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Roles of design in sustainability transitions projects: A case study of Visions and Pathways 2040 project from Australia

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ABSTRACT

Sustainability transitions require structural and systemic changes. Transitions research poses creative as well as analytical challenges due to high complexity and uncertainty associated with these projects. In this article we present an initial and exploratory investigation of roles design plays in transition projects focusing on Visions and Pathways 2040 (VP2040) project as a case study. VP2040 aims to develop visions, scenarios and pathways for low-carbon resilient futures in Australian cities. The project adopts a design-led approach, linking research and engagement in design-led future visioning. Our findings indicate that the roles design can play in sustainability transitions projects is various covering very tangible, technical, skills-based roles, to very intangible roles, relating to how information is received, processed and synthesised. Our findings also imply that, increasingly more, design practitioners will need to bring in skills and knowledge that have not been part of conventional design education, and therefore, institutions providing design education need to start developing and implementing curriculums that will equip graduates with these new professional capacities.

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1. Introduction

1.1. Cities as focus of sustainability and low-carbon transitions

Various sustainability challenges including climate change and associated economic and environmental disturbances, with implications for ecosystem and human, and social order will increasingly challenge the society (Hughes and Steffen, 2013; Huntingford et al., 2013; Rockström et al., 2009; Semenza, 2014; Wright et al., 2013). In the past years, cities have become the focus of strategic action in regards to climate change and sustainability (Ryan, 2013) and there has been a surge of theoretical and empirical explorations covering a diversity of topics including models for governing urban sustainability transitions (Fenton, 2016; Khan, 2013), production and consumption in cities (Vergragt et al., 2016), institutional entrepreneurship, planning for climate change in cities (Wamsler et al., 2013) as well as real-life embedded experiments such as urban transitions labs (Nevens et al., 2013) and urban eco-acupuncture (Ryan, 2013).

Cities are complex systems consisting of social, physical and informational layers which dynamically interact with one another (Johnson, 2012). There are several reasons for this increased interest in cities in the context of sustainability and low-carbon transitions. The first is about the demographic shift to urban areas. Currently more than half the world's population now reside in cities, with populations in cities projected to grow nearly to 70% in 2050 (UN-Habitat, 2011). This demographic shift brings with itself an increasing and concentrated impact associated with cities. Cities account for around 75% of global energy demand and 75% of greenhouse gas production, while occupying only around 2% of the world land area (Hajer and Dassen, 2015; Satterthwaite and Dodman, 2009). The second reason concerns the innovative potential of cities: cities can be instrumental in generating the innovation and creativity necessary for low-carbon transitions (Bettencourt and West, 2011; Leichenko, 2011). The third is about the increasing agency of cities in climate change action: while progress in reaching binding global political consensus for climate change action at the level of nation states has been very slow, individual cities and networks of cities are adopting reduction targets

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and actively investing in programs to reach them (Inayatullah, 2011; Rosenzweig et al., 2010). The fourth reason concerns the historical and current role cities play in social movements reclaiming democratic and environmental rights and thus in re-structuring long-embedded political institutions undermining environmental and social resilience (Arampatzi, 2016; Arampatzi and Nicholls, 2012; Harmanşah, 2014; Harvey, 2012; Leontidou, 2010; Walliser, 2013).

1.2. Urban sustainability and low-carbon transitions as a design challenge

It would be a mistake to problematize urban sustainability and low-carbon transitions merely as a technological issue. Urban transitions are also a socio-cultural and politico-economic challenge, a process of transformation that requires fundamentally different systems, structures and practices to be conceived and implemented by social actors. These transformation processes are referred to as socio-technical transitions or system innovations for sustainability (Geels, 2005; Loorbach, 2010; van den Bergh et al., 2011). Ultimately, transitions and system innovations require significant and structural changes in the systems that support society. The embedded (inter)relationships of these systems suggest that system innovations and transitions involves a re-conceptualization of whole systems and a creative imagination of alternative and desirable futures.

In the context of urban sustainability and low-carbon transitions, these systemic transformation processes can be conceived as a design challenge of three interconnected dimensions: We refer to the first dimension as the creative dimension of the design challenge. This dimension is arguably the most difficult dimension as it requires imagining entirely new socio-technical systems which will support a vibrant, culturally satisfying and productive urban existence in the future. These new socio-technical systems need to be imagined complete with their institutions, organisational models including new business and governance models, technologies including associated products and services and new social practices including norms, values and behaviour. The second dimension involves selecting, designing and developing those system concepts that will support the resilience of communities even as the environment and climate changes. This dimension is the technical dimension of the design challenge. The third dimension requires attending to the political nature of transition processes by designing participatory processes for the purposes of deliberating and negotiating characteristics of those future systems as well as strategies for achieving them with relevant stakeholders. Therefore, this dimension is referred to as the political dimension of the design challenge.

The broad field of design for sustainability has evolved from a single-issue and artefact focus to a multiple-issue and system focus, pointing to the emergence of a new research and practice area referred to as design for system innovations and transitions (Ceschin and Gaziulusoy, 2016; Irwin, 2015; Ryan, 2008). This emerging area is underpinned by complex systems theories and sustainability science, and it integrates theories of social and technological system changes with design theory (Gaziulusoy and Brezet, 2015). Although some recent prescriptive or theoretical (re)positionings of design research and practice has helped us to develop some understanding of the role and potential of design in the context of system innovations and transitions, the documented case studies of system innovations and transitions specifically studying design is very limited. There is a body of growing research on urban transitions stemming from the disciplines such as geography, innovation studies, sociology, and science and technology policies. Nevertheless, this body of work focuses mostly on governance and planning of transitions (McCormick et al., 2013) as conception of transitions as a design challenge is relatively new, leaving ample space for theoretical and practical exploration of transitions through the lens of design discipline.

