policy, the technician installing the smart meter, the button to turn on the solar PV system, the previous customer, the fine incurred by the previous customer, the possible explanations, and the pedometer analogy.

During the last hours of the installation work, a new matter of concern relating to competition and industry-wide issues was brought into sharp focus during a casual conversation between Barrie and Shelly. Shelley recounted how salesmen working for a solar retailer approached her, for the third time, trying to sell their solar panels. Barrie and Shelley compared the quoted costs of solar PV systems. In response to the price difference, Barrie highlighted that the low cost of some solar PV systems might relate to poor quality components and inadequate support. The "machinery" entangled in response to the competition as a matter of concern involved connections to ongoing issues emerging in the solar industry. By 2019, in Australia, sub-standard solar PV systems were found in one in six solar PV installations (Hobday, 2019). The contracting practice here involved responding to the customer who mentioned the information about the competitor by connecting to the industry's current issues and highlighting the quality features.

In summary, the key contracting practices included the referral coming from the customer's business contact (P1), responding to the customer experience with the competition by highlighting the relationship between quality and costs (P2), smart meter installation (P3), and not connecting the solar PV system to the electricity without authorisation (P4). These practices are ways in which Contract 2 was being enacted beyond the central matter of fact of generating 10kW of solar electricity. The contract was also enacted as matters of concern, both past and present. Some of the key matters of concern were trust-based connections, requirements of the customer and the site, fostering relationships, complying with the requirements of major networks such as energy distributors, and dealing with competition.

Contract 3

The central matter of fact of Contract 3 between Barrie and his customer Sampath was installing a solar PV system, about 5kW, on the roofs of a residential property in a metropolitan area. The composition of this matter of fact included several key matters of concern: trusted working relationship, requirements of the installation site and the customer, appropriate resources, and the continuation of the established relationship.

Not unlike the other contracts, one of the matters of concern here was a trusted relationship. In exploring the analysis question on the sociality connected to the contract (Adams & Thompson, 2016), the contract was established based on the existing relationship between Barrie and the customer, who were acquaintances. Forming a contract based on existing relationships was one of the key contracting practices.

Other salient matters of concern were associated with costs formed parts of the slow process of composition. Barrie visited the property to inspect the installation site. He examined material features such as the type of roof, estimated the possible layout of the solar PV system, and understood that the customer required a solar PV system that could produce enough energy for consumption as well as for exporting to the electricity grid to generate an income. Barrie emailed the quote to Sampath; however, the customer requested a cheaper system. In responding to the new request, Barrie considered a number of actor-networks, including the material arrangement of the solar PV system, the energy use, and the standard system size before reducing the number of panels. Barrie reflected:

> *Five kW is pretty much the standard size, and now you wouldn't go lower… Everybody's load keeps increasing all the time. As you can see from the monitoring, he went to 3k; it would just gobble it all up, wouldn't it?* (C3B3Int2, p. 3)

The revised quote was then approved. Here, the contracting practice is to negotiate the dynamic requirement of the customer in forming a matter of fact, which was a smaller solar PV system.

The analysis question "In the wake of a breakdown, accident, or anomaly, what practices and things become more visible?" (Adams & Thompson, 2016, p. 49) scrutinised the enactment of Contract 3 in response to a toxic material. During the early site inspection stage, Barrie discovered a new matter of concern in the switchboard: the presence of asbestos fibres – materials associated with diseases such as lung cancer and asbestosis. The contracting practice was negotiating the requirements of the site when this anomaly was discovered. The negotiation involved Barrie making the presence of the toxic material and the need to replace the switchboard explicit to the customer. Further negotiations ensued: taking additional time to book one of his business contacts, a level-2 electrician – qualified to conduct the work of replacing the switchboard – and on an installation day, coordinating with the level-2 electrician to replace the switchboard before Barrie could connect the new solar cables to the switchboard.

After negotiating the requirements of the site and the customer, having progressed further into the installation work, the availability of material resources became a new matter of concern. A disconnection between the contracted panels and the panels the retailer had in stock led to a change of a matter of fact of the contract. A breakdown occurred when Barrie contacted a retailer to order the solar panels. It emerged that the panels were out of stock. What became "more visible" was the negotiations involving new solar panels, increasing costs, and revising the system design. Barrie selected panels that were in stock and smaller in size, which resulted in adding one extra panel to the design. He also decided to pay for the extra panel and bear the labour cost of installing the additional panel. Barrie recalled that:

> *I called him up, and I said, sorry, those panels are out of stock, and I wanted to get the right price; believe it or not, I get that price for ya. So, he gave me the deposit, and I made up the same amount of watts with smaller panels… By the time you put another panel on you've got extra labour. I was a little bit out of pocket but it's not the end of the world.* (C3B3Int2, p. 4)

The change in solar panels also changed the system design. Barrie explained that as the customer of this contract preferred phone calls, Barrie used the phone instead of email to advise the changes. The deliberate use of the phone indicated the importance of the connection, responding to the customer's preference, even though such preference was not a matter of fact listed in the contract. The customer approved the new solar panels and design, an agreement that formed a new matter of fact in the contract. The matters of concern regarding the availability of material resources formed part of the "machinery" of the contracted work.

In summary, the key contracting practices included: the contractor and the customer were acquaintances (P1); changing the quote to reduce the price, deliberate use of the phone, identifying the asbestos, and organising the authorised electrician to remove the toxic material (P2); replacing the type of solar PV panels and changing the system design (P3); and adding the extra panel without increasing the costs to the customer (P5).

While the central matter of fact of Contract 3 remained consistent – a solar PV system about the size of 5kW – several important matters of concern affected how the contract was enacted. The initial matters of fact of the contract were enacted based on matters of concern such as trust, requirements of the customer and the installation site, income generated from exporting surplus energy, system cost, and toxic material. Emerging matters of concern relating to the network of resources altered the type of solar panels, shaping the design. The new matters of concern resulted in a new agreement between the contractor and the customer, forming new matters of fact. These four key contracting practices significantly shaped the contract's changing agreements. Without considering the contract as matters of concern, the assumption of the contract as a fixed set of itemised agreements leaves little room for examining the changing agreement and how such changes are enacted in everyday work as contracting practices.

Contract 4

The central matter of fact of Contract 4 between Barrie and his customer Sammon was the removal of damaged solar panels and installation of a new solar PV system, about 5kW, on the roofs of a residential property in a regional, semi-rural area. The slow process of composition of these matters of fact included a trusted business relationship, a budget based on an insurance payment, and the alignment between a roof and a row of solar panels. (See Figure 4.10 for an example of a node of connections of roof, rails, and clamps that connect the rails to the roof.)

Analogous to the other contracts, Contract 4 was established upon a trusted relationship, one of the key matters of concern. The customer was a business contact who collaborated with Barrie on several occasions.

Another matter of concern was the customer's budget. Asking the analytical question of sociality and materiality around the budget brought to light several actors. The budget was connected to the insurance company, which determined the amount that could be spent on the budget. Barry responded to this budget by selecting materials that were of high quality and offering a price discount. In exchange, the customer negotiated by offering to assist with installation work on the day, further cultivating the existing trusted business relationship between the two parties. Three essential contracting practices occurred in relation to the budget as a matter of concern. One of the contracting practices was to conduct a site inspection and appraise the customer's energy consumption. The other two practices were responding to customer's key matters of concern by offering a price within the budget and negotiating the use of quality components and the customer's labour assistance. These negotiations served several matters of concern: to address the customer's requirements, secure the necessary resources for the installation, and secure opportunities to strengthen the established relationship.

Figure 4.10 Rails Aligned on a Roof

During the installation, new matters of concern arose in a breakdown of the alignment between the material actors already on the installation site and the new materials being added to the site. After one row of panels was installed on the roof, the customer – standing on the ground looking up – noticed one end of the rail of the mounting system slightly protruding from the roof's edge. The protrusion could only be seen from where the customer was standing when he first noticed it. The customer informed Barrie, and they both stood next to each other on the ground, looking up at the alignment. After some negotiation, Barrie and his customer reached an agreement that the row of panels was to be realigned. The customer helped with some of the tasks as the sun was setting, and extra time was needed to complete the adjustment.

The connections between several human and non-human actors – the panels, the mounting system, the roof's edge, the customer, the physical positioning of the bodies on the ground, the setting sun, and additional time – were part of the contract's composition process. The contracting practice here negotiated connections as the solar PV system was being built, involving the customer, the work site, the resources, and the contractor, responding to the dynamic requirements of both human and non-human actors.

In summary, the key contracting practices included expanding from a business relationship to engaging in a contractor-customer relationship (P1); quality components and reduced price; the importance of reinforcing the business relationship (P2); quality components and the customer's labour assistance (P3); and making explicit the alignment between the solar PV system and its position in relation to the roof (P4). Approaching the contract as matters of concern showed how these four key practices enacted the central matters of fact of the contract (the 10kW size, the installation location, and the removal of the damaged panel). Such an approach also showed the negotiations enacted in the connections and disconnections of the material and social actors as the contracted work unfolded. Contract 4 was not simply a list of agreed items. Rather, Contract 4 was a series of negotiations and compromises that had the effects of enacting ongoing agreements; agreements were negotiated beyond the boundaries demarcated by the initial matters of fact of the contract.

4.2.2 Charlie

Contract 5

The central matter of fact of Contract 5 between Charlie and his customer Sandor was to build a solar PV system, about 10kW, on the roof of a shed in a regional area. What is unusual about Contract 5 was that the installation site was vacant land at the time of the initial communications. The "machinery" involved in the composition of this matter of fact included a range of matters of concern: the prevalent connections to established relationships, estimation of energy consumption, the requirements of vacant land, reducing cost, building construction delay, advancing technology, availability of resources, price change, and proper use of the installed system.

This contract was formed based on established relations as with the previous contracts. The customer contacted a well-established company in the region and was referred to Charlie, who had worked with that company for many years. Again, the contracting practice established the contract based on a trusted relationship.

Other matters of concern were the requirements of the installation site and the customer's needs. Charlie emailed Sandor an Excel spreadsheet that listed typical appliances in a residential house and calculated an estimate of the customer's energy consumption. Charlie also visited the site to conduct an assessment and emailed a quote to the customer. When the customer contacted Charlie, the property was vacant land. One of the matters of concern involved building a shed before installing the solar panels.

Charlie emailed the quote from the initial assessments to the customer, who requested a cheaper system. Responding to the customer's matter of concern for cost reduction, Charlie revised the quote based on the customer's revision of his consumption calculations; the revised quote was approved by email. The sociomaterial actor-networks involved in responding to the requirements of the customer and the site were: the Excel spreadsheet, the appliances that the household would use, the position of the site where the shed was to be built, the customer's requirement for a cheaper quote, the changes made to the calculations, and the revised quoted. The contracting practice responded to the site's and the customer's requirements.

Several months passed; new matters of concern emerged as the site requirements changed, affecting the contract matters of fact. The changes involved numerous actors and their networks, including changes at the local council. While Charlie contacted the customer every few months to stay updated on the ongoing construction of the shed, he was informed of a delay. Due to changes to council requirements, the shed's construction timeline was affected. Many months after the first contact between the customer and Charlie, the customer advised Charlie that the shed had been built. At one point during that time, the price of the batteries listed in the quote had increased, resulting from changes in the supplier's networks. Charlie emailed the customer to advise of the price increase, and the customer agreed to pay for the difference in the price. (See Figure 4.11 for an example of an assemblage of batteries.)

Figure 4.11 A Battery System

The second analysis question examined anomalies (Adams & Thompson, 2016) and revealed two contracting practices. One was responding to the dynamic requirements of the site, which was staying in connection with the progress of the construction of the shed. The other contracting practice was responding to the changing price of the batteries. The contract, as an agreement between the contractor and the customer, was enacted in response to the changes in the matters of concern. The revised matters of fact integrated the system's reduced price (solar PV panels and batteries).

Moreover, by the time the shed was built and the work on refining the system design and procurement of resources could begin, new matters of concern had developed as the cost of resources had changed; the matters of fact of the contract once again changed. The price of solar panels had decreased, and the efficiency of the solar panels had improved. Upon a detailed design drawing, Charlie changed the design from a tilt mounting system to a flat one. This added 12 solar panels to the system and remained within the customer's budget. The contract, as a matter of fact, changed when the customer agreed to the additional 12 solar panels.

The matter of fact of the contract changed again during the procurement of resources as new matters of concern emerged. The solar panels listed on the revised quote were out of stock and must be replaced by a more expensive type that was in stock. The customer approved the change; however, Charlie absorbed the difference in the cost – similar to Barrie in Contract 3, who bore the cost of installing the extra panel. The negotiations here involved key human and non-human actors connected to many networks: the suppliers, the production of better panels and the transportation of panels from one country to another, the computer used to design the solar PV system, and the email to communicate with the customer. There were two contracting practices here: one was responding to changes in the cost of resources; the other was absorbing the extra cost of using a more expensive type of panel to respond to an opportunity for an additional service to foster the contracting relationship.

Even though educating the customer was not part of the contract's matters of fact, for Charlie, the continuing operation of the solar PV system was one of the key matters of concern. One of Charlie's essential contracting practices was apparent in educating his customer:

> *3.30pm Charlie points to the Brand A inverter and Brand B inverter, explaining to Sandor how they convert DC electricity to AC and connect to the batteries. He said: "If you have any questions, just ask as we go. The more you know about it, the better it is for the both of us."* (C5C1Obs2, p. 4)

Charlie's explanation and invitation to ask questions, an instance recorded in the observation data, was an explicit practice to connect the customer to the contracted work. Such an invitation can be easily dismissed as simply communicating questions and answers. However, interpreting this invitation through the lens of matters of concern, this invitation was also about the importance of the relationships between the customer, the contractors, and the slow process of composition. This contracting practice explicitly made connections and disconnections between the human and non-human actors as the work was being completed.

In summary, the key contracting practices included an excellent reputation from having worked for many years for a well-established company in the region – Charlie gained the referral for this contract, being the trusted contractor of the company (P1); estimating energy consumption calculations using the Excel spreadsheet, maintaining regular communication while the shed was being built (P2); updating the battery price, adding 12 extra solar panels due to improved technology and price reduction, using a different type of panels due to stock availability (P3); educating the customer about how the system worked (P4); and offering to use the more expensive panels at no extra cost (P5).

Contract 5 unfolded over an extended timeline and was a rich example of the effects of dynamic networks of actors entwined in the matters of concern that emerged and the various agreements of the matters of fact. A diverse range of networks of human and non-human actors became visible in the analysis: the electrical appliances, the possible energy consumption, the vacant land, the council, the construction of the shade, the decline of the price of batteries over time, the availability of solar PV panels, technological development, and the suppliers' price. During the unusually extended period, the five leading contracting practices above enacted the contract as iterations of matters of fact and matters of concern. Contract 5 was the effect of many negotiations occurring throughout the contracted work. The contractual agreements at an earlier point of Contract 5 were not the same as those at the closing phase of the contract.

Contract 6

The central matter of fact of Contract 6 between Charlie and the customer Sanford was to build a solar PV system, about 5kW, on the roof of a shed, in a regional suburb. Several important matters of concern emerged in the enactment of this contract. These included trusted connections, estimation of energy consumption, site requirements, reducing cost, future energy needs, and providing extra service.

Not unlike the other contracts, one part of the matters of concern involved in the composition of this matter of fact was that the contract was a referral from trusted connections, i.e., the customer's friend.

A significant part of the matters of concern of Contract 6 and all the other contracts was appraising the customer's requirements and the installation site. The appraisal encompassed an estimation of the amount of energy the customer needed for consumption. Similar to Contract 5, this information was gathered via an Excel spreadsheet that Charlie emailed to the customer. The spreadsheet contained a list of the typical appliances used in a house and the expected energy usage. He emailed the quote along with detailed responses to queries. He also called the customer to discuss the electricity required, the use of a generator, and the cost. After the initial negotiations, Charlie adjusted the quote to reduce the cost; the customer approved the revised quote. The composition of the matter of fact of the contract up to the time of the agreed contract integrated the connection of various human and non-human actors: the contractor, the customer, the budget, the vehicle used to visit this site, the location of the building where the solar panels were to be installed, the Excel spreadsheet, the appliances on the property, the energy calculation, and the generator.

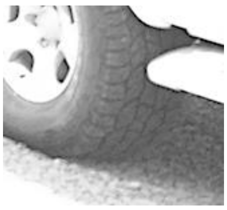
An important matter of concern was not just current requirements, not simply the capacity of the solar PV system to address those current needs, but also considerations of possible future variations. Charlie explained:

> *They usually find out once they get power they wouldn't mind running this or running that. You've got to try and pin them down in the early days as to how much they'll need, and you'd put a little of a buffer in there as well.* (C6C2Int2, p. 2)

As a matter of fact of this contract was the installation of a 5kW solar PV system, Charlie was aware of the possible matters of concern that could arise in the future when the customer's energy consumption might increase. In such a situation, Charlie designed the solar PV system with the capacity to incorporate additional solar panels. However, the number of batteries limited the number of additional panels that could be added to the solar PV system. Therefore, Charlie explicitly responded to a future matter of concern by advising the customer to purchase, within their budget, the largest possible battery system. Asking questions about the actors and their actions (Adams & Thompson, 2016) showed not only the connections between current actors but also connections to future actors. The two contracting practices connected the customer's current requirements to the possibility of future requirements and installing the most suitable battery system with a "buffer" for changing requirements.

When there was a breakdown with the customer's generator, the second analysis question explored practices connected to breakdowns or anomalies (Adams & Thompson, 2016). Maintaining a good relationship with the customer was one of the key matters of concern that became more visible. The composition of this matter of concern was related to a chain of events. Even though not specified in the written quote, after the solar PV system was installed, from a conversation with the customer, Charlie gathered that the customer was buying a new generator. However, as part of his service work, Charlie used a software program to view electricity usage: the data showed that the new generator had not been activated; an anomaly had occurred.

Figure 4.12 A Vehicle on the Road to an Installation Location



Although the new generator was not a part of the contract's matters of fact, Charlie responded to the breakdown by providing extra services without charging additional fees. On the way back from another job, he stopped by the property, found the disconnections in the generator, fixed it, and connected it to the solar PV system. (See Figure 4.12 for an example of a vehicle on the road to an installation location as an effect of an anomaly identified in a software.) The customer was informed of the extra service provided. A range of actor-networks was enacted in connection to the breakdown: the new generator, the computer, the software, the internet connection, a nearby job, the vehicle to access the installation location, and the necessary tools to fix the generator. This event points to the significance of completing work beyond the agreed contract. The contracting practice here was responding to opportunities to provide extra services.

In summary, the key contracting practices included: the customer's friend referred the contractor (P1); using the Excel spreadsheet to gather information on appliances; the customer requiring a cheaper system; installing batteries that could accommodate changing energy consumption (P2); installing a battery system that could accommodate future energy needs (P3); and fixing the new generator (P5). By approaching the contract as matters of concern, these contracting practices can be made visible in the enactment of Contract 6. The central matters of fact and many of the matters concern of this contract were enacted based on existing human and non-human actors. Further, a salient matter of concern in this contract also included future matters of concern.

4.2.3 Matthew

***Contract** 7*

The central matter of fact of Contract 7 between Matthew and his customer Sanni was to install a 10kW solar PV system on the roof of a shed on a regional farm. The contract also included the removal of a damaged system. A range of matters of concern formed part of "the slow process of composition" (Latour, 2010, p. 478). Central to these matters of concern included trusted connections, estimation of energy consumption, site requirements, construction of a new roof, and energy requirements during the harvest season as well as throughout the year.

Contract 7 was formed based on several established relationships. After receiving an insurance claim from the customer, the insurance company contacted one of their contractors, an electrician. The electrician – who had worked with Matthew on various projects and was part of Matthew's contracting network – contacted Matthew, who then contacted the customer and organised a visit to the site. The contracting practice here involved a chain of connections based on existing relationships between many actors: the customer, the insurance company, the electrician, and Matthew.

Other matters of concern involved the requirements of the customer and of the site. A storm in the previous year destroyed the old solar panels and the roof of the storage shed; both the solar panels and the roof had to be replaced. The damaged solar panel and the wait for the construction of the new roof formed part of the composition of the matters of fact: Matthew was to remove the old solar PV system and install a new system. Months passed until the insurance company finalised the claim. By this time, the contract had changed as the customer decided to get a payout from the insurance company and build a larger solar PV system, changing the matter of fact of the contract. The revised quote comprised the matters of fact of a solar PV system with fewer panels but could generate twice the amount of energy output of the old system.

Additional matters of concern included the customer's requirements during the harvest month of peak energy use. Electricity generated from the solar installation powered the equipment required for farm work and a small processing plant. Solar energy was also to be used in the main house and to run their home office. From conversations with the customer, Matthew established that the customer wanted the solar system ready for the harvest season, which would occur over the next four months. In this respect, the installation should be completed within this time frame. The key matter of concern here was that a large amount of energy was required during the harvest season to operate the farm machinery. Without a functioning solar PV system, the customer could incur substantial bills, paying for electricity from the grid.

The design of the solar PV system responded to the issue of high energy demands during the harvest months and low consumption during the other months. Matthew explained:

> *I just tried to design a system to produce a lot of energy this time of the year and also was enough to cover the energy use. So, I came up with a mid-way point; it's not gonna produce [X]kWh per day, but it'll get up there. That was mainly done by the size of this roof. You can't put too much on there. So, this system is twice as big as what they got before and room to upgrade if you want it later. At this stage, it's pretty good value for money, and it's offsetting a lot of his bills.* (C7M1Int2, p. 7)

As can be seen here, the harvest was the central actor in the design of the solar PV system. Connecting the design to the requirements of the customer and the building structure allowed optimal energy output to meet the requirements of the harvest months. During the other months, the system could produce enough energy for reduced consumption, about a third of each harvest month. A range of actors was involved in the changing matters of fact and matters of concern: the harvest season, the energy use throughout the year, the design of the solar PV system, the roof size, the energy output, and bills. The key contracting practice here was responding to the customer's changing requirements.

