Integrating Design Thinking and Systemic Change: An Experimental Study on Methodological Innovation for Sustainable Workshops

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Abstract*—Urban communities are at the center of the world-wide shift to sustainability. Nonetheless, due to their sophisticated stakeholder networks and strong behavioral tendencies, they tend to hinder the achievement of the desired changes. The current approaches to community involvement largely concern the treatment of individual issues, without any overall model to inform systemic innovation. Therefore, interventions are often not capable of overcoming structural impediments. In order to overcome this gap, this paper presents a low-cost and repeatable workshop methodology, namely the Sys-Design framework, which combines the concepts of Design Thinking and Systemic Change theories. Using a Participatory Action Research (PAR) paradigm, the methodology was tried in an urban low-carbon transition workshop under normal community settings. Rather than depending on the resource-intensive controlled experiment, the paper took a pre-post descriptive evaluation of a single group that involved short self-report questionnaires, facilitator field notes, and participant reflection sheets, as well as a transparent output-scoring rubric. The workshop had a total of twelve participants who were drawn based on their background in resident, social organization, and grassroots management. The descriptive findings indicated that there was a significant improvement in participants self-reports of systemic thinking abilities and innovation self-efficacy, and the workshop produced 53 innovative ideas and 6 feasible community action plans. The major theoretical contribution of this paper is to clarify the synergistic mechanism of the divergent-convergent creative process of Design Thinking and the goal-pathway analytical framework of Systemic Change. This paper offers community managers, urban planners, and sustainability practitioners with a practical, low-cost, and replicable methodological toolkit to show how thoughtfully constructed participatory processes can turn diverse sources of community energy into constructive momentum towards systemic transformation.

Keywords*—*Design Thinking, Systemic Change, Sustainable Communities, Participatory Methods, Methodological Innovation

I. Introduction

A. Background

As one of the basic units of socio-economic systems, urban communities have become more vocal about the significance of their sustainable transformation over the years, in the context of solving the global issues of climate change, resource exhaustion, and social injustice [1]. The Sustainable Development Goals of the United Nations (SDGs) include "Sustainable Cities and Communities" as one of the main agendas and focus on making the world more sustainable by building inclusive, safe, and resilient communities [2]. Nevertheless, community-based sustainable innovation has a set of specific and intricate issues: extreme diversity of stakeholder requirements, decades-old behavioral traditions of the population, and multi-layered socio-technical systems. Such structural constraints are why conventional top-down policy implementations and individual technological interventions tend to be largely ineffective [3]. This has led to the creation of efficient participatory intervention mechanisms to initiate endogenous community motivation and systemic change becoming a critical problem in the sphere of sustainable development.

B. Research Problem

As one of the most common ways to promote multi-stakeholder involvement and co-creation, workshops have been used in many projects related to sustainable development [4]. However, there are two fundamental shortcomings in current workshop methodologies. To begin with, although innovation methods such as Design Thinking are very good at stimulating creativity and encouraging human-centric solutions, they tend to focus on the user experience aspect and do not consider larger system limits and structural issues [5]. Secondly, despite the fact that Systemic Change theories offer the conceptual basis of understanding leverage points in complicated systems, their concepts and macro-perspectives may be unclear to non-expert participants, who lack operational micro-innovation mechanisms [6]. The gap between creative micro-interventions and analytical macro-systems is the main issue discussed in this paper.

C. Current Research and Limitations

The implementation of Design Thinking in sustainable development has gained much interest among academics over the last few years. Responsible Design Thinking was cited by Baldassarre et al. [7] via a systematic literature review as a concept that has the potential to close the gap between innovation management and sustainable development. Baldassarre et al. [8] investigated the possible use of Design Thinking tools to innovate sustainable business models. In the area of System Design, academic research has facilitated cross-integration of systems thinking and design practice [9]. Nevertheless, the current research is characterized by the following limitation: (1) Most of the research conducted are still at the stage of theoretical framework construction, and do not have enough operational procedures to be used by an ordinary community practitioner [10]; (2) Empirical research that is present in the literature is scarce, and most of these

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studies tend to use the case study or action research methodology but rarely provide enough detail on low-cost materials, facilitation processes, rating scales, and replication conditions [11]; (3) No in-depth theoretical explanation of the integration mechanism of Design Thinking and Systemic Change paradigm, i.e., how the two produce synergistic effects in the field of operation but can still be applicable in resource-limited community contexts.

