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# Compatible effects of adopting imaginary future generations and systems thinking in exploring future challenges: Evidence from a deliberation experiment

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## Abstract

We adopted an innovative methodology that combines systems thinking with "imaginary future generations" (IFGs), a method for activating "futurability" in people, to discussions about the issues and needs of a future society, and we verified the effectiveness and value of this methodology. We conducted a series of five debate experiments in which groups comprised of company employees and university students worked to formulate a vision of the future state, social issues, and social needs of society in 2050, and to investigate policies that should be adopted in the years ahead. The results of a text analysis of group debates and questionnaire surveys of debate participants showed that (1) adopting IFGs facilitates the exploration of new issues and needs when depicting the images of the future state of society; (2) adopting IFGs gives rise to recognized cognitive changes in debate participants; and (3) combining the IFG methodology with causal loop diagrams (CLDs), a systems thinking tool, makes it possible to generate the effects of systems thinking while simultaneously maintaining a "future generation" perspective. Most importantly, the results show that the IFG methodology and CLDs could be compatible. These findings demonstrate that a combination of IFGs and systems thinking can effectively be used in discussions and decision-making that deal with complex issues related to the future of society.

**KEYWORDS**
causal-loop diagram, debate experiment, futurability, imaginary future generations, systems thinking

## 1 | INTRODUCTION

In recent years, a variety of global-scale issues such as climate change, resource and energy problems, and natural disasters have occurred, threatening the very foundations of human existence and the sustainability of society (Rockström et al., 2009, 2023; Steffen et al., 2015). To address these global-scale threats and risks, enhancing social resilience and ensuring human well-being and sustainability have become vital and urgent challenges for humanity (Kates, 2011). It is also necessary to formulate a clear vision of the future state of society, future social issues and needs among stakeholders, and define and select appropriate measures that should be taken to realize a sustainable society (Kajikawa, 2008; Komiyama & Takeuchi, 2006). It is therefore essential to develop a methodology that facilitates these discussions.

There are numerous methodologies and practices for examining visions of the future state and scenarios of society and for exploring future challenges. Scenario design and backcasting are representative examples of such methods (Kaviani et al., 2023; Kishita et al., 2016; Miller, 2008; Pereverza et al., 2019; Robinson et al., 2011; Tsoukas & Shepherd, 2004; van der Voorn et al., 2012). These methods have been shown to be effective in fostering attitudes and abilities conducive to flexibly examining the future state of societies and preparing for that future. In addition, various types of foresight methods, including the Delphi method, technology roadmapping and horizon scanning, have also been developed and implemented (Belton et al., 2019; Bolger & Wright, 2017; Eto, 2003; Inayatullah, 1998; Magruk, 2011; Popper, 2008; Rowe et al., 2017). For example, technology roadmapping is a widely used method to support long-term planning (Phaal et al., 2004). On the other hand, we argue that these methods are basically implemented from the perspective of the current generation. In this respect, there are challenges and limitations in terms of explicitly grasping the preferences of future generations and overcoming intergenerational conflicts (Hara et al., 2019; Kuroda et al., 2021). This would also be related to human oddities (Saijo, 2020), such as impulse (Sapolsky, 2012) and optimism about the future (Sharot, 2011). It can therefore be difficult to fully grasp the various conflicts of interest and trade-offs between current and future generations, and to make decisions that consider the interests of future generations. Flexibly exploring the nature of a sustainable future society and its issues and needs requires a methodology that facilitates decision-making and judgments in a way that overcomes intergenerational conflicts of interest, by incorporating the standpoint of future generations. Further, since global-scale issues, risks, and human well-being encompass a multiplicity of intricately interrelated factors, we need a methodology for discussing the state of a future society and the measures that should be implemented in the years ahead. Such a method should facilitate a systematic understanding of these interrelationships and provide a comprehensive view of the problem structure.

Given this background, it would be indispensable to develop an approach that explicitly incorporate the perspective of future generations, combined with systems thinking, to cope with future issues. To this end, we applied the approach of "Future Design." In recent years, studies have been conducted in the field of Future Design—the design of social systems for overcoming inter-generational conflicts of interest and for ensuring a sustainable society for future generations. A person exhibits futurability when he or she experiences an increase in happiness as a result of deciding and acting to forego current gains to enrich future generations (Saijo, 2020), and Future Design is the design and praxis of social systems to activate futurability, aiming at dealing with the complex issues of intergenerational conflicts (Saijo, 2018). One promising method to activate futurability is to employ imaginary future generations (IFGs). IFGs refer to people who assume the roles of unseen future generations to represent the interests of those future generations in current decision-making processes and negotiations (Hara et al., 2019; Saijo, 2018).

Through experiments, field experiments, and practices, the adoption of IFGs to activate "futurability" has been shown to be particularly effective in increasing empathy for future generations and for enabling sustainable decision-making that considers the interests of future generations (Hara et al., 2019; Kamijo et al., 2017; Saijo, 2020). To date, the IFG method has been applied to various other fields of public policy, such as, regional revitalization plan (Hara et al., 2019), public facility management plans (Hara et al., 2021), city management (Hiromitsu et al., 2021), city-hall building reconstruction issues (Nishimura et al., 2020), carbon-neutral policy design (Hara et al., 2023), disaster prevention (Tateyama et al., 2019), facilitating renewable energy policy (Uwasu et al., 2020), management of water environment (Kuroda et al., 2021) and waste management issues (Pandit et al., 2021). Outside of Japan, the method has also been tested in the context of other countries, such as Nepal (Pandit et al., 2021; Timilsina et al., 2022), Bangladesh (Shahrier et al., 2017), and Finland (Leino & Kulha, 2023). These previous studies showed that the adoption of IFGs is both effective and useful for grasping the future state of society more clearly, overcoming shortsightedness (Hara et al., 2021; Saijo, 2020).

When considering the future of society, it is also essential to systematically understand the relationships between the various factors that influence society and to guide decision-making from a comprehensive perspective. In particular, systems thinking has proven to be effective for understanding the causal relationships among such complex factors. It is important to develop a method that combines IFGs and systems thinking to cope with complex future issues.

In this study, we proposed a methodology that combines IFGs with systems thinking and tried to evaluate its effectiveness. A related method was first adopted in a policy-making practice involving Kyoto City officials, with a particular focus on achieving carbon neutrality (Hara et al., 2023; Nomaguchi et al., 2023). In this practice, causal loop diagrams (CLDs) were found to be effective for stimulating systems thinking in discussions. However, it remains unclear whether the adoption of IFGs is effective for helping debate participants to simultaneously maintain a future generation perspective and empathy for future generations while retaining the effectiveness of systems thinking. Adopting an IFG perspective allows participants to expand their empathy for future generations and encourages them to make a kind of "leap of logic" to move beyond their current generational perspective. On the other hand, the goal of CLDs is to logically understand the complex cause-and-effect relationships inherent in a system. In other words, IFGs and CLDs could conceivably work in opposition to each other. Thus, while CLDs may stimulate discussion, they could also work to condition discussion in ways that more strongly reflect the current generation's point of view. We considered that determining whether the combination of IFGs and systems thinking can function effectively without either losing its effectiveness might yield valuable insights for establishing a foundation for guiding sustainable decision-making based on an understanding of the complex problem structure of future societies.