With this contract, the essential contracting practices included: the contractor was part of the network of the insurance company, connecting the relationship between the customer, insurance company, the electrician, and the contractor (P1); responding to requirements for energy use during the harvest season and throughout the year (P2). These key contracting practices are discernible when the contract was also considered as matters of concern, such as the trusted connections, harvest season, energy consumption estimation, and construction of a new roof. Enacting the contract involved contracting practices that enacted several trusted relationships and finding the suitable connections between a diverse range of intertwined sociomaterial actors, from the social world of the customer and their insurance company to the non-human world of the natural cycles of seasons and harvests, as well the technical configurations of the system design. Seeing the contract as matters of concern shows how the changing contract is enacted and the many actors shaping the evolving matters of fact of the contract.

Contract 8

The central matter of fact of Contract 8 between Matthew and his customer Sancho was building a solar PV system of about 10kW on the roof of a house in a regional suburb. As mentioned in previous contracts, the prevalent matters of concern across all the sites were establishing the contract based on trust, estimating energy consumption and general site requirements. Product compliance was another salient matter of concern in this contract, which was an effect of a breakdown.

With this contract, as a matter of concern, the trusted connection was the referral from an electrician who worked for Matthew occasionally. Another matter of concern was the installation site's and the customer's requirements. After being contacted by the customer, Matthew visited the site to inspect the installation location and estimated the energy consumption for the installation site. He emailed a quote, which the customer quickly approved. The customer wanted Matthew to make a phone call to discuss the logistics. The solar PV system was installed without any changes to the central matters of fact, such as the size of the system, the type of panels to be used, and the cost of the system.

Even though matters of fact, as listed in the quote, were not changed, new matters of concern emerged related to the compliance of overseas products. This matter of concern emerged as an effect of a breakdown, which was examined by asking questions about the practices that became discernible (Adams & Thompson, 2016). A significant breakdown emerged in the installation of the solar cable and the current transformer (CT) – the CT wraps around the solar cable to measure the flow of electricity – both of which did not fit into the switchboard. The breakdown was in the connection between the solar PV system and the installation site.

The *thing* that became more visible was the requirement of the installation site. The property was a newly built house with three-phase power, rather than single-phase power. A single-phase power operated on a system of two wires (one for electricity and one for safety); a three-phase property had four wires (three for the electrical current and one for safety). Another significant *thing* that became visible was that the three-phase property had a switchboard that did not have enough space to add the solar cable and the CT.

One of the possible solutions to the breakdown was purchasing a current transformer from overseas. However, purchasing overseas products made visible a matter of concern. Matthew had reservations about buying directly from overseas due to compliance issues. He noted that:

> *I am a bit hesitant to buy something directly from overseas because it's harder to know; it's taking more risks whether it's compliant to use in Australia. So, if I buy something from an Australian supplier, then most suppliers, all the good suppliers, would make sure that the products they sell are approved for use in Australia. So, I don't have to worry about verifying whether something is acceptable or not.* (C7M2Int2, p. 2)

The contracting practice was firstly negotiating the resources needed for the work, which were suitable in terms of compliance with Australian standards.

In summary, the central contracting practices included the contractor being referred by a trusted business contact (P1), conducting a site inspection and estimating the possible energy consumption (P2), and compliance of overseas products (P3). Though the central matters of fact of Contract 8 did not change, the main contrasts between this contract and the others are the practices that responded to the matter of concern around compliance. Making explicit the disconnection between the switchboard and the additional solar cables had the effect of making visible new matters of concern relating to the compliance of products. The above three contracting practices traversed key matters of concern: trusted connections, site requirements, customer requirements, and product compliance. Approaching Contract 8 as matters of concern shows the numerous negotiations required to address emerging changes – such as breakdowns – to enact the contract in terms of compliance.

4.2.4 Patrick

Contract 9

The central matter of fact of Contract 9 between Patrick and his customer Solarkey Pty Ltd was a subcontract to install a solar PV system, about 100kW, on the roof of a factory in a regional area. Besides the size of this contract being more than ten times the others, a clear contrast between this contract and the others was that Contract 9 was a subcontract. The factory owners contacted the main contractor, Solarkey, a commercial solar company. Their salesperson visited the site for an assessment and provided a quote to the factory owner, who approved it. The matters of fact of Contract 9 – between Patrick and his customer, the main contractor – were also the effect of the main contract and a slow process of composition. This process encompassed several salient matters of concern: trusted connections, the size of the switchboard, system designs, and procurement of resources.

This contract shared with other contracts the matter of concern of trusted connections. There was a history of the relationship between Patrick and his customer, Solarkey. A staff member working for Solarkey used to work with Patrick. He recommended Patrick as the sub-contractor for this job. Here, the contracting practice was forming the contract based on established connections.

Contract 9 was more than just the matters of fact of the sub-contract agreement. After the contract was agreed upon, new matters of concern emerged in the "theatre machinery", changing a matter of fact of the contract. Whereas the main contract was based on information gathered by Solarkey's salesperson, Patrick's visit to the installation location had the effect of identifying a new requirement that changed the sub-contract. The installation site needed a larger switchboard to accommodate the solar PV system. Patrick conveyed this requirement to his customer, the main contractor, and replacing the switchboard became an additional matter of fact in the contract. The contracting practice here was negotiating the site's requirements as they became visible and connected different actors: the contractor being on site, the size of the switchboard, the size of the solar PV system, and the main contractor.

Another matter of concern related to changing the system design. Numerous actors were involved. Patrick communicated remotely with the main contractor's team to understand their requirements and their choice of components. He also used high-resolution aerial photos provided by the main contractor and re-designed the layout of the panels. The new design incorporated the size of the system, the datasheets for the models of the inverter, and the specifications of the brand of the solar panels. It was a process of fine-tuning the negotiations between the different resources. Patrick explained:

> *So, you have to sit down with a calculator and keep trying different alternatives, different ways of doing until one that actually makes the most sense*. (C9P1Int2, p. 2)

The contracting practice was negotiating the components to be used in the installation to refine the system design.

Notably, the new design was also an effect of connecting Contract 9 to the expertise of the contractor and his team, to their experience and efficiency in handling the components. Interconnected with this matter of concern was a change in the brand of the mounting system that strengthened the relationship between Patrick and his supplier. Patrick negotiated with the main contractor to supply the mounting system of his choice, which was familiar to his team. Patrick's choice of the mounting system enacted two effects: less time is required to install the mounting system, and purchasing from a supplier of his choice strengthened his relationship with his supplier. The contracting practice here involved negotiating with the main contractor on the resources to be used in the installation. (See Figure 4.13 for an example of two rails before being installed as part of a mounting system.)

Figure 4.13 Two Rails Being Prepared Before Installation

In summary, the central contracting practices included the contractor being referred by a previous colleague (P1); inspecting the installation site, using aerial photos, changing the switchboard (P2); and negotiating how the different components fitted together in refining the design, supplying the mounting system, using familiar products, and gaining purchasing power from a trusted supplier (P3). By analysing Contract 9 as matters of concern – including the referral from established connections, the size of the switchboard, refining the design, and procurement of the mounting system – these three significant contracting practices enacted the unfolding sub-contract and simultaneously shaped the main contract. Despite the matter of fact that the factory owned the new solar PV system, the customer of Contract 9 was unequivocally Solarkey, the main contractor. Therefore, many of the changing matters of fact and matters of concern of Contract 9 were negotiated in collaboration with the main contractor. These negotiations were essential in responding to the requirements of the contractor Patrick, the main contractor, Solarkey, and the owner.

4.2.5 Summary of the contracts

Below is a summary of the 12 contracts (see Table 4.2) and the key matters of fact and matters of concern. The order of the sites listed here does not follow the chronological order of the installation dates to protect the anonymity of the electrical contractors.

Table 4.2 Matters of Fact and Matters of Concern

Contractor	Contract	Key matters of fact	Salient matters of concern:
	All 12 contracts	System size, location, major components, design, cost	• Customer and site requirements
Barrie	Contract 1	10kW system & power optimiser on residential roofs	• Trusted connections as friends • Trees casting shadows on the site • Customer's aesthetic specifications • Improved technology of power optimisers • Three-phase power property
	Contract 2	10kW system on residential roofs	• Trusted connections based on business referral • Compliance with energy distributor policy • Upholding business relationship • Competition
	Contract 3	5kW system on residential roofs	• Trusted connections as acquaintances • Energy for both consumption and export • Reducing the system cost • A toxic material, asbestos • Materials out of stock
	Contract 4	5kW system on residential roofs & remove old panels	• Trusted connections as business collaborators • Budget

			• Alignment between a roof and a row of solar panels
Charlie	Contract 5	10kW system on a shed	• Trusted connections based on a referral from a business • The site was vacant land • Reducing the system cost • Delay in the construction of the shed • Reduced price of batteries • Improved solar panel technology • Panels out of stock • Expensive replacement panels • Proper operation of the solar PV system
	Contract 6	5kW system on a shed	• Trusted connections based on a referral from a friend of the customer • Reducing the system cost • Future energy needs • A situation requiring extra service
Matthew	Contract 7	10kW system on a shed & remove the old system	• Trusted connections based on referrals from an insurance company and a business contact • Energy requirements during the harvest season and the rest of the year • Construction of new shed roof
	Contract 8	10kW system on residential roofs	• Trusted connections based on a referral from a business contact • Compliance with overseas products
Patrick	Contract 9	100kW on the roofs of a factory, a sub-contract	• Trusted connections with a previous colleague • Size of switchboard • Changing the design • Familiarity with resources

Barrie	Contract 10 – outlined in this table only	10kW system on residential roofs	• Trusted connections based on previous contracts • Heated site
Barrie	Contract 11 – outlined in this table only	5kW system on residential roofs	• Trusted connections based on a referral from a previous customer • Reducing the system cost • Opportunity for extra service
Matthew	Contract 12 – outlined in this table only	5kW system on residential roofs	• Trusted connections based on a referral from a friend • Opportunity for extra service

4.3 Contracts as matters of fact and matters of concern

In examining the above contracts, the evidence has shown a contract is more than just an agreed list of matters of fact, a signed document of the contract or a handshake of a verbal agreement. The idea of a contract as an agreement, written or verbal, between two parties (Australian Competition and Consumer Commission, 2021) can easily lead to the conventional impression of the certitude of the agreement. Such an approach encourages a sense of stability of a fact, a fact that is well scoped within the boundaries of the wordings in the agreement, on paper or in a conversation. In practice, however, the substantial evidence across the contracts discussed above is that the boundaries of these matters of facts are fluid. For instance, the agreed components, such as the solar panels, changed in size, number, manufacturer, and stock availability.

What constitutes contracts – the agreement between a contractor and a consumer – are open to negotiations throughout the contracted work, negotiations that are connected to various actor-networkss, many of which are not listed in the initial contract.

It is now plausible to suggest that conceiving of the contract only in terms dictated by the agreed matters fact is a significantly limiting approach. The above findings reveal that what is agreed to in the contract does not solidify as stated in the contract's wording, written or verbal. Matters of fact of the contract are malleable, a fluidity arising from connections to the many matters of concern, to the dynamic actor-networks from of which the matters of facts are composed – e.g., the whole sellers, the manufacturers, insurance payment, or the refined designs. What is agreed to is subjected to changes occurring on the installation sites and elsewhere in the connected networks of human and non-human actors. Changes to the sociomaterial actors connected to the contract shape the contract as matters of fact and matters of concern.

The empirical evidence above illustrates the significance of matters of concern. However, highlighting such importance does not imply that matters of concern should replace matters of fact. There is scope to include both matters of fact and matters of concern in this new understanding of contracts. The agreements of the contract in terms of matters of facts are indispensable to the formation of contracts between contractors and their customers. However, an expanded view of the contract is necessary to consider the dynamic actors and their changing networks connected to the various matters of fact. This view includes considerations of contracts as both matters of fact and matters of concern, and contracts are enacted by five salient contracting practices.

4.3.1 Five salient contracting practices

By establishing that contracts are both matters of fact and matters of concern, this chapter opens new possibilities of knowledge on how contracts are enacted. They are the ongoing negotiations and struggles between matters of fact and matters of concern that respond to the many changes connected to the various actors related to the contracted work. As the contractors and customers were important actors in the actor-networks that enacted the contracts, the following five practices acknowledge their connections to the many human and non-human actors connected to the contracts. The contracting practices are "ways of doing things together" (Gherardi, 2019, p. 11). This definition is one of the many definitions of practices. I want to emphasise that the use of the term practice in this study is closer to ANT than to a human-centric approach such as Schatzki's (2001) focus on human practices. Gherardi's definition of practice is largely informed by ANT as a sociomaterial theory that does not privilege humans. These are salient *ways* of doing in connecting together sociomaterial actor-networks (including the contractors and customers) to enact contracts:

1) establishing contracts based on trusted networks of connections – e.g., a referral from a previous customer;
2) appraising sociomaterial requirements connected to the customer and the work site – e.g., a customer's requirement for the panels to be installed at a specific location and appealing to his aesthetic judgment;

3) arranging sociomaterial resources needed as the work unfolds – e.g., a type of solar panel was out of stock which was replaced by a smaller type;
4) connecting the customer to significant sociomaterial changes arising as the work unfolds – e.g., educating customers on how to use the solar PV system; and
5) enacting sociomaterial assemblages as services additional to those contracted – e.g., fixing the connection to the new generator.

Given that this is not an exhaustive list of all contracting practices and that complete and thorough knowledge of all practices is not possible, the above list outlines central practices discernible in the empirical evidence gathered for this study. Contracts are more than just simple and static matters of fact as listed in a document or a verbal agreement. The "machinery" or the contract's composition process as matters of fact could be examined by approaching contracts as matters of concern. The analysis revealed the five key *ways* human and non-human actors "do things together" in contract work. These practices are ways that contracts were enacted in practice.

These key contracting practices engage with both matters of fact and matters of concern. The contracts, as matters of concern, changed as transformations in connected networks became visible. Since human and non-human actors can fully act, "a lot of new and unpredictable situations will ensue (they make things do *other* things than what was expected)" (Latour, 2005, p. 59). Matters of fact, such as the solar panels listed in a contract, were replaced because of variations in the actor-networks, e.g. the suppliers running out of stock, changing the type of mounting system allowing additional panels to be used, or a price reduction allowing more panels to be added to the solar PV system. The solar PV systems enacted in practice differed from those stated in the contract. The data shows no evidence of a rigid assertion of the contract as agreed at the initial stage. The contracts, as matters of fact and matters of concern, are shaped in contracting practices and negotiated as the contract work unfolds.

Notably, if there were a fundamental contracting practice and an essential matter of concern in enacting contracts, those based on trusted connections must be underlined. The continuation of the businesses of the contractors participating in this study depended in substantial ways on referrals from previous customers, business contacts, and friends. The activities in these five contracting practices fostered, continued, and even extended these established relationships, ensuring the ongoing success of the contracting business.

4.4 Summary

The above evidence answers the first of the two sub-research questions: "How are contracts enacted in practice?" In brief, this chapter offers a novel conceptualisation arguing that 1) contracts unfold as both matters of fact and matters of concern; 2) five salient contracting practices enact contracts. This chapter elucidates more comprehensively the complex enactment of contracts in practice: the agreement at the initial stage of a contract is not necessarily the work being completed at the later stage. The novel conceptualisation of the contract addresses the neglect of contracts as identified in the literature review. This chapter extends the existing literature by reconceptualising how contracts are enacted in practice. In conceptualising contracts as matters of fact and matters of concern, involving contracting practices, this thesis joins existing practice-based literature to shift the focus to practice-based work. It adds to the literature by offering concepts that make the invisible in contract work visible: the intertwined matters of fact, matters of concern, and contracting practices.

Having examined contracting practices, the next chapter, Chapter 5, scrutinises installing practices to answer the second subordinate question, "How is learning enacted in solar PV installing practices?"

5 LEARNING IN RE-FORMING, MUTATING, AND PERSISTING NETWORKS

5.1 Introduction

Continuing from the previous chapter, which followed contracts as tracers to answer the first subordinate question, "How are contracts enacted in practice?", this chapter is immersed in the installing practices of the solar PV systems to answer the second subordinate question, "How is learning enacted in solar installing practices?". While there are many actor-networks in solar installation, the iterative analysis processes detailed in Chapter 3 identified the mounting systems as some of the most significant actors in solar installations. In this chapter, the study found evidence to argue that learning is enacted in different connection efforts in re-forming, mutating, and persisting networks.

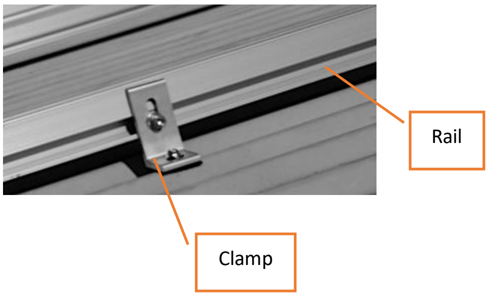
Chapter overview

The present section continues with a brief overview of the different types of mounting systems in the introduction. Section 5.2 outlines learning in solar installing practices as conceptualised in ANT, followed by a brief discussion of the ideas of re-forming, mutating, and persisting networks and connection efforts in the literature. Sections 5.3, 5.4, and 5.5 consider the mounting systems and how they operate in re-forming, mutating, and persisting networks. Each of these sections concludes with a discussion on connection efforts and learning. Section 5.6 summarises the chapter.

Mounting systems – connecting solar panels to the roofs

The mounting systems are identified from the analysis as significant actors. They hold important connections with other essential actors, such as solar panels and roofs. These actors connect extensive networks, linking the networks connected to solar panels to networks of the roof. Rather than being separate entities, actors connect with other actors, enacting networks that include some actors and exclude others (Latour, 2005). When considering an actor, such as a mounting system or a person, for example, "what counts as a person is an effect generated by a network of heterogeneous, interacting material" (Law, 1992, p. 381). The mounting systems comprise rails and clamps, making crucial connections between the solar panels and the roofs (see Figure 5.1).

Figure 5.1 An Example of a Mounting System



The solar PV systems installed on the 12 sites in this study utilise different types of mounting systems: flat mounting systems, pre-fabricated tilt mounting systems, and a customised tilt mounting system. A flat mounting system is constructed flat on the roof (see Figure 5.2). Two parallel metal rails connect the solar panels to the roof. In tilt mounting systems (see Figure 5.3), the solar panels are installed at a calculated angle oriented to receiving optimal sunlight. A pre-fabricated mounting system unfolds into a triangle, ready to be assembled on-site. A customised tilt mounting system is built part by part to suit the roofs. The quickest type to assemble is the pre-fabricated system. The most complicated of the three systems is the custom-made one, where the components are cut to suit the site. All three types of mounting systems were used across the 12 sites, revealing different learning networks.

Figure 5.2 An Example of a Flat Mounting System

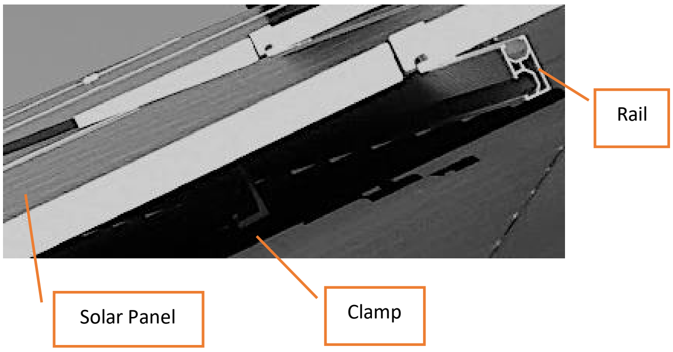
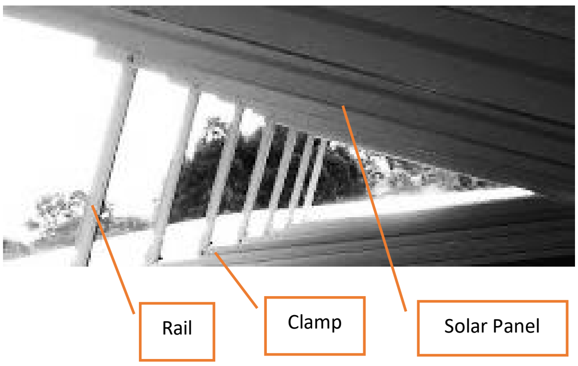


Figure 5.3 An Example of a Tilt Mounting System



5.2 Learning, network effects, and connection efforts

The learning examined in this chapter builds on the current definition adopted in the literature. Recalling the discussions in Chapter 3 on ANT approaches to learning, learning is defined as "a distributed effect, something that continually emerges through negotiations and struggles at myriad nodes of possible connections between human and non-human elements" (Fenwick et al., 2011, p. 117). The following is a brief review of the theoretical foundations of this chapter.

5.2.1 Learning as sociomaterial in solar installing practices

Given that learning involves social and material actors, the everyday work of solar installing practice included both types of actors. The human actors included actors such as the contractors, the customers, and the staff working for the suppliers. The non-human actors involved a myriad of actors, such as solar panels, mounting systems, roofs, and drills. Using the ANT approach of following the actor to trace the mounting system, this chapter discusses the findings involving obviously visible and previously ignored actors. The learning enacted as network effects is explored in this chapter in relation to the interconnections of human and non-human actors involved in various negotiations and struggles.

5.2.2 Learning as network effects

As a network effect, learning is examined in this chapter in the tracing of the mounting systems. In ANT, materials such as mounting systems are not separate entities. They are seen as actors connected to other actors and are formed as enacted networks that include some actors and exclude others (Latour, 2005). ANT distinguishes between networks as emerging in the activities of human and non-human actors, instead of the general conceptions of networks as solidified structures, such as train networks. This chapter does not focus solely on the mounting systems but on the networks of humans and non-humans of the mounting systems, where in negotiations and struggles, "knowledge is generated through the process and effects of these assemblages coming together" (Fenwick & Edwards, 2010, p. 4). This highlights that learning as network effects does not refer to solid, fixed states, but is fluid and continually emerging.

