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Are planners ready for a digital transformation? An exploration of digital planning tools and urban planners' confidence using ICTs

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ABSTRACT

Information and communication technologies (ICTs) present planning professionals with increasing capacity to communicate, analyse, and collaborate. Although there is a plethora of ICTs available to planners, the planning literature has repeatedly asserted that planners are slow to adopt new ICTs. Despite this, little is known about planners' actual usage of ICTs in practice, perceptions of ICTs, and confidence using different practice-relevant ICTs. This article draws on social cognitive theory and data collected through an online survey of planning practitioners in Australia and the United Kingdom, to explore how confident planners are using ICTs in practice and the degree to which their perceptions of ICTs influence their actual usage of ICTs. The paper argues that while challenges remain, a successful transition towards the use of new digital planning tools within planning practice in Australia and the UK is likely due to a high level of confidence by planners in the use of ICTs.

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Information and communication technologies (ICTs); urban planning; confidence; computer self-efficacy; social cognitive theory

1. Introduction

Information and communications technologies (ICTs) are changing planning practice with promises of efficiency, transparency, and public engagement (Hersperger et al. 2021; Wilson and Tewdwr-Jones, 2022). As ICTs become more integrated into planning there has been a shift from discourses focused on the smart/digital city towards more mundane and pragmatic concerns focused on bridging the gap between planning theory, practice, and digital transformation processes (Goodchild 2020). While attention has been focused on the ways digital planning might make planning more transparent, efficient, and democratic, concerns remain about the potential for digital planning to perpetuate digital divides and democratic deficits within communities (Boland et al. 2021; Porwol and Ojo 2019; Webber 1965).

As planning draws on advancements in Digital Twins, AI, and the IoT's to try make planning services more efficient, promote sustainable development, and improve quality

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of life, the potential ways in which these technologies can be institutionalized within planning practice are not clear (Sabri and Witte 2023). To be successful, their implementation will require a focus on socio-technical behaviours and context-specific factors within which planning is undertaken (Nochta et al. 2021). As such, the development of digital literacy skills for planners remains vitally important (Aviram and Eshet-Alkalai 2006). Empirical studies to date have focussed on the increasing availability, applicability, usefulness, and capabilities of various software and hardware in a planning context (Kahila-Tani, Kytta, and Geertman 2019; Lin and Geertman 2019; Russo et al. 2018; te Brömmelstroet 2017; Wilson, Tewdwr-Jones, and Comber 2017). Such research has largely focussed on distinct types of planning-relevant ICTs such as geographic information systems (GIS), planning support systems, e-planning, and urban informatics (Potts and Webb 2023). Many studies have also explored the barriers limiting use of specific ICTs, however, there remains little consideration of planners' confidence using ICTs, and the impact of their cognitive perceptions of ICTs on their use of ICTs in practice.

Responding to this gap, this research seeks to explore the relationship between planners' confidence with ICTs and their actual usage of ICTs in practice. The research is centred around the following questions:

1. What level of computer self-efficacy (i.e. confidence using computers) is evident in planning practitioners?
2. Does computer self-efficacy influence planners' confidence using specific ICTs?
3. Does computer self-efficacy influence the frequency of ICT use by planners in practice?

Understanding this relationship has taken on new urgency as planning policy agendas across the globe actively promote digital planning to improve planning practice. Digital planning, defined by Potts and Webb (2023, 520) as the 'integration of ICTs into planning processes to support planning engagement, decision-making, daily practices, and strategies to achieve desired planning outcomes', is becoming an increasingly common public and private sector organizational objective and an ability to engage with related ICTs viewed as a critical planning skill (Batty and Yang 2022). In this paper, digital planning is situated within the wider literature on digital transformation to focus on the broader individual and organization change that is necessary to support the advancement of a digital planning agenda.

The paper is structured into three parts. Section 2.0 identifies how digital transformation processes are reshaping the way public and private sectors are organized and the potential impact of this for planning practice. Section 2.0 provides an overview of ways of conceptualizing the drivers of individual's use of ICTs and explores the degree to which they have been applied in a planning context. Section 4.0 draws on Social Cognitive Theory (SCT) and the work of Cretchley (2007) to develop a conceptual framework and online-survey methodology to answer the questions above. Section 5.0 presents the results of an online-survey of planning practitioners in Australia and the United Kingdom (UK) and explores the relationship between planners' computer self-efficacy, confidence using specific types of planning-relevant ICTs, and their actual use of ICTs in practice. The paper concludes in section 6.0 with a discussion of the research's key findings, recommendations for practice, and future research.

2. Digital transformation

The last several decades have seen dramatic changes in the use and availability of ICTs within and beyond the workplace. This has led to concerted attempts by private and public organizations to undertake digital transformation processes in response to competition, consumer demands, and in the case of the public sector, citizen and political expectations in relation to service delivery (Mergel 2019). Definitions of digital transformation vary, particularly depending on the focus on either private or public sector organizations. Private sector definitions highlight digital transformation as being at the heart of a holistic process of organizational adjustment that is made possible because of ICTs, resulting in internal institutional change to improve competitiveness as well as spur change within the wider industry (Chanias, Myers, and Hess 2019; Kraus et al. 2021). In contrast public sector definitions of digital transformation focus on the use of ICTs for continuous enhancements to service delivery, citizen engagement, and value creation, alongside the alteration of institutional, organizational, and cultural processes to allow for greater citizen and stakeholder co-production (Gasco-Hernandez et al. 2022).

Important across both sectors is the emphasis on digital transformation to bring about organizational and cultural change as well as a gradual move away from a previous focus in the literature on technology as the key factor for successful digital transformation and more towards individuals and institutional strategies (Kuhlmann and Heuberger 2023; Mergel 2019). For digital transformation strategies to be successful, it is argued that there is a need for a 'level of mastery of digital technologies relevant to the sector' and a 'level of business model readiness for digital operation' (Tekic and Koroteev 2019, 686–687). This highlights the need to understand the existing technological skills and capabilities of planners alongside their willingness to accept new ways of working if digital transformation, and more specifically digital planning, is to be successfully implemented within planning. Yet, as Dukić, Dukić, and Bertović (2017) identified, the introduction of new technologies within workplaces can sometimes result in poor levels of acceptance by workers because of concerns about the usefulness of new ICTs along with decreased staff satisfaction due to a potential lack of support, resources, and poor implementation. This is often coupled with resistance to digital transformation based on concerns about increased workload, decline in working conditions, loss of autonomy, and fears of being replaced by ICTs (Baldwin, Gauld, and Goldfinch 2012; Meijer 2015).