In this study, by conducting a series of group debate experiments, we investigated whether the adoption of IFGs to activate "futurability" is compatible with the application of CLDs as an effective method of systems thinking. More specifically, we conducted five debate experiment workshops to examine the future state and issues/needs of society in 2050. The workshops were attended by company employees and university students. Based on the contents and data of group debates, as well as data from a series of questionnaires administered to participants, we clarify the following three points: (1) the effectiveness of adopting IFGs to envisioning the future state of society and to discussions and decision-making for exploring issues and needs; (2) the cognitive changes among participants resulting from the adoption of IFGs; and (3) whether the application of CLDs is capable of activating systems thinking while maintaining a "future generation" perspective. In particular, the third point is the most essential research question, which has not been clarified in previous Future Design studies.

## 2 | METHODS

### 2.1 | Adoption of IFGs and systems thinking

In Future Design discussions, building a "future generation model" is important; that is, to envision what kind of future society to create and to have an idea of what that future generations would expect of the current generation. For this task, a systems thinking tool called "causal loop diagrams" (CLDs) can be used (Sterman, 2000). Systems thinking is an approach that considers the complex behavior of systems as established patterns, and by understanding the structures that generate such patterns, explores what needs to be worked on to solve problems and achieve the desired changes. The term systems thinking broadly encompasses systems analysis using nonlinear differential equations. The system dynamics used in the report of the Club of Rome (Meadows et al., 1972) is a representative example of such nonlinear system simulation. On the other hand, to analyze subjects that are difficult to describe using such nonlinear simulations, such as business management, economics, and various other human phenomena, a modeling approach focusing on qualitative relationships has emerged (Senge, 1990). A CLD is a representative example.

A CLD is a method of graphically representing the behavior of an entire system. The nodes of CLDs represent the factors or variables involved in the behavior of the system, while the directed links between nodes represent the causal relationships between the factors. Although a system model represented by a CLD is merely qualitative, it is useful for identifying factors that lead to systemic problems and for analyzing guidelines that can be employed to resolve those problems. In the Future Design workshop, any topic related to the social situation would be discussed, so it is appropriate to implement systems thinking through CLD rather than system simulation.

It is also important to consider that CLDs may not be familiar to many workshop participants. Therefore, instead of having the participants model from scratch, the authors, who are familiar with CLD, could create a basic model based on the workshop discussions and present it to the participants. The authors' previous research (Hara et al., 2023; Nomaguchi et al., 2023) has shown this format to be effective.

In this study, we set out to clarify whether the effect of CLDs can be achieved while participants adopt a future generation standpoint in the discussion process. Specifically, we did this by administering questionnaires to participants after each debate experiment (workshop); one to determine the degree to which they assumed an IFG standpoint and one to investigate the effect of CLDs. We then analyzed the changes in the results of each questionnaire. Clarifying the compatible effects of adopting IFGs and CLDs will make it possible to systematically analyze the complex problem structure of a future society and facilitate decision making from the perspective of futurability. Such a process is expected to yield important suggestions for developing new methodologies for discussing future problems and for making decisions about the future.

### 2.2 | Setting up debate experiments

Five workshops were conducted: Workshop 1 (September 12, 2022), Workshop 2 (September 29, 2022), Workshop 3 (October 13, 2022), Workshop 4 (November 1, 2022), and Workshop 5 (November 14, 2022). At each Workshop, the participants examined their vision (image) of society in 2050, the future social issues and needs of that society, and the direction of policies and measures that need to be implemented in the years ahead based on their vision. Each workshop lasted around two and a half hours and the debate experiments were held at the Suita Campus of Osaka University.

At the Workshops, the participants discussed three themes, with a focus on the realization of human well-being and sustainability: (1) the future state of society in 2050; (2) social issues and needs in 2050; and (3) the direction of policies and measures. Two main issue focal points (discussion topics) were set: (A) "livelihood, lifestyle and health," and (B) "ensuring resilience to global crises" (in terms of food, disaster prevention, infrastructure, resources, institutions, and systems). One of these two discussion focal points was allocated to each of the discussion groups.

A total of 26 participants, that is, 11 employees of five companies in different industries and 15 undergraduate and graduate students selected through an open application process at Osaka University, were divided up into five groups. Groups 1 and 2 were allocated discussion focal point (A) "Livelihood, lifestyle and health," while Groups 3, 4, and 5 were allotted focal point (B) "Ensuring resilience to global crises" (in terms of food, disaster prevention, infrastructure, resources, institutions, and systems). There were typically five members per group (with one group having six members). To ensure diversity and balance, no group contained two members from the same company, (post)graduate course, or field of specialization. The group composition remained constant throughout the five workshops. Each group was also supported by an additional university staff member, who acted as a facilitator. A note

taker was also assigned to each group to express the discussion contents of the participants in visual form. All of the discussions were recorded and converted to text data.

## 2.3 | Workshop design and analysis framework

In our design of the discussion process, we considered how to effectively activate "futurability" in participants to get them to assume the standpoint of the future generation, based on the findings of previous research. There has been an accumulation of studies in this regard as shown in the introduction section and our research builds on these findings. In particular, we referred to Hara et al. (2021) and adopted IFGs in participatory debates, and Nakagawa et al. (2019) to allow participants to gain a retrospective perspective, both of which have been demonstrated to be effective for acquiring future generation's perspectives.

At workshop 1, the participants discussed the future state of society in 2050 from the standpoint of the current generation (i.e., conventional approach). At workshop 2, they retrospectively examined past decisions from the standpoint of the present. At workshop 3, we set up the IFG framework to aid participants in examining the future state of society in 2050 from the standpoint of IFGs, as well as the policies and measures that should to be implemented now with a view to the future state of society in 2050.

To measure the effect of IFGs, by comparing the results of discussions and decision-making from current generation and IFG standpoints, we designed the experiments so that participants discussed the same topics from the two perspectives. That is, the same three discussion topics "future state of society in 2050," "social issues and needs in 2050," and "direction of policies and measures that should be implemented by 2030" were discussed from the standpoints of the current generation (workshop 1) and the IFGs (workshops 3 and 4). By looking at the differences in discussion contents and decision-making results, we were able to understand how the discussion contents, ideas, and decision-making changed after the adoption of IFGs (relative to the current generation standpoint), and to determine the impact of IFGs. CLDs was introduced in workshop 4, so that the effects of adopting CLDs and the compatibility between IFGs and CLDs could be analyzed by comparison with the results (i.e., debate results and questionnaire results) from workshop 3, which did not employ CLDs, and workshop 3 which employed CLDs.