As previously discussed in Section 3.4, the word "enacted" used in this thesis is a key term in understanding how learning is enacted in installing practices as part of the emerging nature of networks. Mol (2002) defines "enact" as follows: "In practices, objects are enacted. This suggests that activities take place – but leaves the actors vague. It also suggests that in the act, and only then and there, something is – being enacted" (Mol, 2002, p. 33). Following Mol's usage, this thesis focuses on the action the doing in everyday practice.

5.2.3 Persisting, mutating, and re-forming networks

This chapter draws on existing research to specifically examine learning as network effects when networks reform, mutate, and persist. Fenwick, Edward and Sawchuk (2011) recognise "how all things – natural, social or technical are more accurately some messy mix of these – become assembled and enacted in networked webs, how they associate and exercise force, and how they persist, decline and mutate" (p. 94). Further, this understanding of network effects is explicitly linked to how learning is understood in subsequent research that states "learning is conceptualised as the effects that occur as these networks 'persist, decline and mutate'" (Mitchell, 2019, p. 142). In both research, the concept of "persist, decline and mutate" is mentioned only in these two sentences, without being linked to any specific empirical studies. In this thesis, this concept is empirically explored, and I found evidence to support the idea of network mutating and persisting, but not declining. Instead, I found evidence for networks re-forming.

The concept of reforming, mutating, and persisting networks finds resonance in Lupton's (2020, 2023) work on compost-ism. Building on Donna Haraway's metaphor of compost, Lupton views socialmaterial actors as being composed and de/recomposed, where "compost materialities, forever composing and decomposing into new, rich, and vibrant matter" (2023, p. 303) and in assemblages, various dimensions "work to compose and de/compose human, providing the conditions in which they live, move and grow" (2020, p. 32). Actors, such as data and devices, have the vitalities and agencies to connect with sociomaterial assemblages to enact new effects.

As learning continually emerges, verbs are more suitable for expressing activities. The use of verbs draws on the idea that "action-nets/actor-networks should be understood as verbs, not nouns, as relational effects that recursively generate and reproduce themselves" (Gherardi, 2009, p. 62). In this thesis, the verbs "reform", "mutate", and "persist" – and the corresponding conjugations "re-forming", "mutating", and "persisting" – emphasise the actions, the doings and sayings, rather than states that are conveyed by the adjectives "persisted network", "mutated network", and "reformed network". The choice of the verb form suggests the actions that enact practice, a process of emerging rather than a solid state.

5.2.4 Connection efforts

As discussed in Section 3.4, rather than considering network effects with the rigidity of fishnets, network effects are understood as the connection and disconnection being enacted in everyday practices. Latour notes, "this connection is not made for free; it requires effort" (Latour, 2005, p. 132). Requiring effort, re-forming, mutating, and persisting networks mobilise actors to negotiate connections and disconnections that can be traced by following the actors, such as the mounting systems. Latour (2005) sees that the nodes of connections can be “longer, faster, and more intense connections” (p. 179) or “some sort of more or less durable connection” (p. 221) or “far safer connections with many more places than others” (p. 176) or the multiplying “number of connections” (p. 215). These efforts vary in intensity, durability, or number of connections. The analysis indicated three patterns of variations in the three ways networks were enacted.

The idea of connection efforts is not the same idea as the ANT concepts of intermediaries and mediators; however, they are helpful for understanding the idea of connection efforts. Mediators are actors whose “input is never a good predictor of their output” (Latour, 2005, p. 39), and intermediaries are actors whose “inputs is enough to define its outputs” (Latour, 2005, p. 39). There is minimal work related to actors that are intermediaries. However, extra work is required with mediators. It is possible to draw parallels between connection efforts and the amount of extra work in the “rare exception that has to be accounted for by some extra work – usually by the mobilization of even more mediators!” (Latour, 2005, p. 40). This chapter argues that three different connection efforts are involved in learning in installing practices. Table 5.1 below presents an overview of the learning characteristics discussed in Sections 5.3 – 5.5.

Table 5.1 Learning Characteristics in Re-forming, Mutating, and Persisting Networks

	Re-forming	**Mutating**	**Persisting**
Catalyst for learning	A breakdown in an obligatory passage point creates widespread disconnections and prevents progress on the contract work	A practice is changed due to new actors becoming visible or temporarily halted as further connections cannot be made	An activity on site is changed or temporarily halted as further connections cannot be made
Pre-existing knowledge	Answers to the breakdown are largely unknown initially	Answers as to what and how to connect are known by some; this knowledge needs to be assembled, at times in iteration	The contractor knows what connections to make and how to make them, and the learning is about the particular instance of those connections
(Un)Certainty	Learning unfolds amid high degrees of uncertainty across a network	Learning unfolds amid a mix of certainty and uncertainty as some aspects of the network related to the practice change, and others do not	Learning unfolds amid high degrees of certainty pertaining to a stable (but not rigid) network
Spatiality of learning	Learning involves actors such as peers, suppliers, and national networks	Learning involves actors such as peers, suppliers, and national networks	Learning is more embodied, involving actors on the work site

Connection effort	Learning occurs in high connection effort	Learning occurs in moderate connection effort	Learning occurs in low connection effort
Network effects	New ways of doing things emerge as an established way disintegrates	Established ways of doing things accommodate changes in networks	Ways of doing things are upheld amid tinkering with artefacts and people

Analysis questions

As discussed in Chapters 3 and 4, the below findings emerged from examining the data using the analysis questions:

- "Who-what is acting? What are they doing?... What is the sociality around the object? The materiality?" (Adams & Thompson, 2016, p. 33)
- "What if a particular object breaks or is unexpectedly missing? What happens? In the wake of a breakdown, accident, or anomaly, what practices and things become more visible?" (Adams & Thompson, 2016, p. 49)
- "What are the different kinds of connections and associations created among things? What different kinds and qualities of networks are produced through these connections? What are the different ends served through these networks?" (Fenwick & Edwards, 2012, p. x).

5.3 Re-forming networks

5.3.1 Defining re-forming networks

This section focuses on learning in relation to network effects and connection efforts in re-forming networks. The idea of re-forming networks refers to those undergoing significant disconnections in wider networks that destabilise some installation practices as they might have otherwise been enacted. Re-forming networks involve a breakdown or anomaly of an obligatory passage point “indispensable in the network” (Callon, 1986, p. 204). Following the breakdown or anomaly, various actors previously connected become disconnected since “if the network in which they are embedded falters, the actors may falter too” (Mol, 2010, p. 258). Amid such disintegration, substantial connection effort is needed to negotiate new connections beyond the work site to stabilise new practices and enable the installation to continue.

As this chapter focuses on tracing the mounting systems and the connected networks, only one event identified in the data related to the mounting systems could be characterised in terms of re-forming networks, as described below in Section 5.3.2. When examined with the analysis question, “In the wake of a breakdown, accident, or anomaly, what practices and things become more visible?” (Adams & Thompson, 2016, p. 49), disconnections resulting from a breakdown reveal networks of influential actors, engaging in negotiation requiring high connection effort.

5.3.2 Fires caused by isolators attached to mounting systems

Due to an amendment of the standard AS/NZS 4417.2:2012, some direct current (DC) isolators attached to mounting systems were removed from an approved list of isolators, causing a breakdown (see Figure 5.4 for an example of an isolator). While working on Contract 12, Matthew discovered that the standard relating to the isolator attached to the mounting system on the roof had changed over the weekend. This change disconnected one of the isolators he had in stock from the list of approved isolators. He worried that he would have to replace the isolators in stock, a high cost he had not factored into his contracts.

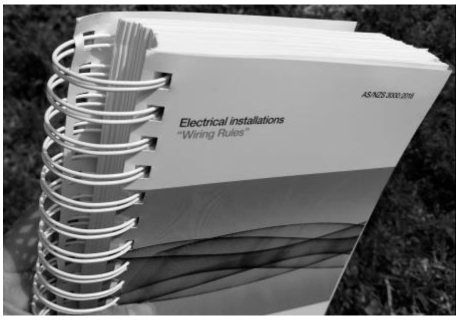
Figure 5.4 An Isolator

At the time of the data collection, the DC isolators attached to the mounting system on the roof were embroiled in emerging controversies (Clean Energy Council, 2019; SEIA, 2019). Isolators allow the electric current to be switched off by hand as a safety measure. Solar panels generate DC electricity, which is converted to another type of electricity (AC or alternating current) that can be used to operate electrical appliances. The controversies were connected to DC isolators attached to the roof's mounting system. In the case of a fire, emergency service personnel could climb up the roof and manually turn off the DC rooftop isolators, hence disconnecting the electricity generated by the solar panels.

However, DC isolators attached to the mounting systems could cause a fire, generally due to water from condensation or rainwater entering the isolator. Between 2018 and 2020, there was a 500% increase in fire incidents related to isolators attached to mounting systems (Dye and Thompson, 2021). Deteriorating isolator components due to exposure to weather conditions on rooftops and incorrect installation also caused fires. Ongoing debates occurred within the solar industry on whether to ban these isolators.

What became visible in the breakdown were networks connected to the DC isolators. The disconnection of some DC isolators from the approved list triggered negotiations, struggles, and connections among a wide range of actors. There was an amendment of the standard AS/NZS 4417.2:2012. The DC isolator was re-categorised from a Level 1 product to a Level 3 product. In Level 1, a product was compliant if supplied by an approved supplier; in Level 3, there are more stringent requirements. Each product and model must be approved with a valid Certificate of Conformity for DC isolators. (See Figure 5.5 for an example of an Australian standard on technical rules titled *Electrical Installations: "Wiring Rules"*.)

Figure 5.5 An Australian Standard – *Electrical Installations: "Wiring Rules"*



There was a great deal of uncertainty since the various ways of working with this type of isolator became destabilised, and knowledge of how to proceed was unknown. What became visible here was the networks related to that standard, to the committee recommending the standard, and to valid certificates. Another network that became visible was a social media page, open to the general public. From postings by commentators on this page, Matthew read about an amendment to the standard. The amendment was already in effect when the contractor read the post. Many actors were connected to this network. Comments were posted in the struggle to establish the current status of what was expected. Several online posts from the same forum expressed surprise and frustration. Two posts mentioning the change of standards attracted more than a hundred comments. The isolator was part of the lively discussion, engaging many commentators posting, for instance:

> *…everyone who was aware please comment who advised them of the change and when they were notified. Would be good to see…*

> *… do all my isolators now have to go on the south end of the array?...*

> *Through Group A. This afternoon.*

> *B has a Group C notification…*

> *D from Group A couldn't give an answer, an old fella from Group E hadn't even read the amendment and didn't know what to do even after reading it and calling me back and Group F didn't know either. We only install Product G but have no idea how we are meant to install them…*

> *Does this mean the Product H isolator isn't compliant anymore?*

> *… reference for all to use and see. As more information come to hand by manufacturers / wholesalers / power authority and installers, we will be updating this post. Each point will need to be verified. Please provide as much information as you may have with back up email, PDF or any other form so the general Community H can be informed on the situation.*

In disconnecting some of the DC isolators, instability became a feature of a re-forming network. The disconnection was at the centre of a lively social media storm. The practice of installing the DC isolators became unstable. The ensuing effects were recursive questions about whether the isolators could be used that day, for scheduled installations, for the next day, or the days after. Another issue was about the future: how did installers learn about the change so that others know where to join the appropriate lists to avoid facing the same situation again? Installers shared comments left on the posts to others in their own networks. The commenters took screenshots of emails and uploaded them to the site. Others took photos of certificates of compliance provided by the isolator manufacturers. Some shared screenshots of newsletters. Many comments offered thanks or asked for clarifications. A few tagged their friends in the comments, nudging for attention. More individuals, groups, and artefacts became visible in the isolator networks.

It was not just individual commentators but also organisations that became visible in responding to the instability in the re-forming networks. Suppliers and manufacturers sent emails to their customers advising them of the change. These emails were then passed on to others in screenshots. Leading organisations in the industry responsible for announcing the change of the standard continued to respond to queries. State authorities worked on drafting and communicating their responses to the change. One state was implementing a transition period. Another state provided evidence of sharp increases in demands for the isolators on the approved list, and the resulting lack of available stock necessitated the use of the existing isolators, those that were not on the new approved list. The unfolding struggle with uncertainty made visible the various connections in practice while the solar PV system was being assembled for this site. Part of the installing practices was connecting to and staying current in the shifting networks as they were being reformed. Learning unfolded amid high uncertainty across re-forming networks, involving the "coming together" (Fenwick & Edwards, 2010, p. 4) of actors such as peers, suppliers, and national networks.

Disconnecting the isolators from the approved list, an obligatory passage point, had the destabilising effect of disconnecting many other actors in different networks, many of which were non-local, beyond the immediate vicinity of the installation site. The disconnection of the DC isolators from the approved list of isolators affected a range of actors such as: the DC isolators (the mounting system, the roof, water damage, rust, fire danger, the purchased stock in storage, the upcoming installation), the governing bodies (the committee reviewing the standards, state authorities, the administrators, categories of isolators, Certificate of Conformity, queries, responses to queries), the fire and rescue agency (emergency service personnel, administrators, fire dangers), the online forum (phones, laptops, internet access, commentators, moderators, posts, screenshots of sources of information, offers of support, tagging friends), suppliers (emails, notifications of the change). This list is not exhaustive but shows the range of sociomaterial actors involved in responding to the breakdown and establishing new practices, "ways of doing things together" (Gherardi, 2019, p. 11).

5.3.3 Connection efforts and learning in re-forming networks

In re-forming networks, learning is a network effect of the actions that respond to the instability resulting from the breakdown. The "ends served through these networks" (Fenwick & Edwards, 2012, p. x) was the need to reform and re-establish some instability of installing practices. The way of installing the DC became uncertain. As the uncertainty affected various actors across the network, a high connection effort was necessary to re-establish some stability. What was done was that many actors were disconnected and connected, and questions were asked. Multiple steps of recursive questions and responses involved actors in extensive networks, such as the commentators on the social media page, the suppliers, and the organisations responsible for the amendment. Many actions and actors are involved in much work to negotiate new connections in response to the breakdown. In the negotiations and struggles of new connections, re-forming networks requires high connection effort due to the uncertainty and the variety of actors involved, widely connected, and dispersed in time and space. Learning is in the negotiations and struggles, as Fenwick, Edwards, and Sawchuck (2011)propose, "a distributed effect, something that continually emerges through negotiations and struggles at myriad nodes of possible connections" (p.117).

From the ANT perspective of tracing the mounting system in relation to sociomaterial actors and network effects, what has emerged is that learning is associated with one of the ways networks are enacted. Here, it is the re-forming network. Following the breakdown of the previous practices related to the DC isolator attached to the mounting system, learning emerges in the negotiations and struggles in re-forming the practices. Learning in a re-forming network is characterised by the following:

- a breakdown in an obligatory passage point creates widespread disconnections and prevents progress on the contract work;
- answers to the breakdown are largely unknown initially;
- learning unfolds amid high degrees of uncertainty across a network;
- learning involves actors such as peers, suppliers, and national networks;
- learning occurs in high connection effort;

- new ways of doing things emerge as an established way disintegrates.

Instability and connection efforts are greatest in re-forming networks, marking the qualitative difference in learning in re-forming networks. In the following two sections, these two characteristics will be contrasted to the learning in mutating and persisting networks.

5.4 Mutating networks

5.4.1 Defining mutating networks

The idea of mutating networks refers to networks undergoing changes due to emerging actors that are important in installation practices but are not obligatory passage points. Practices are temporarily halted, and moderate connection efforts are required to negotiate these changes, resulting in modified practices. Here, the connection efforts are not as demanding as in re-forming networks. In tracing the mounting systems, from the twelve sites, below are three examples of how learning was enacted in mutating networks.

5.4.2 Building a custom mounting system

While Matthew was working on Contract 7, the networks connected to the mounting system mutated when he worked on removing the existing damaged solar panels. Instead of seeing the old mounting system as a flat mounting system, the act of being on the roof to remove the old system made visible additional actors connected to the old system. Matthew noticed how the previous solar system was damaged. Here, the network of the mounting system was mutating.

Figure 5.6 An Actor-Network of Solar Panels and Surrounding Trees

When Matthew removed the damaged panels, he noticed that under the damaged solar panels were piles of debris that had damaged the electrical cables. (See Figure 5.6 for an example of an actor-network of solar panels, leaves, branches of the surrounding trees, and possible networks of habitats for different animals.)

The response to this problem was a custom-made mounting system that could raise the solar panels well above the roof to avoid debris being trapped under the solar panels. Matthew recounted how the system was built:

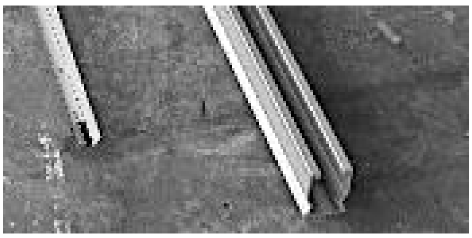
> *Just by reading the installation manual, from their website, which took a long time cos, it's really hard to work out how to do something when you haven't got the pieces in front of you, to see how it goes and see how to pick the pieces. So, I spent a long time, days actually, going through all that and selecting the materials for that, putting in an order. There's a lot of time on it; nearly half of the time I spent was just on paperwork, and the half was installing it. So, a lot of time was spent on it, other than being on-site.* (C7M1Int2, p. 2)

The need for a custom-made mounting system had the effect of mutating the practice of installing the mounting system. Not knowing how to create a custom-made solar PV system, Matthew connected to the manufacturer's website and to the manual, where there was more certainty of knowledge on the practice of installing custom-made mounting systems. The website was accessible and contained assembled instructions on building a custom-made system.

However, some iteration was needed. More connection efforts were necessary to connect the instructions to the pieces of the mounting system. Negotiating material connections without the materials to work with was not an easy activity. Connecting the instructions in the manual to the mounting system took days of work. Each step involved negotiations connecting different materials to create the custom-made mounting system.

While there were some certainties regarding the instructions, in this mutating network, learning was enacted when connection efforts were needed to connect to different actors. Unlike in the re-forming network, the mutating networks had some certainty relating to the practice of building custom-made mounting systems. With some connection efforts to measure the rails, to cut and connect the many pieces of the mounting system, a new installing practice emerged: creating a custom-made mounting system. (See Figure 5.7 for an example of actors such as retractable measuring and rail that could be used to build the mounting system.)

Figure 5.7 Retractable Measuring Tape and Rail



While the solar system did not undergo drastic changes at that moment, this was an instance of a mutating network because many actors were made visible by Matthew working on the removal of the old system. There were connections to actors such as: the roof (the angle of the roof, the location, flora, and fauna in the area), the damaged panels (the electric cables, the panels, the mounting system, the angle of the mounting system), the custom-made mounting system (the supplier, the retractable measuring tape, the rails, the pieces of mounting system, the manual), and the computer (the internet, electricity, the websites). In building the custom-made mounting system, "knowledge is generated through the process and effects of these assemblages coming together" (Fenwick & Edwards, 2010, p. 4).

Learning enacted in a mutating network was "negotiations and struggles at myriad nodes of possible connections" in responding to the emerging actors connecting to the network of the mounting system. Learning was a network effect of the connection efforts between diverse actors that were relatively stable actors available on the installation sites or online, located on a website.

5.4.3 Roofing screw for soft tin roof

Contract 6 enacted a mutating network involving connections to a 15N roof screw. A problem with attaching the mounting system directly to the roof was that the roof was made of soft tin material. This soft material required a special screw that could withstand strong winds. The need for the special screw had the effect of mutating the network of the mounting system.

In connecting the correct screw to the network of the roof made of soft tin material, Charlie went to the local supply shop. The local shop was connected to many actors, including a physical brick-and-mortar shop, the materials that were in stock and could be sourced from networks of suppliers, the employees working at the shop, and the networks that connected the staff to the existing and new technology that the shop supplied. The local shop was connected to a network where stable knowledge of many products could be sourced. He asked about the screw but gained no useful information. Iterative actions to identify the solution occurred. The shop contacted the sales representatives, but they could not solve the problem either. Charlie then sourced the screw from another supplier. (See Figure 5.8 for an example of a node of connections of parts purchased from a supplier and stored in plastic bags and a cardbox box.)

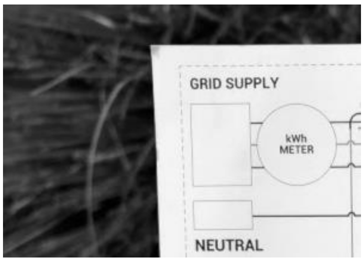
Figure 5.8 Carboard Box of Parts

While the actors involved were relatedly stable, some connection efforts were required to identify the correct screw. Negotiations of connections were made between actors such as: the roof, the mounting system, the contractors, a 15N screw, and the suppliers (the local shop, the customer service staff, and the sales representatives). Iterative connections were made to different suppliers until the correct screw could be used on this installation site. The practice of installing a mounting system on a roof was modified to include a new actor in the installation on a soft tin roof. In this mutating network, learning was an effect of the connection efforts between relatively stable actors, having high certainty, yet recursive connections were necessary towards serving "the ends" (Fenwick & Edwards, 2012, p. x) of accurately connecting the mounting system to the roof.

5.4.4 Identifying shadows casting on solar panels

Relating to Contract 5, a mutating network involved possible shadow on solar panels. Charlie drew the solar panels to scale at the stage of refining the technical drawings at Site 5. The panels were designed for a tilt mounting system. However, in refining the drawing, on this particular roof size and with the amount of energy required, the shadow that one row of solar panels could cast on the next row emerged. This could prevent the solar PV system from generating electricity. The possible shadows on solar panels were a breakdown that halted the practice of designing the mounting system. (See Figure 5.9 for an example of a technical drawing.)