Resistance is not universal, however, as recent research has shown high levels of acceptance of digital transformation strategies, such as within the public sector in Greece (Bousdekis and Kardaras 2020). While acceptance might be high in some cases, it was also noted that digital skills were low, leading to concerns that attempts to implement digital transformation could be stifled by a lack of employee knowledge and expertize (Bousdekis and Kardaras 2020). Opportunities for digital learning can occur spontaneously through collaboration and discussion among employees or more deliberately through the provision of educational resources, support, and training (Sousa and Rocha 2019). Digital confidence then becomes key, as noted by Armstrong's (2019) research on digital confidence in higher education that suggests it is a critical, yet often underappreciated, factor in the successful adoption of new technologies. Armstrong notes that while digital competence refers to technical skills, digital confidence

encompasses the belief in one's ability to use those skills effectively, especially in dynamic or high-stakes environments. She argues that confidence, not just competence, is central to technology-enhanced learning, as it influences an individual's willingness to experiment, take risks, and persist through technical or conceptual challenges.

Bousdekis and Kardaras (2020) argue that the incorporation of educational programmes for employees based on their department, background, and job role are fundamental to support digital transformation. The study by Bousdekis and Kardaras (2020) largely focussed on benchmarking how public administrations in Greece are defining and approaching digital transformation. It does not explore these issues specifically in the context of planning, nor does it engage with the individuals within local government and their capacity to engage with digital transformation. The emphasis Bousdekis and Kardaras (2020) place on individual skills and digital learning in driving digital transformation suggests that there is a need to more clearly understand the role of planners and their confidence with ICTs as individuals working in local government and engaging with digital transformation.

Goodchild (2020) argues for a conceptualization of digital technologies based on pragmatic approaches that work to bridge technology and planning theory. To do this he leans on socio-technical studies which argue for a 'technology in practice' understanding that acknowledges the ways in which technology engages with people, their practices, and the tangible, material conditions that underpin decision-making processes (Orlikowski and Scott 2008). Technology is therefore understood to be embedded within a social context, not merely as an artificial object, but as something that individuals actively use, alter, and interpret in their everyday lives. This interaction between technology and users was explored by Orlikowski (2005) through reference to a relationship between resistance and accommodation. Here, resistance occurs because of the introduction of technology that disrupts established routines, challenges existing power dynamics, or creates barriers to useability. Yet, through the course of the interaction between technology and users, the users may adapt to the technology through a process of accommodation, changing their practices, or altering the technology to suit their individual needs and local context. Drawing on Pickering's (1995) notion of the 'mangle of practice' where human agency and technologies co-construct themselves, Orlikowski (2005) likened this to a process of 'entanglement' resulting in a complex, dynamic relationship between people and technologies. This is explored in this research in relation to planners relationship with ICTs, identifying areas of resistance and accommodation within local and individual planning practice and how the process of 'entanglement' unfolds based on an understanding of individuals' and planners' use of ICTs.

3. Understanding individuals' and planners' use of ICTs

Theories of how adults learn, both in a workplace environment and in their private lives have been debated for over 70 years by scholars in psychology, mathematics, science, anthropology, and other disciplines. Theories of learning in the twentieth century conceptualized learners as passive and the process of learning driven by the cognitive abilities and other individual characteristics of learners (Glaser 1989). However, more contemporary studies of learning argue that learning as an active process in which learners are influenced by a range of dynamic factors (e.g. their learning environment, personal

motivation, and social interactions) (Illas-Limson 2025; Murtonen and Lehtinen 2020). These studies see learning as a nuanced process that can be incidental or deliberate, through different methods such as observation, memorization, or repetition (Marsick and Watkins 2015). Newer theorizations of learning emphasize that a person's cognitive or individual mindset influences their willingness to engage in learning activities, and this willingness (and thus learning) adjusts over time in response to environmental and social factors in their learning environment (such as a workplace) (Illas-Limson 2025).

Since the 1960s theorists across disciplines (including those exploring theories and practices of learning) have sought to explain what specifically motivates individuals' to learn and use different types of ICTs (Compeau and Higgins 1995; Davis, Bagozzi, and Warshaw 1989; Frambach and Schillewaert 2002; Katz, Haas, and Gurevitch 1973; Rogers 1962). Day to day life has become increasingly reliant on ICTs, however, use of ICTs varies spatially, professionally, culturally, and demographically. Numerous digital transformation studies in the last two decades have found that an individual's cognitive perceptions play a significant role in the degree to which they actually use different types of ICTs in their home or workplace (Shiau et al. 2020; Wangpipatwong, Chutimaskul, and Papasratorn 2008).

The Technology Acceptance Model (TAM) and Social Cognitive Theory (SCT) are two of the most cited approaches to studying the use of ICTs by individuals. Both these theories view the use of ICTs 'as the result of a set of beliefs about technology and a set of affective responses to the behaviour' (Compeau and Higgins 1995, 146). While the TAM is predominantly focussed on individual's cognitive perceptions and beliefs related to a single ICT, SCT takes a more holistic approach that suggests individuals' use of ICTs reflect a reciprocal interaction between their perceptions of computer self-efficacy, environment, and experiences with ICTs (Shu, Tu, and Wang 2011), echoing the process of entanglement discussed in socio-technical studies. The TAM was proposed by Davis, Bagozzi, and Warshaw (1989) as a framework to theorize individuals' use of ICTs. TAM has been used and verified in a multitude of disciplines over 30 years (Kim and Shin 2015; Marangunić and Granić 2015). Drawing on the sociological theories of reasoned action and planned behaviour, the TAM can be used to predict or explain the uptake of innovative ICTs, or identify bottlenecks preventing the adoption of new technologies in an organization or sector (Evans et al. 2014).

The framework is centred around two constructs: the perceived usefulness, and the perceived ease of use of a specific computer technology (Davis, Bagozzi, and Warshaw 1989). TAM assumes that these two constructs then influence an individual's intentions, and subsequent actual use of a technology (See Figure 1). The model was extended by Venkatesh and Davis (2000) with the inclusion of external social influences as an additional contributing factor to individuals' use of technology (TAM 2), and again by Venkatesh and Bala (2008) with an expansion on the relationship between computer anxiety, behavioural intention, and perceived ease of use (TAM 3). The TAM has continued to be applied, developed and extended based on studies in a variety of contexts since the 2000s, including education (Binyamin, Rutter, and Smith 2019), financial services (Venkatesh and Bala 2008), construction (Elshafey et al. 2020), and urban planning (Vonk, Geertman, and Schot 2005).