D. Research Objectives

The gap in this research is addressed by suggesting and preliminary testing an inventive, inexpensive and repeatable workshop approach that combines Design Thinking and Systemic Change theories. Particularly, it has been set to achieve the following goals: (1) to develop the concept of the "Sys-Design" methodological model, its conceptual background and practical stages; (2) to assess the effectiveness of the developed method in improving the systemic thinking and innovation results of the participants based on a single group pre-post pilot application; and (3) to identify the synergistic process of implementation of both paradigms under regular community workshop circumstances. This paper is concerned with the context of urban community low-carbon transition and does not aim at the confirmation of the applicability of the methodology to the activities of corporate organizations or the sphere of education.

II. Literature Review

A. The Evolution of Design Thinking and Its Sustainability Turn

As an innovative approach to products, Design Thinking has extended beyond the sphere of product design to other fields, including social innovation, the field of government, and education, since the methodology was systematized by the Stanford d.school and IDEO [12]. The authors Brown and Wyatt [13] describe the concept of Design Thinking as follows: "a human-focused way of innovating, which incorporates the designer's toolbox to combine what people need, what is feasible through technology, what is needed to be successful in business." The central part of its process contains five steps: Empathize, Define, Ideate, Prototype, and Test.

This shift towards sustainability in the Design Thinking approach is a recent topic in academia. Ceschin and Gaziulusoy [14] have followed the evolution of design of sustainability as eco-design of products, which led to product-service system design and then design of system innovation and transitions. They observed the current dilemma to be what needs to be done to raise design solutions to solve the so-called tame problems to the wicked problem solution. The response to this challenge is the framework offered by Irwin [15] known as Transition Design, which focuses on the fact that designers should comprehend the dynamic evolutionary principles of socio-technical systems. Nevertheless, the way these theoretical frameworks could be translated into replicable workshop methodologies in the operational context is still a matter of speculation.

B. Theoretical Foundations of Systemic Change

Change on a systemic level is based on systems science and complexity theory. The concept of Leverage Points developed by Meadows [16] is a pioneer in this area as it defines 12 stages of system intervention points, which are: adjustment of parameters, and shift of paradigms. This framework was also used by Abson et al. [17] in their study of sustainability transitions, where they noted that most of the sustainability interventions merely stay on the surface level of leverage points (e.g. subsidies and taxes), and real change needs to address the core of the system (i.e. information flows, rules and goals).

ToC in practice is a planning and evaluation tool and has broad applications in social innovation projects [18]. ToC makes the practitioners begin with desired long term objectives and work backwards in order to identify causal paths and pre conditions that would be required in order to achieve those objectives. This reverse planning logic could be a complementary relationship to the Design Thinking process known as divergent-convergent: Design Thinking is good at finding new solutions to problems in the space of possibilities whereas ToC offers an organized structure to convert ideas into actionable paths.

C. Application of Participatory Methods in Sustainable Innovation

The Participatory Action Research (PAR) approach focuses on the balanced cooperation of researchers and practitioners as well as the joint creation of knowledge and the promotion of change through a cyclical process of action-reflection-action [19]. PAR is seen as a useful link between scientific knowledge and local practice in the area of sustainable development [20]. Reason and Bradbury [21] have pointed out that the most important aspect of PAR is its dual aim of creating academic knowledge as well as practical change at the same time.

