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A Systematic Review of Systemic Design Frameworks for Complex Challenges.

Skye Smith [a] * | Eleni Kalantidou [a]

[a] Griffith University, Queensland College of Art, Brisbane, Australia.
* Corresponding author: skye.smith@griffith.edu.au

ABSTRACT

Systemic design, as a strategic approach, has been noted as a promising scaffold to approach the emerging challenges faced by designers in understanding the dynamic and interconnected problems that define contemporary reality. The field can briefly be described as an attempt to integrate systems thinking and design thinking and combine problem-framing methods that explore complexity with solution-oriented methods. Systemic design frameworks offer a valuable contribution to the realm of strategic design by providing a comprehensive approach to problem-solving that considers the interconnectedness and dynamics of complex systems. While a range of literature on systemic design is available, its defining framework remains elusive and further development is needed to understand and investigate its viability. This article employs a systematic qualitative literature review in order to explore and synthesise existing systemic design mindsets, processes, and methods. The synthesis of frameworks acts to provide greater insight into the orchestration of applying systemic design to complex problems. It concludes by identifying potential challenges and limitations within the field. In particular, a limited exploration of consumer behaviour is present, with more focus given to material and production throughput.

Keywords: Design Theory, Social Design, Strategic Design, Sustainability, System(s) Design, Systemic Design.

INTRODUCTION

In order to understand the potential of integrating systems thinking and design thinking, this article provides an overview of current systemic design research by employing a qualitative systematic literature review. As a starting point, this study adopts a definition of systemic design that is broadly applicable across design disciplines. As outlined by the Systemic Design Association (2021), systemic design is "distinguished from service or experience design in terms of scale, social complexity and integration"; "concerned with higher order systems that entail multiple subsystems (that might be defined services)" and "brings human-centred design to complex, multi-stakeholder service systems". Its intention is to modify theoretical, methodological and practical design tools in order to provide new ways of approaching social and environmental complexity.

In saying this, the field of systemic design is still young and is constantly adapting. Due to the wide range of approaches associated with systems thinking, the literature surrounding systemic design is complex and multifaced (Battistoni et al., 2016, p. 885). This review aims to map and make sense of current systemic design frameworks in order to identify key mindsets, processes and methods. It is not a direct response to a specific set of principles, but rather aspires to create a holistic view of the current situation, highlight trends, illuminate

differences and identify areas of future research in order to build a more accessible platform for newcomers to the field. In this light, systemic design is perceived as a strategic approach, due to enabling a systems-led ideation and development of design responses related to contemporary challenges.

1. METHOD

To obtain a thorough understanding of systemic design, a qualitative systematic literature review was performed. This methodology was selected to "produce a synthesis of available evidence in answer to a focused research question" (Bearman et al., 2012, p. 625). Systematic reviews place an emphasis on transparent, structured and comprehensive approaches to searching literature in order to synthesise the findings. This approach is particularly beneficial for exploring new fields as it facilitates a methodological organisation of information to achieve a profound reading of the available literature (Bearman et al., 2012). For the purposes of this research, it aided in synthesising and illuminating current systemic design frameworks.

The first stage of the process consisted of scoping and defining the topic by undertaking a brief narrative literature review, from which, key words were extracted to devise search terms. The terms selected were tested by conducting an initial search across multiple databases, after a period of trial and error, the following search terms were deemed most effective: ("systemic design") AND ("framework" OR "model" OR "principles" OR "methods").

Resources were identified by searching two prominent databases—Google Scholar and Web of Science. To refine the Google Scholar results the search was restricted to the title field, while the Web of Science search included the topic. A timeframe of 2000–2020 was used to consolidate the search efforts. The title, abstract and keywords were screened to determine if a publication was relevant to the guiding research questions. The selected publications were then read in full, and the quality assessment checklist was used to determine if they should be included in the systematic literature review. The criteria for the quality assessment included: type of source, scale of complexity (molecular, product, process, or system), peer reviewed (yes or no), and number of citations.

In total, the database searches produced 131 results, of which 17 papers were determined to be relevant. To further expand the scope of the results, reference lists from the selected articles were also analysed. This increased the total amount of selected papers to 39. Article details like publication date, author, author location, institute, number of citations, and discipline were captured to help evaluate the papers. Once this process was complete, the papers were further studied to extract information relevant to the research questions. This information was categorised under seven broad headings: context, origins, concepts, principles, processes, methods and limitations. Microsoft Excel was used to store and organise this information, with the data collected preserved in the form of figures, lists, tables, charts, and text.