For each workshop, data on the discussion contents and decision making was obtained in the form of recorded audio of the discussion and notes recorded by the note takers. While the discussion design has been described above, Figure 1 shows the "analysis framework" based on the purpose of this study. Comparing the discussion contents and decision-making results of workshop 1 (current generation standpoint) with those of workshop 3 and workshop 4 (IFG standpoint) allowed us to analyze the effectiveness of adopting IFGs and the characteristics of the discussions. To verify the effectiveness of adopting IFGs, we also conducted questionnaire surveys (described in detail below in Section 2.5) to determine the cognitive changes in participants in relation to generating futurability. By comparing the answers to questions (in question categories 1 and

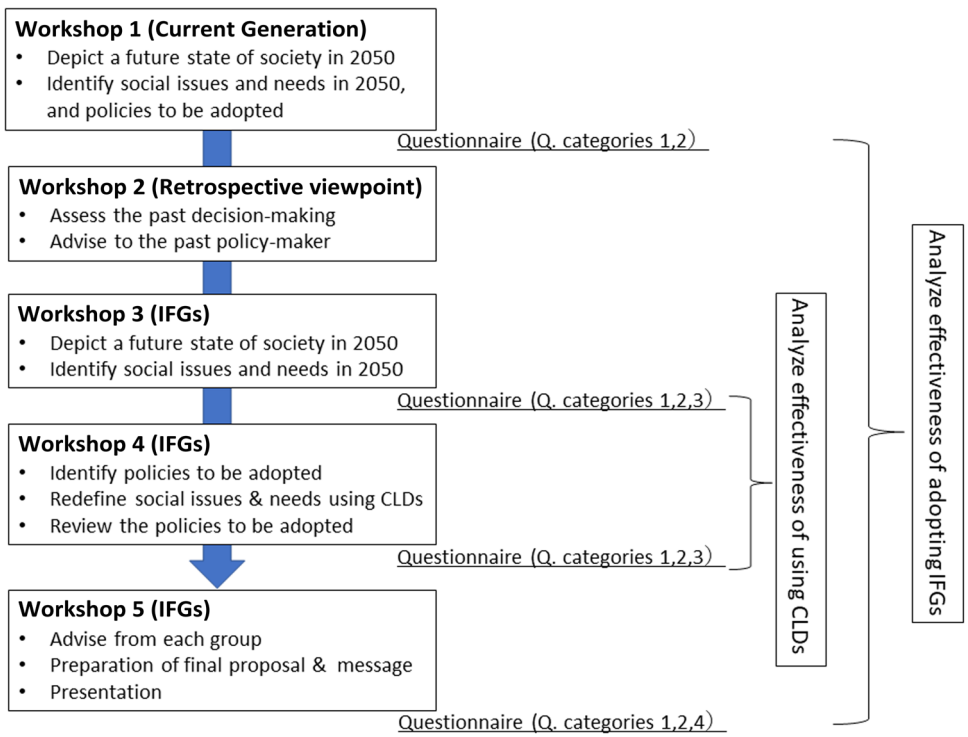


**FIGURE 1** Discussion flow and analysis framework.

2) asked at the end of workshops 1, 3, 4, and 5, we tracked the cognitive changes between current generation (workshop 1) and IFGs (workshops 3, 4, 5) standpoints, to analyze how the IFGs and treatments adopted at each time point affected the cognition of participants.

An additional question category 3 was administered at workshop 3 immediately after introducing the IFG and at workshop 4 to ascertain the effectiveness of introducing CLD. We compared the questionnaire results from workshop 3 before the introduction of CLDs and those of workshop 4 after the introduction of CLDs to check the changes in mean scores to see if the IFG standpoint was maintained (i.e., question categories 1 and 2 associated with futurability) and if the introduction of CLDs was effective (i.e., question category 3). We then analyzed whether the concepts of IFGs and CLDs are effective when implemented simultaneously (i.e., compatible effects).

An outline of the discussion design, which takes into consideration the above, is shown in Table 1. Details of discussion contents, conditions, and treatments at each workshopare presented below.

(1) **Workshop 1:**

Before the commencement of the workshops, the participants were provided with basic preparatory information, consisting of basic data on socioeconomic and environmental indicators that could be relevant to the discussion topics. While taking into account the assigned themes of (A) Livelihood, lifestyle, and health (Groups 1 and 2), or (B) Ensuring resilience to global crises (Groups 3, 4, and 5), the groups were asked to focus on these

**TABLE 1** Workshop design and discussion contents.

| | Discussion contents |
|---|---|
| Workshop 1 (Current generation) | Theme: [Define a future state of society in 2050, its social issues and needs, and policies that should be implemented]<br>• Receive instructions and basic information (e.g., various data)<br>• Session 1: "Depict a future state of society in 2050"<br>➢ Step 1: Analyze social transformation to 2050<br>➢ Step 2: Organize factors influencing society in 2050<br>➢ Step 3: Write textual description (depiction) of society in 2050<br>• Session 2: "Examine social issues and needs in 2050 and direction of policies and measures"<br>➢ Step 1: Examine social issues and needs in 2050<br>➢ Step 2: Policies and measures that should be implemented by 2030 |
| Workshop 2 (Retrospective viewpoint) | Theme: [Review and redesign of past policies]<br>• Receive information on past policies related to the Kyoto Protocol<br>• Session 1: "Analyze and comparatively assess past decision-making"<br>➢ Step 1: Understand background and conditions of policy decisions<br>➢ Step 2: Compare state of society and conditions in relation to climate change action and policies, then and now<br>• Session 2: "Advice to past policymakers" |
| Workshop 3 (IFG) | Theme: [Define a future state of society in 2050 and its social issues and needs]<br>• Receive information about Future Design<br>• Session 1: "Depict a future state of society in 2050"<br>➢ Step 1: Share an image of society as of 2050<br>➢ Step 2: Create a timeline from 2050 back to the present<br>➢ Step 3: Write a textual description of the state of society as of 2050<br>• Session 2: Examine the social issues and needs in 2050 |
| Workshop 4 (IFG) | Theme: [Redefine social issues and needs, and policies that should be implemented after applying CLD]<br>• Session 1: "Examine the direction of policies and measures"<br>➢ Step 1: Check "social issues and needs" as of 2050<br>➢ Step 2: Propose "direction of policies and measures" as advice to past<br>• Explanation of causal loop diagrams<br>• Session 2: "Redefine social issues and needs using causal loop diagrams"<br>• Session 3: "Review the direction of policies and measures" |
| Workshop 5 (IFG) | Theme: [Final proposal after advice from other groups]<br>• Session 1: Advice on direction of policies and measures from each group<br>➢ Step 1: Preparation of presentations<br>➢ Step 2: Presentations/advice from each group<br>• Session 2: "Preparation of final proposals for direction of policies and measures and preparation of message"<br>➢ Step 1: Final proposal of direction of policies and measures<br>➢ Step 2: Preparation of "message to past generations"<br>• Final presentations |

matters as they examined scenarios of the future from the standpoint of the current generation and explore "a future state of society in 2050," "social issues and needs in 2050," and the "direction of policies and measures that should be implemented by 2030." In Session 1, after analyzing possible events and policies up to 2050 and their impact on society (Step 1), the participants examined the various factors conditioning society in 2050 (Step 2) and defined a future state of society in 2050 in writing by summarizing these factors (Step 3). In Session 2, the participants examined the social issues and needs of society in 2050, which were defined in Session 1, and then discussed the direction of policies and measures that should be taken (Step 2). For the direction of policies and measures, each group selected their five most important proposed policies.