Figure 5.9 A Technical Drawing



The mutating network included a new type of mounting system. Instead of the planned tilt mounting system, which could lead to shadows, a flat mounting system was used. Panels attached to a flat mounting system could not cast as much shadow as the panels installed on a tilt mounting system. Further, the new design of the flat mounting system connected to the changes that occurred within the months between the time of inquiry and the finishing of the construction of the shed on which the solar panels were to be installed. The changes in the solar industry resulted in lowering the costs of the panels as well as an improved technology that allowed for a higher energy output of the solar panels. The mutating network also included lowering costs, advancing technology, and implementing a new design. The solar PV system now had 12 additional panels.

The mutating network of the mounting system on this site involved connecting to actors such as: the size of the roof, solar panels (panel outputs, supplier, technology changes, price changes), the mounting system (dimensions, distance between rows), the sun (light, shadows, movement of the sun), design drawing (computer, pen, paper), and time (construction progress, months). A new way of designing the mounting system was enacted after some iterative negotiations occurred between local and non-local actors that were more or less stable. The practice of installing the mounting system at this site mutated from the use of a tilted system within a limited space to the use of a flat mounting system.

5.4.5 Connection efforts and learning in mutating networks

Learning in a mutating network is an effect of connections between relatively stable actors, having some certainty of reaching a solution for a breakdown or an anomaly that temporarily halts a practice. A difference in connection effort between re-forming and mutating networks is that in re-forming networks, high connection efforts are needed to respond to a breakdown involving an obligatory passage point. In mutating networks, the connections involved fewer actors and lower intensity of negotiation in connections. Here, some connection effort was required when different actors were connected to the network in response to changes to connections within the network modifying a practice.

The learning enacted in mutating networks involves breakdowns or new configurations of sociomaterial actors that change the installing practices. Learning in the mutating networks is identified by the following characteristics:

- a practice is changed due to new actors becoming visible or temporarily halted as further connections cannot be made;
- answers as to what and how to connect are known by some; this knowledge needs to be assembled, at times in iteration;
- learning unfolds amid a mix of certainty and uncertainty as some aspects of the network related to the practice change and others do not;
- learning involves actors such as peers, suppliers, and national networks;
- learning occurs in moderate connection effort;
- established ways of doing things accommodate changes in networks.

While uncertainly and connection efforts are most significant in re-forming networks, in mutating networks, the actors are more or less stable and certain, involving local or non-local actors.

5.5 Persisting networks

5.5.1 Defining persisting networks

The idea of persisting networks refers to those that appear relatively stable, but which, in fact, are dynamic. Unlike re-forming and mutating networks, where practices are modified, in persisting networks, practices remain largely unchanged. These dynamics involve connections and disconnections that are micro-negotiations, evident through a focus on embodied actions and granular connections between contractors and specific materials. Because persisting networks are not rigid, connection effort is still involved, and other aspects of learning come into view at this micro-level.

Of the twelve sites, there were several instances of persisting networks. This section focuses on four of those instances to illustrate the micro-negotiations between actors in close proximity to each other. A useful metaphor for the connection effort required in persisting networks is that of the duck, appearing stable, but such an image of a persisting state is the effect of duck feet padding under the surface of the water.

5.5.2 Discovering an uneven roof

Related to Contract 8, a persisting network was enacted in connection to an uneven roof. When Matthew and his assistant Morgan were connecting the mounting system to the roof, it gradually became visible that the roof was uneven. The installation work was momentarily halted. As Matthew and Morgan continued the installation, they connected different material arrangements to measure, check, and re-check four rows of the newly installed mounting systems. They identified the uneven roof and made the necessary adjustments to align the rails. The installers knew how to connect the actors; however, some iterative actions were required. The excerpt below illustrates the various actions necessary to enact the everyday practice of installing a mounting system while identifying issues and then making corrections. Here, Matthew and his assistant were drilling the rails to the brackets (which acted in a similar way to power poles holding up electrical cables), which were anchored under the roof tiles.

> *12:10pm Morgan walks, left to right, using a drill to secure the rail to the stands. Morgan finishes one rail. He walks three steps away to gauze the alignment of the attached rail. Matthew uses a tape measure to measure the distance between the rails.*
>
> *12:15pm Matthew: How much is overhanging there?*
>
> *Morgan: 200mm.*
>
> *Matthew: Same here.*
>
> *Morgan walks along to tighten the screws on the 4th rail. They then move to the 2nd rail and secure the nuts to the rail.*
>
> *12:2pm 0 Morgan: These ones are way out.*
>
> *Matthew: These are sticking up? . . . These are different brackets or something. He bends over to look.*
>
> *Morgan: Do you want to replace it?*
>
> *Matthew: Those tiles are getting higher, the ones you are standing on.*
>
> *12:25pm Matthew walks to the left side and uses a plier to adjust the point where the rail connects with the bracket. They then attach the nuts to the joints and tighten the connection. Matthew walks down the ladder. He carries a long rail up. He walks to the 3rd rail and lies down to gauge the length of the rail.*
>
> *Matthew: Pretty wonky . . . Maybe needs to go to the middle. Drop that one.*
>
> *Morgan: What about this one?*
>
> *Matthew: Go right to the end and drop that one right down . . . Oh no, maybe . . . I think the problem is this joint.*
>
> *Matthew: Yeah, tighten that up.*
>
> *12:30pm Morgan: We might have to lower this.*
>
> *They adjust some of the joints.* (C8M2Obs2, p.4)

With each action they took, new negotiations arose that demanded connections. To the question, "*How much is overhanging there*?", using a measuring tape, the answers were "*200mm*" on one end of the rail and "*same here*" on the other end. A few minutes later, additional micro-negotiations occurred to ensure the correct alignment of the actors. Lying down on the roof and gauging the length of the rail, Matthew noticed, "*Pretty wonky*". The uneven rail was a disconnection that moved a connection point a bit lower, then another point, and then a new disconnection emerged, "*I think the problem is this joint*". They connected the rails to the brackets and checked the 4th, 2nd, and 3rd rails. (See Figure 5.10 for an example of some installation tools.)

Figure 5.10 Plier and Electric Drill

One after another, a series of micro-negotiations involving the senses took place, enacting learning in the tinkering of connections to enact the network to persist. For the work to continue, negotiation took place: Was the length of this mounting system the correct length? Were the lines straight? Were they parallel? If the answers were affirmative, the negotiations proceeded to the next step. Tinkering with the micro-connections allowed the following activity to take place. Where they did not align, the mounting system was disconnected and connected until they, and the other actors, such as the panels and brackets, aligned.

While there were no changes in the installing practices, learning in this persisting network related to the low connection efforts in the negotiations and struggles between actors physically close to each other. These included the mounting system (rail, brackets, screw, nuts), roof (tiles), measuring tapes, ladder, and the two workers. The learning enacted here was closely linked to the micro-negotiation, particularly the embodied adjustments made by the human actors in relation to the non-human actors.

5.5.3 Selecting tiles to adapt

Related to Contract 11, brackets were used to ensure that the mounting system was securely attached to the roof by connecting long rails of the mounting system to the roof. In a persisting network with a high degree of stability and certainty, Barrie removed some tiles from the roof and cut a dent to allow the bracket to be installed under the tile. He used an electric saw to carve the tile. At one point, the activity of cutting the tile was temporarily halted. Barrie stopped cutting and touched the blade quickly before replacing the blade with another one. He then cut another tile. This instance shows the negotiation that occurred between Barrie's body, eyes, fingers, the tile, the electric saw, and the sharpness of the blade before it was replaced. (See Figure 5.11 for an example of a bracket securely attached to a tile.)

Figure 5.11 Tiles and A Bracket

In this situation, the practice of installing the bracket persisted. Requiring low connection effort, learning in this persisting occurred through the micro-negotiations that occurred in a local network that included the tile, the old saw blade, Barrie's embodied attunement using his visual, auditory, and tactile senses, the new saw blade, and the electric saw.

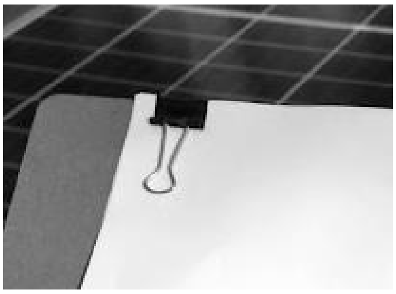
5.5.4 Changing from two isolators to one

Related to Contract 10, on the second day of the installation, Barrie was sitting amongst the components of the mounting system already stabilised on the roof, and the rows of panels were already attached to the mounting system. Seated among the partially formed solar PV system, securing a conduit to a roof, Barrie decided to change the design. He changed the design from using two isolators to using one. He recounted the decision:

> *Barrie: When I come back, I'll have one isolator instead of two.*
>
> *Researcher: How did you come to that decision?*
>
> *Barrie: When I sat here, I realised I could connect it to this one [tilt mounting system], and these [cables] are long enough [to go under the tilt mounting system]. I can put four cables here.* (C10B6Obs2, p. 7)

The persisting network here involved connecting to actor-networks such as: the mounting system (connected to the roofs, the various components), the panels (connected to the mounting system and the roof), the design (connecting the electrical wiring, the conduit, the panels, the mounting system, and the isolator), roof (the layout of the roof, the conduit) and Barrie (being on site, sitting on the roof), the isolators (stored in the vehicle). (See Figure 5.12 for an example of a clipboard for securing design documents.)

Figure 5.12 A Clipboard



Rather than a breakdown, an installation activity was temporarily halted. Learning in this persisting network was enacted when Barrie was physically sitting among the materiality of the mounting system. This persisting network involved only local actors being on-site, and learning required low connection effort, tinkering with local material and human actors.

5.5.5 Negotiating a two-storey building

Relating to Contract 3, a mounting system was moved to the roof in a persisting network. As the house Barrie worked on was a two-storey building, the distance from the ground to the roof required some coordination to move the mounting system to the roof. The node of negotiation connected Barrie, Bryan, the ladder, and a pack of rails, as observed below:

> *9.15am Barrie asks Bryan to help carry the rails. Barrie holds one end of the pack of rails. Bryan has the other end. Barrie walks up the ladder with the pack on one shoulder.*
>
> *Barrie: "I can't see you, Brandon."*
>
> *Bryan: "I'm still on the ground, keep going. Now, I'm on the first rung."*

> *Barrie stops, steps back, and lowers the pack to carry it under his arm as he walks up. He steps on the roof and carries the pack a few steps before putting it down.* (C3B3Obs1, p. 4)

From asking Bryan for help to negotiating the ladder and Bryan's position on the ground, the negotiation continued as Barrie struggled to go up further, so he stopped, stepped back down, and lowered the rail pack. He held it under his arm as he walked up. They successfully moved rails from the van to the roof.

Learning in the persisting network occurred in micro-adjustments involving the ladder being in the correct position, the trust between Barrie and Bryan, Bryan giving feedback to the emerging node of connection (Barrie, Bryan, the ladder, the pack of rails), the packet of rail secured in the proper connection to Barrie's movement, the correct grip of Barrie's shoes on the ladder, and carrying the pack of rail under his arm. These small connections were micro negotiations and struggles where the learning occurred. Learning occurred in the micro-negotiations that connected local actors close to each other, such as the mounting system, the roof, and the ladder. Once again, learning here was also embodied in the workers' physical presence.

5.5.6 Connection efforts and learning in persisting networks

In summary, learning in persisting networks did not change the installing practices. The way to respond to an uneven roof, the way to connect a bracket to the roof, the way to connect isolators, and the way to move the mounting systems from the ground to the roof remained essentially unchanged. However, learning in these persisting networks was related to the low connection effort involving a few local actors and the embodied sense of sight, touch, and sound. In practice, the seemingly stable networks were fluid and emerging, enacted in connections and disconnections in the micro-negotiation of human and non-human actors. Some connection effort was required; however, the effort was more immediate and embodied, requiring less effort than in re-forming and mutating networks.

Using the ANT method of following the actors, no matter how mundane they might seem, and through the ANT lens of viewing learning as network effects, in persisting networks, learning is identified by the following characteristics:

- an activity on site is changed or temporarily halted as further connections cannot be made;
- the contractor knows what connections to make and how to make them, and the learning is about the particular instance of those connections;
- learning unfolds amid high degrees of certainty pertaining to a stable (but not rigid) network;
- learning is more embodied, involving actors on the work site;
- learning occurs in low connection effort;
- ways of doing things are upheld amid tinkering with artefacts and people.

5.6 Summary

The findings related to learning in this chapter begin with an ANT definition of learning as "a distributed effect, something that continually emerges through negotiations and struggles at myriad nodes of possible connections between human and non-human elements" (Fenwick et al., 2011, p. 117). Through the ANT lens that views learning as sociomaterial and network effects, learning is enacted in installing practices in the "negotiations and struggles at nodes of possible connections" that occur in networks that are re-forming, mutating and persisting networks. This chapter has argued that learning is enacted in relation to three different connection efforts occurring in re-forming, mutating and persisting networks. Below is a summary of different learning characteristics.

Learning in a re-forming network is characterised by the following:

- a breakdown in an obligatory passage point creates widespread disconnections and prevents progress on the contract work;
- answers to the breakdown are largely unknown initially;
- learning unfolds amid high degrees of uncertainty across a network;
- learning involves actors such as peers, suppliers, and national networks;
- learning occurs in high connection effort;
- new ways of doing things emerge as an established way disintegrates.

Learning in the mutating networks is characterised by the following:

- a practice is changed due to new actors becoming visible or temporarily halted as further connections cannot be made;
- answers as to what and how to connect are known by some - this knowledge needs to be assembled, at times in iteration;
- learning unfolds amid a mix of certainty and uncertainty as some aspects of the network related to the practice change and others do not;
- learning involves actors such as peers, suppliers, and national networks;
- learning occurs in moderate connection effort;
- established ways of doing things accommodate changes in networks.

Learning in mutating is characterised by the following:

- an activity on site is changed or temporarily halted as further connections cannot be made;
- the contractor knows what connections to make and how to make them, and the learning is about the particular instance of those connections;
- learning unfolds amid high degrees of certainty pertaining to a stable (but not rigid) network;
- learning is more embodied, involving actors on the work site;
- learning occurs in low connection effort;
- ways of doing things are upheld amid tinkering with artefacts and people.

The next chapter, Chapter 6, will weave together the findings of Chapters 4 and 5 to answer the overarching research question: "How is learning in contract work enacted in solar PV installations?

6 LEARNING AS CRAFTING-FORWARD IN CONTRACT WORK

6.1 Introduction

Chapter 4 traced the contracts to answer the first subordinate question, "How are contracts enacted in practice?" The evidence showed that contracts unfold as both matters of fact and matters of concern, with five salient contracting practices enacting the contract. Chapter 5 traced the mounting systems and sought to answer the second subordinate question, "How is learning enacted in solar installing practices?" The chapter argued that learning is enacted in different connection efforts in re-forming, mutating, and persisting networks. This chapter draws on the findings in these two chapters to address the overarching research question, "How is learning in contract work enacted in solar PV installations?" The answers to this question add new conceptual layers to Chapters 4 and 5. They are woven together to establish the central argument of the thesis, which is a novel conceptualisation that I refer to as "crafting-forward", i.e., actions that move forward, not to static goals or rigid agreements, but forward in orientation to the completion of the work.

The central argument of the thesis is that learning as crafting-forward in contract work has three components:

1) entwined contracting and installing practices oriented towards completing the work, building reputation, and fostering future referrals;
2) four conditions of crafting-forward: learning in contracting practices – related to matters of fact and matters of concern, that they a) matter, b) are liked, c) are populated, and d) are durable; and
3) learning in tinkering installing practices, enacted in different connection efforts in re-forming, mutating, and persisting networks.

Chapter overview

This chapter comprises six sections. Following the introduction in 6.1, in Section 6.2, the terms "crafting" and "forward" are examined first in relation to quality, reputation, future contracts, and orientation of contract work. Section 6.3 draws on Chapter 4 to focus on learning in contracting practices. Section 6.4 extends the findings of Chapter 5 to discuss learning in re-forming, mutating, and persisting practices. Section 6.5 builds on the previous two sections to discuss entwined practices. Section 6.6 concludes the chapter with a summary of the key arguments.

6.2 Learning as crafting-forward

The central thesis of this study is the novel conceptualisation of learning as crafting-forward in contract work. This section discusses "crafting" as a notion reflecting the importance of quality work oriented "forward", towards contract completion, influencing reputation and future contract.

6.2.1 Crafting quality contract work and reputation

The term "crafting" is not unfamiliar in ANT research. For instance, "crafting" has been used to refer to the careful process of confirmations of Newton's law (Mol, 2010). Graizbord, Rodriguez-Muniz, and Baiocchi (2017) studied the crafting of ethnography in expertise research. Demil and Lecocq (2015) also use the concept of crafting as an equivalent to redesigning in business model. ANT was used to examine traditional crafts (e.g., ceramic production and ironworking) concerning technological distribution, cultural knowledge, communication, and interaction networks (Ashby & Sindboek, 2020).

In this research, the word “crafting” does not refer to a craft like ceramic production but to the actions, to the working and producing quality work, or “making things well”, as Richard Sennett (2008, p. 8) phrased it in his influential work on craftmanship. The term “crafting” foregrounds the importance of reputation and “making things well” in the 12 solar installation contracts. Quality contract work builds reputation, helps to generate referrals, and contributes to ongoing work opportunities for contractors. While prior studies have reported strong relationships between training and improved work opportunities for self-employed workers (Brooks & Urmee, 2014; Michaelides & Benus, 2012; Silwal & Bhatta, 2017; Votteler et al., 2014), the evidence generated for this study overwhelmingly indicates that referrals help secure new contracts and ensure ongoing contract work.

Rather than a state of craftsmanship, the emphasis is on the act of “crafting”. In this thesis, the idea captures the ongoing actions necessary in the enactment of contracting practices and installing practices, involving the practices of highly experienced solar electrical contractors. As mentioned, my concept of crafting builds on Sennett’s (2008) established concept of producing quality work. From craftsmanship being grounded in “the desire to do a job well for its own sake” (Sennett, 2008, p. 9), the concept of crafting, as developed in this research, extends beyond human-centric understandings of crafting. Unlike Sennett’s work, which centres on humans and their motivation to labour and produce quality work, this research focuses on crafting as learning that involves both human and non-human actors. The following section turns to Mann and Mol’s (2019) concept of taste-forward to explore “forward” as an orientation.

6.2.2 Orientation rather than fixed future

In crafting-forward, the term "forward" refers to an orientation towards quality and reputation in completing the current contract work and gaining future contracts, rather than towards fixed goals. The term relates to Mann and Mol's (2019) work on regional food tasting in practice and their concept of "taste-forward". Tasting food being prepared in Vorarlberg in the Netherlands can prompt the word "*schmecka*" (which can be roughly translated as "that was good"):

> That one has eaten the same dishes before, makes it possible to "taste-forward". Here, then, the unity of *schmecka* is afforded, not by a particular organisation of bodily perceptions, but by the fact that in the Vorarlberg settings we investigated food constancy is highly appreciated. This makes it possible to anticipate tastes of foods eaten on earlier occasions. (Mann & Mol, 2019, p. 780)

High food quality is not an innate quality of the current food being eaten and its interaction with physical sensations. Quality is enacted in three dimensions: the activity of tasting some consistent elements of the dish on previous occasions, the anticipation of the dish to be eaten (based on past enactments), and the current enactment of the dish (based on both the past and the future). In solar contract work, anticipating specific experiences "on earlier occasions", crafting-forward refers to how the quality and standards of the current solar PV system, while being built, are based in part on the entwined contracting and installing practices assembled on previous occasions. The practices enacted in the past contracts are actor-networks being enacted as the "future", orienting forward the practices of the present contacts.

Learning as crafting-forward in contract work is enacted in relation to an orientation to the completion of the work instead of aiming towards fixed goals or plans. The crafting in contract work is crafting-forward, oriented to the future. Where learning is directed at a future, from an ANT perspective, the future is an actor in the networks of connections instead of being a wholesome state to achieve from the preceding deficit state. Regarding the future,

> since ANT views all things as emerging through their inter-connections in networks, where their nature and behaviours are never inherent but are produced through continuous interactions and negotiations, an imagined future, if any would be treated as yet another actor. It would not be simply imposed to shape the present. (Fenwick et al., 2012, p. 106)

The solar PV system, to be built according to contracted specifications to be enacted in the future, is another actor. However, this actor is not an unchanging state being imposed on the present. For Zaher, Sykes and Keevers (2022), valuable outcomes of project work can be qualities such as needs and priorities, "without dictating pre-defined, universal and rationality-driven characteristics on the type of success or achievement" (p. 703). Learning involves actions that move in an evolving direction, a direction being unfolded and crafted. The crafting-forward of contract work is enacted dynamically in the unfolding of contracts as matters of fact and matters of concern, as discussed in Chapter 4 and in the installing practices enacted as network effects, as mentioned in Chapter 5. It is also enacted in the entwined unfolding contracting and installing practices.

Crafting-forward is more than just working towards a plan. This thesis takes the concept of the plan a step further by questioning the dichotomy of working without a plan and with a plan. The 12 contracts are enacted between the two poles of having no plan and having rigid, fixed plans. Mol (2010) remarks that tinkering occurs "one step after another, without an overall plan" (p. 265). For Fenwick, Nerland and Jensen (2012), the idea of the fixed plan of the future to which the present is moulded is brought into question. There are plans for solar installation contract work, but the plans are subjected to changes occurring to actor-networks related to the installations. The agreed specifications planned at the beginning of the contract are often not the same specifications at the completion of the contract.

This thesis advances the current understanding of goals and plans in the literature on contract work. Recent research has identified focus capability, which includes the human-centric focus on the owner's passion, foundation, and self-confidence, and properties that allow contractors who are sole proprietors to "direct all their resources and abilities towards a goal" (Olazabal & Avila, 2022, p. 17). In crafting-forward contract work, the focus is more than just a goal. The findings in Chapter 5 showed that goals, such as the initial matters of fact of a contract, adapt to emerging matters of concern, to changes that emerge throughout the work on the contract. This open-ended approach to concepts such as plans and goals is consistent with ANT concepts of actors and network effects, "each holding important histories, each mediating action, connecting and reconnecting in ways that produce particular assemblages of identity, values, purpose and knowledge" (Fenwick et al., 2011, p. 180).