Computer self-efficacy is the key anchor in the TAM 3 (see Figure 1) and is considered a significant determinant of individuals' use of ICTs according to SCT (Middleton, Hall,

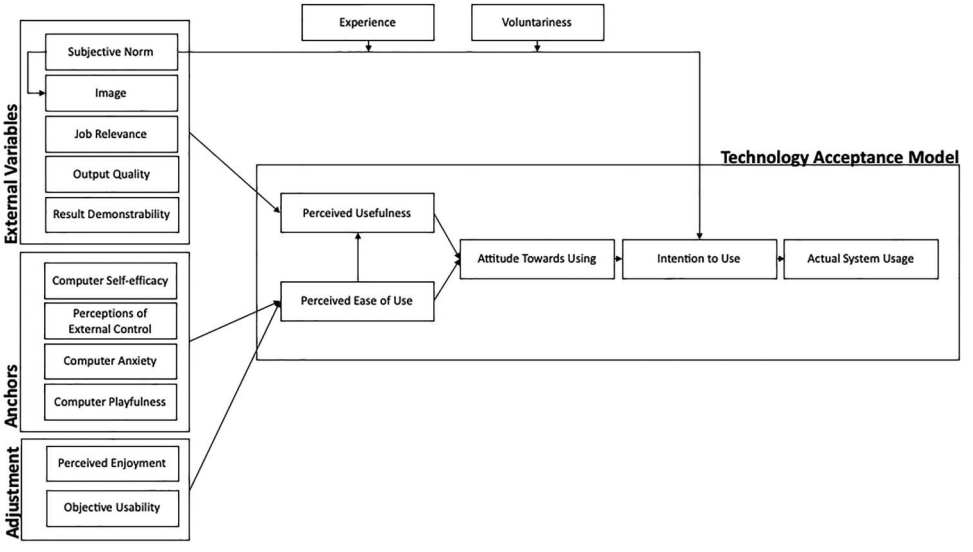

Figure 1. A simplification of the Technology Acceptance Model (TAM) 3 (Source: Authors, based on the work of Venkatesh and Bala (2008)).

and Raeside 2019; Taherdoost 2018; Venkatesh and Bala 2008). The concept of computer self-efficacy was developed by Compeau and Higgins (1995, 191) based on SCT and refers to 'an individual's perception of his or her ability to use computers in the accomplishment of a task'. It is argued that individuals who have a high degree of computer self-efficacy perceive themselves to be capable of completing tasks using computers, and competently use a variety of software packages (Ball et al. 2020; Kul, Aksu, and Birisci 2019; Wangpipatwong, Chutimaskul, and Papasratorn 2008). SCT argues that computer use is shaped by a combination of behavioural, cognitive and personal factors, with self-efficacy acting as the primary regulatory mechanism and influence on human behaviour (See Figure 2) (Hwang and Yi 2002; Shiau et al. 2020).

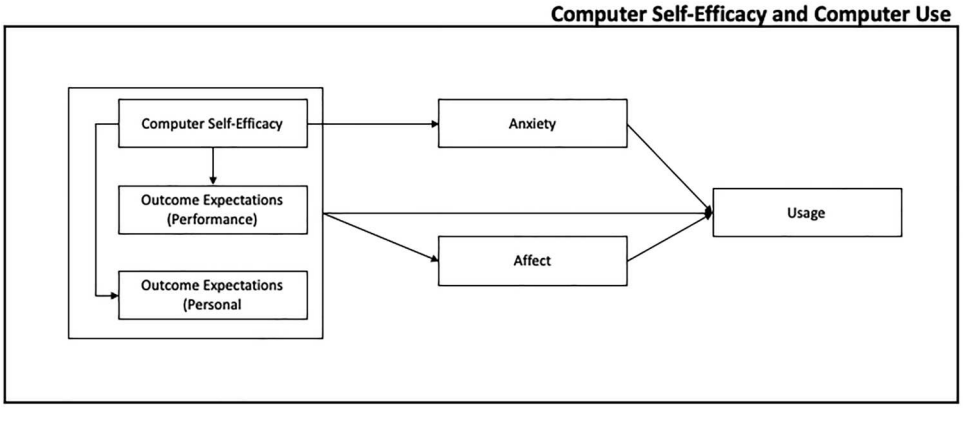

Figure 2. The relationship between computer self-efficacy and use of computers (Source: Authors, based on the work of Compeau and Higgins (1995)).

There is currently no research that explores the self-efficacy of urban planning practitioners, however the principle of 'perceived usefulness' of ICTs has been applied in a limited way to explore the use of Planning Support Systems (PSS) by spatial planning consultants and researchers (Vonk, Geertman, and Schot 2005). The PSS literature has focussed on the perceived usefulness section of the TAM by developing the concepts of utility and usability as measures of the usefulness of PSSs in greater detail (Jiang, Geertman, and Witte 2020; Pelzer 2017; te Brömmelstroet 2017). This stream of PSSs research seeks to measure the usefulness of PSSs and whether limited use of PSSs in practice is due to limited perceived usefulness of PSSs to planners in practice to achieve specific outcomes (te Brömmelstroet 2017). Studies of the usefulness of PSSs generally concentrate on the efficiency, outputs, effectiveness, and added value, with a focus on the specific PSS instrument, rather than the users of PSSs (Jiang, Geertman, and Witte 2020; Pelzer 2017; Pelzer et al. 2014).

PSS are only one of many ICTs used by planners. While there is an abundance of academic studies exploring how different ICTs can be used in planning practice (e.g. GIS, e-planning, design software, etc.) (Crichton 2018; Jiang, Geertman, and Witte 2020; Kempa and Lovett 2019; Lin and Geertman 2019; Wilson, Tewdwr-Jones, and Comber 2017), there are currently no studies exploring the cognitive perceptions, self-efficacy or confidence of planners as users of different types of ICTs. Additionally, aside from PSS, little is known about the perceived usefulness or perceived ease of use of ICTs in planning practice such as GIS, or e-planning platforms. Studies have repeatedly argued since the 1990s that planners have been slow to adopt and integrate certain ICTs into their practice, suggesting a need to better understand the cognitive factors influencing planners' uses of ICTs (Goodspeed 2016; Hanzl 2007; Klosterman 1997; Stillwell, Geertman, and Openshaw 1999). There are also numerous papers demonstrating the usefulness of different ICTs to planning practice (Jiang, Geertman, and Witte 2020; Larsson et al. 2014), further emphasizing a gap in our understanding of planners cognitive perceptions of ICTs and how that influences the ICTs planners ultimately use in practice. This paper seeks to fill this gap.