(2) **Workshop 2:**

At workshop 2, as a preparatory treatment for assuming the standpoint of the future generation, the participants evaluated and analyzed past policies from the perspective of the current generation and worked to write a message of advice to past generations. As a concrete case study, they took as their subject matter the past climate change policies of the Japanese government, including the Kyoto Protocol. First, a researcher presented relevant information. Next, after analyzing past policy and decision-making (Session 1) and comparatively assessing social issues and policy needs then and now, the participants provided advice to the people in charge of past policies at the time (Session 2).

(3) **Workshop 3:**

At the beginning of workshop 3, a researcher (one of the authors) explained the meaning of IFGs to the participants. He then gave instructions, asking the participants to imagine time-traveling to the year 2050 and living in that world at their current age, to assume the standpoint of that IFG. (From this workshop through to workshop 5, the participants would hold discussions and make decisions from the standpoint of a person living in 2050). To maintain the standpoint of the future generation, they were asked to use the present tense when discussing the situation in 2050, and the past tense when discussing earlier years. Discussions at workshop 3 were focused on describing and defining an image of society in 2050 from the standpoint of the IFG (Session 1) and on identifying the issues and needs of that society in 2050 (Session 2).

(4) **Workshop 4:**

At workshop 4, based on the results of the discussion at workshop 3, the participants worked to propose a direction for the policies and measures that should be implemented by 2030 and to select from these the five most important policies, as advisors from the IFG standpoint (Session 1). Up to this point, the participants discussed the same topics that they discussed from the standpoint of the current generation at workshop 1. Next, CLDs were introduced. A researcher (one of the authors) explained the significance of CLDs and how to utilize them, presenting each group with a CLD created using the method described in Section 2.4. In the next session, each group modified and updated their social issues and needs in 2050 based on the presented CLD (Session 2). Finally, the groups applied these new insights to revise and update the direction of the policies and measures that they examined in Session 1 (Session 3).

(5) **Workshop 5:**

In Session 1 of workshop 5, each of the groups presented their advice to other groups from the IFG standpoint. In accordance with their allocated "focal points," Groups 1 and 2 split off together on one side, while Groups 3, 4, and 5 split off together on another side. Within these two general groups, each group presented its advice on the appropriate direction of policies and measures. Then, after considering the advice of other groups, each of the five groups prepared their final proposal for the direction of policies and measures, along with a written message to the past generation (Session 2). Then, the organizers concluded the workshops.

## 2.4 | Creation of CLD

Since CLDs are essentially systems analysis tools, they are highly abstract, so describing and interpreting them requires a certain level of experience. Workshop participants are generally not familiar with such tasks, so the use of CLDs poses a challenge. To address this issue, a method for effectively utilizing CLDs in Future Design workshops was proposed in a previous study (Hara et al., 2023; Nomaguchi et al., 2023). Basically, in a Future Design practice, several workshops with the same participants are conducted several days apart, with each workshop including a session on reviewing the discussions of the previous one. As part of this proposed method, a note taker records the contents of discussions at the $n^{th}$ workshop as they happen. After the $n^{th}$ workshop, a system modeling expert creates CLDs based on the contents of the discussion. The created CLDs are presented in the review session at the $(n+1)^{th}$ workshop, and the participants are encouraged to use them as a basis for their discussion. The note taker records the contents of these discussions and updates the CLDs.

For this study, the authors adopted the above method to analyze the discussions of each group after workshop 3 and create a single CLD incorporating the discussions of all the groups. More specifically, we extracted all of the noun phrases from the textual description of the "state of society as of 2050" of each group, which was the product of workshop 3, and used these noun phrases as factors in the CLD. Since the timelines of the past portrayed the changes in society, by interpreting them in accordance with the contents of the textual description, we defined cause-and-effect relationships between the extracted factors to describe the links in the CLD. The CLD created is shown in Figure 2. The rectangular nodes in the created CLD shown in Figure 2 represent factors, the blue directed links represent positive causal relationships among factors, and the red directed links represent negative causal relationships. The color coding of the nodes represents the social situation in white, social issues in pink,