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2. RESULTS

Systemic design research has seen a steady increase in publications since 2009 with an emerging focus on sense-making practices using visualisations. Two of the most notable and developed theories have formed in Italy and between Canada and Norway. In 2018 these major schools of thought were brought together with the formation of the Systemic Design Association (SDA). To verify the extent of influence the two frameworks have had on each

other and in relation to other countries, is important to visualise the dynamics of systemic design frameworks on a global scale. Thus, the author's country of residence, where the journals were published, and which papers are connected via references were analysed to build a landscape of the current body of work. As shown in Figure 1, little cross-pollination between the two major philosophies has occurred. Of the 19 Italian papers in the review, only 5 referenced Canadian and Norwegian papers by Jones and Sevaldson, while Canadian and Norwegian connections to Italian work have remained absent, and sources from other countries reference either Italian papers or Canadian and Norwegian papers—but rarely both.

Figure 1. Three radial convergence maps that highlight the geography of the papers included in the systematic review and visually connect the papers that reference each other.

To get a clearer view of the design aids that have had the most influence on the field of systemic design, Table 1 provides a summary of the papers with the most citations, their topic and the date they were published. They have been grouped by their topic and then arranged from most cited to least. Many of the design aids are in the form of literature reviews, which, in some instances, are supported by case studies.

Table 1. A summary of current and significant design aids for systemic design.

Topic	Application Area	Reference	Cited	Location
Framework	General complexity	Stolterman and Nelson (2012)	1318	USA
	General complexity	Jones (2014b)	164	Canada
	General complexity	Ryan (2014)	35	Canada
	Sustainable production	Bistagnino (2011)	22	Italy
	Policymaking	Barbero (2017b)	14	Italy
	General complexity	Zivkovic (2018)	9	Australia
	Healthcare	Jones (2013)	4	Canada
	Sustainable production	Battistoni and Barbero (2017)	3	Italy
	Sustainable entrepreneurship	Battistoni and Barbero (2019)	3	Italy
	Sustainable production	Battistoni et al. (2019)	3	Italy

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Methods and concepts	General complexity	Jones (2014a)	24	Canada
	Sustainable production	Barbero (2016)	4	Italy
Data visualisation	General complexity	Sevaldson (2011)	117	Norway
	General complexity	Jones and Bowes (2017)	17	Canada
	General complexity	Sevaldson (2018)	5	Norway
Dialogic design	General complexity	Jones (2018)	13	Canada
Case study	Landscape architecture	Berger and Sijmons (2009)	55	USA
	Agriculture	Barbero and Toso (2010)	15	Italy
	Policymaking and sustainable production	Barbero (2017b)	14	Italy
	Sustainable production	Ceppa and Marino (2012)	12	Italy
	Agriculture	Barbero and Tamborrini (2012)	8	Italy
	Sustainable production	Gaiardo and Tamborrini (2015)	6	Italy
	Sustainable production	Coelho et al. (2017)	4	Italy
	Sustainable production	Battistoni et al. (2019)	3	Italy

The majority of frameworks exist within the academic arena and are taught in universities, including the Master of Science in Systemic Design at Politecnico di Torino (Italy), the Master of Design in Strategic Foresight and Innovation at OCAD University (Canada), and the Master of Systems Oriented Design at the Oslo School of Architecture and Design (Norway) (Barbero, 2018). Part of the reason systemic design is so prominent in the realm of academia may be due to the complexity of the field, along with the fact that the discipline is still young and evolving.

Consequently, many frameworks have generally been confined to the classroom, with a limited number of real-world applications beyond the domain of design education. An exception to this is the methodology developed at Politecnico di Torino in Italy, which is supported by a plethora of case studies and real-world projects. Regardless of its merit and the momentum it has gained, the methodology has been criticised as being confined to the realm of production, excluding consumer demand and consumption behaviours (Ceschin & Gaziulusoy, 2016). For this reason, cross pollination between the various schools of thought would be valuable. Across the 39 papers, systemic design has been used to approach a variety of application areas (Figure 2), including general complexity (13 papers), sustainable production (12), general sustainability (3), sustainable entrepreneurship (2), agriculture (2), sustainable urban transitions (1), economic development (1), energy networks (1), health care (1), landscape architecture (1), policymaking (1), and sustainable household consumption (1).