This paper aims to contribute into developing an understanding of the roles of design in system innovations and transitions focusing on the first year of a recent project on low-carbon transitions in Australian cities as a case study. In the following section we provide a conceptual framework of design and sustainability transitions. We briefly explain foundations of sustainability transitions using a multi-layered model adopted from system innovation and transition theories and link this with design theory. In the third section we present and discuss the case study findings which is followed by conclusions.

2. Conceptual framework: design and sustainability transitions

The conceptual framework we use to explain and analyse the roles of design in socio-technical transition processes is informed by the multi-level perspective (MLP) of system innovations. The first version of MLP was introduced by Rip and Kemp (1998). In 2000s it has been refined and developed with the empirical research of Geels (2005). MLP is based on historical studies of transitions in areas such as energy and transport, and is particularly powerful in understanding the complex interplay of different forces at the macro-, meso- and micro-level in creating disruptive change as well as dynamics between transition actors. It explains development of niches, institutions and social and economic subsystems as a co-evolutionary innovation process.

The MLP consists of three levels (Geels, 2005). These are landscape (macro-level), regimes (meso-level) and niches (the micro-level) levels. ***Landscape level*** *(macro)* is the uppermost level and it provides an overview of the overall socio-technical setting. At this level, the dynamics of deep cultural patterns, macro-economics, macro-political developments that make up the environment or context of socio-technical transition are present. Landscapes consist mostly of long-term changes and factors that do not change or change only very slowly and sometimes of rapid external shocks (Van Driel and Schot, 2005). They cannot be changed by actors in the short-term (Geels and Schot, 2007). Landscape level stimulates and exerts top-down pressure upon the socio-technical regime which is the middle level of the MLP (i.e. regimes level). ***Regimes level*** *(meso)* represent the dominant rules of scientific, technological, business and market activity. This level is stable and reinforces the prevailing socio-technical systems, thus often demonstrate activities that are barriers for change. ***Niches level*** (micro) is the level of experimentation for conception of new technologies, organisational models, social and cultural practices as well as institutional innovations. This lower-most level of the MLP framework has a loose structure compared to the upper levels, and is less likely to be subject to market and regulatory influences. The coordination between niche level actors is also less compared to the coordination between regime actors.

MLP has been developed with a focus on less complex systems than cities and therefore its applicability to cities is still up for debate (e.g. Naess and Vogel, 2012). Nevertheless, the framework continues to be a helpful heuristic and analytical tool for studying and activating sustainability transitions in cities.

According to Loorbach (2010) there are three activities required by transitions and system innovations: 1. Strategic activities; 2. Tactical activities; 3. Operational activities. These activities are summarised as follows (Twomey and Gaziulusoy, 2014

- *Strategic activities* involve the formation of long term goals and visions that will lead to changes in the culture and structure of a socio-technical system. The long term goals and visions should include not only new technologies, products and services that will jointly meet a specific societal function but also norms and values, social identity, legislative and regulatory arrangements and politico-economic model that together will enable governance of the future depicted in these visions.
- *Tactical activities* are directed at implementing a transition agenda towards the desired goal and relate to interactions between actors that can build and align the new vision into the regime level. This can include activities relating to changes in structures, such as investments and other resource distributions, rules, incentives, and underlying infrastructure. Negotiations regarding interests are more common in this sphere. It also involves understanding barriers that may inhibit the advancement of the visions and propose adjustments that may be needed.
- *Operational activities* relate to the experiments and learning-by-doing at the niche level, often with an emphasis on radical and disruptive innovations that may potentially filter up into the regime and landscape level.

Socio-technical transitions in general, sustainability and low-carbon transitions in particular display typical characteristics of wicked problems; they are ill-defined, political and systemic (Rittel and Webber, 1973). This is particularly true for transitions in the context of cities. Transitions require several interventions across different layers of nested socio-technical systems to be identified and aligned. Both mainstream and niche actors as well as the general public are required to be involved in these activities. These interventions require long-term timeframes to be considered that span beyond election cycles, business strategic outlook and in some cases life-time of the members of currently alive human population (Gaziulusoy et al., 2013; Holling, 2001; Jansen, 2003; Loorbach et al., 2010). It is not possible to precisely foresee the outcome of interventions. Therefore there is an emphasis on experimentation and risk taking while adopting a pre-cautionary approach (Frame and Brown, 2008; Ravetz, 2004, 2006). Alternative future propositions need to be developed attending to different political agendas that are inherent in visions of sustainable, low-carbon futures as there is not a single preferable version of the future (Scoones et al., 2015).

Design as a practice-relevant discourse has been distinguished from the discourses of natural science, medicine, engineering and business (Cross, 2007; Krippendorff, 2006; Gruber et al., 2015). Design, different to these approaches, observes humans and the systems they interact with in their context and using the insights acquired during this phase frames the problem with due emphasis on human experience and the meaning derived through that experience; i.e. it is human-centred and constructivist (Krippendorff, 2006). It has been argued widely and for long that, design is suitable for addressing wicked problems (Dorst, 2003; Goldschmidt, 1997; Rittel and Webber, 1973). It is a unique attribute of design problems that definition of them accommodate technical as well as socio-cultural and behavioural issues resulting from the dynamic interactions between humans and systems, which together create system behaviour (i.e. physical properties) and meaning derived from that (i.e. experiential properties).

It is a mistake to assume that we can design generic and widely applicable solutions to sustainability problems in a top-down manner using prediction and control-based approaches (Wahl and Baxter, 2008). It is acknowledged in transitions theory that, due to the complex dynamics within socio-technical systems, it is impossible to single-handedly direct transitions; they can only be steered at best and with the co-creative participation of diverse stakeholders (Geels, 2002; Quist and Vergragt, 2006). Design can attend to creation of alternative futures and to different values underlying what constitutes “desirable” both at micro and macro levels of systems (Buchanan, 1995). Design participation has the potential to facilitate collaborative co-creation between partners, frame and stage production and reproduction of social and spatial relations, and can attend to diverse politics of stakeholders by helping these to be identified, made transparent and reflected upon (Akama, 2008; Asaro, 2000; Keshavarz and Maze, 2013; Lee, 2008).