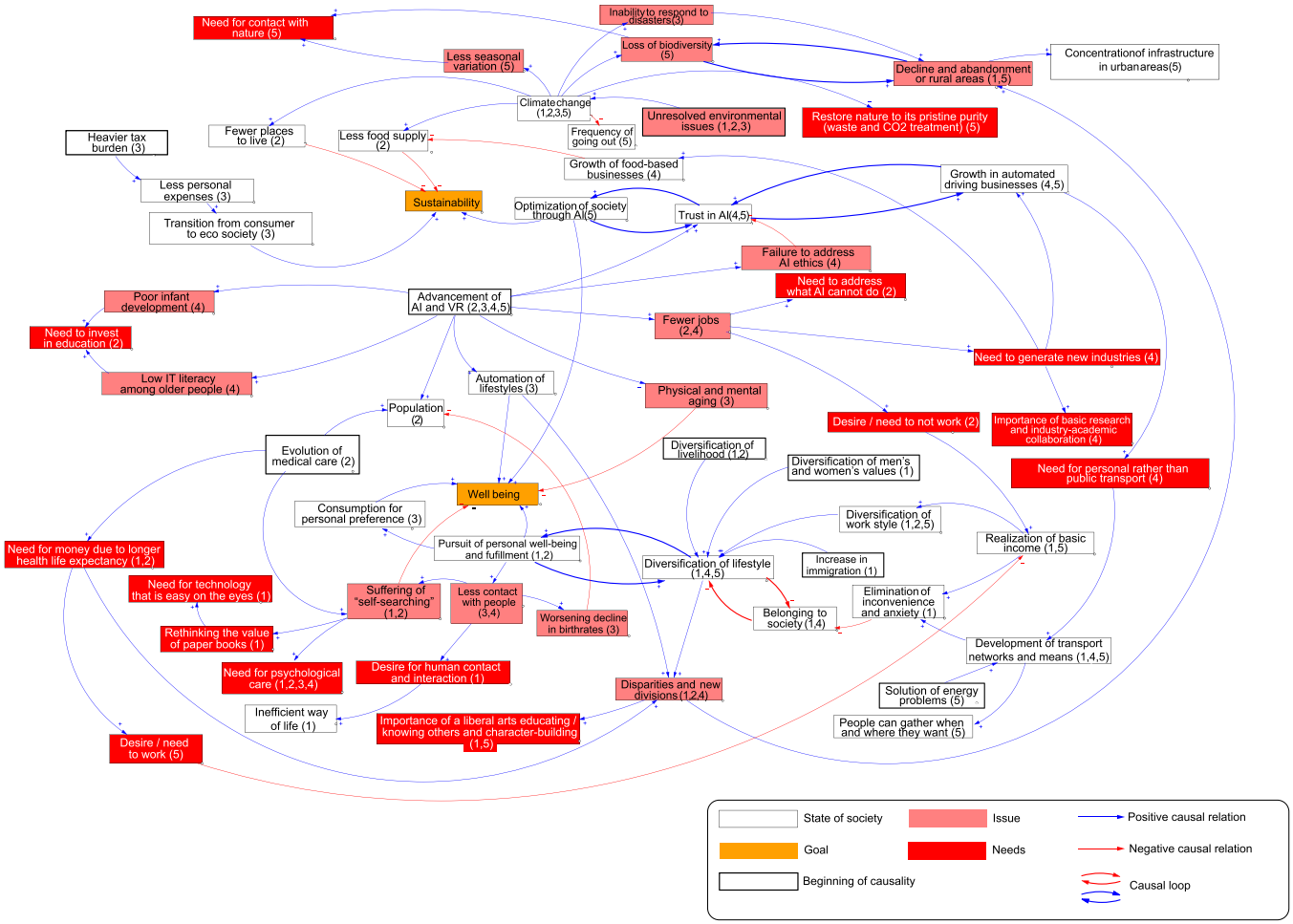


**FIGURE 2** Causal loop diagram (CLD) created based on discussions in workshop 3.

social needs in red, and goals in orange. The number in parentheses at a node is the number of the group that discussed the factor. For example, the factor "Advancement of AI and VR" was discussed by Groups 2, 3, 4, and 5. Nodes with bold lines are factors that are the starting points of causal relationships. The directed links in bold lines indicate causal loops. In Figure 2, there are five causal loops, all of which are reinforcing loops. For example, there is a reinforcing loop between "Trust in AI" and "Optimization of society through AI," and it is shown that they have a positive causal effect on both goals, "sustainability" and "wellbeing." The balanced loop is not explicitly shown. On the other hand, there are some cases where conflicting causal relationships are shown between the same factors. For example, "Advancement of AI and VR" has a positive causal relationship to "Trust in AI"-, but also has a negative causal relationship via "Failure to address AI ethics." These conflicting causal relationships, along with causal loops, are key points in understanding the system.

The created CLD was presented to each group before the discussions of Session 2 of workshop 4. The participants reflected on their group's discussions while looking at the CLD and grasped the contents of the discussions of other groups and the differences (relationships) between their own discussion contents and those of other groups.

## 2.5 | Questionnaire surveys

To understand the cognitive changes induced by the treatments adopted at each workshop, we administered questionnaires to the participants. Based on previous studies (Hara et al., 2021, 2023; Nomaguchi et al., 2023), the questionnaires were designed to clarify: (1) What kind of cognitive change did the adoption of IFGs cause?; and (2) How did the introduction of CLDs affect discussions? The questionnaires were administered at the end of workshop 1 (discussions from current generation standpoint), workshop 3, workshop 4, and workshop 5 (all from the IFG standpoint). The common questions (i.e., question categories 1 and 2) presented to respondents at each of these four time points were as follows (see Appendix A for the details of individual questions of question categories 1 and 2).

- Question category 1: Items about the perceptions of the relationship between current and future generations

➢ Question category 2: Perspectives and items that are important when considering policies

Participants were asked to respond to both questions with a score of 1–5. Question categories 1 and 2, which were designed to investigate the generation of futurability and creation of empathy for future generations, were designed to determine what changes in thinking and cognition occur when an IFG standpoint is adopted. This is in accordance with a previous study (Hara et al., 2021), with some adaptation and amendments to accommodate the contents of this study. Question category 1 consists of 13 questions, such as "That which we enjoy today must be passed down to future generations." Question category 2 consists of 10 questions, such as "Leaving room for people in the future to be able to make choices for themselves." These items can be seen as indicators for measuring empathy for future generations.

For workshop 3 and workshop 4, an additional question category 3 was included to measure the effectiveness of introducing CLDs (see Figure 1). Based on previous studies (Hara et al., 2023; Nomaguchi et al., 2023), with some amendments and additions, this included questions about whether participants were able to generate new ideas or come up with ideas by making connections with other items to investigate the effects of adopting CLDs aiming to assess the effects of systems thinking, with responses rated similarly on a scale of 1–5 (see Appendix B for details). It is important to note here that questionnaire 3 was administered both at the end of workshop 3, when CLDs were not utilized, and workshop 4, when CLDs were utilized (see analysis framework shown in Figure 1). If, in the questionnaire survey after workshop 3 and workshop 4, the mean response scores for question category 3 on the effectiveness of introducing CLDs are maintained without any reduction in the mean response scores of question categories 1 and 2 from the IFG standpoint, then we can conclude that the effectiveness of adopting IFGs and systems thinking can be achieved simultaneously.

A further question category 4 was included at the end of workshop 5, asking whether participants assumed an IFG standpoint and recognized the effectiveness of CLDs after participating in all the workshops. Specifically, question 1 (q1) asked, "Compared to the discussions at workshop 1 from the current generation standpoint, were you able to generate new perspectives, insights, or new ideas in discussions from an IFG standpoint starting at workshop 3?" and question 2 (q2) asked, "Do you feel that CLDs (used at workshop 4) were helpful in generating ideas and organizing thinking in your discussions?" The participants were asked to respond to the questions with a score of 1–5 (i.e., 5: "Yes, very much" 4: "Yes, somewhat" 3: "Undecided": 2 "No, not much," and 1: "No, not at all").

## 2.6 | Text mining analysis

To analyze how the contents of each group's discussions changed at each workshop, we applied text mining to textual transcriptions created from the recordings of each group's discussions. Using AI Text Mining tool (User Local Inc.: https://ir.userlocal.jp/en/), the highest scoring words that appear frequently in the discussion are selected.

In this study, we analyzed the characteristics of the discussions from an IFG standpoint by comparing and analyzing them by means of text mining, based particularly on the contents of discussions of each group at workshop 1 (current generation) and workshop 3 (IFG) on "a future state of society in 2050" and "social issues and needs in 2050."