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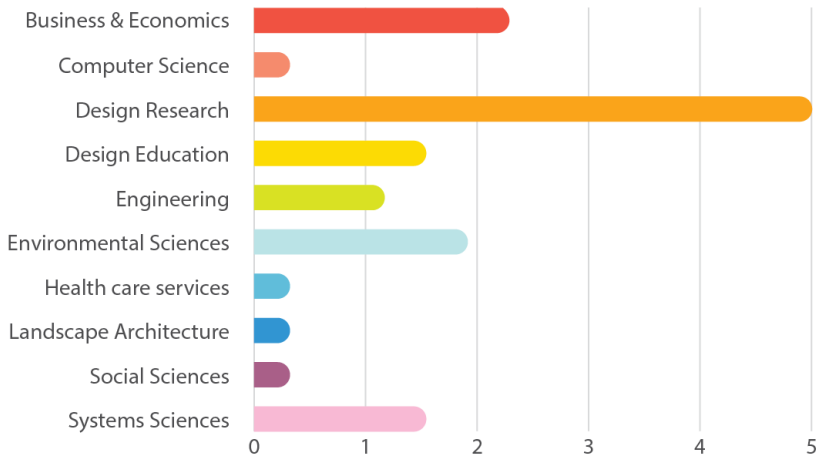

Figure 2. Application areas of the papers.

Considering the variety of application areas that systemic design can be used to address, along with its inclusive a0nd wide-ranging nature, it is unsurprising that the field is being researched across multiple disciplines, as seen in Figure 3. As expected, most of the publications came from the field of Design (56%), followed by Business and Economics (10%) Environmental Sciences (8%) and Systems Sciences (8%). The results indicate that while systemic design has a strong foundation in Design, other disciplines are also beginning to acknowledge its relevance.0

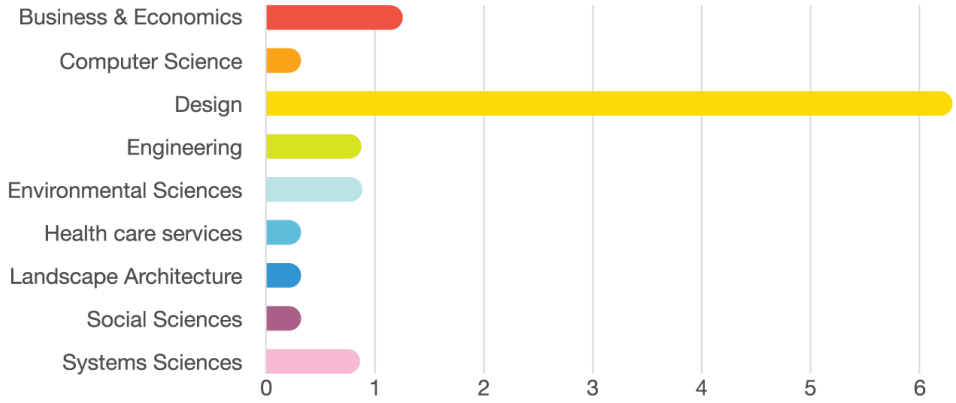

Figure 3. The disciplines researching systemic design.

While frameworks outside of scholarly literature exist, they exhibit a lack of referencing, making it difficult to determine the origin of the information. In addition, there are a variety of terms associated with the field that exist both in and out of academia (systems-led design, systems-oriented design, whole systems design, and system thinking for design). Inconsistencies like this are not limited to the name of the field, and a variety of assorted principles, processes and methods exist, in part, because of the complex nature of systems thinking and the large family of systems approaches (Jones & Bowes, 2017). Consequently, there are numerous frameworks that are similar, but use different terminology and have minute variations. An interesting commonality between the various schools of thought is their limited acknowledgement of established human-centred design techniques from organisations like IDEO (2020). Instead, methods tend to focus on systems thinking principles, with the integration of design focused primarily on design thinking processes and visual communication techniques (Jones, 2014a).