Dewberry and Johnson (2010) argue that in the context of transitions, policy making is designing sustainable futures and there is a need to acknowledge design at any level of socio-technical systems as relative to design at all other levels, therefore, designers need to think outside of their narrow specialisms and reflect on how their work fits within and impacts the politically-charged transitions. The characteristics explained in this section potentially posit design to a special place in the context of system innovations and transitions for sustainability. Nevertheless, the particular roles design can play in system innovations and transitions are yet to be understood. In the following section, we present a case study to empirically explore and discuss the different roles design plays in a real transitions project.

3. Exploring roles of design in transition projects: VP2040 Australia case study

3.1. Case study background

3.1.1. The project

Visions and Pathways 2040: Transitions to Low-carbon Resilient Futures in Australian Cities (VP2040) is a four-year multi-partnered research and engagement project. VP2040 is funded by an Australian Cooperative Research Centre, namely the Low-carbon Living one (CRC LCL). The project aims to develop visions of desirable, low-carbon and resilient futures, and strategies to achieve the scenarios that are derived from them. Victorian Eco-innovation Lab (VEIL) which is a research unit residing in Melbourne School of Design of the University of Melbourne (UoM) is the project leader and two other universities in addition to UoM (University of New South Wales (UNSW) and Swinburne University (SU)) are research collaborators in the project. Local governments from four Australian cities (Melbourne, Sydney, Adelaide, Perth) and several businesses including local branches of three large international architecture, design, engineering and planning consultancies operating across the built environment sector are partners in the project (Ryan et al., 2015).

3.1.2. The project team

VP2040 is a transdisciplinary project requiring integration of a wide array of knowledge relevant to low-carbon transitions in cities (Gaziulusoy et al., 2016). Five researchers with different expertise relevant to VP2040 consists the core project team (Table 1). These researchers are based in the three collaborating universities each of which also accommodate three PhD students undertaking research on energy transitions, governance of open space in cities and urban density and walkability in cities. In addition to the core research team and PhD students, the project also receives in-kind and commissioned contributions from experts in order to meet the need of knowledge diversity. The knowledge embodied by these experts covers but not limited to sustainable energy, climate change governance, new business models, peer-to-peer economies, distributed systems, and climate finance.

Table 1
Core members of the research team (reproduced from Gaziulusoy et al., 2016).

Role	Base	Expertise Relevant to the Project
Project Leader	UoM, VEIL	urban eco-innovation, design for sustainability, environmental policy, project leadership
Researcher 1	UoM, VEIL	design for system innovations and transitions, sustainability science, design research, transdisciplinary research, qualitative research, group facilitation
Researcher 2	UNSW, Faculty of Built Environment	climate policy, energy policy, environmental economics
Researcher 3	SU, Swinburne Institute for Social Research	science and technology studies (including innovation studies, sociology of expectations), futures studies, community and stakeholder engagement, strategic management, qualitative applied social research
Research Assistant	UoM, VEIL	cultural geography, qualitative research, consumer insight, event management

3.1.3. The project process

Fig. 1 shows the project process during the first year of the VP2040 project. At the beginning of the project the core research team undertook some background research on topics, theories, methodologies and other significant projects relevant to VP2040. They also started engaging with stakeholders, primarily with project partners, in order to develop an understanding of stakeholder perspectives relevant to transitions to low-carbon in Australian cities. This exercise resulted in insights on risks and opportunities perceived by the stakeholders and particular domains of significant structural change that they found relevant to their organisations.

The primary methodological component during the first year of the project was a series of participatory visioning workshops. These workshops brought together members of the existing socio-technical regimes, niche-innovators, activists, designers and researchers. A total of 96 participants attended these visioning workshops held in Melbourne and Sydney. These participants were selected from the broad network of project researchers and project partners based on three criteria: 1. Not a climate denier or skeptic; 2. Has agency to make or influence decisions about the future of Australian cities; 3. Has substantial knowledge about one or more aspects of urban context in regards to climate change. Following a Latourian position, participants were framed as network configurations (with official and unofficial components) bringing in other in-direct (intentional or unintentional) participants rather than stand-alone subjects (Andersen et al., 2015). Table 2 presents a breakdown of workshop participants by sector. In Melbourne 10 of 17 participants representing business were from built environment consultancies. In Sydney, 9 of 14 participants from business sector represented built environment consultancies. In total, there were representatives from 15 different built environment consultancies and three of these were international.

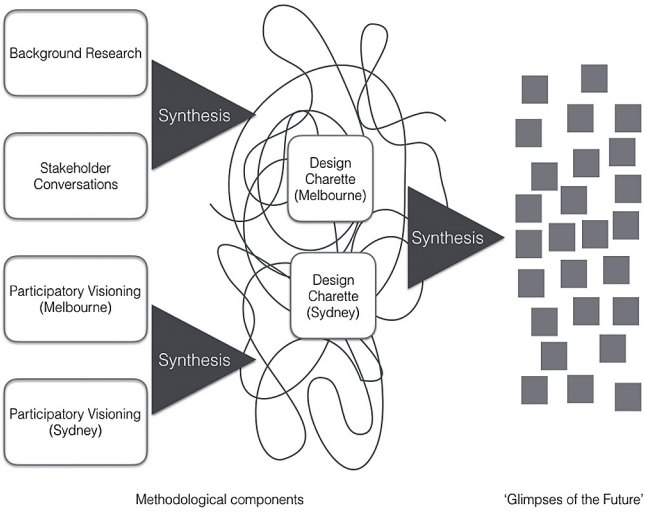

Fig. 1. VP2040 project process during its first year.

Sixteen professional designers commissioned by the research team to carry out the visualisation work during the design charrettes were also present during these workshops; in Melbourne as table facilitators, in Sydney as observes of table discussions. These commissioned designers came from a range of design disciplines including architecture, urban design, industrial design, service design and interaction design. These 16 designers were commissioned based on three main criteria: 1. Ability to think systemically; 2. Knowledge of sustainability; 3. Skills of visualisation. Professional designers were also present as participants in these workshops from different stakeholder and partner organisations. These were mostly architects, landscape architects and urban designers.