4. Research design and methods

This research uses a SCT approach to understanding planners' computer self-efficacy. Numerous scale instruments have been developed to measure computer self-efficacy (Cassidy and Eachus 2002; Chen 2017; Compeau and Higgins 1995; Cretchley 2007; Laver et al. 2012; Murphy, Coover, and Owen 1989). In this research we chose to use the Technology Confidence and Attitude (TCAT) instrument developed by Cretchley (2007) to explore planners' computer self-efficacy and use of different ICTs in practice. The TCAT instrument is an 11 item, five scaled Likert-based survey instrument based on SCT used in tertiary education research designed to measure individual adult's confidence (including self-efficacy) with computers (See Table 1) (Cretchley 2007). The 11 questions predominantly focus on self-efficacy, but also include questions exploring self-concept (perceptions of an individual's abilities), anxiety, and motivation as factors influencing confidence using computers (Cretchley 2007). The TCAT instrument was selected because of its simplicity, applicability across settings, and demonstrated reliability as an instrument to measure individuals' confidence using computers.

Table 1. TCAT instrument for measuring computer confidence.

	Questions
1.	I have less trouble learning how to use a computer than I do learning other things
2.	When I have difficulties using a computer, I know I can handle them
3.	I am not what I would call a computer person*
4.	I enjoy trying new things on a computer
5.	It takes me longer to understand computers than the average person*
6.	I have always struggled learning how to use computers and software*
7.	I find having to use computers frightening*
8.	I find many aspects of using computers interesting and challenging
9.	I don't understand how some people seem to enjoy so much time at a computer*
10.	I have never been very excited about computers*
11.	I find using computers confusing*

* Questions worded negatively to reduce the effect of responses biased towards favouring the direction suggested by the wording.
Source: (Cretchley 2007).

This research focussed on benchmarking planners' confidence and use of ICTs by combining the TCAT with questions focussed on quantifying planners' use of different ICTs (Figure 3). The TCAT instrument was used to establish planners' confidence using computers/ICTs in a broad sense. Once this was established, planners were queried on their confidence using 15 ICTs commonly mentioned in the planning literature, such as geographic information systems, social media, and planning support systems, and their frequency of use of such ICTs each week. This approach revealed the most used ICTs by planners, and planners' confidence using computers generally, and how this influences the use of different discipline/task specific ICTs in planning practice.

An online survey was designed around the TCAT instrument, and included additional questions on the frequency, and confidence using specific types of ICTs discussed in the planning literature (see Figure 3). A mixture of 17 open and closed ended questions were used to extrapolate the relationship between planners' cognitive perceptions of different

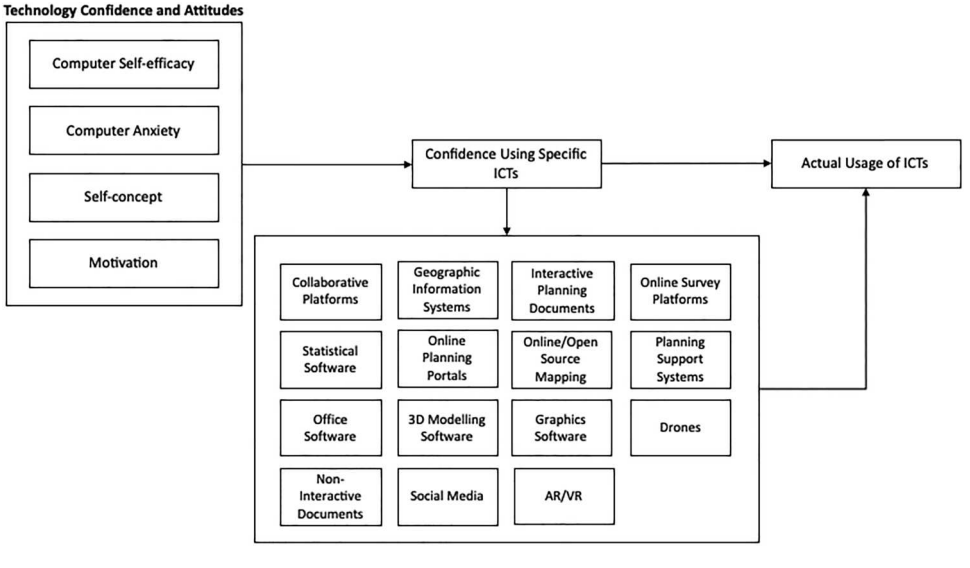

Figure 3. Conceptualization of the relationship between TCAT, planners' confidence using specific ICTs, and their actual usage of specific ICTs in planning practice (Source: Authors).

ICTs and their actual use in practice. Australia and the UK were selected as the case studies for this research due to their planning systems having shared 'historical, cultural, and legal' values and administrative systems, reflecting Australia's history as a British colony (Austin, Gurran, and Whitehead 2014). This, combined with the increasing attention on digital planning in both countries and the significant investment being made by different scales of government in progressing the digital planning agenda in each country, made them ideal to study and compare the confidence of planners in using ICTs. Consequently, the findings of this study are likely to be applicable to other countries with similar structures and values underpinning their planning systems, such as the USA, Canada, New Zealand, Ireland, and others. Previous studies have demonstrated that the use of ICTs is measurably different between the UK and Australia (Daniel et al. 2024; Potts and Webb 2023), and this study seeks to explore this difference further.

Participants for the survey were recruited through professional bodies, mailing lists, LinkedIn, Twitter, and the personal networks of the authors in Australia, and the UK. The recruitment of participants though social media may mean that some participants already had a base level of skills and confidence using technology, however the recruitment of participants through membership groups such as the Royal Town Planning Institute and Planning Institute of Australia mailing lists was intended to reach participants with a more varied level of technological skills. Participants were invited to participate between September 2020 and June 2021.

A total of 66 planners completed the survey (Australia = 31, UK = 35). The small sample size is likely due to the timing of the survey during the global COVID-19 pandemic, and a key limitation in the representativeness of the data presented in this study. Participants represent views from all the devolved nations of the UK, and states of Australia. Consequently, different devolved planning arrangements are represented in the findings of this study, and individual responses reflect significant geographic variability in local, state and national planning cultures, structures and resourcing within each country.

A summary of participants can be found in Table 2.

Table 2. Summary of participants (Source: Authors).