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3. METHODOLOGICAL OVERVIEW

Despite some similarities between frameworks and the collaboration developed among territories to form the Systemic Design Association (SDA), little cross pollination in the literature has occurred. In order to bring more cohesion to the field of systemic design, the 39 papers in the review were compared to reveal commonalities between mindsets, processes and methods. The aim of the findings was to create a comprehensive methodological overview for designers new to Systemic Design.

It is important to acknowledge that due to the unique characteristics of complex problems an adaptive methodology that is flexible and open to the diverse demands of practice is needed (Jones & Kijima, 2018). An overreliance on rigid and inflexible tools can undermine the design project by restricting the process to a constrained set of procedures that limit options in the face of complex and multifaceted problems (Sevaldson, 2018). Therefore, the following mindsets, processes and methods presented here are not an authoritative or a prescriptive set of principles, rather they describe general concepts that aim to create a comprehensive synthesis of existing frameworks. To ensure room is left for exploration, iteration and divergence, an unstructured playful and loose application of methods is recommended. In addition, Jones (2014a) asserts that methods must be accepted and understood by stakeholders, because, when tools become too technical and inflexible, they can marginalise and intimidate stakeholders from engaging in the conversation.

Systemic design mindsets

Concepts related to systemic design mindsets are termed differently across papers; in some cases, they are referred to as principles, in others as guidelines. Systemic design mindsets are defined by Ryan (2014) as "a set of values and habits that guide the interpretation of methodology and the application of methods" (p. 5). In total, 10 key mindsets were extracted from the data, which encourage designers to (1) Recognise that humans are connected to the environment, (2) Act locally, (3) Get inspiration from nature, (4) Redefine waste as a resource, (5) Create systems that sustain and organise themselves, (6) Approach complexity with variety, (7) Work as part of an interdisciplinary team, (8) Be inquisitive in the world and with their own biases, (9) Explore top-down and bottom-up approaches, and (10) Envision preferred futures and take action towards them. A more detailed description of each mindset can be found in Table 3, located in the Appendix. Due to the broad range of terms across papers, the most inclusive and comprehensive wording was chosen. The concepts presented encourage the exploration of new ways of thinking to create socially and environmentally conscious outcomes. They provide guidance and a foundation that supports human-centred design for complex, multi-stakeholder systems (Jones, 2014b).

Systemic design processes

The systemic design process assists in applying methods in a sequential order from the initial stages of a project, through to completion. The processes revealed in the literature vary slightly in their order and terminology, but in general, follow a generic design thinking process. Van Patter and Paster (2016) have mapped over 80 innovation processes across various disciplines and found that four stages are applicable across all innovation frameworks:

1. Discovery and orientation,
2. Definition and concept formation,

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3. Optimisatio0n and planning,
4. Evaluation and measurement.

Each of these phases can be found in the systemic design frameworks that were extracted from the systematic review. A summary of these processes and their source can be seen in Table 2. In total, seven frameworks were collated and documented in chronological order, from the oldest to the most recent. Where the same process was used in different papers, only the most recent publication has been presented. The approach documented by researchers Battistoni, Giraldo and Barbero (2019) is of particular interest, as it is not only the most current framework, but has also been developed and tested over the past sixteen years at Politecnico di Torino. Furthermore, the framework draws strong parallels with the methodology developed by Alex Ryan (2014). The basic structure of these frameworks has been summarised into six main steps: (1) Inquiry, (2) Identification of leverage points, (3) Designing the system, (4) Analysis, (5) Implementation, and (6) Feedback.

Table 2. A summary of systemic design processes.

Source Title	Process phases					
Jones (2014b)	Strategy	Discover	Design	Develop	Deploy	
Ryan (2014)	Inquiring	Framing	Formulating	Generating	Facilitating	Reflecting
Barbero (2017a)	Quality and quantity analysis	Best practices selection in different context	Identification of problems	Creation of solutions	Implementation	
Battistoni and Barbero (2017)	Diagnose territory (holistic diagnosis)	Analysis of production model and Identify problems	Turn problems into opportunities	Define a new systemic model	Define relations in the whole territory	Produce a summary of outcomes
Zivkovic (2018)	Form	Explore	Map	Learn	Address	Share
Barbero (2018)	Analysis	Project	Action			
Battistoni et al. (2019)	Holistic diagnosis (assess, research, collect, visualise, interpret)	Definition of problems and leverage points for change	Design of a system	Analysis of possible results	Implementation	Analysis of outcomes and feedback