Understanding the crafting of contract work as positioned between the poles of solidified plans and the absence of a plan is to understand contracts, enacted in dynamic networks, as more than rigid structures or loose fragments. This finding reflects the existing concept, identified in the wind energy industry, called dynamic stability, requiring a knowing-in-practice sensibility, "working in uncertain, opaque and unstable spaces, rather than striving for certainty and order" (Scoles, 2017, p. 231). This thesis conceptualises "forward" as the orientation of the dynamic, open-ended process of crafting to the completion of the contract, rather than to unchanging goals attached to rigid specifications of the contracts.

Future contracts

Orienting the crafting-forward of quality contract work is the contractors' reputation, which fosters future contracts. Crafting-forward in contract work refers to work that is not just done but is done well to shape reputation, encourage referrals, and establish future contracts. Crafting-forward anticipates that the "goods internal to that form of activity are realised in the course of trying to achieve those standards of excellence which are appropriate to, and partly definitive of, that form of activity" (MacIntyre, 1981, p. 175). Both the internal goods – such as the contractors' past performance – and external goods – such as reputation and referrals – are intertwined (Hager, 2013). Indeed, "pasts and futures come together in temporal sensemaking of an emergent present" (Dawson & Sykes, 2019, p. 97). In crafting-forward solar PV installations, both experience of the past and anticipation of the future guide the quality of the installations.

The contractors' reputation is enacted in a network of trusted actors. Ongoing solar installation contract work is affected by social influences, informational and normative, which influence decisions to purchase solar PV systems (Liang et al., 2021). In a dynamic industry where new technologies and suppliers are continually emerging and becoming obsolete within a few years, the reputation of the electrical contractor is based on the quality of the installed solar PV system. Charlie observed, "*in this small community, your reputation is paramount*" (C6C2Obs1, p. 2). With the reputation to protect, Charlie would use the same type of high-quality equipment for every site and Matthew selected a product because it won an award. Suppliers with good reputations can be trusted to provide quality components for a quality solar PV system. Here, trust is established in solar installing practices, entwined with contracting practices.

In addition to quality products, trust in contract work is built on how contracts are enacted. The key findings of this thesis highlight the significance of approaching contracts as both matters of fact and matters of concern. Such an approach builds trust and reputation. For Şengün and Önder (2011), goodwill trust between small businesses is based on the willingness to offer beyond formal agreements and "exploit new opportunities over and above what they explicitly promise . . . The notion of goodwill trust refers to the fulfilment of the spirit, as opposed to the letter, of the contract by demonstrating commitment and fair behavior" (Şengün & Önder, 2011, p. 794). Further, research in learning and contract work has reported that trust facilitates learning. The trust involved in face-to-face connections is important in sharing knowledge (Carr et al., 2013), and even in relationships of weakened trust, learning opportunities can also be found (Geneste & Galvin, 2015). How learning is enacted in contract work occurs in the crafting-forward of contract work, which serves not only the individual contracts in the present but also future contracts and the ongoing success of the contracting business.

6.3 Learning in contracting practices: four conditions

One of the three components of the concept of learning as crafting-forward is that learning in contracting practices requires four conditions. Built on the findings established in Chapter 4 that contracts are enacted as matters of fact and matters of concern and that there are five salient contracting practices, this section highlights another conceptual layer. The proposal here is that the making of quality contract work requires more than just quality installing practices and underpinning crafting-forward are four conditions of learning in contracting practices where matters of fact and matters of concern 1) matter, 2) are liked, 3) are populated, and 4) are durable. These four conditions are informed by Latour's four conditions regarding matters of concern.

Latour's four conditions

One of the findings of Chapter 4, fundamental to the discussion in this section, is the analysis of the contract beyond matters of fact to include matters of concern. Based on established ANT concepts, it is argued here that this reconceptualisation of the contract as matters of concern requires four conditions, which Latour regards as "the conditions which you have to fulfil" (Latour, 2008, p. 47). These conditions are that matters of concern matter, that they are liked, that they are populated, and that they are durable.

First, matters of concern *matter*. This means looking at various actors and their concerns with "interest and a redirected attention" (Latour, 2008, p. 47). Second, matters of concern are *liked*, meaning the matter being examined is not seen as indisputable facts used to force the end of disputes. Instead, concerns are made visible, where "discussions are what are in question with matter, then . . . carry them on instead of stopping them abruptly" (Latour, 2008, pp. 47–48). Third, matters of concern are *populated*, acknowledging the work done by various actors to enable the matter being examined to come into being. For example, the CAD design software is not just an object. The CAD drawing requires other actors, "the people necessary to activate what you have drawn on a CAD design software" (Latour, 2008, p. 48). Fourth, matters of concern are *durable*. As matters of fact, the matters being studied are assumed to be given and are stable objects. As matters of concern, the key analysis is how the endurance of the matter is sustained. Endurance is "what has to be *obtained*, not what is already given by substrate, or some substance" (Latour, 2008, p. 49). Here, matters of concern matter, are liked, populated, and durable. In other words, in a study on safety as an emergent competence, for example, a leading researcher of workplace learning has remarked that "matters of concern have to be liked, appreciated, tasted, put to the test" (Gherardi, 2018, p. 18).

Four conditions of learning

In this thesis, the wording of the four conditions remains the same as Latour's; however, the conditions apply to approaching contracts as both matters of fact and matters of concern. As discussed in Chapter 3 on the methodological and conceptual framework, the relationship between matters of fact and matters of concern is not unlike that of the stage and the theatre. I argue that just as the four conditions apply to matters of concern (the theatre), the conditions also apply to a matter of fact (the stage).

Considering how learning is enacted in contract work involves considering the conditions of making visible contracts as both matters of fact and matters of concern. I propose that there are four conditions involved in learning in contracting practices, where matters of fact and matters of concern:

1. they matter – seeing the importance of not just matters of fact but also matters of concern;

2. are liked – engaging both matters of facts and matters of concern in further consideration, instead of matters of fact being used as unmovable facts;
3. are populated – seeing matters of fact and matters of concern as constituting various actors that have ongoing effects;
4. are durable – seeing that ongoing work is necessary to sustain both matters of fact and matters of concern.

In other words, in solar installation contract work, these four conditions facilitate the learning that occurs in the enactment of contracts and contracting practices.

I note that Latour was not writing about workplace learning when writing about the four conditions concerning matters of concern. In proposing that the four conditions are learning conditions, I draw on the ANT definition of learning that has guided this research. As discussed in Chapter 3, learning is "a distributed effect, something that continually emerges through negotiations and struggles at myriad nodes of possible connections between human and non-human elements" (Fenwick et al., 2011, p. 117). I want to be clear, by defining learning as a distributed effect, I am not suggesting that learning is the same as any change. Specifically, learning is the network effect of negotiations and struggles generating differences and transformation. The evidence presented in Chapter 4 showed that central to the five contracting practices are the negotiations and struggles at the nodes of connections involving various sociomaterial actors: how learning emerges. Learning at the nodes of connections, i.e. the nodes that involve negotiations and struggles, is enacted by the four conditions. As matters of fact and matters of concern are 1) matter, 2) are liked, 3) are populated, and 4) are durable, the learning and contracting practices can be enacted.

Consider an example already discussed in Chapter 4, Contract 2, when Barrie visited his customer to appraise the sociomaterial requirements. He recounted:

> *I take the shade readings. I take the measurements on the roof. On that particular job, with the voltage rise calculation, and I worked out the biggest variable is 10kW. I measured for the string to make sure I could fit. I went inside and talked to them, and we can do straight 10kW... Explain to them the benefits. And you've got power spread across the whole array… which will work your air-conditioning loads, your cooking loads and things like that.* (C2B2Int1, p. 2)

This excerpt shows that the contracting practice of appraising the sociomaterial requirements connected to the customer and work site is enacted by the four conditions of learning. The matter of fact was the contract for the 10kW solar system. The matters of concern mentioned were the shade readings, roof measurements, voltage rise calculation, string measurements, communicating with the customers, the benefits of this solar system, the layout of the solar panels, the electricity that will be used, the air-conditioning and the cooking. The matter and fact and matters of concern mattered because their importance was highlighted in this excerpt. They were liked since they were engaged in an extensive consideration. Various sociomaterial actors and their effects were considered – for instance, the shade reading influenced the energy output, which influenced the energy available for cooking; therefore, the evidence here shows that both mattters were populated. Lastly, the ongoing work, such as measuring, communicating with the customer, building the solar array, and ensuring energy outputs for consumptions, enacted a durable assemblage of matter of fact and matters of concern. I propose that the four learning conditions are integral to enacting the five contracting practices in crafting quality contract work.

The findings of this research support the idea that the fixed, standard approaches to learning in contract work should be replaced with "contract appropriate practices" (Scheel et al., 2014, p. 750). Based on the present research findings, learning is integral to how contracts are enacted. Learning occurs as the contracts – as both matters of fact and matters of concern – and the contracting practices are enacted. This thesis extends our understanding of learning in contract work beyond training or the skills and ability of the owner or social connections – as discussed in Section 2.3 – offering a new understanding of the conditions for how learning is enacted. The following section considers learning in installing practices.

6.4 Learning in installing practices: tinkering

Tinkering is one of the components of the concept of learning as crafting-forward. To analyse installing practices, Chapter 5 traced the 12 mounting systems to answer the subordinate question: "How is learning enacted in solar PV installing practices?" The key argument of that chapter is that learning as network effects unfolds in re-forming, mutating, and persisting networks "in unanticipated and unpredictable ways" (Hager, 2011, p. 27). Chapter 5 also discussed how learning unfolds according to different degrees of connection efforts (Latour, 2005). Beginning with the ANT conceptualisation of learning as a network effect (Fenwick et al., 2011; Fox, 2005; Smith et al., 2017), this thesis gives an account of learning as emergence in practice (Hager, 2011; Hager & Beckett, 2019; Reich & Hager, 2014). The findings of Chapter 5 also addressed the messiness in practice (Law, 2004), the fragility of heterogeneous systems (Law, 2008b), and the uncertainties and messiness in ways of learning (Thompson, 2012).

As learning is not limited to an individual's acquisition or participation in communities, the evidence in Chapter 5 showed that learning occurs in persisting, mutating, and re-forming networks. Respectively, this is where practices are enacted, but not duplicated, where practices are transformed, and where practices are enacted differently. Corresponding to the three enactments of networks, there are three ways in which learning is enacted in relation to different connection efforts. As Latour (2005) observes, "this connection is not made for free; it requires effort" (p. 132). Building on the evidence in Chapter 5, this chapter argues that learning occurs in tinkering across all three connection efforts in installing practices in the crafting-forward quality present contracts and future referrals.

Tinkering and ANT

Tinkering is already a prominent ANT concept (Latour, 2008; Law & Mol, 2001; Mol, 2010; Turnbull, 2000). For Latour (2008), in considering the work of scientists as tinkering, he contrasts a photograph of a scientist working in a laboratory, whom he calls the Tinkerer, and Rodin's statue, The Thinker. Unlike the seated Thinker, the scientist is standing by a workbench, surrounded by flasks and other instruments, operating a "rather the active pragmatic pose of the Tinkerer: she is standing up, actively engaged in pipetting, shaking reagents" (Latour, 2008, p. 33). The Tinkerer acts in mundane activity such as pipetting liquid and shaking materials.

Mol (2010) notes the significance of tinkering in the completion of diverse types of work, from building cathedrals to aircraft signalling. In deliberating on the strategic connotation of the term "co-ordination" and the passivity of the word "association", Mol foregrounded the term "tinkering" as it denotes the persistent activity done bit by bit, one step after another, without an overall plan. Cathedrals have been built in a tinkering mode, and signallers or aircraft designers also work in this way. As technologies and techniques are being tinkered with, they are fluidly adapted. (Mol, 2010, p. 265)

Tinkering occurs in the small actions that connects various actors. In the crafting of solar installations, material assemblages often invite tinkering. For instance, the connection between an uneven roof, the rails, and the joiners is a material assemblage. This assemblage acts by shaping the solar installer's action, the way Latour (2005) describes how the design of a lecture hall acts upon a lecturer teaching in that space (see Section 3.3). The solar installer, seeing the material assemblage, was invited to work with his eyes near the lines of the rails, the roof, and the joiners and paused to ask: Is this rail's length correct? Is the line of the rail straight? Are they parallel? If the answers were affirmative, the negotiations between the different actors were completed within the short pause, and the next activity could unfold. It is in these small actions of tinkering with connections that learning occurs. In installing work, the findings in Chapter 5 also showed the many negotiations and struggles in which small actions connect and disconnect various actors and activities.

Tinkering is how the activities in crafting-forward occur. Tinkering is not unlike Gabriel Tarde's view that tiny parts build a whole. Latour considers Tarde's work as one of the early roots of ANT, particularly in seeking to "explain collective resemblances of the whole by the massing together of minute elementary acts – the greater by the lesser and the whole by the part" (Tarde, 1899/2000, p. 35 in Latour, 2005, p. 15). Learning as crafting-forward involves learning in tinkering, in the "negotiations and struggles at myriad nodes of possible connections between human and non-human elements" (Fenwick et al., 2011, p. 117). This section argues that learning occurs in the tinkering within installing practices. Learning as tinkering occurs across the three different connection efforts in persisting, mutating, and re-forming networks.

Persisting networks

Learning in tinkering at the nodes of negotiations and struggles is apparent in the connection efforts occurring in persisting networks. As discussed in Section 5.5, in persisting networks, learning occurs in the small pauses in installation activities that needed some negotiations and struggles in connecting actors. These small pauses are the obstacles (Callon, 1989) that require some efforts, albeit minimal in scope, to find a resolution, albeit mundane, compared to those occurring in mutating and re-forming networks. In persisting networks, the contractor already knows the installing practice relevant to a particular activity. Tinkering occurs between artefacts and people who are mostly already on the installation sites, connecting and disconnecting iteratively until the proper connections are made. Tinkering in persisting networks occurs in what Callon (1989) refers to as "the area of certainties… which does not call into question the final integrity of the individual elements" (p. 212). In persisting networks, tinkering requires low connection efforts between relatively stable actors until the correct connections are established to allow the next activity to occur. The installing practice, the way of doing things together, does not change; however, I contend that in persisting networks, learning occurs in "activity done by bit", as Mol put it (2010, p. 265).

Learning in persisting networks is enacted in the tinkering, the micro-negotiations of actors that form part of stabilising patterns of connections. The major streams of research reviewed in Section 2.2 – the dominant foci of the literature on contract work approaches learning as training (to name a few, Idris et al., 2020; Lyons, 2020; Martin et al., 2013; Saastamoinen et al., 2017), focusing on the self-employed owners (Coetzer et al., 2019; Cormier-MacBurnie et al., 2017; Nolan et al., 2020), and connections to networks (Ipiranga & Aguiar, 2014; Lans et al., 2022; Suryanti et al., 2021) – overlook the learning that occurs in persisting networks. The learning in persisting networks in solar installing practices has not been previously explored. Considering the data from tracing the mounting systems in Chapter 5, for example, seemingly mundane yet prevalent connections were made between several components: the rails, the joiner, the electric drill, and the screw. Minor negotiations and struggles occurred: aligning the joiner in the correct position next to the rail, placing the screw in the correct place on the joiner, and drilling the screw into the joiner and the rail. In this way, the mounting system was built, tinkering one step after another.

To examine tinkering and learning in persisting networks is to "inquire about how they are made stable and how long they keep a stability before melting into something different" (Gherardi, 2019, p. 214). Networks persist in the micro-negotiations that enact the correct alignments, such as discovering an uneven roof while connecting a mounting system. Law (2004)recognises the "provisionally stable" (p. 2) status of persisting networks such as CO2 emission and trade terms; persisting networks are constructed, and they need to be maintained (Smith, Kempster & Barns, 2017). This idea is not unfamiliar in practice-based research, which recognises "stability and change as co-present features of practices" (Hopwood, 2016, p. 350). Learning as crafting-forward occurs in the micro-negotiations that have the effects of enacting persisting networks.

What emerged from the data in Chapter 5 is the main characteristic of learning in persisting networks: sensory-based learning, a finding that is consistent with Strati's (2007) work on sensible knowledge. In solar installing practices, much of the learning in persisting networks was embodied and sensory-based. Learning in persisting networks in installing practices involved small activities such as Barrie's fingers touching the blade of an electric saw to check its sharpness, or his feet and body moving up a ladder with a heavy load of rails (see Section 5.5). Solar installing work enacts significant learning that attunes to the relationship between the human and non-human actors in persisting networks. Strati (2007) refers to sensible knowledge when he studied the learning of tradespeople who worked as roof removers, stripping roofs from buildings. For Strati (2007), examples of this form of sensible knowledge are learning "by 'feeling with the feet' or by 'leaning with the body' or by 'listening to noises'" (p. 70). Just as Strati had observed, records of these kinds of minute bodily activities are extensive in the data discussed in Chapter 5. Such data is possible due to adopting the ANT methodological and conceptual framework and applying the ANT instruction to "follow the actors" (Latour, 2005, p. 68), no matter how mundane they may seem. While these actions seem mundane, they enact connections that demand focus and precision to attune to the correct alignments that build the mounting systems.

Tinkering in persisting networks includes routines, and in this ANT study, tinkering is a network effect involving sociomaterial actors. Routine Dynamics theory draws significantly on practice theory and ANT to conceptualise routines as practices in relation to stability and change (Feldman et al., 2021). Similar to ANT's concept of human and non-human actors and network effects, Routine Dynamics theorises routines not as a thing but as emerging in situated actions, requiring explicit reflective effort, involving artifacts and materiality, relational and multiple performances of the same routine. The theory builds on Latour's concept of ostensive and performative definition to conceptualise change in routine as internal dynamics that are performative and ostensive, involving different patterns of performing routines. Routine Dynamics identifies that "repetition and replication are not straightforward. Repetition introduces opportunities for changes that overcome minor or temporary obstacles but also introduces opportunities to do the routine differently or better" (Feldman et al., 2021, p. 7). Unlike Routine Dynamics, this study proposes that routines are enacted in persisting networks whereas improvement occurs in mutating networks and reforming networks, which account for changes that are not routine.

In persisting networks, the "ways of doing things together" (Gherardi, 2019, p. 11) are stabilising and do not change significantly. The routine ways of cutting a rail to build a mounting system do not vary significantly. Some of the practices are well established enough to persist across different installation sites, industries, or regions, including the cutting of the rail, the drilling of the bracket to the roof to support the mounting system, and the straight alignment of the rail across the uneven roof. The connection efforts of tinkering in persisting networks support the stability of the persisting networks. The connections involving mundane objects such as a rail joiner or, as identified in the literature, a biscuit tin act as a central aspect of "network maintenance: The learning will not happen simply because the actor-network has been built – the network needs constant maintenance" (Smith et al., 2017, p. 137). In the persisting network, the relationships between the actors and how they connect stabilise parts of the networks. Bringing them together required a few simple connections. Small negotiations occurred in the tinkering, insignificant as these components may seem and minute as the connection effort may appear. As ANT sees learning occurring in the negotiations and struggles, I argue that learning as crafting-forward in solar installation contract work also occurs in the oriented miro-negotiations of tinkering in persisting networks.

Mutating networks

To craft contract work and enact quality work, tinkering also occurs in mutating networks, enacting moderate connection efforts. From the results in Section 5.4, learning in the mutating networks is identified by several characteristics. Unlike in persistent networks, where tinkering does not change practices, in mutating networks, practices are changed as a result of responding to breakdowns, accidents or anomalies – as the analysis in Chapter 5 showed. Following Adams and Thompson's (2016) analysis questions, a pause in the progression of the installing activity requires new knowledge, knowledge that the contractors do not presently have. Moderate connection efforts are necessary to connect to actors such as peers, suppliers, and national networks, actors who have the knowledge: learning occurs in the negotiations and struggles that allow the work to continue. As in previous research, contractors in the present study also connect to social networks for knowledge (Fenwick, 2012). The findings in Chapter 5 showed that learning emerges in mutating networks, connecting to both human and non-human actors. In mutating networks, "as technologies and techniques are being tinkered with, they are fluidly adapted" (Mol, 2010, p. 265). Adapted ways of doing things emerge in the connections to sociomaterial actor-networks that can readily enact the answers to the breakdown. Connections to new knowledge need to be assembled, and at times, in iteration.

In mutating networks, learning occurs in tinkering at the sociomaterial nodes of negotiations and struggles where new knowledge changes a practice, "coming to practise differently" (Kemmis, 2021, p. 282). In mutating networks, learning is enacted in ways that resonate with Antonacopoulou and Fuller's (2019) observation of the unfolding formations of practices that relate to a change, such as using a new product. For instance, the ways of installing a mounting system changed when Contract 7 required Mathew to build a new product, which was a custom-made mounting system (see Section 5.4). With Matthew, the different ways of configuring technology were negotiated in connecting to various actors to search for the needed solutions: he used the computer to connect with the supplier, read the instructions on the website, arranged the purchase and shipping of the product, and tinkered with various parts of the mounting system to find the correct connections. With meso-level connection effort, with some trial and error, the contractors connect to the existing knowledge that leads to the solution to the breakdowns.

What is important but unsurprising in the findings of this thesis is the connections to suppliers in facilitating solutions to breakdowns. On the one hand, the literature review in Chapter 2 identified a range of actors important to learning in contract work: multiple digital screens (Thompson, 2018), a connection within the internal team (Nolan & Garavan, 2019), acting in meetings via questions and answers (Lefebvre et al., 2015), being within social and physical proximity as necessary for learning (Coetzer et al., 2022), acting in a peer learning network (S. Smith et al., 2017), and actors connecting across an external network of professionals (Lans et al., 2022). On the other hand, unlike the literature on contract work, the literature on learning in the solar industry specifically highlights suppliers as key actors (Gao et al., 2022; Lema & Lema, 2016).