	Australia	UK	Total
Gender			
Female	14	16	30
Male	17	19	36
Age			
21–30	11	16	27
31–40	10	9	19
41–50	7	3	10
51–60	3	6	9
>61	0	1	1
Experience			
< 1 year	0	3	3
>1–5 years	8	9	17
>5–10 years	11	7	18
>10–15 years	4	3	7
>15 years	8	13	21
Sector			
Public/Government	25	16	41
Private	6	17	23
Other	0	2	2

Data was analysed using descriptive statistics to identify the median and mode across the Likert scale categories used as well as percentages to compare different responses. This was complemented by non-parametric statistical tests. Mann–Whitney was utilized to determine statistical difference between public and private sector responses as well as between country of origin. Independent Samples Kruskal–Wallis was utilized to determine statistical difference between age and experience across multiple age groups and years of experience. Kendall's tau-b was used to determine the association between frequency of use of ICTs and confidence using them as well as confidence with software and troubleshooting ICTs.

5. Findings

5.1. Planners' computer self-efficacy

At an individual level, successful digital transformation of planning practice requires an alignment between an ability to build off employees existing skills, confidence to engage with change and new technology, and willingness to learn new skills. Survey results highlight that planners may be well prepared to engage with digital transformation in the workplace (Table 3). Most participants agreed that they can manage difficulties when using a computer, enjoy trying new things on a computer, and find computers interesting and challenging, demonstrating an openness to the use of new technology and software. Many participants also felt that that they were more computer literate than the average person, did not struggle to learn computers or software, were not afraid of using computers, and did not find computers confusing. This self-identified self-efficacy suggests there should be a relative ease in introducing new technology or software within planning practice.

The level of resistance to digital transformation is not evenly spread across sectors (Bjerke-Busch and Aspelund 2021), and indeed as noted earlier the very definition of digital transformation can vary by public and private sector. Bjerke-Busch and Aspelund (2021) highlight a wider range of institutional barriers to digital transformation in the public sector compared to the private sector. It is therefore important to consider whether there is variation in terms of response between the public and private sectors. The survey highlights two questions with statistical differences between sectors (Table 4). At first glance Question 2 (When I have difficulties using a computer, I know I can handle them) appear similar between sectors (all 'agree' responses across the median and mode). A statistical difference between public and private sector responses is however noted for this question as a closer look at the distribution highlights a contrast between the public sector (10% 'strongly agree') versus the private sector (29% 'strongly agree') in terms strength of agreement and contrast in relation to the disagree response (4% 'disagree' versus 20% 'disagree'). This suggests that while there is general confidence among participants in dealing with difficulties there is a greater pool of those who feel more able within the private sector compared to the public sector. In a UK context, this largely reflects the impacts of austerity policies on local planning authorities, whose limited funding is generally focussed on delivering core planning functions, rather than digital innovation or developing planners' digital skills. In both countries, however it also reiterates the findings of Potts and Milz (2024) that private sector

Table 3. All participants' responses to 11 items in the TCAT instrument (Source: Authors).

	Questions	Median	Mode	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
1.	I have less trouble learning how to use a computer than I do learning other things	Neither agree or disagree	Neither agree or disagree	0	7.7	**47.7**	32.3	12.3
2.	When I have difficulties using a computer, I know I can handle them	Agree	Agree	0	13.8	24.6	**44.6**	16.9
3.	I am not what I would call a computer person*	Neither agree or disagree	Neither agree or disagree	24.6	23.1	**27.7**	23.1	1.5
4.	I enjoy trying new things on a computer	Agree	Agree	0	15.4	21.5	**43.1**	20
5.	It takes me longer to understand computers than the average person*	Disagree	Disagree	21.9	**43.8**	28.1	6.3	0
6.	I have always struggled learning how to use computers and software*	Disagree	Disagree	23.1	**49.2**	21.5	6.2	0
7.	I find having to use computers frightening*	Strongly Disagree	Strongly Disagree	**53.8**	30.8	13.8	1.5	0
8.	I find many aspects of using computers interesting and challenging	Agree	Agree	3.1	7.7	35.4	**44.6**	9.2
9.	I don't understand how some people seem to enjoy so much time at a computer*	Neither agree or disagree	Neither agree or disagree	15.4	21.5	**40.0**	15.4	7.7
10.	I have never been very excited about computers*	Disagree	Disagree	18.5	**33.8**	24.6	18.5	4.6
11.	I find using computers confusing*	Disagree	Disagree	40	**43.1**	10.8	3.1	3.1

*Questions worded negatively to reduce the effect of responses biased towards favouring the direction suggested by the wording.

planning consultancies invest greater amounts of time and funding into the use of ICTs because they see them as enhancing their marketability and desirability to clients over other consultancies.

The other statistical difference in response by sector was to the question 'I find many aspects of using computers interesting and challenging'. Here there was greater indifference with 40% of the public sector selecting 'neither agree or disagree' compared to 26% of the private sector. Public sector planners may therefore require more of a push to engage with some digital transformation processes as suggested within the wider public sector focused literature.

A more pronounced difference was seen when the survey results were broken down by country (Table 5). Australian planners were generally more positive and confident in their use of computers and software compared to UK planners. Statistical differences were seen across 5 of the 11 TCAT instrument questions. At 27% a higher percentage of Australian participants strongly agreed that when they have difficulties using a

Table 4. Participants' responses by sector to 11 items in the TCAT instrument (Source: Authors).

	Questions	Private Sector ($N = 23$)		Public Sector ($N = 40$)		Mann-Whitney
		Median	Mode	Median	Mode	
1.	I have less trouble learning how to use a computer than I do learning other things	Agree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	0.117
2.	When I have difficulties using a computer, I know I can handle them	Agree	Agree	Agree	Agree	**0.028****
3.	I am not what I would call a computer person*	Disagree	Strongly Disagree	Neither agree or disagree	Neither agree or disagree	0.814
4.	I enjoy trying new things on a computer	Agree	Agree	Agree	Agree	0.153
5.	It takes me longer to understand computers than the average person*	Disagree	Disagree/ Strongly Disagree^	Disagree	Disagree	0.988
6.	I have always struggled learning how to use computers and software*	Disagree	Disagree	Disagree	Disagree	0.324
7.	I find having to use computers frightening*	Strongly Disagree	Strongly Disagree	Disagree	Strongly Disagree	0.069
8.	I find many aspects of using computers interesting and challenging	Agree	Agree	Neither agree or disagree	Neither agree or disagree / Agree^	**0.027****
9.	I don't understand how some people seem to enjoy so much time at a computer*	Neither agree or disagree	Neither agree or disagree / Disagree^	Neither agree or disagree	Neither agree or disagree	0.628
10.	I have never been very excited about computers*	Disagree	Disagree	Neither agree or disagree / Agree	Disagree	0.501
11.	I find using computers confusing*	Strongly Disagree	Strongly Disagree	Disagree	Disagree	0.096