Systemic design methods

Systemic design methods provide a set of tools to generate and distil the systemic design process into actionable steps. The methods extracted from the systematic review borrow techniques from both systems thinking (systems maps, causal loop diagrams, process models) and design thinking (brainstorming, prototypes, rapid sketching) (Jones, 2014a; Ryan, 2014). A summary of methods that fit into each stage of the systemic design process are listed below:

Inquiry: Inquiry begins by defining the topic and scope of the study to identify system boundarie0s and specific categories of interest. Techniques like boundary framing, and visual sense making are carried out to define the topic and create a lens through which the system can be examined (Stolterman & Nelson, 2012). In reality, systems are a continuum, and rarely have boundaries, but they are necessary to define otherwise endless concepts (Battistoni et al., 2019). The use of visual sense-making assists in communicating the collected data in a comprehendible manner due to its ability to increase cognitive perception, reveal patterns and

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assist collaborative problem-solving. The categories uncovered in the initial stages of inquiry are then used to guide primary and secondary research in relation to the current situation. Research methods can range from stakeholder ethnography to statistical analysis and interviews. This phase is the most critical in ensuring the validity and effectiveness of the project (Silvia Barbero, 2016). Inquiry is not just about collecting information; its essential role is to uncover different world views and expand perspectives (Ryan, 2014).

Identification of leverage points: Leverage points represent places within a system where small modifications have the potential to generate significant change (Meadows, 2008). This phase of the project involves identifying the major problems to be addressed within the system, exploring relationships between system structures to establish a comprehensive understanding of its characteristics and what makes it produce results (Battistoni & Barbero, 2017). To support and guide this exploration, Sevaldson (2012) has developed a "Library of Systemic Relations" that catalogues structural, social, causal and semantic relations (Sevaldson, 2012). Another technique developed by Sevaldson (2018) to find potential areas for interventions is known as ZIP analysis. ZIP stands for Zoom, Innovation and Potential. Zoom represents areas within the project that need more research. By marking these areas on the maps developed in the inquiry stage, it acts as a prompt to make additional maps that zoom further into the system at points of ambiguity. The next step is "P" for potential and problems. It symbolises areas of the project that have room for improvement. To identify areas of potential it can be helpful to search for problems, as these are obvious areas that need attention. Areas of potential are comparable to the leverage points for intervention developed by Donnella Meadows (2008), which act as an invitation to think more broadly about systems change (p. 147). Meadows (2008) identifies 12 areas within a system to explore for leverage: numbers (constants and parameters), buffers (stabilising stocks), stock and flows (physical systems), balancing feedback loops, reinforcing feedback loops, information flows (information access), rules (incentives, constraints), self-organisation (the ability to change and evolve), goals (purpose of a system), and paradigms (the mind-set out of which the system arises) (p. 162). The final stage of a ZIP analysis is "I" for innovation or intervention. This step involves generating new ideas to address a problem or connecting relations in new ways to tweak how the system behaves.

Designing the system: Designing the system, also referred to by Alex Ryan (2014) as 'formulating', involves shifting from understanding the current situation to imagining the future we would like to see. Changing existing circumstances into desired ones is where design makes its greatest contribution to the process. Herbert Simon (1996) clarifies the distinction between science and design by claiming that science is a practice that studies what is, while design is focused on how things "ought to be" (p. 4). The concept of "idealised design" developed by Russel Ackoff, Herbert Addison and Jason Magidson (2006) reinforce this belief by asserting that identifying ideal future scenarios based on fundamental values is the most effective way to compel action towards a desirable outcome. Methods that support this process include techniques like envisioning and backcasting. Envisioning is a future-finding process that involves a collective imagining and evaluation of possible futures (Jones, 2018). This process is comparable to design futuring developed by Tony Fry (Jones, 2014b). Design futuring refers to the act of reimagining and redirecting future possibilities towards ecological, ethical and social outcomes (Fry, 2009). Within these practices it is important to emphasise the role of co-creation to promote participatory stakeholder engagement. Co-creation enables value creation by supporting collective planning, social change and organisational

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development (Jones, 2018). Once desirable future scenarios have been envisioned, backcasting can be used to work backwards and identify specific steps that will connect the future to the present. Backcasting is a retroductive mode of planning system evolution and can help to create transition roadmaps (Jones, 2018).