In the workshop methodology framework, Fernandes and Rachão [22] have created a workshop methodology focused on sustainable innovation in the tourism sector, grounded on the three pillars of Theory of Change, Design Thinking, and Sustainable Business Models. Their study has shown the possibility of using integrated methodologies to facilitate systemic change, creativity and cooperation. Nevertheless, that paper used a single-case action research approach, did not compare with a control group, and restricted itself to the tourism industry, so that the generalizability of its findings is questionable and should be tested more.

III. Related Work

A. Application of Design Thinking in Community Engagement

To organize a co-creation workshop of 50 participants in the redesign of the post-COVID campus experience, Victorino et al. [23] used Design Thinking methods as a way to illustrate the usefulness of Design Thinking in multi-stakeholder cooperation. Chang et al. [24] examined the effect of virtual reality technology on Design Thinking creativity by using a quasi-experimental design, which offers methodological references to the quantitative assessment of Design Thinking. Robbins and Fu [25] used a two-stage research design (questionnaire survey quasi-experimental field study) to measure the first-time indirect effects of Design Thinking practices on R&D performance. The given studies are valuable sources of reference to evaluate the design of the current study, however, none of them can cover all aspects of translating Systemic Change tools into low-cost and repeatable community workshop processes.

B. Systemic Design and Sustainability Transitions

Systemic Design is a relatively new field that seeks to integrate the analytical power of systems thinking with the creativity of design practice [26]. The core principles of Systemic Design suggested by Jones [27] were idealized design, purposeful exploration and boundary critique. Visualization tools like GIGA-mapping were developed by Sevaldson [28] to assist designers to comprehend and influence intricate systems. Nevertheless, they are focused on professional designers and scholars, and much remains to be done to make them more accessible and easy-to-use to ordinary members of the community.

C. Evaluation of Workshop Methodologies

In terms of assessing the impact of workshops, most of the available studies have been done based on qualitative approaches (e.g. participant observation and interview) and there are few quantitative assessments [29]. Wölfel and Merritt [30] suggested a multi-dimensional approach to assess co-creation workshops, which includes dimensions like engagement, idea quality, and effectiveness of collaboration. Braun and Clarke [31] were concerned with the standardized qualitative methods of analyzing data that can be used when coding and analyzing workshop data. Paulus and Kenworthy [32] reviewed the effective brainstorming techniques in a systematic manner, which gives a theoretical justification to the optimization of ideation connections in participatory workshops. Nevertheless, the studies that provide clear, inexpensive, and straightforwardly reproducible assessment practices of workshop approaches still lack.

IV. Methodology

A. Research Strategy and Technical Route

The research framework The research framework used in this study will be a two-stage research strategy; theory construction and pilot implementation. The first step is to develop the methodology framework of the "Sys-Design" workshop using the literature synthesis and theoretical analysis. The second step involves applying the methodology into a real community project and assessing its feasibility, usability, and preliminary results descriptively with a low-cost single-group pre-post design.

B. The "Sys-Design" Methodological Framework

After a close examination of the theories of Design Thinking and Systemic Change, the framework of the workshop, which is called Sys-Design in this research, consists of four main stages (as shown in Figure 1):

Process of System Mapping & Empathy. The current step combines a streamlined form of Causal Loop Diagram (CLD) in systems science with the empathy approach in the Design Thinking. In order to decrease implementation costs, the participants are provided with input materials in the form of the current observations of the community, brief informal discussions, advertisements, photos and personal experience cards instead of performing resource-consuming field work. Next, under the help of facilitators, they convert the identified events into elementary systemic cause and effect diagrams. Through such a process, participants can simultaneously receive not only a micro-empathy (understanding individual pain points) but also a macro-system perspective (understanding structural factors).

Reframing Leverage Points - Phase 2. According to system mapping, participants use Meadows leverage point hierarchy theory to find the intervention points with the highest transformative potential in the system. Next, using the abstraction of the leverage points into the form of the Design Thinking "How Might We" (HMW) statement, the abstraction is turned into a particular design challenge statement.