This study has found that new knowledge which changes a practice involves connecting to suppliers and their resources (training manual or knowledgeable staff), which often provides a significant part of the solution to the breakdowns. Suppliers are not the only source of knowledge, however. Contractors frequently search for knowledge from suppliers, peers, and industry associations; crucially, solutions are rarely readily available. Tinkering is required: trial and error, iterative searches, and arranging and re-arranging the relevant components of the installation until the next activity can commence.

The instances of change identified in Chapter 5 originate within the installing practices, unfolding as the installations progressed forward. To address these changes, tinkering with connections allows the installation to orient forward. Tinkering occurred in small and mundane activities, such as when the contractors searched websites, monitored product developments, talked to suppliers, refined the design drawing, and connected the components. These actions, also done bit by bit, changed the "ways of doing things together" (Gherardi, 2019, p. 11). Learning in tinkering in mutating networks modifies existing practices in the crafting-forward of contracts.

Re-forming networks

In re-forming networks, crafting quality contract work also requires tinkering at the nodes of negotiations and struggles that demand exceptionally high connection effort. The findings in Section 5.3 – relating to fire accidents and the isolators connected to the mounting systems – show that learning in a re-forming network is identified by several characteristics. Tinkering occurs in the high connection effort needed to respond to breakdowns related to an obligatory point of passage, disconnecting many actors from an established way of doing things. An obligatory point of passage is "indispensable in the network" (Callon, 1986, p. 204). It is an actor that can "impose itself as an obligatory point of passage between the two networks" (Law & Callon, 1994, p. 46), i.e., Matthew's installation location for Contract 7, the online community, various organisations, suppliers, and other installers. Section 5.3 discusses in detail the amendment to the standard AS/NZS 4417.2:2012, where authorisation was changed, relating to the use of some DC isolators attached to the mounting systems on the roofs. The previous practices relating to DC isolators were disintegrating, and knowledge of how to proceed initially became largely unknown. In the online community or broader network, there are high degrees of uncertainty regarding a way of practice amongst various actors, including peers, industry associations, and national organisations.

In the process of re-forming, small activities that occur bit by bit, i.e., tinkering recursively, constitute the high connection effort required between many sociomaterial actors. Related to the incident above, one online post sought to connect various actors:

> *… reference for all to use and see. As more information come to hand by manufacturers / wholesalers / power authority and installers, we will be updating this post. Each point will need to be verified. Please provide as much information as you may have with back up email, PDF or any other form so the general Community H can be informed on the situation.*

The reforming networks in this example involved connecting a range of actors: the isolators on the amended list, a social media page, the page's administrators, comments and questions left on the page, a community of installers, manufacturers, wholesalers, power authority, emails, and Pdf. The act of posting this comment and numerous other acts of replying to comments, clicking the "Like" icons, taking screenshots of emails and sending PDFs are tinkering acts that seek to re-establish a new way of practising, where, for a period of time, such knowledge had not existed. Not a single actor or a group of actors knew how the practice should unfold. The involvement of the many actors in the solar PV industry in response to the change reflected the far-reaching distribution of the effect. In a re-forming network, more visibly than in the other two networks, the connection in "action is dislocal, it does not pertain to any specific site; it is distributed, variegated, multiple, dislocated" (Latour, 2005, p. 60). In re-forming networks, widespread disconnections and uncertainty are being enacted, and learning occurs in high connection efforts, in tinkering acts of negotiation and struggles with diverse types of actors, many of whom are dislocal, to re-form a practice.

6.5 Crafting-forward in entwined practices

Crafting contract work in solar PV installations that unfolds in the entwined contracting and installing practices is essential to producing quality work. Although solar installing practices and contracting practices were discussed separately in Chapters 4 and 5, they are far from occurring in isolation. I am not alone in identifying the entanglement of practices, and as Schatzki (2016) prominently theorises, practices are linked in overlapping bundles of relations such as prefiguration, intentionality, and materiality. The empirical evidence of this study indicates that contracting and installing practices are intimately entwined in solar contract work. Changes in the installing practices can lead to changes in the contract and vice versa – contracts, as matters of fact, change when new matters of concern arise, such as matters relating to installing practices.

Some examples illustrate how contracting and installing practices are entwined. Contracting practices determine the initial matters of fact of the contract and subsequent installing practices; however, the work that unfolds does not follow a rigid path towards an unchanging goal. Following changes on the side of contracting practices, for instance, as discussed in Section 4.2, an agreement for Contract 1 was reached when the customer requested a different layout of the cables to suit his aesthetic preference. Similarly, in Contract 3, customer's decision resulted in the mounting system being re-installed further away from the roof's edge. In both examples, agreement changes shaped how the installation practices unfolded.

Following changes on the side of installing practices, as discussed in Section 5.4, the lack of stock of the quoted solar panels for Contract 3 meant that the contract was modified. A new agreement included using a different type of solar panel, changing not only the size of the panels but also the quantity. In another example, changes to Contract 5 did not arise from the supplier's network selling the panels but from the progression of the work in the ongoing assembling of the social and material actors. Installing the modification of the mounting system, from a flat system to a tilt mounting system, results from the installation practice of refining the design. Installing practices being enacted in everyday work bears an influence on contracting practices.

In the emerging and challenging solar industry (see, for example, Bibas et al., 2015; Bosetti et al., 2012; Kavlak et al., 2018; Schelly, 2015; A. Smith et al., 2014), changes in solar installation contract work are enacted in the dynamic connections between various actors. Changes in the materials installed for the solar PV systems affect the agreement between the contractor and the customer; vice versa, changes in the agreement influence how installing practices are enacted. In practice, the enactment of learning as crafting contract work is influenced by the interconnections between solar installing and contracting practices. Enacting a quality contract work occurs as "'responsible' action emerges in the sociomaterial mix, in being attuned to possibilities available in this mix at any moment, and in being sufficiently resilient to improvise with these possibilities" (Fenwick, 2016, p. 18). Learning as crafting-forward is enacted in the negotiations and struggles, the actions in both contracting and installing practices that respond to dynamic changes connected to contract work.

Crafting-forward unique contracts

Learning as crafting-forward in the entwined contracting and installing practices creates unique enactments of the actor-networks of contracts. On the one hand, the learning in tinkering of installing practices results in unique products. Each of the 12 solar PV systems is unique, a custom-made product. On the other hand, the learning in contracting practices shapes the installations according to the contracts as both matters of fact and matters of concern, responding to, for instance, the emerging preferences of the customer, the materiality of the installation site, and the fluctuations occurring in other connected actors such as the supplier networks. No two enactments of the 12 contracts are the same.

In practice, none of the solar installations studied in this research is an exact replication of a standard, abstract installation model. Training guidelines are useful – for example, in addressing a significant gap between theoretical and on-field training formats (Sharma & Sengar, 2022) – however, work-integrated "learning is achieved in action and is inseparable from what seems to be the commonplace activities" (Dean & Sykes, 2022, p. 523). Considering the 12 roof-mounted solar systems in this study, they are not just items listed in training guidlines as either flat or tilted systems. The findings discussed in Chapter 5 showed that the enactment of the mounting systems is much more complex than being flat or tilted. For instance, in Contract 1, a change in the supplier stock availability had the effect of changing the agreement between the contractor and installer about the type of panels to be used, consequentially changing the mounting system from a tilt to a flat one. In training, learning about a mounting system can be about the location and structure of the mounting system. In practice, learning about the mounting system entails connecting to a wide range of emerging actors affecting the contracts and the installations. The concept of learning in the entwined enactment of both contracting and installing practices allows for another layer of understanding of learning as emergence.

The work unfolding in crafting contract work in practice, enacted in the entwined contracting and installing practices, is different for each contract. In the enactment of the contracting and installing practices, the contractors' practice is not unlike that of the surgeons who "enter into an operating theatre that has the wrong (or simply a different) spatial arrangement [the] expertise temporarily dissolves" (Nicolini et al., 2018, p. 314). Each installation contract presents fresh configurations of actors, causing temporary pauses in the unfolding of some practices. The pauses and breakdowns occur at the nodes intersecting different trajectories that enact possible innovation and knowledge-making (Morita, 2020), customising each contract and crafting-forward contract work.

This chapter highlights the complexity and dynamic of the learning enacted in crafting customised contract work, conceptualising parts of the actual work occurring rather than the prescribed work (Deranty, 2016). The contract work that is formally recognised is not necessarily the same as the work being enacted (Zukas & Malcolm, 2019). The importance of making more aspects of contract work visible is highlighted in the literature where the lack of explicitness causes significant challenges (Saetre & Munkejord, 2021). The literature has reported that contractors educate clients, negotiate the contradictions, hide exhaustion, hide the chaos of work while portraying control and were "absorbing the project overruns and myriad unanticipated details or problem-solving" (Fenwick, 2008a, p. 19). This work costs the contractors the labour time necessary for the "persistent tinkering in a world full of complex ambivalence and shifting tensions" (Mol et al., 2010, p. 14). The concept of learning as crafting-forward has made visible some of the work and learning actually completed in contract work.

6.6 Summary

This chapter builds on the findings in Chapters 4 and 5 to answer the central research question, "How is learning in contract work enacted in solar PV installations?" The ANT concepts of human and non-human actors and network effects (Fenwick et al., 2011; Fenwick & Edwards, 2013; Latour, 2005; Law, 1992, 1999; Mol, 2010) were used to generate rich data to analyse the learning enacted in the 12 solar PV installations. This study draws the established ANT definition that learning is "a distributed effect, something that continually emerges through negotiations and struggles at myriad nodes of possible connections between human and non-human elements" (Fenwick et al., 2011, p. 117). In extending the above ANT definition of learning, this thesis conceptualises learning as crafting-forward in contract work, drawing on the findings in Chapters 4 and 5.

Based on Chapter 4, this study makes visible four conditions of learning in contracting practices related to both matters of fact and matters of concern in that they:

1. matter – seeing the importance of not just matters of fact but also matters of concern;
2. are liked – engaging both matters of facts and matters of concern in further consideration instead of matters of fact being used as unmovable facts;
3. are populated – seeing matters of fact and matters of concern as constituting various actors that have ongoing effects;
4. are durable – seeing that ongoing work is necessary to sustain both matters of fact and matters of concern.

Building on the insights of Chapter 5, this chapter has establishes that learning occurs in installing practices as tinkering in different connection efforts in re-forming, mutating, and persisting networks.

The present chapter has maintained that enacting quality contract work requires both contracting and installing practices. Hence, the answer to the central research question argues that learning as crafting-forward in contract work consists of three components: 1) entwined contracting and installing practices oriented towards completing the current contract, building reputation, and fostering future referrals, 2) four conditions of learning in contracting practices – related to matters of fact and matters of concern, that they a) matter, b) are liked, c) are populated, and d) are durable, and 3) learning in tinkering in installing practices, enacted in different connection efforts in re-forming, mutating, and persisting networks. Through the ANT lens, the findings in this thesis account for the learning that is prevalent yet often ignored in the research on learning in solar electrical contract work. These conceptualisations offer fresh insights addressing the emergent learning enacted in the everyday dynamics of crafting-forward in contract work.

The next chapter presents the conclusions of this study, summarising the answers to the research questions, highlighting empirical and knowledge contributions, and reflecting on accountabilities, trustworthiness, and quality of the research, as well as considering some limitations of the study. The conclusions will also discuss relevant implications for future research, the contractors, and organisations.

7 CONCLUSIONS

1. Introduction

This thesis aims to illuminate how learning occurs in contract work in practice and to understand how electrical contractors learn while working in the solar (PV) industry. This research contributes to the literature an empirical study by using ANT as a novel methodological and conceptual framework to study learning in contract work in solar PV installations. Based on 12 solar installation locations, qualitative methods – observation, interview, and document review – were used to generate rich data on everyday practices involving four solar electrical contractors. This thesis makes significant empirical and conceptual contributions to the fields of workplace learning, learning in contract work, and learning in solar electrical contract work and the construction industries. The empirical contribution is a study using ANT to study learning in contract work. There are several conceptual contributions: 1) a conceptualisation of contracts as both matters of fact and matters of concern, enacted by five salient contracting practices; 2) a conceptualisation of learning being enacted in different connection efforts in re-forming, mutating, and persisting networks; and 3) a conceptualisation of learning as crafting-forward in contract work, in entwined contracting and installing practices, requiring four conditions of learning and tinkering towards completing the work, the building of reputation, and securing future referrals.

Chapter overview

This chapter addresses the central research question and the two subordinate questions in Section 7.2. Section 7.3 highlights the substantial empirical and conceptual contributions of this thesis. Whereas Section 7.4 discusses the research's accountabilities, trustworthiness and quality, Section 7.5 identifies the limitations and offers critical reflections. Section 7.6 considers the implications of this research, offering suggestions for future research, contract workers, and organisations. Section 7.7 gathers final reflections as ways of closing the chapter and the thesis.

7.1 Answers to the research questions

This section summarises the findings of the research as discussed in Chapters 4, 5, and 6 to answer the central research question:

How is learning in contract work enacted in solar PV installations?

In answering this central research question, the study is guided by the two subordinate questions:

How are contracts enacted in practice?

How is learning enacted in solar PV installing practices?

The answers to the research questions arose from a thorough analysis of the fine data generated by using ANT as a conceptual framework and a methodology to "follow the actors" (Latour, 2005, p. 68). The rich and detailed data generated from 12 installation locations, across eight months, includes 395 typed pages of 303 hours of observation and 24 interviews, along with documents including quotes, drawings, emails, manufacturing information, audit reports, industry publications, and media coverage. The installation sites involved the work of four solar electrical contractors, referred to in this thesis by their pseudonyms: Barrie, Charlie, Matthew, and Patrick. This data was examined using the ANT key concepts of human and non-human actors and network effects. The meticulous analysis of the data, from multiple and careful readings to data labelling and mapping, identified extensive evidence that supports the answers to the research questions. These are presented below.

7.1.1 How are contracts enacted in practice?

The answers to the first subordinate question, “How are contracts enacted in practice?”, examined in Chapter 4, are that contracts are enacted as both matters of fact and matters of concern, and that there are five salient contracting practices which enact the contract. To answer the first subordinate question, the 12 contracts were carefully traced in the analysis, which revealed that contracts were enacted as both matters of fact and matters of concern. On the one hand, matters of fact are matters taken to be fixed, isolated and objective realities, and are studied with limited consideration of their composition; on the other hand, matters of concern involve the composition of matters of fact (Latour, 2005, 2008, 2010). An analysis examining matters of concern does not dismiss or ignore matters of fact but gathers the composition of such matters of fact. To see the matters of facts of the contract as matters of concern is analogous to “shifting your attention from the stage to the whole machinery of a theatre” (Latour, 2008, p. 39).

Instead of the existing approach to contracts as written or verbal agreements between two parties (Australian Competition and Consumer Commission, 2021; Phillips, 2016), this thesis argues that such agreements are enacted in practice as both matters of fact and matters of concern. Substantial evidence across the examined contracts shows that the contract agreements, the matters of fact, are essential to contract work; however, they are not fixed, unchanging matters of fact. In practice, matters of fact of the contract are malleable, a fluidity arising from connections to the many matters of concern, the dynamic actors out of which the matters of facts are composed.

Having established the findings that contracts, in practice, unfolds as both matters of fact and matters of concern, the analysis further established evidence for the findings that contracts are enacted by five salient contracting practices. For practices defined in this thesis as "ways of doing things together" (Gherardi, 2019, p. 11), the analysis revealed the five key ways in which human and non-human actors are "doing things together" in contract work. The five salient contracting practices enacted in solar installation contract work are 1) establishing contracts based on trusted networks of connections, 2) appraising sociomaterial requirements connected to the customer and the work site, 3) arranging sociomaterial resources needed as the work unfolds, 4) connecting the customer to significant sociomaterial changes arising as the work unfolds, and 5) enacting sociomaterial assemblages as services additional to those contracted. Contracts are more than just simple and static matters of fact as listed in a document or a verbal agreement, and the five contracting practices listed above are the ways that contracts were enacted in practice.

7.1.2 How is learning enacted in solar PV installing practices?

The answer to the second subordinate question, "How is learning enacted in solar PV installing practices?", discussed in Chapter 5, is that learning is enacted in different connection efforts in re-forming, mutating, and persisting networks. The analysis identified the mounting systems as significant actors among the many actors involved in installing practices. The analysis traced the mounting systems – asking questions about the materiality, the sociality, the breakdowns (Adams & Thompson, 2016), the kinds of connections and networks being enacted (Fenwick & Edwards, 2012), the ways components of the mounting system are connected to other actors, including some actors, and excluding others (Latour, 2005). Further, Latour (2005) has observed that "this connection is not made for free; it requires effort" (p. 132). This study builds on the definition of learning as a network effect (Fenwick et al., 2011) to identify different ways learning occurs in re-forming, mutating, and persisting networks in relation to different connection efforts. These different ways of learning are as follows:

Learning in a re-forming network is characterised by:

- a breakdown in an obligatory passage point creates widespread disconnections and prevents progress on the contract work;
- answers to the breakdown are largely unknown initially;
- learning unfolds amid high degrees of uncertainty across a network;
- learning involves actors such as peers, suppliers, and national networks;
- learning occurs in high connection effort;
- new ways of doing things emerge as an established way disintegrates.

Learning in the mutating networks is characterised by:

- a practice is changed due to new actors becoming visible or temporarily halted as further connections cannot be made;
- answers as to what and how to connect are known by some, and this knowledge needs to be assembled, at times in iteration;
- learning unfolds amid a mix of certainty and uncertainty as some aspects of the network related to the practice change and others do not;
- learning involves actors such as peers, suppliers, and national networks;
- learning occurs in moderate connection effort;
- there are established ways of doing things accommodate changes in networks.

Learning in mutating network is characterised by:

- an activity on site is changed or temporarily halted as further connections cannot be made;
- the contractor knows what connections to make and how to make them, and the learning is about the particular instance of those connections;
- learning unfolds amid high degrees of certainty pertaining to a stable (but not rigid) network;
- learning is more embodied, involving actors on the work site;
- learning occurs in low connection effort;
- ways of doing things are upheld amid tinkering with artefacts and people.

7.1.3 How is learning in contract work enacted in solar PV installations?

The answer to the central research question, "How is learning in contract work enacted in solar PV installations?", discussed in Chapter 6, is that learning occurs as the crafting-forward in contract work. This novel concept has three components: 1) entwined contracting and installing practices oriented towards completing the current contract, building reputation, and fostering future referrals, 2) four conditions of learning in contracting practices, attuning to contracts as matters of fact and matters of concern, that they a) matter, b) are liked, c) are populated, and d) are durable, and 3) learning in tinkering in installing practices, enacted in different connection efforts in re-forming, mutating, and persisting networks.

Drawing on the findings in Chapter 4 and Latour's suggestion that four conditions are necessary for approaching matters of concern in that they matter, that they are liked, populated, and durable (Latour, 2008), Chapter 6 argued that the crafting-forward of contract work required the learning that occurs in contract practices. Four conditions of learning in contracting practices relate to both matters of fact and matters of concern in that they: 1) matter – seeing the importance of not just matters of fact but also matters of concern; 2) are liked – engaging both matters of facts and matters of concern in further consideration, instead of matters of fact being used as unmovable facts; 3) are populated – seeing matters of fact and matters of concern as constituting various actors that have ongoing effects; and 4) are durable – seeing that ongoing work is necessary to sustain both matters of fact and matters of concern.

Building on the findings of Chapter 5 and existing ANT research regarding tinkering, Chapter 6 also argues that learning in installing practices in re-forming, mutating, and persisting networks occurs as tinkering. Tinkering refers to small actions enacted in practice, completed one after another (Mol, 2010). It is described by Latour (2008) in reference to the Tinkerer, the scientist pipetting liquid and shaking reagents. Tinkering, according to Mol (2010), is also how cathedrals are constructed (Turnbull, 2000) and how aircraft signalling operates (Law & Mol, 2001). In solar installing practices, tinkering occurs in different connection efforts in re-forming, mutating, and persisting networks.

Having established learning in contracting practices and installing practices in contract work, Chapter 6 argues that learning occurs in the entwined practices as the contract work is being crafted forward to completion rather than fixed goals. The analysis reveals that most of the contracts were based on referrals from previous customers and colleagues, and referrals are based on the quality of the contract work and the contractors' reputation. Crafting refers to "making things well" (Sennett, 2008, p. 8), to quality work in both contracting and installing practices. Crafting-forward leans on Mann and Mol's (2019) work on tasting-forward to argue that crafting quality work progresses in contracting and installing practices, progressing forward, in orientation to malleable agreements and goals. In other words, learning occurs in the crafting-forward of contract work, in entwined contracting and installing practice, towards completing the work rather than to fixed goals, reputation building, and securing future referrals.

7.2 Contributions to knowledge

Based on the above answers to the research questions, this thesis presents critical new knowledge via its empirical and conceptual contributions to the three sets of literature on workplace learning, learning in contract work, and learning in the solar and construction industries.

7.2.1 Empirical contributions

This thesis contributes a rich and extensive empirical study of learning in contract work. Through the lens of ANT (Adams & Thompson, 2016; Fenwick et al., 2011; Latour, 2005; Law, 1999, 2004; Mol, 2010) as the conceptual and methodological framework, this study used praxiographic methods (Mol, 2002) of observation, interview, and document review, to generate rich data. Across 12 solar installation sites involving four solar electrical contractors, this study generated extensive and detailed dataset of 395 pages of transcripts, along with various documents, which formed robust empirical evidence of the complexity of everyday practices in contract work, a complexity often overlooked in the literature. Such an extensive dataset provides fine descriptions that make visible the nuanced and complex ways contracts, contract work, and learning are enacted.