Analysis: This phase of the project evaluates the environmental, economic and social benefits of the designed system (Battistoni et al., 2019). A process of verification and validation is undertaken to foresee possible outcomes and identify gaps before the strategy is implemented (Barbero, 2017a). At this stage it is instrumental to consider that diverse systems with many connections and approaches are more resilient (Barbero, 2017a). As stated by Ashby's law requisite variety, systems need to be approached with a variety of strategies, in order to match the complexity of the system (Jones, 2014b). The connections generated at this stage can enhance the outcome and offer new possibilities. Methods generally involve foresight models that analyse the inevitable evolution and adaption of a system over time (Jones, 2014b). Ryan (2014) suggests that mapping situations to account for their history, present state and possible future, creates frames that can illuminate discord between existing patterns and emerging developments. Several types of diagrams can be used to map sequentially ordered scenarios, for example spatial maps, flow charts, causal loop diagrams, Gantt charts and PERT diagrams (Sevaldson, 2011).

Implementation: Once the design has been analysed through preliminary studies and simulations, the strategies produced by the team can be injected into the real world (Barbero, 2017a). The project is realised in the specific territory and context that it was designed for, rather than acting as a global solution (Battistoni et al., 2019). Implementation, also referred to by Ryan (2014) as "generating", serves multiple functions. The implemented project aims to approach the complex problem, while also providing a deeper understanding by comparing expected outcomes with actual outcomes (Ryan, 2014).

Feedback: Complex problems are constantly evolving and hard to predict, making it rare for a project to produce the anticipated results. Feedback coordination is fundamental to systemic design as it guides the performance of a system by facilitating the observation of positive and negative feedback loops (Jones, 2014b). System mapping methods like causal loop diagrams, iceberg models and convergence maps can be used to analyse and coordinate system feedback. Feedback coordination recognises that positive and negative feedback loops can be used to guide desired system outcomes (Jones, 2014b). The process involves an iterative and continuous gathering of information in order to measure gaps between the present and desired state of a system. The data gathered, provides an opportunity to improve the project, develop a deeper understanding and discover new opportunities (Battistoni et al., 2019). A continuous cycle of feedback and reflection from the first phase of the project through to the last, enables the project to become reflexive and adaptive in the face of inevitable fluctuations within the system (Barbero, 2017a). The analysis of expected outcomes and actual outcomes informs and facilitates the coordination of new approaches and strategies. Meadows (2008) asserts that there are two main types of feedback loops: (1) balancing and (2) reinforcing (p. 30). Balancing (or stabilising) feedback loops occur when elements within a system seek equilibrium. Conversely, reinforcing loops are self-enhancing leading to exponential growth or collapse over time (Meadows, 2008, p. 30). Understanding feedback loops provides deeper insight into causality and how system elements relate.

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4. CHALLENGES AND LIMITATIONS

Systemic design is met with a variety of challenges in the face of complex problems. A significant limitation identified by Murphy and Jones (2020) is the role interpretation plays when constructing system models. Within the large amounts of information presented by complex problems, data that may seem unimportant can be over simplified or forgotten, leading to a detrimental weakness in the project. The process of engaging in complex systems to analyse data, identify leverage points and design models, introduces inevitable bias and chance into the equation. A particular challenge within this sphere, is ensuring that stakeholders are making decisions based on outcomes beneficial to the system, rather than decisions based on personal interests. Dealing with an extensive array of stakeholders presents additional challenges in the coordination and implementation of a systemic design project and can be problematic due to converging opinions, a lack of commitment, limited economic incentives and a required paradigm shift from a competition mindset to one of collaboration (Battistoni & Barbero, 2019).

In relation to the impact systemic design has on sustainability, limitations within the research highlight a lack of integration regarding social innovation, with a majority of the literature focused on production models of input and output. While systemic design is continuing to evolve and expand as new areas of development are explored, the approach requires the management of multiple variables, active stakeholder engagement and many years of implementation. Due to these factors, results within the field are slow to emerge, making the research more challenging to fund and implement (Barbero, 2018).