# 3 | RESULTS

## 3.1 | Results of debates—State of society and social issues/needs in 2050

In this section, we compare the results of discussions from the standpoints of the current generation (workshop 1) and the IFGs (workshop 3 and workshop 4), and briefly summarize the characteristics of discussions and decision-making from the standpoint of IFGs. Table 2 shows a comparison of the discussion results for the respondents' "a future state of society in 2050." Appendix C shows the discussion results for "directions of five policies and measures" selected by each group in the discussions at workshop 1 (current generation standpoint) and at workshop 4 (IFG standpoint).

These comparisons show that for both "a future state of society in 2050" and "directions of policies and measures" there was a change in the contents of discussions after the adoption of IFGs. For example, Group 1's discussions on "a future state of society in 2050" at workshop 1 (from current generation standpoint) basically depicted a society of improved "efficiency," whereas the group's discussions from an IFG standpoint are notably different; they depict a society in which people dare to live "inefficiently," struggling with "self-searching" and seeking "connection with others" (see Table 2). There was thus a radical shift in keyword frequency from "efficiency" to "inefficiency." In Group 1's discussions on the direction of policies and measures, the IFG standpoint gave rise to points that were totally absent in their discussions from a current generation standpoint, with proposals such as "promptly change policies that need to be changed (thoroughly discuss and firmly decide what needs to be reset, and establish data management frameworks and mechanisms)," "promptly promote research to maintain good health," and "solve the food supply problems for health and sustainability" (Appendix C). This clearly shows that their proposals were made from a broader perspective, with a comprehensive examination of the relationship between food and health.

In addition, although "diversity" and "value diversity" emerged as keywords in the discussions of most groups in their "future state of society in 2050" discussions at workshop 1, the importance and frequency of these keywords tended to drop after they adopted an IFG standpoint, as the groups focused their discussions on more concrete matters rather than merely addressing such diversity. For example, in its "future state of society in 2050" discussion from the

**TABLE 2** Comparison of "the future state of society in 2050" discussions.

| | Discussion from current generation standpoint (Workshop 1, Session 1) | Discussion from IFG standpoint (Workshop 3, Session 1) |
|---|---|---|
| Group 1 | In 2050, as limits are reached in all kinds of fields, efficiency will increase to compensate for this, and crowded trains will be a thing of the past. The society that allowed us to live somewhat comfortably will come to an end, and diversity will become obsolete because it is taken for granted. By knowing their life expectancy, hardworking people will work hard, whereas other people will take life easy. So, there will be a polarization of lifestyles. It will be considered important to live according to one's own values. | With the development of transport networks and adaption of a universal basic income system, inconveniences and anxieties have been eliminated in 2050. Rather than belonging to any social system, individuals choose their lifestyles from a variety of options that match their way of living. There is a high degree of diversity in terms of immigration, gender, and working styles. On the other hand, there are people who struggle and who engage in "self-searching" in pursuit of personal happiness and purpose in life. There are also people who dare to live inefficiently for the sake of connecting more with others. |
| Group 2 | By 2050, lifestyle will not be limited by location.<br>Diversification will be widely accepted, and people will have more choices in all areas of life, by means according to function.<br>E.g.) Work = not urban, countryside = not inconvenient; equitable medical care will be available to all everywhere. | In 2050, there is a strong focus on resources. Population is growing due to AI and advanced medical technology. Meanwhile, the SDGs have not been met, and various other environmental challenges remain unresolved. There are fewer places to live and choices of food. Lifestyles (and work styles) are changing.<br>There are still many challenges that must be tackled. |
| Group 3 | In 2050, the problem of declining birthrate and aging population will be even worse, and people will all live in compact cities, with AI and robots supplementing the human workforce. Energy shortages will cause considerable suffering. People gather, so are exposed to new infectious diseases. At the same time, there will be increasing homogenization and good old traditions and values will be lost. | We live in a world of high tax burden, but low personal burden, in transition from a consumer society to an eco-society. Pervasive use of AI and robots has led to advanced automation in people's lives. On the other hand, people spare no expense for their personal obsessions. |
| Group 4 | In 2050, individual values will be even more diverse, and thanks to advances in various technologies, people will have more free time and the value of that time will increase. In addition, environmental problems will worsen, and business to fulfill the SDGs will accelerate efforts. | In 2050, people enjoy a lifestyle with a high degree of freedom to choose what they want to do, without social restrictions. Problems related to energy in urban infrastructure have been solved and there is a wealth of transport options. Autonomous driving and food-related businesses (e.g., breeding, cultured meat) are growing. |
| Group 5 | In 2050, people will be able to live as dispersed as they like, with lifestyles that allow them to live without doing anything. Diverse values will be taken for granted in society. | In 2050, we enjoy a coexistence that can accept diverse values. Climate change has worsened to the point that people tend to stay indoors. We can travel anywhere using autonomous vehicles and mobile shelters. Since the introduction of a universal basic income, people no longer need to work.<br>Now that rural areas have been abandoned, people are all concentrated in cities (where there is infrastructure). People can gather wherever and whenever they want.<br>People now trust the decisions of AI, and everything is optimized. Everything has been reset, but people are learning to accept that. |

IFG standpoint, Group 2 anticipated the development of problems due to a failure to fulfill the SDGs, thereby focusing their discussion on more concrete issues facing the future society.

## 3.2 | Analysis and discussion of text mining results

Table 3 shows a comparison of high-score nouns in "future state of society in 2050" discussions from the current generation standpoint (workshop 1, Session 1) and IFG standpoint (workshop 3, Session 1). In Group 1, for example, while the current generation discussions often touched on "efficiency," the IFG discussions focused more on "self-searching," "SDGs," and other factors. This shows that the vision of society in 2050 depicted by the members of Group 1 changed significantly between their current generation discussions and IFG discussions. Table 4 shows a comparison of high-score nouns in the discussions on "social issues and needs in 2050" between the current generation (workshop 1, Session 2) and IFG (workshop 3, Session 2) standpoints. This table shows that the adoption of an IFG perspective significantly changed the way that the social issues and needs in 2050 were perceived. For example, some of the most frequent keywords in the IFG discussions of Group 1 were "non-cognitive

**TABLE 3** Comparison of high-score nouns: "the future state of society in 2050."

| | Current generation (Workshop 1, Session 1) | IFG (Workshop 3, Session 1) |
|---|---|---|
| Group 1 | Efficiency, yardstick, diversity, disparity, age 70, infrastructure, retirement, energy, packed trains | SDGs, self-searching, universal basic income, immigration, old days, autonomous driving, pursuit, enthusiasts |
| Group 2 | Polarization, SDGs, city, ropeway, urban, infrastructure, COVID, robots, value | High-rise apartments, resources, SDGs, subscriptions, AI, nuclear power, average life expectancy, medical care, artificial |
| Group 3 | Compact cities, AI, declining birthrate and aging population, workforce, robots, energy, automation, low birthrate, maglev trains, COVID | Metaverse, cold war, subscriptions, world war, share economy, gasoline cars, Nankai Trough, AI, maglev trains |
| Group 4 | SDGs, expertise, pharmaceuticals, infrastructure, individuals, business, AI, diversity, COVID, values | VR, disaster mitigation, infrastructure, Nankai Trough, language, culturing, autonomous driving |
| Group 5 | AI, values, TCFD (Task Force on Climate-related Financial Disclosures), universal basic income, cities, international cooperation, rich-poor disparity, optimization | Shelter, quantum computers, VR, singularity, infrastructure, AI |