Process of Systematic Ideation. The present stage uses systematic brainstorming, supplemented by the use of the Sustainable Business Model Canvas [32] as an ideation scaffold. In contrast to conventional brainstorming, every idea is tagged by the system level it operates at (behavioral level, structural level, or paradigm level), which guarantees that ideas have a certain amount of innovativeness and systemic depth.

Phase 4: The Prototyping and Theory of Change. Participants produce low-fidelity prototypes (e.g., a storyboard, role-play, or paper model) of the prioritized solutions, and they apply the Theory of Change (ToC) to backward-plan the cause-and-effect pathway between the long-term vision and initial actions. In this stage, the rapid prototyping of Design Thinking is naturally integrated with the pathway planning of Systemic Change.B.Pilot Design

The research design that is used in this paper is a single-group pretest-posttest pilot design done alongside the implementation of a "Green and Low-Carbon Community Co-construction Project" in a particular city. This design focuses on low cost, ease of implementation, and procedural transparency as opposed to costly experimental control.

The Recruitment of Participants: By making use of community announcements as well as suggestions by partner organizations, the recruitment of 12 participants with different backgrounds (community members, members of a social organization, and grassroots administrators) took place. In order to make the method applicable in standard community situations, there were neither control groups nor stratified randomization. Instead, the research documented basic background information about participants to portray the composition of the workshop group and to facilitate clear replication.

1) Workshop Procedure:

The participants were given a one-day workshop on Sys-Design which was delivered based on the four-phased framework outlined earlier. Low cost materials like printed templates, sticky notes, paper prototypes, reflection sheets and facilitator checklists were used to conduct the workshop.

The lack of a control group has not been identified. In order to facilitate the comparison with the traditional workshop practice, the facilitator noted what phases were typical in the context of standard brainstorming and SWOT style problem analysis and what was added by the Sys-Design framework to the process in the form of system mapping, leverage-point reframing and Theory of Change pathway planning.

C. Data Collection Methods

The low-cost mixed method of data collection used was able to be carried out by an average community organizer, which explicitly includes:

1) Quantitative Data:

a) Systemic Thinking Scale: The simplified version of the Systemic Thinking Scale that was based on Plate was applied as it consists of eight items rated on five-point Likert scale (1 = strongly disagree, 5 = strongly agree). It was given both before and after the workshop to achieve descriptive changes in self-reported systemic thinking of the participants.

b) Innovation Self-Efficacy Scale: Based on the Creative Self-Efficacy Scale with 6 items also rated using a 5-point Likert scale. Cronbach' s alpha is 0.83.

c) This is Innovation Self-Efficacy Scale: It is based on the Creative Self-Efficacy Scale and the general self-efficacy concept and consists of 6 items measured using a 5-point Likert scale. The scale was employed as an inexpensive self-report measure to capture the level of confidence felt by participants regarding their ability to come up with and foster ideas related to community innovation.

2) Qualitative Data:

a) Process Observation: The facilitators maintained systematic field notes during the whole workshop which recorded interaction patterns between participants, the level of discussion, challenges encountered when using the tools, and points of agreement or disagreement. This strategy helped minimize the number of people needed but still provided some valuable process evidence.

b) Reflection of the Participants: After the completion of the workshop, participants filled in short written reflection sheets that were used to explain how they felt during the workshop, what cognitive changes they had noticed during the process, and what they would change about the workshop. The reflections were summarized on the basis of simple thematic codes.

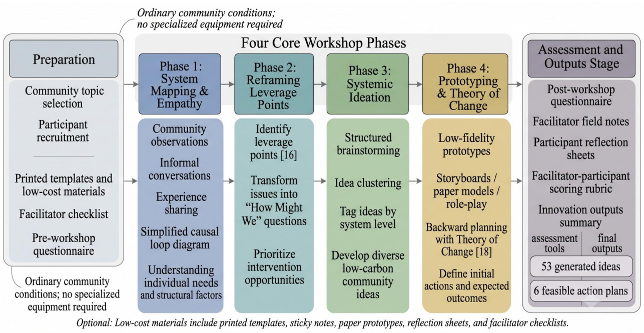

Fig. 1. Flowchart of the low-cost and reproducible Sys-Design workshop methodology and assessment phases.