In addition, the review indicates that systemic design has been grounded in a Eurocentric perspective and has not incorporated different cosmologies and ontologies. This omission may, in part, stem from the limitation of including only English-language publications in the search criteria, consequently excluding a wealth of systemic design resources originating from other linguistic contexts. Moving forward, the integration of indigenous and local knowledge into systemic design should be prioritised. As pointed out by Arturo Escobar (2018) contexts like Latin America, “a land with an intense historical dialectic of commonality and diversity, might be offering to the rest of the world particularly valuable elements for the pensamiento para la transición (the thought for the transition)” (p. 167).

5. CONCLUSION

Systemic design is an area of research that is steadily growing and gaining increasing attention across the globe. It is widely acknowledged that incorporating systems thinking into design will play a key role in supporting designers to approach the dynamic and interconnected, environmental, economic and social challenges that are emerging across the world. This systematic literature review has presented an overview of systemic design and its associated frameworks, using scholarly journal papers published within the last 20 years. Based on this literature, a contemporary understanding of systemic design was established, along with a synthesis of prevelent mindsets, processes and methods. The information presented in this review has been devoted to establishing greater cohesion within the field and developing greater insight into the mechanics of applying systemic design in a practical manner.

What this review revealed was that current systemic design frameworks aim to integrate design and systems thinking methods in order to expose hidden relationships within a system, facilitate collaboration among stakeholders and identify opportunities for transition. A

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notable pattern within the frameworks, was a strong focus on sense-making practices using visualisations and systems maps (holistic diagnosis in Italy, giga-mapping in Norway and synthesis maps in Canada) (Jones, 2014a). In contrast to the focus given to visual communication techniques and the design process, limited acknowledgement has been attributed to established human-centred and earth-centred design techniques.

An additional disparity within the field was the heavy focus on material and production processes, resulting in a minimal amount of exploration in relation to influencing consumer demand and consumption behaviours (Ceschin & Gaziulusoy, 2016). For systemic design to continue to gain momentum and become more impactful, there is a need to address these limitations, as well as create a more accessible education platform for newcomers, so as to expand the research beyond a niche group of educational institutions. Moreover, deeper insight into sustainable consumption transitions and the initiation of grassroot initiatives needs to be incorporated into systemic design approaches. This could involve exploring industry incentives and government policy for transparent production models that prioritise ecosystem preservation and human well-being. Finally, in relation to the existing systemic design philosophy, different knowledge systems, localities and psychologies are required to activate more inclusive interpretations of system dynamics.

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APPENDIX

Table 3. A summary of systemic design mindsets.