By focusing on the evidence relating to the contracts themselves, this empirical study contributes a unique and innovative approach to researching learning in contract work. Instead of overlooking contracts, as is the current situation in the literature (see Section 2.5), the findings of this study show that studying contract enactments proves to be essential for understanding learning in contract work and requires more research. Rather than approaching contracts as only written or verbal agreements between the contractors and customers (Australian Government Business, 2019; Phillips, 2016), or mostly overlooking contracts in workplace learning research, this study is the first to demonstrate that contracts, in practice, are enacted as both matters of fact and matters of concern. Further, by examining the extensive dataset on how contracts are enacted in relation to learning, this research brings to the foreground the five salient ways contracts are enacted (see Sections 4.4 and 7.2), requiring four conditions of learning (see Section 6.3). This research contributes to the literature by addressing the critical knowledge gap about "contract-appropriate practices" (Scheel et al., 2014, p. 750). This significant contribution is made to not just the literature on contract work, but also the literature on workplace learning and the literature on learning in the solar and construction industries.

At the same time, this study contributes an empirical study of contract workers other than knowledge workers; here, the study examined electrical contractors who were trade workers. While several studies have focused on the experience of educated and skilled self-employed workers (Marín-Sanchiz et al., 2021; McKeown & Leighton, 2016; McKeown & Pichault, 2021; Thompson, 2011, 2012, 2018), prior to the present research, there was scant knowledge of learning as emergence in the practice of contractors such as trade workers. As small business contractors, trade workers often operate without structured learning support and have limited resources for training (Idris et al., 2020; ILO, 2016). This study offers new knowledge that responds to the learning challenges facing contemporary industries increasingly relying on contract work arrangements.

Considering the literature on workplace learning, this study contributes a unique empirical study of workplace learning specific to the context of contract work and solar PV installation. In building on significant foundations of workplace learning research approaching learning as emergence (Gherardi, 2009b; Hager, 2011; Hopwood & Clerke, 2012; Reich & Hager, 2014; Schatzki, 2012) (see Section 2.2), this research has used ANT to examine learning as it emerges in practice and advances the literature by contributing empirical knowledge about the unique intersection of learning, contract work, and solar installation work. Turning to the literature on learning in the solar and construction industries (see Section 2.4), in examining the way learning as emergence is enacted in contracting and installing practices, this thesis contributes to examining learning as emergence in practice in exploring beyond the dominance of learning as acquisition (Brooks & Urmee, 2014; Hemson & Peek, 2017; Mohammadi et al., 2018; Sharma & Sengar, 2022; Silwal & Bhatta, 2017; Tsoutsos et al., 2013; Votteler et al., 2014), learning-by-doing and cost reduction (Beck & Rai, 2019; Bollinger & Gillingham, 2019; Nemet et al., 2020), suppliers and local networks (Gao et al., 2022; Gressgård & Hansen, 2015; Hastie et al., 2017; Lema & Lema, 2016; Neij et al., 2016; Ulsrud et al., 2018; Wong & Wong, 2014).

While much of this literature has approached learning as acquisition and participation, it has begun to explore learning as emergence in wind and solar plants (Gorrie, 2014; Scoles, 2017). This present study advances the literature by focusing specifically on solar PV installation work conducted by self-employed contractors, a significant portion of the workforce in the solar PV industry (see Section 1.5). In presenting this original knowledge of learning in contract work in the solar PV industry, this study is a novel empirical contribution to these industries, exploring learning in contract work beyond sets of soft and technical skills. The findings of this study shed new light on the much-needed knowledge of a significant workforce, particularly that of electrical contract work, as we seek to mitigate the climate crisis.

7.2.2 Conceptual contributions

This thesis contributes a novel conceptualisation of learning as crafting-forward in contract work. This insight is built on several conceptual contributions: 1) a conceptualisation of contracts as both matters of fact and matters of concern, enacted by five salient contracting practices; 2) a conceptualisation of learning being enacted in different connection efforts in re-forming, mutating, and persisting networks; and 3) a conceptualisation of learning as crafting-forward in contract work. Leaning on the idea of crafting as "making things well" (Sennett, 2008, p. 8) and the concept of taste-forward (Mann & Mol, 2019), crafting-forward in contract work contributes a theorisation that highlights quality contract work is more than simply delivering products adhering to rigid contractual agreements (Australian Government Business, 2019; Phillips, 2016).

Latour's (2005, 2008) concept of matters of fact and matters of concern pertinently accords with the findings of this thesis that contracts are enacted as both matters of fact and matters of concern involving the five contracting practices (see Section 4.2). This thesis offers new knowledge of the relationships between learning and contracts (see Chapter 5 and Section 6.3), as well as novel contributions to the existing ANT literature that examines the multiple ways actors such as the body multiple or practice multiple are enacted (Law & Singleton, 2014; Mol, 2002; Stewart, 2014). Instead of viewing contracts and practices as ontological multiplicities, this study offers another way of viewing contracts, not as contract multiple but in terms of composition, a shift of the gaze from the stage to the theatre (Latour, 2005), enacted by the five contracting practices. Further, this study contributes to Latour's (2005) concept of four conditions for matters of concern by extending it to refer also to matters of fact involving the four conditions of learning in contract work (see Section 6.3).

This study contributes original knowledge to understanding learning as emergence in relation to learning orientation. Crafting requires the entwined contracting and installing practices, and crafting-forward features the contract work being enacted towards completing the contract – rather than towards specific goals (Olazabal & Avila, 2022) or without overall plans (Mol, 2010) – and towards shaping reputation and forstering referrals for future contracts (see Section 6.2). This thesis gathered evidence to support a unique theorisation that extends and enriches practice approaches to workplace learning. In addition to approaching workplace learning as emergence in terms of the six strands (Reich & Hager, 2014) – as discussed in Section 2.2, knowing-in-practice (Gherardi, 2009a); social and material (Schatzki, 2012); embodied (Hopwood & Clerke, 2012); relational (Nicolini et al., 2018); situated in history and fluctuating contexts (Schatzki, 2006); and emergent (Hopwood, 2016) – this novel theorisation of crafting-forward offers the notion of orientation to conceptualising learning as emergence. With this conceptual dimension, learning as emergence in contract work remains complex and changing, yet shifting forward to an orientation that is also emergent.

Before this study, knowledge of learning in contract work was articulated predominantly in terms of acquiring training or the skills and ability of the owner or participating in social connections (see Section 2.3). In advancing the field, this thesis contributes the theorisation that learning in contract work involves a reconceptualisation of learning as emergence, by theorising (see Chapter 4) learning in re-forming, mutating, and emerging networks. Instead of the emphasis on social connections in the literature, this thesis provides evidence of learning in sociomaterial connections in contract work, particularly the connections at nodes of negotiations and struggles, building on Fenwick, Edwards, and Sawchuck's (2011) work.

Another original contribution of this thesis is conceptualising different ways learning occurs in re-forming, mutating, and persisting networks in relation to different connection efforts (Latour, 2005), and in doing so, this study offers a new way to understand the movements of actors beyond Callon's (1986) translation. This study extends Latour's (2005) idea of efforts and quality of connections, for instance, "longer, faster, and more intense connections" (p. 179) (see Section 3.4) to characterise the nodes of connections. Without prematurely limiting the study by imposing the four moments of translation – problematisation, interessement, enrolment and mobilization – learning in negotiations and struggles (Fenwick et al., 2011) is not primarily linked to the problematisation moment where problems are redefined to include the actor leading the translation. In this study, the problems and the breakdowns are responded to in the negotiations and struggles, i.e. the learning distributed in the different nodes of connections and connection efforts. Connection effort in the re-forming, mutating, and persisting networks offers a new way of understanding problems and the responses to problems as different connection efforts and network effects.

The insights gained from this study contribute to addressing some critical issues reported in the literature relating to the gap between training and knowledge in practice, particularly relating to the rapid rate of technological development (Australian Industry Standards, 2019; Hemson & Peek, 2017; Sharma & Sengar, 2022; Strupeit, 2017; Urmee, 2016) (see Section 2.4). This study also contributes new knowledge regarding the much-discussed connections between learning-by-doing and cost reduction (Beck & Rai, 2019; Bollinger & Gillingham, 2019; Nemet et al., 2020), bringing a more comprehensive understanding to open "the blackbox of learning-by-doing" (van Poeck et al., 2020, p. 298). This thesis' theorisation of learning in practice, rather than in training programs, particularly relates to installing practices – where the learning enacted in tinkering in different connection efforts in re-forming, mutating, and persisting networks – helps to unpack the nuance of the extensive learning that occurs in practice relating to technological changes.

Taken together, the conceptual contributions of this study indicate that learning in contract work is much more complex and extensive than currently conceptualised in the literature. In practice, learning as crafting-forward contract work occurs in everyday enactment of contracting and installing practices, beyond the confines of existing focus on training programs or the skills of the self-employed owners. As discussed above, this theorisation of learning as crafting-forward in contract work advances the literature in several ways to address the critical question: "How might we catch some of the realities we are currently missing" (Law, 2004, p. 2)? By drawing on ANT, the novel and unique theorisation of this unveils previously invisible yet powerful factors. The study provides a deeper insight into the dynamic gap between the prescribed, boundary-based contracts and the actual work (Deranty, 2016) that contractors perform while negotiating workplace changes and demands.

7.3 Accountabilities, trustworthiness, and quality of research

The accountabilities, trustworthiness and quality of this ANT study are assessed by two frameworks: Thompson and Adam's (2020) posthumanist framework and Shenton's (2004) framework for qualitative research. Thompson and Adam's framework for accountabilities in posthumanist offers three criteria: attuning to more-than-humanness and learning to speak with things, weaving human and non-human storylines, and lively accounts of the performativity of difference. As a qualitative study, the trustworthiness and quality of this study are also assessed by considering Shenton's framework of four criteria – which were built on Gupa's (1981) constructs: credibility, transferability, dependability, and confirmability.

Attuning to more-than-humanness and learning to speak with things

In order to attune to more-than-humanness and learn to speak with things, the "creativity and agility of the researcher to be open and adapt to the object(s) of interest is critical…objects may come to attention in multiple ways beyond initial interest in a particular technology" (Thompson & Adams, 2020, p. 340). In the dataset, particularly in the 290 typed pages of observation data, I gathered records of actors with openness and agility, noting not just the human actors but the gathering of human-nonhuman entanglements. As an example, in the excerpt below, openness and agility are demonstrated when I paid attention, beyond static interests, to the mundane gatherings of Barrie + orange string + left end of the rail + row 1 + right end of the rail + piece of wood.

> *11.05am Barrie ties an orange string to the left of the rail on row 1, then walks over to the right to tie the string. He places a piece of wood under the string at both ends.* (C3B3Obs 1, p. 6)

Throughout the data generation, analysis, and discussion of findings, accountability in attuning to the more-than-humanness is crucial to the novel empirical and conceptual contributions of this study.

Weaving human and non-human storylines

In weaving human and non-human storylines, accountability is demonstrated by asking the questions, "Are humans the only (or main) narrators? How do objects appear in these anecdotes and in what ways?" (Thompson & Adams, 2020, p. 342). This study has established accountability by presenting the findings in Chapters 4 and 5 as anecdotes descriptive of both human and non-human actors. The anecdotes of the contracts and instances in installing practices were full of detailed descriptions about the "masses" (Latour, 1992) of mundane actors such as rails, shadows and measuring tapes while not eliding the contractors' activities. Several direct quotes, excerpts from observation data, and images were included in both chapters.

Lively accounts of the performativity of difference

Accountability of this research is also demonstrated in the lively accounts of the performativity of difference where ongoing questioning is necessary and "methods must remain open throughout data collection and analysis, as the researcher struggles to articulate the dynamics of fleeting and stable human–objects relations and relating" (Thompson & Adams, 2020, p. 345). Throughout the thesis, and more explicitly in Chapter 3, detailed accounts were provided of the importance of resisting premature explanations (Latour, 2005), the data generation method of following the actors, and the extensive inductive analysis process that iteratively engages with the large dataset in this research.

Credibility

The ANT conceptual and methodological framework (see Sections 3.2 – 3.5) is essential to this study of learning as emergence in practice. In generating extensive data not limited to reductive foci, it enables the research to form unique conceptualisations based on fine, but seemingly mundane data. Credibility is established on the bases of several criteria: the use of well-established methods, familiarity with the research site, triangulation, debriefing with the supervisor, peer scrutiny of the research, reflective commentary by the researcher on the research process, thick descriptions, and discussion in relation to previous research (Shenton, 2004).

The novel findings of this practice-based research are grounded on the well-established theories and methods of ANT and praxiography as described in Sections 3.2-3.5 (Adams & Thompson, 2016; Fenwick et al., 2011; Latour, 2005; Law, 1999, 2004; Mol, 2010; Thompson & Adams, 2020). By adhering to the ANT instruction to follow the actors, both the powerful and mundane, this study gathered an extensive dataset of 395 typed pages. As ANT resists premature explanations, the inductive analysis began with the extensive dataset, and through an iterative and thorough process, the unique findings of this study align with the ANT sociomateriality and relational ontology of network effects. From the 303 hours of observation and 24 interviews, familiarity was established with the research sites. Further, during the first year of my candidature, my internship for a solar company facilitated some familiarity with the solar industry. The triangulation of data generation involved three different types of data – observation, document reviews and interviews over 12 different installation sites. The thick descriptions of the findings (Latour, 2005) were provided in Chapters 4 and 5. Regular debriefing with my supervisors and doctoral assessment presentations generated scrutiny, challenged my assumptions, and facilitated constructive feedback.

Transferability

Transferability refers to the generalisation of the study findings beyond the study to assess how the result can be adopted in different contexts and qualitative studies. By adhering to the ANT approach to "follow the actors" (Latour, 2005, p. 68), this study has generated an extensive database of 395 pages of transcripts along with various associated documents. The rich data generated from the 12 installation sites allowed the tracing of carefully selected actors and a discussion of the fine detail of the findings as presented in Chapters 4 and 5. While a specific context prevents transferability, this thesis applies this notion by providing sufficient contextual information and detailed descriptions that allow the reader to decide the transferability to their contexts (Shenton, 2004). What can be determined as sufficient is a matter of debate; however, as Shenton discussed, in this present study, sufficiency may include relevant and rich details about the human and non-human actors related to the practices and activities enacted in practice. Such rich data establishing the findings of this research can allow the reader to identify resonance in other contexts.

Dependability

While positivist studies seek to demonstrate that the study can be repeated by another researcher and the same result would be obtained, qualitative studies are site-specific, and dependability is shown in the rich details provided so that the reader can judge the relevance of the methods, allowing other researchers to adopt the same approach to repeat the study (Shenton, 2004). Following Shenton, in this study, dependability is demonstrated via the detailed descriptions of the processes undertaken in the conceptual and methodological framework (see Chapter 3), the thorough description of the careful analysis process (see Section 3.8), and specific considerations regarding the writing of an ANT text (see Sub-section 3.8.8). Further, detailed vignettes and raw data were provided in Chapters 4 and 5, the findings chapters. In this thesis, the chapters on conceptual framework and methodology, findings, and discussion have described in rich detail the processes that can be assessed and adopted by other researchers.

Confirmability

In contrast to the physical sciences, which rely on instruments to remove as much human error as possible and ensure objectivity, in qualitative research, confirmability seeks to base the data on the participants and the subject studied (Guba & Lincoln, 1989). While bias is a part of human work, triangulation, audit trails, and the researchers' explicit reports of their preferences promote confirmability (Shenton, 2004). My reflections on reflexivity were discussed in Section 3.9, where I acknowledge my past experiences and professional background working in the field of organisational learning and development. To ensure confirmability, this study included the audit trails in Sections 3.4 – 3.9, which establish the quality of the findings. Further, having considered how criticisms of ANT relate to this investigation in Section 3.2, the choice of ANT as a conceptual and methodological framework has been necessary for addressing research questions, conducting the fieldwork, and establishing the significant contributions of this research.

7.4 Limitations and critical reflection

Three limitations of the study relate to the following of actors, the expertise of the participants, and the sample size of four contractors. As this study generated observation data that emerged on installation sites across 303 hours of observation, numerous other actors connected to the installations could not be followed as extensively. These other actors included government agencies, industry associations, suppliers, manufacturers, and distributors. However, with the three methods of observation, interview and document review, some relevant activities of other actors related to the installations could be included in the analysis, allowing me to answer the research questions. The strength of the ANT method to "follow the actors" (Latour, 2005, p. 68) as they emerge in practice is that this method allows the study to generate data without using predetermined actors that limit the scope of the research. The rich and organic data formed the foundation for this study's fresh and unique insights into learning in contract work.

The contractors participating in this study are self-selected experts in the solar industry. Their willingness to contribute to empirical research indicates a partiality towards knowledge generation and knowledge contribution, which could influence their approach to learning. They are experts in the industry who offer high standards of quality solar PV installations, working with at least one assistant to handle heavy components like solar panels and batteries. Practices involving other types of contractors, such as novice contractors, self-employed contractors working for solar

PV retailers, or solo contractors working in the office of solar suppliers, might face different challenges requiring different practices. Also, all the contractors who participated in this study were male participants. The male gender of the participants in this study aligns with the majority of solar installers who identify as male (IRENA, 2022). However, it is not possible to suggest to what extent the result of this research also relates to female contractors and female solar installers. However, female workers can apply relevant knowledge to their own work.

The small sample size of four contractors can be viewed as a relatively small sample size. However, this study does not seek generalization or representatives of a population. As a study on learning in contract work, moving away from human-centric approaches, the sample size of this practice-based study involves 12 contracts or 12 installation sites. While this is a relatively small number of sites – if compared to, for example, a dataset of 240,626 residential solar PV systems (Nemet et al., 2020) – the breadth and depth of the data generated with the ANT approach supports this study's insightful contributions to knowledge.

7.5 Implications and future research

This section reflects on the contributions of the thesis and the implications for future research, contract workers such as solar installers, and organisations working with contractors or serving the learning needs of contractors. While the small sample size does not guarantee generalisations, the rich details of contextual information in the thesis enable transferability to the readers specific to their contexts (Shenton, 2004). By questioning the dominance of the assumption of learning as acquisition and participation, the novel concept of learning as crafting-forward in contract work offers fresh insights to approaches in workplace learning, where "a major overhaul of adult learning programmes to increase their coverage and promote quality is essential to harness the benefits of the changing world of work" (OECD, 2019d, para. 5). With the publication of this thesis as well as future publications of articles in networks of scholarly journals and general media publications, as well as presentations at conferences and industry events, this research can reach a wider audience of researchers, practitioners, and organisations.

7.5.1 For future research

Based on the substantial empirical and conceptual contributions of this research, this study has several implications for future research. Future research can apply the novel conceptualisations of learning as crafting-forward to study other types of contract work and solar installation work, as well as a broader range of demographics. Further it would also be a fruitful area for further research to apply the concept of contracts as both matters of fact and matters of concern, which can explore the relationship between contracts and learning in different contexts. Multiple enactments of contracts can also be further examined following Mol's (2002) lead. Also, the five salient contracting practices can be used as a framework to examine how contracting practices are enacted in different contexts.

Considering other types of contract work, since the contractors in this study are self-employed owners of small companies, future research can focus on novice contractors, contractors in large corporations, or sub-contractors contracted to work on another organisation's contract. In the solar PV and construction industry, future research can apply the theorisation from this thesis to explore contracting in large solar projects of more than 100kW and different types of contract workers in the industries. More research can focus on a specific type of solar installers, such as sub-contractors who work for solar retailers. Research can examine other types of contract workers working in the informal, often hidden, and precarious economy of solar development, such as mining and disposal, known as solar lumen proletariats (Stock, 2020).

Considering a wider demographic, further research can consider how research can support "equal opportunities for individuals and workers to gain the skills demanded in the local economy is critical to creating a vibrant labour market." (OECD, 2019). What is now needed is to address the gender imbalance in green skills, which has received "little or no consideration" (Cedefop, 2019, p. 15). Future research can use the findings of this study, along with feminist (new) materialism (Truman, 2019) to study how female contractors learn in industries of dynamic technological changes, such as the solar industry (IRENA, 2022). According to the Australian Government Job Outlook (2020), only 2% of electricians are female, compared to the average of 48% in the workforce. Given the high interest from women in educational content in the renewable industry (Lucas et al., 2018), further research can focus on how to increase gender equality in the industry. Further research can apply learning as crafting-forward to explore how learning in contract work is enacted in minority communities. More research can direct attention to contractors with specific needs, as, for instance, Ashley and Graf (2018) who studied self-employment and workers with disabilities, reported that "the majority of participants revealed negative and/or unhelpful interactions with vocational rehabilitation counsellors" (p. 90). Further research can be undertaken to explore learning contract work in indigenous communities, especially mentoring and apprenticeship for at-risk youth (OECD, 2019). Given that connecting to networks affects the likelihood of self-employment for workers belonging to ethnic minority groups (Martín-Montaner et al., 2018), especially for refugee women (van Kooy, 2016), these are also important areas for future research.

7.5.2 For self-employed contract workers and solar electrical contractors

For self-employed contract workers, several contributions to knowledge from this study will have implications for future practice-based applications in industries that encounter widespread challenges in responding to changing contexts while relying on a flexible workforce, as well as applications in traditionally stable sectors, such as higher education, which are becoming increasingly dependent on contract work.

For self-employed contractors, including solar PV electrical contractors, this study identifies specific practices that indicate possible ways for contractors to navigate the challenges of everyday contract work. As discussed in the Introduction chapter (see Section 1.5), a dynamic industry such as the solar industry requires appropriate and timely responses to changes (Australian Industry Standards, 2019; Hemson & Peek, 2017; Sharma & Sengar, 2022; Strupeit, 2017; Urmee, 2016). Contractors can expand their understanding of learning beyond attending training programs and connecting to people, to being attentive to the different ways learning as emergence occurs in everyday contract work in re-forming, mutating, and persisting networks. By approaching contracts as more than just rigid agreements, the electrical contractor can consider the emerging changes and educate their customer on how the contract unfolds (see Section 4.3). The five contracting practices provide a framework to organise the contracted work and to communicate to the customer the key ways the contract unfolds (see Section 4.4). The insights gained from examining learning in installing practices may assist contractors in considering the technical practices in their contract work. The contractors can also use the knowledge that future contracts rely on reputations shaped by quality work, completed not only by the careful enactment of installing or technical practices but also by the attentive performance of the five key contracting practices, directed towards agreements that are malleable as the work progresses.