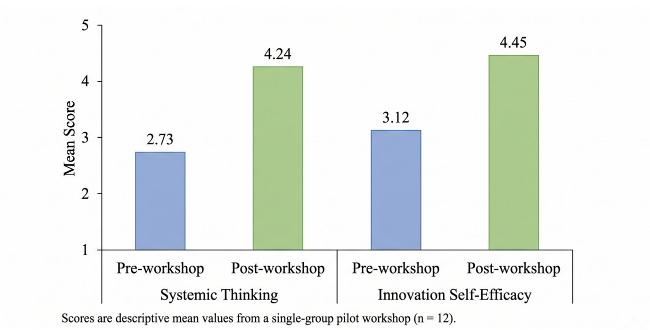

Fig. 2. Descriptive Pre- and Post-Workshop Changes in Core Indicators

V. Data and Results

A. Baseline Data and Pre-processing

The total number of participants who finished the whole workshop, and pre- and post-test questionnaires as well did not have missing data on the primary self-report variables. Since the aim of the present research was to offer a low-cost and repeatable pilot assessment instead of performing inferential hypothesis testing then the analysis was based on descriptive differences in mean scores, workshop results and reflections of participants.

B. Core Measurement Results

Table I shows the descriptive pre-and post-workshop scores on the systemic thinking and innovation self-efficacy of the pilot group. B.Descriptive Pre-Post Analysis

After taking part in the workshop named the Sys-Design, the pilot group demonstrated descriptive growth in self-reported systemic thinking and innovation self-efficacy as presented in Figure 2. The average systemic thinking score rose by 2.73 to 4.24 whereas the average innovation self-efficacy score increased by 3.12 to 4.45. These findings ought to be viewed as preliminary descriptive information and not as evidence of causal effectiveness since the research lacked a control group and random allocation.B.Innovation Output Efficacy

In terms of real workshop outputs, the pilot implementation proved to be divergent as well as convergent. As indicated in Figure 3, the participants produced a total of 53 unique ideas which were eventually narrowed down to 6 practical community action plans that were arrived at using the facilitator-participant rubric. The action plans had explicit problem statements, target actors, needed resources, anticipated short-term actions, and potential long-term community benefits.

C. Multi-Dimensional Post-test Comparison

The Figure 4 shows an all-inclusive post-workshop descriptive profile based on five dimensions in a form of a radar chart. In addition to systemic thinking and innovation self efficacy, the participants also indicated that they had positive impressions about community belonging, cross sector collaboration willingness and action orientation. The dimensions were not included in order to measure the perceived experience of the workshop but to describe it. B.Implementation burden and reproducibility profile

The Figure 5 depicts the implementation burden and reproducibility profile of the Sys-Design workshop. It needs to be facilitated in an ordinary space, printed templates, sticky notes, paper proto-typing materials, short questionnaires, and facilitator notes. This profile shows that the method does not necessarily require special equipment, external expert groups, trained research assistants or experimental infrastructure over a long term period.

TABLE I. Descriptive Pre- and Post-workshop Results of Core Indicators in the Pilot Group

Indicator	**Pre-workshop ($M\pm SD$)**	**Post-workshop ($M\pm SD$)**	**Descriptive Change**	**Evidence Source**	**Interpretation**

Systemic Thinking	2.73$\pm $0.30	4.24$\pm $0.29	1.51	8-item self-report scale	Participants reported clearer awareness of causal links, system boundaries, and leverage points after the workshop.
Innovation Self-Efficacy	3.12$\pm $0.27	4.45$\pm $0.25	1.33	6-item self-report scale	Participants reported greater confidence in generating, refining, and communicating community innovation ideas.
Workshop Ideas	—	53 ideas	—	Idea cards and group records	The workshop generated a diverse pool of low-carbon community ideas.
Feasible Action Plans	—	6 plans	—	Facilitator-participant rubric	Six ideas were developed into feasible action plans with clear actors, resources, and initial steps.