* Questions worded negatively were reverse scored.
**Statistically significant result at 0.05 level.
^Multiple modes exist.

computer, they know they can handle them compared to only 9% of UK planners. 20% of Australian planners also 'disagreed' with the statement 'I enjoy trying new things on a computer' compared to 10% of UK planners while only 3% of Australian planners 'strongly disagreed' or 'disagreed' that they found many aspects of using computers interesting and challenging compared to 17% of UK planners who 'strongly disagreed' or 'disagreed'. In addition, 3% of Australian planners 'neither agreed or disagreed' with the statement 'I find having to use computers frightening' compared to 27% of UK planners while 93% of Australian planners 'strongly disagreed' or 'disagreed' with the statement 'I find using computers confusing' compared to 74% of UK planners. These country differences suggest that wider cultural, educational, and institutional factors may impact how planners engage with computers and software in their daily working practices.

Studies related to the relationship between age and the perceived ease of use, perceived usefulness, and intention to use a technology have been mixed, however a meta-analysis by Hauk, Hüffmeier, and Krumm (2018) has shown a negative relationship overall between these variables. In contrast to the meta-study, planning survey participants showed little variability across ages (Table 6). The only statistical difference was found in relation to the question 'I find using computers confusing', where 54% of 21–30 year old participants strongly disagreed with this statement compared to 37% of 31–40 year olds and 40% of 41–50 year olds and 10% of participants older than 51.

Table 5. Participants' responses by country to 11 items in the TCAT instrument (Source: Authors).

	Questions	Australian Planners ($N = 31$)		UK Planners ($N = 35$)		Mann-Whitney
		Median	Mode	Median	Mode	
1.	I have less trouble learning how to use a computer than I do learning other things	Agree	Agree	Neither agree or disagree	Neither agree or disagree	0.434
2.	When I have difficulties using a computer, I know I can handle them	Neither agree or disagree / Agree	Strongly Agree	Agree	Agree	**0.047****
3.	I am not what I would call a computer person*	Disagree	Disagree	Neither agree or disagree	Neither agree or disagree	0.930
4.	I enjoy trying new things on a computer	Agree	Agree	Agree	Agree	**0.043****
5.	It takes me longer to understand computers than the average person*	Disagree	Disagree	Disagree	Disagree	0.720
6.	I have always struggled learning how to use computers and software*	Strongly Disagree	Strongly Disagree	Disagree	Disagree	0.334
7.	I find having to use computers frightening*	Disagree	Disagree	Disagree	Strongly Disagree	**0.014****
8.	I find many aspects of using computers interesting and challenging	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	**0.010****
9.	I don't understand how some people seem to enjoy so much time at a computer*	Disagree	Disagree	Neither agree or disagree	Neither agree or disagree	0.183
10.	I have never been very excited about computers*	Strongly Disagree	Strongly Disagree	Neither agree or disagree	Disagree	0.161
11.	I find using computers confusing*	Disagree	Disagree	Disagree	Disagree	**0.020****

* Questions worded negatively were reverse scored.
**Statistically significant result at 0.05 level.

Professional experience working as a planner was used to identify whether institutional and cultural barriers to ICTs changed the longer a participant worked in the field. As with age, there was very little variation in terms of responses by working experience (See Table 7). The only statistically significant difference was in relation to the question 'I enjoy trying new things on a computer'. Those with less than 1–5 years of experience and more than 5–10 years of experience were more likely to Agree (55% and 47%) to this statement than those with more than 10 years of experience (32%).

5.2. The impact of self-efficacy on use of ICTs by planners

As planning practice internationally works towards digital transformation, high levels of computer self-efficacy will become important to ease the transition to a more digital working environment. This was first measured through an exploration of the relationship between how frequently an ICT was used and an individual's confidence using it (Table 8). A range of common ICTs was identified for inclusion, such as office software, statistical software, GIS, and social media alongside more novel technologies. 3D modelling software was included due to its potential role in assessing urban growth, impacts of developments, and potential to improve stakeholder engagement (Al-Douri 2010). Planning support systems were included due to their ability to assist planners in scenario-analysis and

Table 6. Participants' responses by age to 11 items in the TCAT instrument (Source: Authors).

		21–30 (N = 45)		31–50 (*N* = 26)		51+ (*N* = 10)		Independent Samples Kruskal-Wallis
	Questions	Median	Mode	Median	Mode	Median	Mode	
1.	I have less trouble learning how to use a computer than I do learning other things	Agree	Agree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	0.719
2.	When I have difficulties using a computer, I know I can handle them	Agree	Agree	Agree	Agree	Neither agree or disagree / Agree	Disagree / Agree^	0.781
3.	I am not what I would call a computer person*	Neither agree or disagree / Disagree	Neither agree or disagree / Disagree^	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	Agree	0.683
4.	I enjoy trying new things on a computer	Agree	Agree	Agree	Agree	Neither agree or disagree	Disagree / Neither agree or disagree^	0.228
5.	It takes me longer to understand computers than the average person*	Disagree	Disagree	Disagree	Disagree	Neither agree or disagree	Neither agree or disagree	0.087
6.	I have always struggled learning how to use computers and software*	Disagree	Disagree	Disagree	Disagree	Disagree	Disagree	0.916
7.	I find having to use computers frightening*	Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree	Disagree	Disagree	0.182
8.	I find many aspects of using computers interesting and challenging	Neither agree or disagree	Neither agree or disagree	Agree	Agree	Agree	Agree	0.574
9.	I don't understand how some people seem to enjoy so much time at a computer*	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	0.886
10.	I have never been very excited about computers*	Disagree	Disagree	Neither agree or disagree	Disagree	Disagree	Disagree	0.852
11.	I find using computers confusing*	Strongly Disagree	Strongly Disagree	Disagree	Disagree	Disagree	Disagree	**0.019** **

*Questions worded negatively were reverse scored.
**Statistically significant result at 0.05 level.
^Multiple modes exist.

Table 7. Participants' responses by professional experience to 11 items in the TCAT instrument (Source: Authors).