**TABLE 4** Comparison of high-score nouns: "social issues and needs in 2050."

| | Current generation (Workshop 1, Session 2) | IFG (Workshop 3, Session 2) |
|---|---|---|
| Group 1 | Diversity, $CO_2$, whip, policy, industry, safety net, candy | Noncognitive ability, healthy life expectancy, environmental problem, society, education, R&D, literature, self-esteem |
| Group 2 | Sharing economy, COVID, optimization, industry, electric power, leasing, education, burden | SDGs, 2100, disparity, factory ships, middle, issues, society |
| Group 3 | (*See footnote*) | Self-sufficiency, AI, food self-sufficiency, automation, eco, robots, revival, society |
| Group 4 | Biodiversity, global warming, diversity, Silicon Valley, disaster prevention, human resources, society, issues, energy | Supply chains, industry, VR, resources, R&D, basic research, value chain, economic disparity |
| Group 5 | AI, tipping point, DAO, diversity, energy, natural disasters, disclosure, resources, universal basic income | AI, climate change, waste, motivation, biodiversity, energy, $CO_2$, food, singularity |

*Note*: The current generation discussion results of Group 3 (Workshop 1) are blank due to some missing data in the audio recording of the discussion. Therefore, we present the main keywords written on the board for that session, as follows. We argue that these keywords are strikingly different to the high-score nouns (keywords) listed in the table for the IFG discussion.

Keywords (Group 3, Workshop 1): addressing energy shortages, addressing advances in AI/robotization, maintaining a balance between homogenization and diversity, and addressing a declining birthrate and aging/declining population.

ability," "healthy life expectancy," and "R&D," despite these keywords not appearing at all in the current generation discussions, indicating a dramatic difference. In the case of Group 4, IFG discussions turned up the keywords "supply chain" and "value chain," was well as "R&D" and "basic research," suggesting that the group considered social issues and needs from both a longer-term time perspective and broader spatial perspective. Interestingly, while the keyword "diversity" was used by Groups 1, 4, and 5 in their current generation discussions, this keyword did not appear in any of the discussions of these same groups from the IFG standpoint.

Previous research has shown that a current generation standpoint, from which the future is considered from the present, and an IFG standpoint, from which the present is considered from the future, differ in terms of the way society is envisioned and how decision-making criteria are implemented (Hara et al., 2019, 2021; Saijo, 2020; Uwasu et al., 2020). Thus, adopting the IFG mechanism activates "futurability" in respondents, facilitating a decision-making process that views future societies and future generations in a more concrete way. We consider that this same phenomenon is observable in this series of workshops.

## 3.3 | Discussion process with CLDs

The following is a brief summary, based on transcription data, of how the groups utilized CLDs and what kind of discussions they developed at workshop 4 (Session 2).

After using CLDs for their discussion, Group 1 noticed new factors that were not previously mentioned by the group, such as food, technology and ethics, mental aging, and tax burden. The group

also quite actively made use of the opinions of the other groups from the CLD, inspiring them to develop some new ideas and opinions of their own. Group 2 formed new insights in their discussions, such as the point that the diversification of lifestyles simultaneously reduces people's sense of belonging to society and increases new values. A new point of discussion emerged on the relationship between automation and well-being; essentially, disparities are not necessarily bad if examined from a perspective that sees well-being as a goal. As well as becoming aware of the importance of problems with established cause-and-effect relationships, Group 3 questioned causality itself, and considered the exceptions while considering the possibility that it may not be easy to clearly discern the cause and effect of problems. Group 3 also realized that energy, eco-society, pursuit of individual happiness, infrastructure, and AI are all somehow related in a circular way. Group 4 came to appreciate that food is essential for a sustainable society. The group concluded that while change is necessary, rapid change is never good. Finally, the group noted a circular relationship between three factors—correction of overconcentration, environmental issues, and infrastructure efficiency. Group 5 tended to react negatively to the opinions of the other groups in the CLD, which only served to reaffirm the importance of its own opinions. The group also noticed a new causal relationship in the CLD between elements that were not connected by arrows.

As the above overview shows, each group utilized the CLD, using the opinions of the other groups to develop and deepen its own discussions and gain new perspectives. The groups also noticed new causal relationships that were not explicitly indicated on the CLD, and considered the correctness of some cause-and-effect relationships and exceptions. As a result of this process, they also expanded their awareness of new social issues and needs that escaped their attention before using the CLD.

For Groups 2, 3, and 4, the selections of "policies that should be taken" discussed in Session 3 after using the CLD to reconsider social issues and needs were essentially unchanged from those made in Session 1, before the CLD was used. On the other hand, in the case of Groups 1 and 5, some changes in policy selections were observed. Two policies selected by Group 1 in Session 1, (4) "Improve financial stability" and (5) "Enable voting on a policy basis" (see Appendix C), were replaced with new policy proposals, "solve the food supply problems for health and sustainability" and "solve technology and ethics issues." This shows that the use of CLDs can lead to the discovery of new issues and needs, as well as changes of judgment. Group 5 put forward a policy that combined two selected policies—(1) Waste disposal and (3) Energy, but at the same time, it also selected a new policy that was also discussed by other groups—"Population problem" (declining birthrate and population are not necessarily a bad thing in terms of sustainability; the development of AI has reduced the necessary workforce, and a population decline can help to improve sustainability, and measures from this perspective are also necessary). This suggests that in addition to promoting a deeper discussion of the issues and needs of the future society, the use of CLDs may also have impacted policy selection and decision-making.

## 3.4 | Questionnaire survey results—Analysis of compatible effects

### 3.4.1 | Effects of assuming an IFG standpoint

Figures 3 and 4 show the changes in the mean scores of the responses to question categories 1 and 2, respectively. Note that the analysis here is based on a sample size of 20 respondents ($n = 20$), the number of valid responses to all four questionnaire surveys. This sample of 20 consisted of 11 students and 9 company employees. Details of average scores and standard deviation for each question of question categories 1 and 2 are summarized in Appendix D.

These two figures reveal some basic trends. First, looking at questionnaire question category 1, from workshop 1, where participants held discussions from a current generation standpoint, through to workshop 3, where they discussed a state of the future society and its social issue and needs from an IFG standpoint, the mean scores for several questions tended to decrease. On the other hand, from workshop 3, to workshop 4 (use of CLDs, social issues and needs, and review of directions of policies and measures) and workshop 5 (advice from other groups and design of final proposal), when the participants continued discussions from the IFG standpoint, the mean scores of questions tended to increase. In other words, from workshop 3 onward, when participants assumed an IFG standpoint, the mean response scores for many questions increased, including at workshop 4 when CLDs were utilized.