7.5.3 For organisations

A significant contribution of this thesis is the articulation of learning in contract work, making visible the learning that occurs in practice. The findings of this study may be useful to organisations planning workplace learning and managing policies for workforce development, contributing to improving HR practices (Cross & Swart, 2021). It is not just the importance of articulating a learning plan in self-employed work (Margaryan, 2019) but also the importance of articulating how such learning occurs in everyday practice as crafting-forward in contract work. Organisations can attent to how contracts are enacted, and different ways of learning is enacted as network effects in connection to changes at work sites, in organisations or industries. By questioning the dominance of learning as acquisition in training programs, organisations can also consider that training does not equate to learning (Antonacopoulou, 1999). The enactment of practices, such as safety (Eggerth et al., 2018; Gherardi & Nicolini, 2000; Mohammadi et al., 2018; Ripamonti & Scaratti, 2015; Zhao & Lucas, 2014), can improve when conceptualised beyond individuals' acquisition or group participation to include learning considerations such as crafting-forward quality contract work, tinkering towards enacting the work, building reputation, and fostering future referrals. Further, when learning is no longer limited to acquisition or participation, organisations and individuals can use the novel concepts of this study to manage learning initiatives to address the current skill shortage in the solar industry (see Section 1.4).

7.6 Final reflections

At the broadest level, this thesis is an empirical study of learning in contract work as emergence. Rather than viewing learning as acquisition or participation, this thesis has offered a novel and unique conceptualisation of the remarkable learning enacted in solar PV installations: learning as crafting-forward in contract work. By applying the well-established ANT approach of following the actors, the innovative approach of tracing the enactment of contracts in practice has revealed the important findings of contracts being enacted as both matters of fact and matters of concern, as well as the five salient contracting practices and the four conditions of learning. With the ANT sensibility, the fine data, seemingly mundane details, generated by tracing the twelve mounting systems revealed the distinctive learning that occurs in tinkering and different connection efforts in re-forming, mutating, and persisting networks. These substantial findings form the foundations for the learning that this study has identified as crafting-forward in contract work, towards completing the work, building reputation, and fostering future referrals. In contributing to the three sets of literature on workplace learning, learning in contract work, and learning in the solar and construction industries, this thesis brings fresh light to a critically important, yet previously neglected, area of research and helps to expand possible directions for future research on the relationships between learning, contracts, and contract work.

8 APPENDICES

Appendix 1: Participant information sheet – electrical contractor

UTS UNIVERSITY OF TECHNOLOGY SYDNEY

PARTICIPANT INFORMATION SHEET FOR ELECTRICAL CONTRACTOR
LEARNING IN CONTRACT WORK (UTS HREC REF NO. ETH16-0883)

WHO IS DOING THE RESEARCH?
My name is Anne Nguyen and I am a doctoral researcher, in the Faculty of Arts and Social Sciences at the University of Technology Sydney. My supervisor is Dr Ann Reich (PhD, Senior Lecturer, ann.reich@uts.edu.au, 02 9514 3857).

WHAT IS THIS RESEARCH ABOUT?
I would like to find out about how learning occurs in contract work, especially in the context of electrical contract work in the solar industry. The aim of the research is to understand how contractors learn to work with materials and other workers in order to complete solar installations. By looking closely at the everyday work and changes as they occur, I hope to uncover new ways of thinking about learning in contract work, which enhance responses to change and delivery of solar installations in Australia.

WHY HAVE I BEEN ASKED?
You have been invited to take part in this study because you work as a contractor. Your current work as an electrical contractor in the solar industry places you in the ideal position to give me the information I need to find out about learning in contract work that demands high collaboration and teamwork to respond to the many changes, especially technological changes.

IF I SAY YES, WHAT WILL IT INVOLVE?
If you decide to participate, you will be asked to allow me to observe you, while you work on 4 installations, and to photograph you. The photos are only for research purposes and will be used in our interviews to assist in recalling particular situations. In situations where it may be difficult for me to access part of a site, you will be invited to participate in an interview of no more than 30 minutes about your work in these areas. After the installation you will also be asked to participate in a 40-minute interview and you will be able to choose where the interview will happen. You will also be invited to participate a 20-minute phone interview after the system is switched on, and to provide work documents relevant to the installation, for example, installation contract, installation designs and work orders. The interviews will be audio recorded and the audio recordings will be transcribed for research purposes.

ARE THERE ANY RISKS/INCONVENIENCE?
You might feel a little self-conscious about being observed and recorded in interviews. Throughout the research, when you are uncomfortable, you can tell me to stop my observation, to stop taking photographs or turn off the audio-recording. You also don't have to answer any questions that you don't feel comfortable to do so. You might be concerned about being identified in a publication or linked to your confidential and honest opinions about your everyday work. However, I can assure you that your name and the name of your organisation will not be linked to transcript or observation notes, and pseudonyms will be used in all publications. Everything you say will remain confidential – that means I will not repeat what you say to your team or to your employer because this research is not about evaluation but it is about enhancing our understanding of the learning processes in contract work. Your time and schedule will be highly respected and valued. I will maintain regular contacts to make sure our schedules are convenience for you.

DO I HAVE TO SAY YES?
Participation in this study is voluntary. It is completely up to you whether or not you decide to take part.

WHAT WILL HAPPEN IF I SAY NO?
If you decide not to participate, it will not affect your relationship with the researchers or the University of Technology Sydney. If you wish to withdraw from the study once it has started, you can do so at any time without having to give a reason, by emailing Anne Nguyen, anne.nguyen-2@student.uts.edu.au or texting [redacted].

Participant information sheet – V02, 14/11/2017 *Page 1 of 2*

If you withdraw from the study, any recordings and transcripts will be destroyed. However, it may not be possible to withdraw your data from the study results as any details identifying you will be already removed.

CONFIDENTIALITY

By signing the consent form you consent to the research team collecting and using personal information about you for the research project. All this information will be treated confidentially. The management of collected data will be in compliance with the Research Data Management Vice-Chancellor's Directive (UTS, 2014). Data records will be stored in the following format: handwritten notes, photographs, voice recordings, transcripts and photocopies of documents. Current data will be saved on a university computer, locked with a password. A backup copy will be saved in university cloud storage system and in accordance with requirement of university unit responsible for records (UTS, 2017). Data in storage will not contain participants' personal details. Hard copies of data will be stored in UTS researcher lockers. Only my academic supervisors and I will have access to the data. Your information will only be used for the purpose of this research project and it will only be disclosed with your permission, except as required by law.

In any publication, information will be provided in such a way that you cannot be identified.

WHAT IF I HAVE CONCERNS OR A COMPLAINT?

If you have concerns about the research that you think I or my supervisor can help you with, please feel free to contact us at anne.nguyen-2@student.uts.au and ann.reich@uts.edu.au or on 02 9514 3857.

NOTE:
This study has been approved by the University of Technology Sydney Human Research Ethics Committee [UTS HREC]. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 2478 or email: Research.Ethics@uts.edu.au], and quote the UTS HREC reference number. Any matter raised will be treated confidentially, investigated and you will be informed of the outcome.

Appendix 2: Participant information sheet – key stakeholders

UNIVERSITY OF TECHNOLOGY SYDNEY

PARTICIPANT INFORMATION SHEET FOR KEY STAKEHOLDERS
LEARNING IN CONTRACT WORK (UTS HREC REF NO. ETH16-0883)

WHO IS DOING THE RESEARCH?

My name is Anne Nguyen and I am a doctoral researcher, in the Faculty of Arts and Social Sciences at the University of Technology Sydney. My supervisor is Dr Ann Reich (PhD, Senior Lecturer, ann.reich@uts.edu.au, 02 9514 3857).

WHAT IS THIS RESEARCH ABOUT?

I would like to find out about how learning occurs in contract work, especially in the context of electrical contract work in the solar industry. The aim of the research is to understand how contractors learn to work with materials and other workers in order to complete solar installations. By looking closely at the everyday work and changes as they occur, I hope to uncover new ways of thinking about learning in contract work that enhance responses to change and delivery of solar installations in Australia.

WHY HAVE I BEEN ASKED?

You have been invited to take part in this study because you are a key stakeholder working on the solar installation. Your current work as a key stakeholder places you in the ideal position to give me the information I need to find out about learning in contract work that demands high collaboration and teamwork to respond to the many changes, especially technological changes.

IF I SAY YES, WHAT WILL IT INVOLVE?

If you decide to participate, you will be invited to participate in a 20-minute interview and you will be able to choose where the interview will happen. You will also be invited to participate a 20-minute phone interview after the system is switched on, and to provide work documents relevant to the installation, for example, installation contract, installation designs and work orders. The interviews will be audio recorded and the audio recordings will be transcribed for research purposes.

ARE THERE ANY RISKS/INCONVENIENCE?

You might feel a little self-conscious about being recorded in interviews. Throughout the research, when you are uncomfortable, you can tell me to turn off the audio-recording. You also don't have to answer any questions that you don't feel comfortable to do so. You might be concerned about being identified in a publication or linked to your confidential and honest opinions about the good and not so good in your everyday work. However I can assure you that your name and the name of your organisation will not be linked to transcript or observation notes, and pseudonyms will be used in all publications. Everything you say will remain confidential – that means I will not repeat what you say to your team or to your employer because this research is not about evaluation but it is about enhancing our understanding of the processes of contract work. Your time and schedule will be highly respected and valued. I will maintain regular contacts to make sure our schedules are convenience for you.

DO I HAVE TO SAY YES?

Participation in this study is voluntary. It is completely up to you whether or not you decide to take part.

WHAT WILL HAPPEN IF I SAY NO?

If you decide not to participate, it will not affect your relationship with the researchers or the University of Technology Sydney. If you wish to withdraw from the study once it has started, you can do so at any time without having to give a reason, by emailing Anne Nguyen, anne.nguyen-2@student.uts.edu.au or texting [redacted].

If you withdraw from the study, any recordings and transcripts will be destroyed. However, it may not be possible to withdraw your data from the study results as any details identifying will be already removed.

CONFIDENTIALITY

By signing the consent form you consent to the research team collecting and using personal information about you for the research project. All this information will be treated confidentially. The management of

Participant information sheet - 02, 14/11/2017 *Page 1 of 2* collected data will be in compliance with the Research Data Management Vice-Chancellor's Directive (UTS, 2014). Data records will be stored in the following format: handwritten notes, voice recording, transcripts of audio recording and photocopies of documents. Current data will be saved on a university computer, locked with a password. A backup copy will be saved in university cloud storage system and in accordance with requirement of university unit responsible for records (UTS, 2017). Data in storage will not contain participants' personal details. Hard copies of data will be stored in UTS researcher lockers. Only my academic supervisors and I will have access to the data. Your information will only be used for the purpose of this research project and it will only be disclosed with your permission, except as required by law.

In any publication, information will be provided in such a way that you cannot be identified.

WHAT IF I HAVE CONCERNS OR A COMPLAINT?

If you have concerns about the research that you think I or my supervisor can help you with, please feel free to contact us at anne.nguyen-2@student.uts.au and ann.reich@uts.edu.au or on 02 9514 3857.

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This study has been approved by the University of Technology Sydney Human Research Ethics Committee [UTS HREC]. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 2478 or email: Research.Ethics@uts.edu.au], and quote the UTS HREC reference number. Any matter raised will be treated confidentially, investigated and you will be informed of the outcome.

Appendix 3: Participant information sheet – incidental participants

UTS UNIVERSITY OF TECHNOLOGY SYDNEY

PARTICIPANT INFORMATION SHEET FOR INCIDENTAL PARTICIPANTS
LEARNING IN CONTRACT WORK (UTS HREC REF NO. ETH16-0883)

WHO IS DOING THE RESEARCH?
My name is Anne Nguyen and I am a doctoral researcher, in the Faculty of Arts and Social Sciences at the University of Technology Sydney. My supervisor is Dr Ann Reich (PhD, Senior Lecturer, ann.reich@uts.edu.au, 02 9514 3857).

WHAT IS THIS RESEARCH ABOUT?
I would like to find out about how learning occurs in contract work, especially in the context of electrical contract work in the solar industry. The aim of the research is to understand how contractors learn to work with materials and other workers in order to complete solar installations. By looking closely at the everyday work and changes as they occur, I hope to uncover new ways of thinking about learning in contract work, which enhance responses to change and delivery of solar installations in Australia.

WHY HAVE I BEEN ASKED?
You have been invited to take part in this study because you work with the electrical contractor. Your current work with electrical contractor in the solar industry places you in the ideal position to give me the information I need to find out about learning in contract work that demands high collaboration and teamwork to respond to the many changes, especially technological changes.

IF I SAY YES, WHAT WILL IT INVOLVE?
If you decide to participate, you will be asked to allow me to observe you, while you work with the electrical contractor, and to photograph you. The photos are only for research purposes and will be used in interviews to assist in recalling particular situations. You will also be invited to provide work documents relevant to the installation, for example, purchase order or work contract.

ARE THERE ANY RISKS/INCONVENIENCE?
You might feel a little self-conscious about being observed. You might be concerned about being identified in a publication. However, I can assure you your name and the name of your organisation will not be linked to observation notes, and pseudonyms will be used in all publications.

DO I HAVE TO SAY YES?
Participation in this study is voluntary. It is completely up to you whether or not you decide to take part.

WHAT WILL HAPPEN IF I SAY NO?
If you decide not to participate, it will not affect your relationship with the researchers or the University of Technology Sydney. If you wish to withdraw from the study once it has started, you can do so at any time without having to give a reason, by emailing Anne Nguyen, anne.nguyen-2@student.uts.edu.au or texting .

If you withdraw from the study, any recordings and transcripts will be destroyed. However, it may not be possible to withdraw your data from the study results as any details identifying you will be already removed.

CONFIDENTIALITY
By signing the consent form you consent to the research team collecting and using personal information about you for the research project. All this information will be treated confidentially. The management of collected data will be in compliance with the Research Data Management Vice-Chancellor's Directive (UTS, 2014). Data records will be stored in the following format: handwritten notes, photographs and photocopies of documents. Current data will be saved on a university computer, locked with a password. A backup copy will be saved in university cloud storage system and in accordance with requirement of university unit responsible for records (UTS, 2017). Data in storage will not contain participants' personal details. Hard copies of data will be stored in UTS researcher lockers. Only my academic supervisors and I

Participant information sheet – V02, 14/11/2017 *Page 1 of 2* will have access to the data. Your information will only be used for the purpose of this research project and it will only be disclosed with your permission, except as required by law.

In any publication, information will be provided in such a way that you cannot be identified.

WHAT IF I HAVE CONCERNS OR A COMPLAINT?

If you have concerns about the research that you think I or my supervisor can help you with, please feel free to contact us at anne.nguyen-2@student.uts.au and ann.reich@uts.edu.au or on 02 9514 3857.

NOTE:
This study has been approved by the University of Technology Sydney Human Research Ethics Committee [UTS HREC]. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 2478 or email: Research.Ethics@uts.edu.au], and quote the UTS HREC reference number. Any matter raised will be treated confidentially, investigated and you will be informed of the outcome.

Appendix 4: Participant consent form – electrical contractor

UTS UNIVERSITY OF TECHNOLOGY SYDNEY

CONSENT FORM FOR ELECTRICAL CONTRACTORS
LEARNING IN CONTRACT WORK
UTS HREC REF NO. ETH16-0883

I ______________________________ agree to participate in the research project, *Learning in Contract Work (UTS HREC REF NO. ETH16-0883)*, being conducted by Anne Nguyen, 15 Broadway, Ultimo NSW 2007, .

I have read the Participant Information Sheet or someone has read it to me in a language that I understand.

I understand the purposes, procedures and risks of the research as described in the Participant Information Sheet.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time without affecting my relationship with the researchers or the University of Technology Sydney.

I understand that I will be given a signed copy of this document to keep.

I agree to:
- ☐ Be observed at the installation site
- ☐ Be photographed
- ☐ Be interviewed and audio recorded during interview
- ☐ Provide key work documents.

I agree that the research data gathered from this project may be published in a form that:
- ☐ Does not identify me in any way

I am aware that I can contact Anne Nguyen if I have any concerns about the research.

____ ____/____/____
Name and Signature [participant] Date

____ ____/____/____
Name and Signature [researcher or delegate] Date

NOTE:
This study has been approved by the University of Technology Sydney Human Research Ethics Committee [UTS HREC]. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 2478 or email: Research.Ethics@uts.edu.au, and quote the UTS HREC reference number. Any matter raised will be treated confidentially, investigated and you will be informed of the outcome.

Consent form – V01, 20/09/2017 *Page 1 of 1*

Appendix 5: Participant consent form – key stakeholder

UNIVERSITY OF TECHNOLOGY SYDNEY

CONSENT FORM FOR KEY STAKEHOLDERS
LEARNING IN CONTRACT WORK
UTS HREC REF NO. ETH16-0883

I ______________________________ agree to participate in the research project, *Learning in Contract Work (UTS HREC REF NO. ETH16-0883)*, being conducted by Anne Nguyen, 15 Broadway, Ultimo NSW 2007, .

I have read the Participant Information Sheet or someone has read it to me in a language that I understand.

I understand the purposes, procedures and risks of the research as described in the Participant Information Sheet.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time without affecting my relationship with the researchers or the University of Technology Sydney.

I understand that I will be given a signed copy of this document to keep.

I agree to be:
☐ Interviewed and audio recorded during interview
☐ Providing key work documents.

I agree that the research data gathered from this project may be published in a form that:
☐ Does not identify me in any way

I am aware that I can contact Anne Nguyen if I have any concerns about the research.

____ ____/____/____
Name and Signature [participant] Date

____ ____/____/____
Name and Signature [researcher or delegate] Date

NOTE:
This study has been approved by the University of Technology Sydney Human Research Ethics Committee [UTS HREC]. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 2478 or email: Research.Ethics@uts.edu.au, and quote the UTS HREC reference number. Any matter raised will be treated confidentially, investigated and you will be informed of the outcome.

Consent form – V01, 20/09/2017 *Page 1 of 1*

Appendix 6: Participant consent form – incidental participants

UTS UNIVERSITY OF TECHNOLOGY SYDNEY

CONSENT FORM FOR INCIDENTAL PARTICIPANTS
LEARNING IN CONTRACT WORK
UTS HREC REF NO. ETH16-0883

I ____________________________ agree to participate in the research project, *Learning in Contract Work (UTS HREC REF NO. ETH16-0883)*, being conducted by Anne Nguyen, 15 Broadway, Ultimo NSW 2007, .

I have read the Participant Information Sheet or someone has read it to me in a language that I understand.

I understand the purposes, procedures and risks of the research as described in the Participant Information Sheet.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time without affecting my relationship with the researchers or the University of Technology Sydney.

I understand that I will be given a signed copy of this document to keep.

I agree to:
☐ Be observed by the researcher in interactions that I have with electrical contractors. I understand that the focus of the observation will be on the electrical contractors, and not on me.

I agree that the research data gathered from this project may be published in a form that:
☐ Does not identify me in any way.

I am aware that I can contact Anne Nguyen if I have any concerns about the research.

____________________________________ ____/____/____
Name and Signature [participant] Date

____________________________________ ____/____/____
Name and Signature [researcher or delegate] Date

NOTE:
This study has been approved by the University of Technology Sydney Human Research Ethics Committee [UTS HREC]. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 2478 or email: Research.Ethics@uts.edu.au, and quote the UTS HREC reference number. Any matter raised will be treated confidentially, investigated and you will be informed of the outcome.

Consent form – V1, 20/09/2017 *Page 1 of 1*

Appendix 7: Observation guidelines

Observation Guidelines

Location code:
Date code:
Time code:

Category	Focus	Reflections
Social actors	• How many people are working on the site? • What are their roles? • How many organisations are there? • What is the power structure?	
Material actors	• What are they? • How are they used? • When are they used – in relation to what? • What difference (if any) do they make to the action?	
Communication	• What is said? • What language is being used? • What terms or words recur? • By whom? • What are the objects of the communication?	
Relations	• How do people behave towards each other? • How do people work with materials? • How do materials shape people's behaviours? • Who and what are making connections? • What are the disconnections?	
Time (record in 10-15 minutes time slots)	• When are things happening? • Is the activity/event unfolding quickly/slowly? • Is there a sense of rushing? Inertia?	
Space (draw a diagram of the site)	• What is the site layout? • How do social and material actors move around? • Where to they start and finish?	

Further clarifications: What should be followed up? What networks should be explored further?

Appendix 8: Interview guide

Interview Schedule – Follow Up Interview

In-depth follow-up interview will be used to clarify and follow up on the actors identified in the document research, observations and interview-to-the-double. For each of the 4 installations, there will be 3 interviews, individually with the electrical contractor, project manager and engineer as well as key stakeholders whose work are essential to the installation project (e.g. general manager and procurement manager).

- Within one week after the installation, the interview will be conducted in person, for 40 minutes with each of the above participant. The locations of the interviews will be determined based on the participant's preferences.

- Within one week after solar power is switched on, which could occur up to 1 month after the installation, the interviews will be conducted over the phone with the above participants for 20 minutes. This interview will explore learning that occurs after the installation.

Broad topics for discussion

- Background to the relationship between the contractor and organisations involved in the installation
- Learning and lessons gained from the installation
- Special tools and systems used to complete installations
- Common problems and issues in installations
- The expected roles and tension with everyday contract work
- Factors facilitating collaboration in installation contract work

Examples of prompts

- I noticed during the installation [situation x] happened. Can you please tell what you think of that situation?
- It was interesting that [actor x] is involved. Can you tell me about how that came about?
- And what do you think lead to [actor x]?
- About that [decision x] you mentioned, how did it come about?
- What were some of the changes that you had to make throughout this installation? How were those changes negotiated?
- I notice that [action x] is different from what is listed in [document x]. Can you tell me how the change was negotiated?
- What do you think are the influential factors contributing to the success of this installation?
- How did [factor x] come about?
- What are the missing links in this installation?
- How do you think they came about?
- What learning did you gain from this installation?
- What learning arise for you and your team?
- How did the learning arise?
- What were some of the learning/issues since you finished installing the panels?

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