Because the research team intended for generation of systemic visions of future cities (rather than visions focusing on specific city support systems for example), there was no blueprint visioning process design the research team could adopt and use. Therefore, the process was designed from scratch with the involvement of the project leader and researchers; the first prototype was used in the first visioning workshop held in Melbourne and, following a group reflection on its fit-for-purpose, was improved and the new design was used in the second visioning workshop held in Sydney a month after the Melbourne workshop.

In Melbourne the commissioned designers took notes and made sketches on large pieces of paper that covered the tables, whereas in Sydney, they used personal tools for capturing the conversation such as notebooks and video cameras without taking part in conversations. In both cities, all workshop participants were encouraged to use the papers covering the tables for note taking and sketching. Following each visioning workshop a week-long design charrette was held with the involvement of the core research team and the commissioned designers. During these design charrettes, the research team articulated findings from their background research and stakeholder conversations. The designers, on the other hand, fed back their findings from the visioning workshops.

The aim of these charrettes were creation of visualisations depicting, what the research team called 'glimpses of the future' (Moy and Ryan, 2011). Glimpses of the future are visual snapshots of desirable and plausible but not business-as-usual, systemic city futures which are radically low-carbon and resilient. These glimpses were developed iteratively by cross-referencing and synthesising the input of workshop participants and insights of the project researchers derived from the exploratory research they had been undertaking on emerging disruptive technological and social innovations that could assist with low-carbon transitions.

The task at hand was complex and started with a debrief of visioning workshops in conjunction with findings of exploratory research. Then, the research team provided the expert designers with design briefs; each designer was given system levels to focus (city, precinct, neighbourhood), particular changes to depict (technological innovations, behavioural elements, products and services) but were not briefed about output format. The designers and the research team met several times during the weeks the charrettes were held until the visualisations were finalised.

Table 2
Breakdown of workshop participants by sector in Melbourne and Sydney visioning workshops.

City		Melbourne	Sydney
Sector	Business	17	14
	NGO	12	2
	Research	15	6
	Local Government	10	2
	State Government	5	4
	Peak Body	5	3
	Statutory authority	–	1

3.1.4. The outputs of the project

As a result of the design charrettes held in Melbourne and Sydney a total of 83 visualisations were generated. Seventy-two of these visualisations were images and 11 of them were short videos. Figs. 2–7 show a selection of these visualisations.

Fig. 2 shows Melbourne CBD in 2040 which is easily identifiable by residents of Melbourne while communicating the many changes that took place in the city. In 2040, the CBD operates as an integrated network of interconnected systems. In order to reduce the heat island effect, the city has been significantly greened. The green zones also play a role in creating comfortable and attractive walking and cycling paths. Yarra River, which had been subjected to polluted water run off for several decades has been turned into its pristine state. It is suitable for swimming although its characteristic brown colour prevails. Main urban connections are made through active transport; there're additional bridges connecting the two banks of the river which are all dedicated to walking and cycling.

Fig. 3 is displaying the iconic Sydney Harbour Bridge in 2040 which is equally familiar to the residents of Sydney as the image depicted in Fig. 1 was to the residents of Melbourne. The iconic bridge, which used to be a highway, is now prioritising public transport and cycling. Heavy rail connects Sydney with other districts. Electric bus connects Sydney CBD with the suburbs and a cycling super highway. There are also urban gardens running as small businesses on the sides of the bridge which has now become a social hub where people hang out and walk across.

Fig. 4 displays the 'Living Road' concept developed by one of the designers who were commissioned for the Sydney workshop. In 2030, prime minister of the time (the leader of the Green Party) set a vision and launched the national Living Roads projects. This project between 2030 and 2040 has invested in building Living Roads in Australian cities. The surface of the Living Road absorbs sunlight, converts it into energy and provide electricity for surrounding homes. It also provides universal Wi-Fi. The Living Road consists of several layers and is a hybrid bio-technological system. Living Road construction projects are initiated by local councils in neighbourhoods who also provide the funding for the first 'growing' of the road. Then, the ownership is transferred to the community along with the responsibility to maintain the road.

This image shows a Melbourne neighbourhood community in

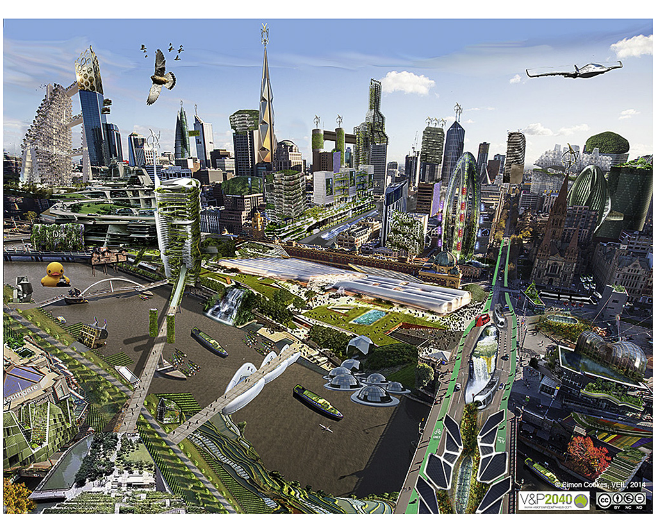

Fig. 2. Melbourne CBD in 2040.

Fig. 3. Sydney harbour bridge in 2040.