[a] Note: The table reports descriptive pilot results only. No inferential significance testing or causal comparison is claimed.

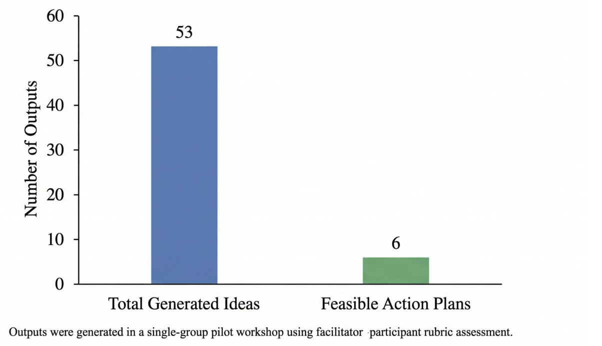

Fig. 3. Summary of workshop innovation outputs, including total generated ideas and feasibleaction plans developed in the pilot group.

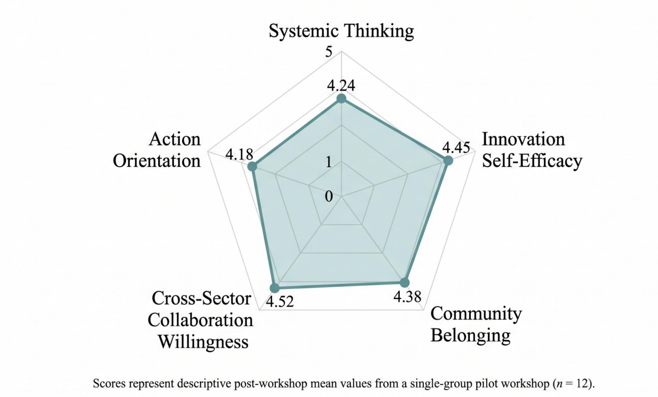

Fig. 4. Radar chart of post-workshop descriptive scores across five assessment dimensions in the pilot group.

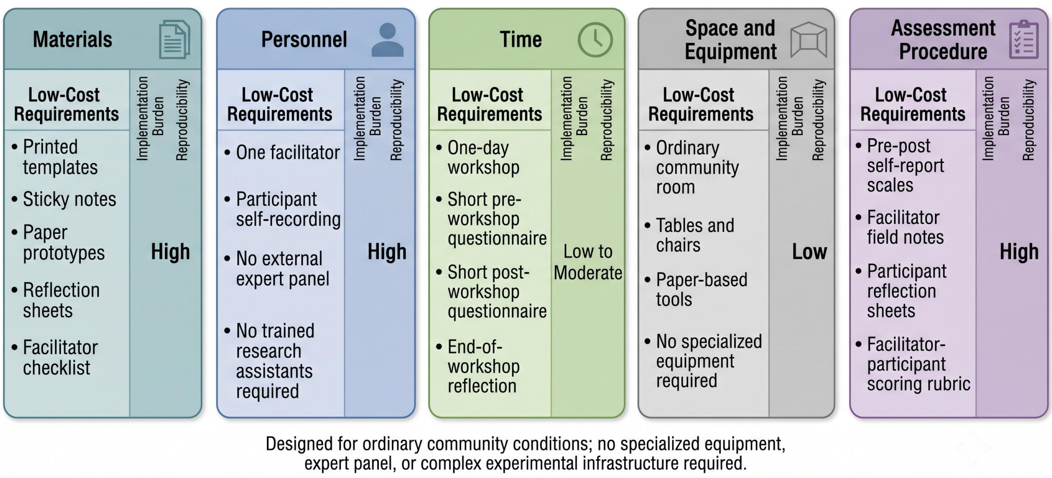

Fig. 5. Implementation burden and reproducibility profile of the Sys-Design workshop, showing required materials, personnel, time, and assessment procedures under ordinary community conditions.