	Questions	<1–5 years ($N = 20$)		>5–10 years ($N = 17$)		>10 years ($N = 28$)		Independent Samples Kruskal-Wallis
		Median	Mode	Median	Mode	Median	Mode	
1.	I have less trouble learning how to use a computer than I do learning other things	Agree	Agree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	0.195
2.	When I have difficulties using a computer, I know I can handle them	Agree	Agree	Agree	Agree	Agree	Agree	0.617
3.	I am not what I would call a computer person*	Disagree	Disagree / Strongly Disagree^	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	Agree	0.404
4.	I enjoy trying new things on a computer	Agree	Agree	Agree	Agree	Neither agree or disagree	Neither agree or disagree / Disagree^	**0.04****
5.	It takes me longer to understand computers than the average person*	Disagree	Disagree / Strongly Disagree^	Disagree	Disagree	Neither agree or disagree / Disagree	Neither agree or disagree	0.176
6.	I have always struggled learning how to use computers and software*	Disagree	Disagree	Disagree	Disagree	Disagree	Disagree	0.604
7.	I find having to use computers frightening*	Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree	Disagree / Strongly Disagree	Strongly Disagree	0.559
8.	I find many aspects of using computers interesting and challenging	Neither agree or disagree / Agree	Neither agree or disagree / Agree^	Neither agree or disagree	Agree	Agree	Agree	0.38
9.	I don't understand how some people seem to enjoy so much time at a computer*	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	Neither agree or disagree	0.422
10.	I have never been very excited about computers*	Disagree	Disagree	Disagree	Disagree	Neither agree or disagree	Disagree	0.828
11.	I find using computers confusing*	Strongly Disagree	Strongly Disagree	Disagree	Disagree	Disagree	Disagree	0.073

* Questions worded negatively were reverse scored.
**Statistically significant result at 0.05 level.
^Multiple modes exist.

Table 8. Frequency of use of specific ICTs and confidence using specific ICTs (Source: Authors).

	Correlation coefficient	Sig. (2-tail)
Office software	−0.40	0.750
Collaborative platforms	**0.270****	**0.020**
Interactive planning documents	0.130	0.248
Statistical software	**0.374****	**<0.001**
Online/open-source street mapping	**0.348****	**<0.001**
Online planning portals	**0.467*****	**<0.001**
GIS	**0.592*****	**<0.001**
Non-searchable planning documents	**0.240****	**0.018**
Social media	**0.377*****	**<0.001**
Online survey software	**0.300*****	**0.003**
Graphics software	**0.599*****	**<0.001**
3D modelling software	**0.385*****	**<0.001**
Planning support systems	**0.504*****	**<0.001**
AR/VR	**0.435*****	**<0.001**
Drones	**0.367*****	**0.002**

**Statistically significant result at 0.05 level.
***Statistically significant result at 0.01 level.

decision-making (Geertman, Stillwell, and Toppen 2013). AR/VR meanwhile can be used to visualize development proposals in real-time (Schrom-Feiertag et al. 2018) while drones can provide high-resolution mapping for environmental monitoring (Bayomi and Fernandez 2023) and therefore were also included. In most cases, there was an association found, with the exception of office software and interactive planning documents. The strongest associations were found for graphics software, GIS, and planning support systems, perhaps due to the more technical nature of the graphics and GIS software and the variety of different types of planning support systems that exist. Weaker associations were found for collaborative platforms and non-searchable planning documents perhaps because these ICTs tend to be simpler to use and with more limited functionality.

Second, computer self-efficacy was explored through an analysis of the relationship between positive responses to the question 'When I have difficulties using a computer, I know I can handle them' and individual's confidence using specific ICTs. Table 9

Table 9. Association between confidence with software and troubleshooting ICTs (Source: Authors).

	Correlation Coefficient	Sig. (2-tail)
Office software	0.068	0.574
Collaborative platforms	0.188	0.096
Interactive planning documents	**0.304*****	**0.008**
Statistical software	0.201	0.066
Online/open-source street mapping	0.145	0.193
Online planning portals	0.077	0.486
GIS	**0.331*****	**0.002**
Non-searchable planning documents	0.124	0.262
Social media	**0.216****	**0.042**
Online survey software	0.099	0.350
Graphics software	0.133	0.217
3D modelling software	0.119	0.277
Planning support systems	**0.262****	**0.016**
AR/VR	0.158	0.157
Drones	0.052	0.646

**Statistically significant result at 0.05 level.
*** Statistically significant result at 0.01 level.

identifies four sets of ICTs that demonstrate a significant relationship between confidence with software and an individual's perceived ability to troubleshoot computer issues. A weak-to-moderate association was found between confidence using social media (0.216) and planning support systems (0.262) and an individual's perceived ability to handle computer issues. This may be because both ICTs tend to be user-friendly tools that individuals opt into using rather than an ICT that is typically required for their job. Social media is also likely an ICT that planners use in their private life, and thus be overall more familiar with its functions and interfaces. A moderate-to-high association was identified for interactive planning documents (0.304) and GIS (0.331). These ICTs tend to be less user-friendly but more regularly used in daily practice, perhaps suggesting individuals that use these feel more tech-savvy than those that use more user-friendly ICTs. No significant association was found between ICTs that are commonly used in practice such as office software and online planning portals or with more specialist, less frequently used, ICTs such as graphics software and drones.

The preceding analysis suggests that the increase in the use of ICTs in planning practice is likely to reduce resistance and ease the digital transformation transition, as the more ICTs are used in practice the more confident planners become using them. It can also be seen that some types of ICTs increase planners' confidence in technology more generally, suggesting a need to perhaps expose planners to a wider range of ICTs to help build their confidence in the use of different formats and types of ICTs.

More specifically, analysis of the survey data revealed that participants who expressed confidence in using more specialist ICTs, such as graphics software, 3D modelling tools, planning support systems, AR/VR, and drones, did not share any common demographic characteristics such as age, gender, experience, country, or sector. Additionally, their confidence was not consistent across different specialist tools, suggesting that these individuals are likely specialists in a narrow set of ICTs required by their specific roles, rather than broadly confident digital practitioners. This indicates that digital confidence in specialist ICTs is task-driven and context-specific, emerging from necessity rather than general digital fluency. As such, widespread adoption of these tools in planning practice is unlikely to occur until they become institutionalized and essential for performing core planning functions, highlighting the importance of aligning digital transformation efforts with practical, job-relevant applications.