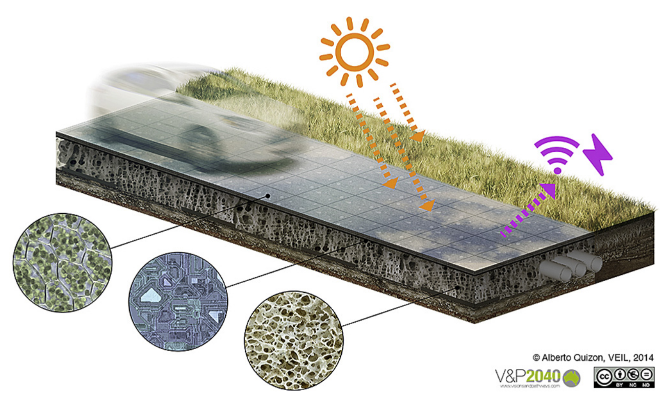

Fig. 4. The 'Living road'.

Fig. 5. A Melbourne neighbourhood community in 2040.

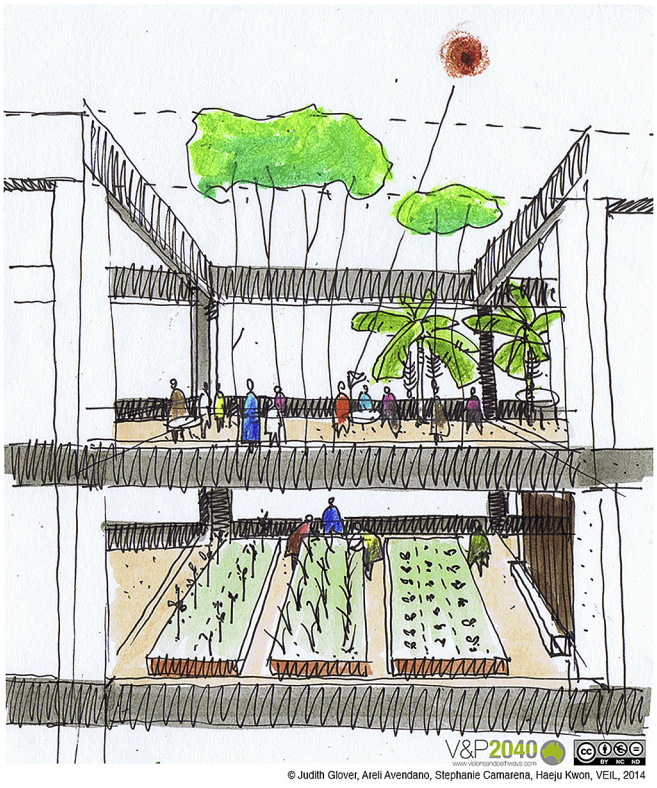

Fig. 6. Urban agriculture in reclaimed buildings.

2040. In this community resources are shared as part of a neighbourhood commons. There is a communally owned 3D printer as part of this commons and the members of the community can 3D print parts to repair the appliances in their homes. They can also use these 3D printers to produce other goods needed by the community using open-sourced designs shared in global digital commons. The carbon footprint of the neighbourhood is tracked and the overall score is displayed publicly. Neighbourhoods compete to have the lowest carbon footprint.

Some of the building stock in cities have become uninhabitable over the years for not being suitable climatically. For some years these buildings remained abandoned. Slowly, surrounding communities following negotiations with the local council overtook these buildings and reclaimed them as urban agriculture facilities (Fig. 6). In 2040 there are more than a thousand of these reclaimed community urban farms in broader Melbourne area.

In addition to public space and private space, the past decades have seen emergence of a third type of space in cities: the shared space. Shared space is privately owned and shared voluntarily with selected people. Gradually the fences around backyards of Australian houses have started to be taken away to create more neighbourly interactions. Then, borders between lots have become vague and backyards are turned into neighbourhood gardens where the community started to spend most of their time both for socialising but also for growing food.

3.2. Case study findings

3.2.1. Methodology and methods

As this is an initial attempt to identifying roles played by design in system innovations and transitions, our research has been exploratory. We used the process and outputs of VP2040 project as a case study. Case study is an appropriate methodology if the

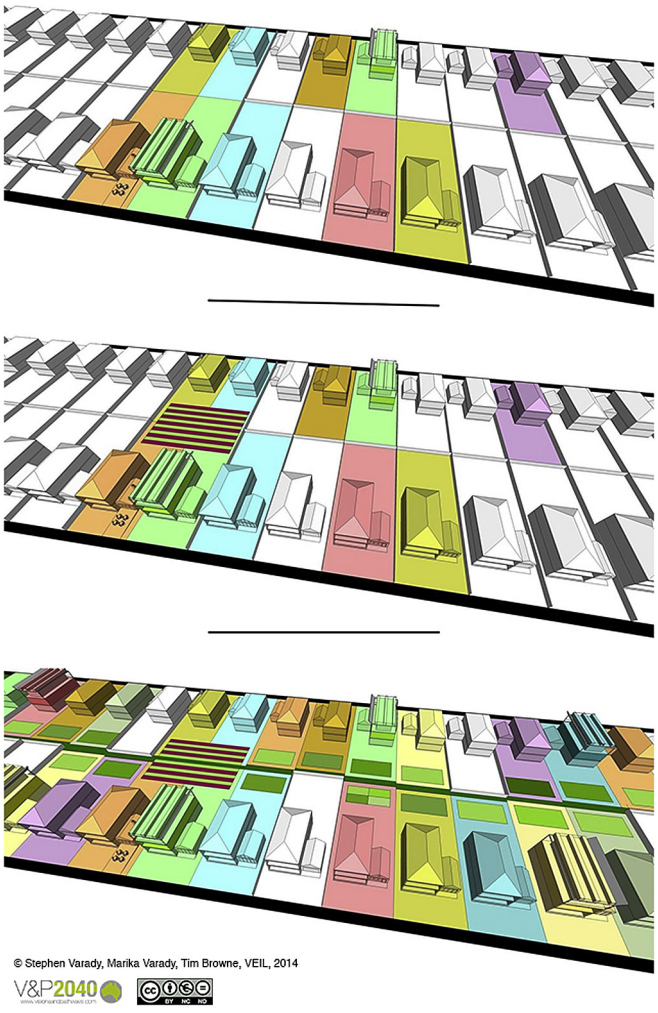

Fig. 7. Emergence of shared space.