VI. Discussion

A. Horizontal Comparison of Results

The descriptive findings of this paper have some initial support of the possibility of combining Design Thinking with Systemic Change during normal community workshop settings. In contrast to other research that uses Design Thinking only, this research focuses more on low-cost system mapping, leverage point reframing, and Theory of Change path planning. The results indicate that such tools can be used to counteract the weaknesses of conventional Design

Thinking when dealing with macro-complexity, but additional controlled studies are required to confirm the causality.

B. Attribution of Differences

One of the most significant descriptive results of this pilot study is the development of 6 viable action plans out of 53 original ideas. The reasons are as follows: a process-based analysis.

Cognitive Perspective Shift: In the stage of the so-called system mapping participants were led to go beyond linear solutions that only addressed superficial symptoms, like merely adding more sorting bins. They were able to identify underlying structural causes through the visualization of causal feedback loops and suggest interventions that would affect system leverage points.

The optimization of Convergent Mechanisms: The fundamental weakness of the conventional brainstorming is the absence of a proper converging mechanism. The adoption of the Theory of Change (ToC) served as a realistic feasibility filter whereby people would reverse engineer the cause sequence starting with the final objective through to initial actions which filtered the ideas that had no clear actors, inadequate resources or disrupted logic sequences.

C. Limitations and Error Analysis

Although the pilot results have a practical value, the present research has some constraints. The number of cases (n = 12) is quite small and narrow down to one particular community project in one city. In addition, the research design used was a single-group descriptive with no control group, randomization or follow up over time. The results should then be viewed as initial indications of feasibility and usability and not as final indications of effectiveness. Subsequent studies must consider the long term memory of participants systemic thinking and survival of created plans when implemented.

VII. Conclusion

A. Core Conclusions

Using a low-cost single group pilot design, the present study has shown for the first time that the new workshop approach using both Design Thinking and Systemic Change theory (the Sys-Design framework) is viable, feasible, and possibly useful in enhancing the systemic thinking ability and innovation self-efficacy of community participants. This methodology is valuable not only as the description of the change in the self-report cognitive indicator but also as the creation of active community innovation output.

B. Research Implications

Theoretical contribution: The research indicates the synergistic relationship in the so-called "divergent-convergent" innovation process of Design Thinking and the so-called "goal-pathway" analytical framework of Systemic Change. Design Thinking introduces human warmth and creativity into systems analysis whereas system mapping and Theory of Change contributes structural depth and pathway clarity to the idea.

The Practical Contribution: The research offers a low-cost, standardized and easy-to-replicate operational model to community managers, urban planners and sustainability practitioners and implies that using the right «cognitive scaffolding», average community members can engage in the design of complex systems in a meaningful way.

C. Future Research Directions

Further studies ought to increase the size of the sample, test cross-case in populations with diverse culture and type, and compare Sys-Design framework with traditional workshop forms when applicable. The longitudinal tracking studies of 12-24 months are also required to assess the real impact of the workshop outputs, as well as the retention of changed cognition in the participants.

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AVAILABILITY OF DATA

Not applicable.

AUTHOR CONTRIBUTIONS

Siheng Lu contributed to the conceptualization of the study, development of the Sys-Design workshop framework, methodology design, and drafting of the manuscript. Xuerong Gong contributed to workshop organization, data collection, descriptive analysis, figure preparation, and manuscript revision. Dingxiang Song contributed to research supervision, project coordination, methodological refinement, interpretation of results, and critical review of the manuscript. All authors reviewed and approved the final version of the manuscript.

COMPETING INTERESTS

The authors declare no competing interests.