Principle	Definition	Framework
Recognise that humans are connected to the environment	Humans are a product of their coupling with the surrounding environment, and the environment is in turn shaped by the actions of humans (Magalhães & Sanchez, 2009). Systemic design acknowledges the impact of human actions on environmental, social and cultural systems (Bistagnino, 2017). Traditional design practices are limited to linear flows of production and consumption that fail to recognise the complex ecology that impacts our behaviours, attitudes and actions. This mindset emphasises the importance of acknowledging connections of not only material flows, but also between society, culture and the surrounding ecosystem.	Ceppa & Marino (2012) Bistagnino (2017) Barbero (2018)
Act locally	Complex problems are context specific and need to be understood in relation to their surrounding environment (Zivkovic, 2018). A local approach seeks to engage stakeholders at a community level to address issues experienced within a neighbourhood, region or ecosystem (Bistagnino, 2011). This mindset highlights the need to utilise local, social, cultural and material resources. In doing so the cultivation of local development promotes the preservation of the culture, increases local jobs, and establishes a resilient and self-preserving system.	Ceppa & Marino (2012) Bistagnino (2017) Barbero (2018) Zivkovic (2018)
Get inspiration from nature	Buckminster Fuller (1975) proclaimed that technology evolved by man is amateur compared to the elegance found in nature. He insisted that nature should be recognised as a technology itself. In natural systems there is no such thing as waste, even surplus materials are metabolized (Ceppa & Marino, 2012). Nature provides insights into creating human systems that are not only symbiotic with the natural world, but are also self-sustaining and resilient. The technical term used for emulating the models found in nature is biomimicry (Benyus, 2002). The word is derived from ancient Greek, 'bio' meaning life, and 'mimesis' meaning imitation.	Ceppa & Marino (2012) Bistagnino (2017) Barbero (2018)
Redefine waste as a resource	This mindset aims to inspire a new definition of waste, whereby all concepts of waste are redefined as a material resource. Waste does not exist when the components of a product are designed to fit within a circular system (Ellen MacArthur Foundation, 2013). The biological components of a product are designed to be non-toxic and compostable, while the technical elements are designed for reuse with the highest quality retention. The result is a continuous flow of matter and energy to generate new products, services and systems (Bistagnino, 2017).	Ceppa & Marino (2012) Bistagnino (2017) Barbero (2018)
Create systems that sustain and organise themselves	The concept of self-generating and organising systems dates back to Maturana and Varela's (1974) theory of autopoiesis and Luhmann's autopoietic social systems (1986). Autopoiesis is the term used to signify a system that is capable of rebuilding and maintaining itself. As a mindset the theory highlights the need to create systems that have the capacity to regenerate and organise themselves in order to sustain a state of equilibrium (Barbero, 2018). Self-sustaining systems are able to support themselves by employing feedback mechanisms to maintain internal balance.	Bistagnino (2017) Jones (2014b) Ceppa & Marino (2012) Barbero (2018)
Approach complexity with variety	This mindset acknowledges a concept known as Ashby's law of requisite variety. The law states that complex systems need to be approached using a variety of design strategies that match the complexity found in the system (Jones, 2014b). Likewise, the more variety, connections and relations within a system, the stronger and more resilient it becomes (Barbero, 2018). The concept can be visualised using the metaphor of a fishing net. The knots that make up the fishing net represent various design strategies, and the connections between each knot (or design) give strength to the strategy as a whole (Bistagnino, 2017). For this to happen it is important to engage stakeholders that represent a diverse range of perspectives.	Jones (2014b) Ceppa & Marino (2012) Bistagnino (2017) Barbero (2018)
Work as part of an interdisciplinary team	The nature of systemic design is interdisciplinary and acknowledges that all areas of design are components of one complex system (Battistoni et al., 2019). This involves working as part of an interdisciplinary team with a focus on analysing information in context, and synthesising information from diverse sources (Ryan, 2014). An interdisciplinary approach, also known as a 'horizontal approach', facilitates the discussion of varied perspectives on a topic to create 'bridges' between different understandings (Dominici, 2017). In this scenario, the role of the designer shifts to one of a 'mediator', with skills needed to transcend individual interests and integrate different types of knowledge (Battistoni & Barbero, 2017).	Jones (2014b) Ryan (2014) Ceppa and Marino (2012) Barbero (2017a) Barbero (2018) Jones (2018)
Be inquisitive in the world and with your own biases	Being inquisitive involves asking, rather than assuming. It encourages observation, learning and curiosity to cultivate a deep understanding that can then be used to inform more accurate action (Ryan, 2014). This action can be employed to stimulate new knowledge. The maps and connections we create are intermingled with our own biases and beliefs (Murphy & Jones, 2020). To alleviate these issues, it is important to stay open minded to multiple opinions, and to examine gaps between our own mental models of reality.	Ryan (2014) Battistoni et al. (2019)
Explore top-down and bottom-up approaches	Systemic design maps systems from multiple angles to understand various perspectives and explore all sources of potential (Ryan, 2014). A bottom-up approach represents working from the ground up using a grassroots tactic to engage individuals and create social change. A top-down approach represents impacting policy, local government, and private or public industry partnerships (Giraldo Nohra & Barbero, 2019).	Ceppa & Marino (2012) Giraldo Nohra & Barbero (2019)
Envision preferred futures and take action towards them	A defining aspect of design is the belief that the future is subject to creation. Design has impacted every system on Earth, meaning that these systems can also be redesigned (Ryan, 2014). This mindset emphasises the importance of envisioning and bringing to life desired futures that engage our imagination and illuminate our values (Molina & Maya, 2017). This process is referred to using a variety of terms, like future finding, idealisation, speculative design and backcasting (Jones, 2014b).	Pourdehnad et al. (2011) Jones (2014b) Ryan (2014) Molina & Maya (2017)