research is exploratory and attempts to generate initial qualitative insights about the subject area (Yin, 2003). Two methods were used to collect and analyse data. The first of this was qualitative analysis of participant-generated visual and textual content on the table covers used in visioning workshops (Prosser and Loxley, 2008). In this analysis we looked at the proportion of visual content (e.g. sketches, mindmaps) versus textual and the level of detail expressed of the ideas generated. The second method employed was participant observation (Jorgensen, 1989) during researcher meetings, visioning workshops and design charrettes. Data was collected and analysed using reflective journaling of the observations made by the first author. The first approach enabled us to gain insights into roles played by design in situations where there was direct involvement of professional designers in the process. The latter, on the other hand, enabled us to record and reflect on instances when design played a role indirectly in new knowledge generation either through outputs of design process or approaches of design problem solving.

3.2.2. Findings and discussion

In analysing the roles of design in VP2040, we found the concepts of diffuse and expert design as proposed by Manzini (2015) useful. According to Manzini, design is a natural human cognitive capacity and everyone can undertake design activity. He calls this activity ‘diffuse design’. On the other hand, the activity that is

performed by professional designers is called 'expert design'.

In VP2040 both diffuse and expert design were significantly evident and occurred both individually and in dynamic interaction with each other. For example, diffuse design on its own was particularly evident during designing of the process used in visioning workshops. On the other hand, expert design on its own was particularly evident in creation of visualisations of the futures envisioned by the participants during the visioning workshops.

Throughout the project's execution, more frequently than their individual occurrences, diffuse and expert design dynamically interacted. This interaction was particularly evident during visioning workshops between the commissioned and participating professional designers and participants from non-design backgrounds as well as during the following week-long design charrettes between the commissioned designers and the project researchers.

In comparing sheets of papers that covered tables in Melbourne and Sydney workshops, where we employed slightly different process designs, we have not observed a significant difference in the overall graphic qualities. Both involved a combination of bullet pointed lists, unconnected single sentences or phrases, mindmaps displaying connections between ideas and sketches. Nevertheless, table papers from the Melbourne workshop had more mind maps and detailed sketches, some to a degree that can be accepted as initial concept designs. Figs. 8 and 9 show a selection of details from table papers.

Although, this was not a controlled experiment as both the participants and the commissioned designers were different in Melbourne and Sydney, and there were professional designers present as participants in both workshops in addition to those commissioned by the project, the higher prevalence of graphic elements as well as the level of detail on table covers in Melbourne workshops compared to Sydney may be interpreted as expert design playing a role in connecting otherwise unconnected ideas in a problem domain towards proposing a systemic concept. Also, it can be concluded that the level of co-design was higher in Melbourne workshop as, through detailed sketches of initial design concepts, the participants had a chance to negotiate the proposals for city futures not only at ideas level (functions of systems) but also at design level (physical manifestations of systems). Therefore, it can be concluded that, expert design enabled stakeholder input to be embedded in the design output more effectively. There are numerous examples of this in literature on user-centred design and co-design, particularly focusing on product and service innovation (Bowen et al., 2013; Wilkinson and De Angeli, 2014). Nevertheless, this contribution of expert design has not been systematically documented before specifically in projects about futures of cities and in projects focusing on transformations of large systems in general. This is suggestive evidence that expert design can improve the quality of diffuse design not only in small scale and short-term projects but also in longer-term projects focusing on large, complex, socio-technical systems. Asaro (2000), echoing this dynamic resonance between expert and diffuse design, warned that participatory design should not be seen merely as an insertion of public dialog within design practices but instead should be seen as a model for critical practice of design.

The design charrettes held following the visioning workshops were mainly a process of knowledge synthesis and required generation of new design knowledge by the expert designers based on participant and researcher input. During these design charrettes, 'transitions as a creative design challenge' (Section 1.2) was very evident. The designers not only contemplated what might be called 'could-be systems' but also brought a lot of additional information into the process to be able to connect disparate types of knowledge but also system components displaying appropriate relations as a whole (Goldschmidt, 1997; Johnson, 2005).

Although throughout this process, diffuse design and expert design interacted continuously, expert design played a very significant role: a role of mediation between the diverse views on 'desirability' and perceived plausibility of visions they observed during the visioning workshops as expressed by the participants and by the research team (McGrail et al., 2015), thus indirectly negotiating the politics of system innovations and transitions and, addressing 'transitions as a political design challenge'. This diversity was communicated in the visualisations the designers developed. The research team used these visualisations later to develop four distinct future scenarios each with different emphasis on the role of technological change versus socio-cultural change in achieving low-carbon resilient city futures (Ryan et al., 2016a). A similar role played by design was identified by Akama (2008) in her research. She described this role as "to initiate and facilitate a discussion that can then illuminate the politics and any stakeholder agendas or assumptions within projects (p.9)". This is defined as the 'dialogic role' of design (Manzini, 2016; Ryan et al., 2016b).

We observed that the dialogic role of design is more eminent in glimpses that were perceived by the stakeholders as technologically or technically non-feasible. The 'Living Road' explained in Fig. 4 is a good example of this. While with glimpses that are perceived as feasible the conversations mostly revolved around the policies and funding required to achieve the innovations depicted in the glimpses, with those glimpses perceived as non-feasible, after an initial period of resistance to engage with the glimpse for the effort to do so was seen as waste of time by some of the stakeholders, the conversations shifted from feasibility to questions around values and social practices implied by the glimpses. Using the 'Living Road' glimpse, some stakeholder groups problematized the conventional model of infrastructure governance and discussed potential alternatives.