6. Discussion and conclusion

Digital transformation has become a critical objective for organizations across a range of sectors, driven by the need to remain competitive and meet the needs of citizens and consumers (Mergel 2019), with planning being no exception. Central to achieving digital transformation is a greater understanding of the link between individual factors and the use of ICTs rather than a focus on the functions of specific technologies (Kuhlmann and Heuberger 2023). This process of negotiation between users and technology results in what Orlikowski (2005) describes as 'entanglement' or the 'mangle of practice', where human agency and technological systems continually shape and redefine each other. This process shapes how planners engage with technological change and can be understood through Orlikowski's (2005) concepts of resistance and accommodation. SCT and the TCAT instrument provided a useful framework for operationalizing these concepts by

identifying the link between self-efficacy, self-concept, and the use of ICTs in planning practice. It enabled this study to look beyond planners' confidence using a single type of ICT and instead look more broadly at their confidence using planning-relevant ICTs and associated entanglements. Based on this application, this research found evidence suggesting a successful transition towards the use of new digital planning tools within planning practice in Australia and the UK is likely due to a high level of confidence by planners in the use of ICTs. This indicates that digital confidence not only helps the adoption of digital planning ICTs but also facilitates dynamic interactions between planners and technology, where initial resistance can give way to accommodation, and ultimately to a deeper entanglement in which planners and ICTs co-evolve through practice. The research identifies specific gaps, particularly in the public sector and among different national contexts, where targeted training and support could further enhance digital capacity. By emphasizing the importance of individual confidence and organizational support, the research contributes to addressing the urgent need for more digital planners by offering a roadmap for developing a digitally skilled planning workforce, aligning with broader policy goals to modernize planning systems and improve service delivery through technology.

Despite this potential for optimism, challenges remain. The research suggests that public sector planners may require further supports and training to engage with digital planning practices, in line with previous research suggesting additional institutional barriers exist within the public sector (Bjerke-Busch and Aspelund 2021). The types of training needed by each planner to feel confident using job-relevant ICTs is likely determined by the specific needs of their job, with some types of planners needing to use certain specialized software (such as GIS) more frequently than other types of planners. Consequently, where increased training is made available to planners, it should focus on improving their confidence using ICTs that are most relevant to their day-to-day jobs, and the specific planning system that they are operating within, thereby reducing potential resistance to the technology as the users accommodate them through adaptation and the localization of specific ICTs to their daily needs.

The importance of a particular working culture was also apparent within the research, with differences found between Australian and UK planners. Confidence with the use of ICTs was higher amongst Australian planners who demonstrated more aptitude, enthusiasm, and comfort in problem-solving ICTs than their UK counterparts. This higher level of confidence is likely the reflection of the culture around digital transformation in each country and the systemic structures established to enact digital transformation of planning practice. Cultural differences between planners in the UK and Australia were explored in the context of digital planning by Potts and Milz (2024). Their study found that the culture around digital planning in the UK was founded in scepticism and concern around investing in new digital approaches that may not improve planning processes or outcomes. On the other hand, the same study found the culture around digital planning in Australia to be relatively positive, and founded on the idea that integrating ICTs in planning was a 'no brainer' for ensuring the transparency, efficiency and efficacy of planning processes (Potts and Milz 2024).

Differences in culture around digital planning are also likely tied to the degree to which planning education in each country includes ICTs, and the exposure of planners to best practice use of ICTs in planning processes, which in turn have an influence on

planners' confidence using ICTs. Digital confidence therefore becomes a critical enabler of innovation and transformation within planning. As planning increasingly relies on a wider range of digital tools, such as GIS, planning support systems, and data visualization platforms, planners' confidence in using these tools may directly affect their ability to engage with emerging digital planning practices. The research discussed in this paper highlights that planners with higher digital confidence are more likely to use a wider range of tools and to use them more frequently, suggesting a positive cycle of exposure, confidence, and adoption. Conversely, a lack of digital confidence may lead to risk aversion, reliance on outdated methods, and missed opportunities for more participatory, data-driven, and transparent planning processes.

The need for a digital transformation of urban planning in Australia's States and Territories has been acknowledged since the late 2000s, and has led to progressive reforms in data accessibility and availability, and the development of guidance regarding the structuring of plans and policies to enhance their consistency and interoperability (Williamson 2023). Simultaneously, broader State and National Government policies and legislation in Australia have been published over the last decade, requiring all levels of government to enhance their transparency through open data, and establishing a culture of technology use to enhance public services (Australian Government, 2022; Queensland Government 2015). These institutional processes have helped normalize digital planning practices and reduce resistance by integrating ICTs into everyday planning practice. In contrast, the UK's more fragmented and resource-constrained environment may have limited certain planners' opportunities to accommodate and entangle with new technologies. This suggests success factors for digital transformation may extend beyond just individual organizations and professions but be influenced by wider State and national institutional factors alongside wider process of entanglement. Unlike nationality, age and professional experience did not considerably vary, suggesting opportunities exist for digital transformation regardless of age or mix of experience within a planning organization, providing digital transformation is well structured and supported by broader planning governance structures. This research in combination with the findings of the work of Potts and Webb (2023) suggest that planning in Australia and the UK is at different stages of digital transformation. Given the evolving nature of ICTs, the planning systems in each country are well placed to learn from adjacent sectors who are further along in the digital transformation journey such as the property and real estate sector. Further research could explore the mechanisms and tipping points of digital transformation in the planning and property sectors, and best practice approaches to digital planning and public services.

The findings of the survey further strongly align with the UK report produced by the Digital Planning Taskforce which emphasized the need to build digital capacity and confidence within the planning profession (Batty and Yang 2022). The survey results highlight that planners generally possess high levels of computer self-efficacy, with many expressing confidence in handling computer-related challenges and a willingness to engage with new technologies. This supports the Taskforce's recommendation that digital transformation efforts should leverage existing digital competencies among planners while addressing sectoral disparities and become advocates of systemic change within the organizations that work within. The report's call for targeted investment in digital training and education in spatial planning is further echoed in the findings of this research.

The focus on the individual rather than a reliance on technology itself to spur digital transformation is well founded. The research identified the importance of frequency of use by a worker and their confidence in using specific ICTs. This suggests strong organizational support for the regular use of ICTs as a core work function alongside the importance of providing time and training is critical for supporting digital transformation. Yet, previous research has demonstrated that resourcing and time for training are viewed as lacking within planning practice in both countries (Potts and Webb 2023), potentially hindering future digital transformation efforts within planning. Exposure to a range of technology provides a further avenue for increasing planners ICT confidence, but again, this requires organizational support, training, and resourcing which is increasingly lacking in the planning sector. While planners are eager to engage in the digital transformation of their profession, the success of future digital planning efforts rests on the capacity of planning organizations to develop strategies that can tap into that enthusiasm while providing the resources necessary to continue to develop the confidence needed to embrace the expanding range of planning ICTs on offer.

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