If we refer back to the activities required for system innovations and transitions, i.e. strategic, tactical and operational activities (Section 2), and break down the roles played by design based on this framework we can link the roles played by design with the activities undertaken in system innovations and transitions. The roles played by design in facilitating human-centred and participatory inquiry in envisioning desirable futures as well as assisting with articulation of diverse politics embedded in these visions is directly related to the strategic activities. We have observed this role in VP2040 in visioning workshops and the following design charrettes. The dialogic role design plays is also crucial in tactical activities as these involve deliberation between proponents of the new futures proposed and actors embedded in incumbent regimes. In our case, this happened more organically and dynamically during the visioning workshops rather than through a linear progression of visioning followed by vision negotiation. The participants in the visioning workshops covered niche innovators as well as stakeholders who were operating within the existing socio-technical regimes. Therefore the visions generated were not only instrumental in kick-starting a transition project, a key role they have in most transition projects, but they were also operational, i.e. they depicted futures that stakeholders would be inclined to act upon. In a way, the buy-in of incumbents was assured through participation into vision development at the outset. The scope of VP2040 project does not include undertaking operational activities but instead identifying what operational activities could assist in low-carbon transitions; therefore, it has a strategic role rather than an implementation role. This role has partly been played by identifying participants' view on emerging disruptive innovations through visioning workshops and the ongoing dialog facilitated by the visualisations. The glimpses of the future generated following the visioning workshops and the stakeholder

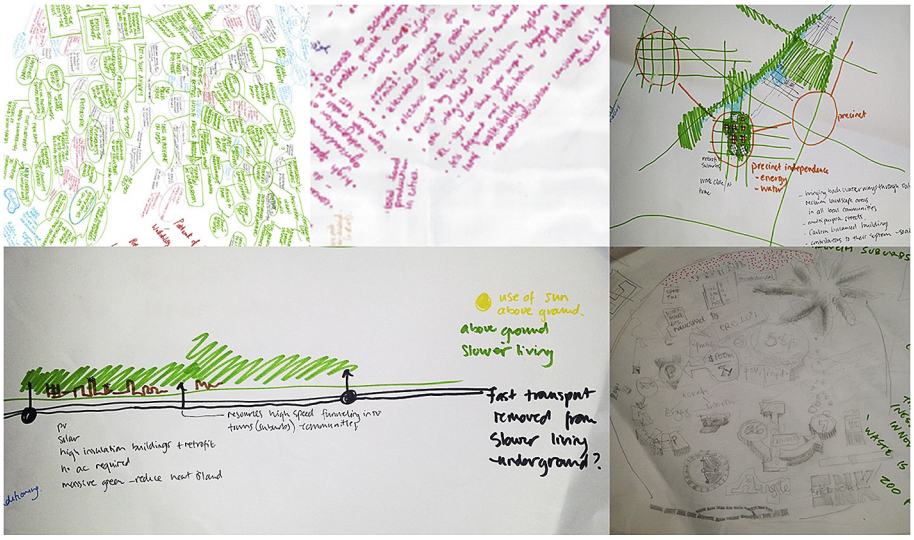

Fig. 8. Selection of details from table covers in Melbourne workshop.

Fig. 9. Selection of details from table covers in Sydney workshop.

interaction these workshops enabled resulted in new projects to be formulated.

Table 3 presents the roles we observed as played by design across different elements of the VP2040 project. Fig. 10 maps these roles over the three transition activities explained in Section 2.

4. Conclusions

Design is generally understood by the general public through the outputs it creates; without a product or a process it remains somewhat invisible. Nevertheless, the roles design plays in knowledge generation within society in general and generation of knowledge and strategies in the context of system innovations and transitions are numerous. Both the design discourse and the ever expanding discourse on system innovations and transitions have understudied roles of design in inspiring, informing and triggering large, systemic, societal transformations to achieve sustainability. In this paper we explored some of these roles using VP2040 project – a project that focuses on participatory exploration of low-carbon resilient futures in Australian cities - as a case study. Through this exploration we identified several instances of expert design – design activity undertaken by professional designers - and diffuse design – design activity undertaken by anyone as a basic human cognitive ability - operating on their own as well as in a dynamic interplay with each other in this process. Only a small portion of the roles that were explicitly observed in this exploration were related to generation of traditional forms of design outputs such as visualisations. Majority of the roles played by design were related to inquiry and process, in how problems and potential solutions were framed and how knowledge was acquired and synthesised.

Given ours was an initial attempt to systematically observe the roles design can play in system innovations and transitions, our findings may not be exhaustive or some of the roles observed through this case study may not be valid for all system innovations and transitions projects. Nevertheless, through the case study we demonstrated that design plays roles in three main categories, namely, in inquiry, in process and in outputs. The case study also demonstrated that these roles span across the three activity

Table 3
Roles of design in transition processes.

Roles of design observed in VP2040	
in inquiry	Participatory inquiry
	Human-centred inquiry
	Analysis and synthesis of different knowledge forms in vision development
	Systematising problem framing and solving methodologies dealing with wicked problems
	Attending to different politics and value sets of stakeholders through articulation and option creation
	Dealing with uncertainty
	Dealing with complexity of socio-technical systems
	Transdisciplinarity
in process	Iteration and prototyping
	Facilitation of participatory inquiry, design and deliberation
in outputs	Visual communication of future technologies, city forms, products and services and social practices
	Formulation of scenario prototypes pre-negotiated by the stakeholders

spheres – strategic, tactical and operational - that are necessary for transitions.

A necessary reflection is related to the socio-cultural context. Our findings on the roles of design need to be tested and expanded in a diversity of socio-cultural contexts to gain an understanding of the extent of generalisability and to identify unique roles that may be specific to certain socio-cultural contexts.

The potential implications of the findings of our exploratory study on design education and design practice in the short-term and longer-term are somewhat different. In the short-term, it is likely that design practice will continue to be mostly on demand for creation of tangible outputs and driven mainly by the commercial interests with marginal but increasing use in transitions projects. In this time-frame, practitioners who have a keen interest in contributing into transitions projects with their professional capacity may need to, on one hand communicate with the stakeholders to articulate several roles that can be played by design in addition to bringing in their conventional skills and knowledge, and, on the other hand they may find it difficult to be reimbursed fully for their hours of labour which may force them either to do pro bono work or to withdraw. Rather than practitioners themselves, such communication may be more widely and successfully achieved by the professional organisations representing design practitioners. In the longer term, it is likely that demand for the

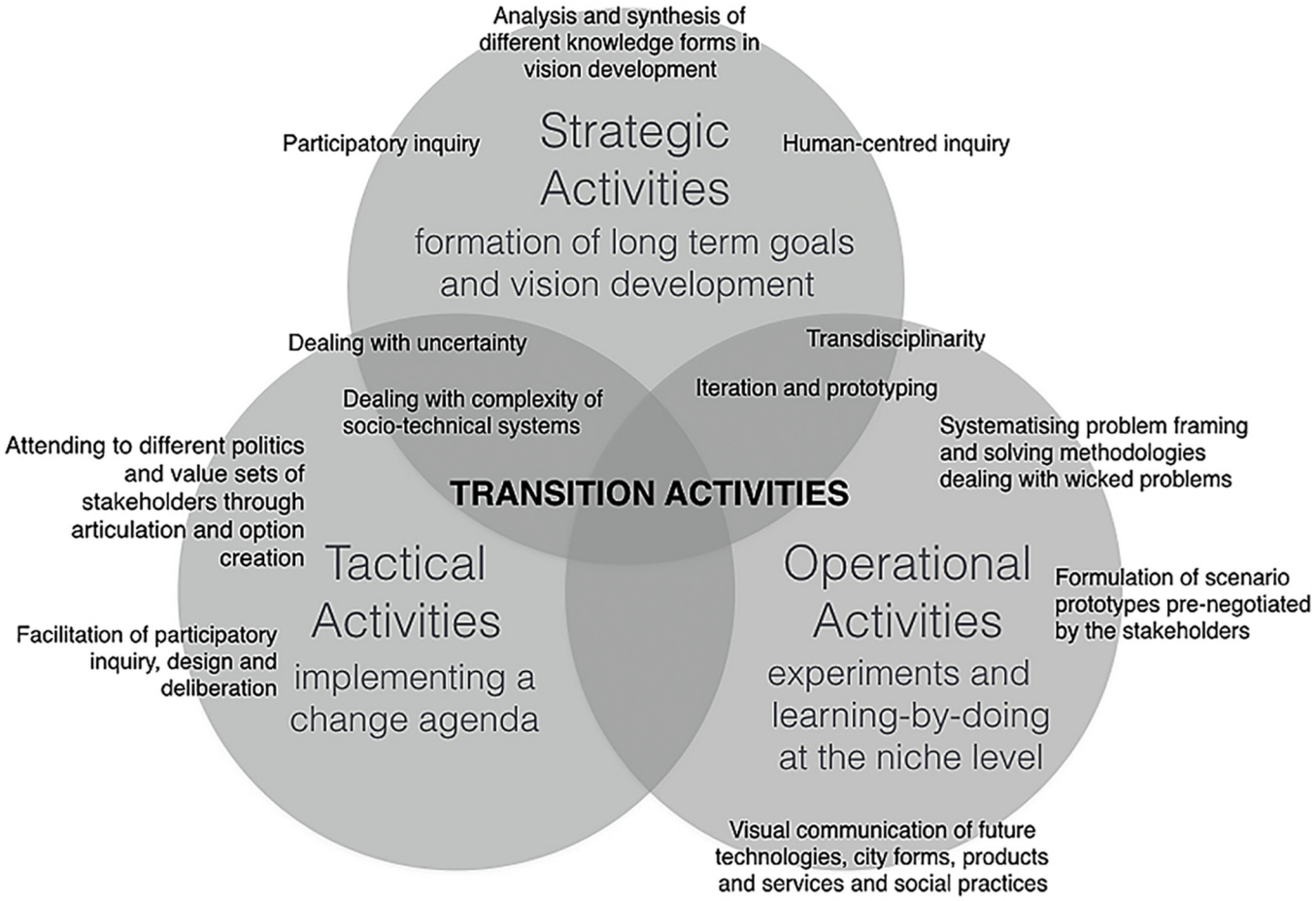

Fig. 10. Roles of design corresponding to transition activities.

currently emerging practice will somewhat take off (Sanders and Stappers, 2014) and more practitioners will be engaged with it as their time investment will be financially better acknowledged. As transitions projects require large-, multi-stakeholder, multi-sector consortiums, the most likely bases for such practice will be strategic design consultancies and organisations responsible for public policy making rather than companies providing business-to-customer products and services. As this emerging practice require professional skills and knowledge additional to what is traditionally gained in design schools, there is an urgent need for curriculum development planning and implementation in educational institutions which take into account the new roles of design relevant for societal transitions. This work in the short-term requires benchmarking and evaluation of currently emerging programs - such as the Transition Design PhD program in Carnegie Mellon (Irwin et al., 2015) -, and creation of collaborative networks between design schools as well as local and international professional organisations. In the longer-term, this short-term work should yield to a complete transformation of design education, as part of a larger educational project, i.e. creating the transdisciplinary university (Jantsch, 1972; Hammer and Söderqvist, 2001; Lozano, 2010).

In the light of these reflections, we identify the following future research opportunities to build on and expand our findings from the exploratory study presented in this article:

- further exploring the breadth of roles that can be played by design in transition projects and processes;
- exploring how each of these roles are played in depth;
- expanding the roles identified and reflecting on the extent of generalisability or context-specificity of certain roles through executing similar research on roles of design in different socio-cultural contexts where transitions research and practice is undertaken;
- identifying best-practices in design education in terms of learning goals and teaching methods that are aiming to meet the emerging needs for new professional skills and knowledge required from design practitioners;
- integrating theories of socio-technical and socio-ecological transformations with theories of design and design education in general and design for sustainability in particular.

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