On the other hand, for many of the questions in question category 2, the mean scores tended to increase uniformly as the discussion proceeded from workshop 1 (current generation) to workshop 3 (IFG), workshop 4, and workshop 5. Thus, the mean score continued to increase even with the additional treatments, that is, use of CLDs and advice from other groups, after the adoption of the IFG standpoint.

### 3.4.2 | Effectiveness of applying CLDs

As shown in Figure 5, a comparison of workshop 3, where CLDs were not used, and workshop 4, where they were used, shows that the mean score of questionnaire responses in question category 3 decreased in the case of divergence of ideas (question 1) and creativity (question 2), but increased for perspective enlargement (question 3), discovering connections (question 4), and concreteness (question 5) (Note that the analysis is based on a sample size of 17 respondents ($n = 17$), the number of valid responses). Details of average scores and standard deviation for each question of question category 3 are also summarized in Appendix D.

As will be discussed below in Section 4, the conditions at workshop 4 were different from those of workshop 3, which was more focused on discussion (see Table 1), since participants were more engaged in both analytical thinking and discussion while studying the CLD; thus, the decrease in the divergence of ideas may be due to this difference. However, the results suggest that the introduction of CLDs was effective in terms of promoting more concrete and cross-sectional discussion of issues.

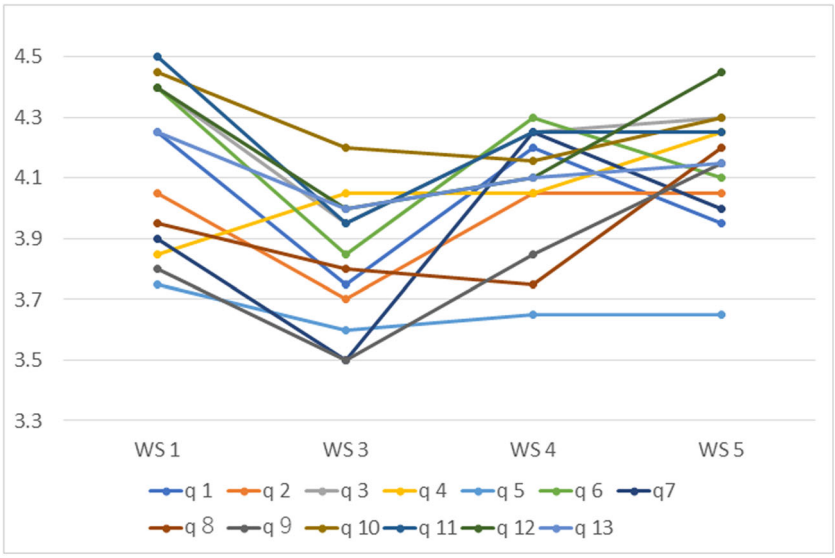


**FIGURE 3** Change in response mean scores for each question in question category 1 ($n$ = 20).

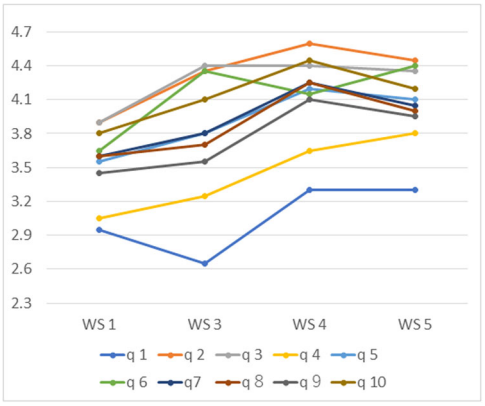


**FIGURE 4** Change in response mean scores for each question in question category 2 ($n$ = 20).

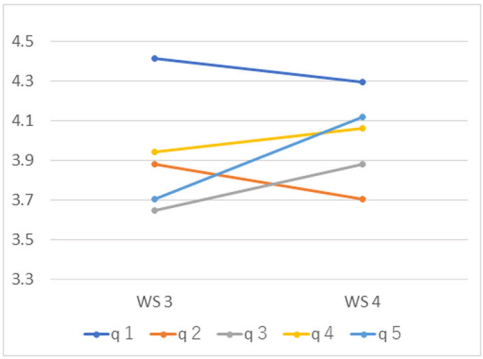


**FIGURE 5** Change in response mean scores for each question in question category 3 ($n$ = 17) (between workshop 3 and workshop 4).

Furthermore, as shown in Figures 3 and 4, for both question categories 1 and 2, the mean scores of responses for many of the questions increased between workshop 3 and workshop 4 after the adoption of IFGs. This suggests that the use of CLDs effectively promotes analytical discussion through systems thinking without diminishing the IFG perspective (i.e., Assumingly, "futurability" remains activated). That is, these results suggest that the participants were able to maintain the positive effects of both IFGs and systems thinking in their discussions and decision-making. In other words, it is clear that CLDs can be applied effectively in future discussions that make use of IFGs.

### 3.4.3 | Differences in the effects between participants

One of the unique features of these workshops is that the debate participants were a mix of company employees and students. In this section, we try to verify whether there was a difference in the response mean scores of company employees and students for questions in question categories 1, 2, and 3.

Tables in Appendix E compare the mean scores of responses to the questions in question categories 1, 2, and 3 of the questionnaire survey by company employees and students. The tables reveal some differences between the mean score trends of students and company employees. These differences are particularly pronounced in the case of question category 1. For example, the mean scores of students increased steadily between workshop 1 (current generation standpoint) and workshop 3 and later workshops (IFG standpoint) without any drop-off, whereas the mean scores of company employees tended to drop off at workshop 2 before increasing again thereafter (e.g., questions 1, 2, 3, 6, 7, and 8 in question category 1). However, for some questions, the opposite trend is evident (e.g., question 5 in question category 1).

On the other hand, in question category 2, there was no significant differences between the mean scores of students and those of company employees. The general trend was that mean scores tended to increase with each successive workshop. We also observed that the mean response scores of students, on the whole, tended to be slightly higher than those of company employees for all questions in question categories 1 and 2.

### 3.5 | Participants' perceptions of implementation methods

Based on the results of the responses to question category 4, the questionnaire administered at the end of workshop 5, after all discussions were completed, we summarized how the participants perceived the effectiveness of introducing IFGs and CLD treatments. To the question 1: "Compared to discussions of workshop 1 from the standpoint of the current generation, do you feel that you gained new perspectives, insights, or new ideas after the discussion of workshop 3 and later workshops from the standpoint of IFGs?," a total of 64% of respondents responded "5: Yes, very much" or "4: Yes, somewhat." That is, more than half of participants recognized the effectiveness of examining issues from the perspective of a future generation after workshop 3. Thus, in addition to the cognitive changes revealed by question categories 1 and 2, the participants' own perceptions support our conclusion that the adoption of IFGs is effective to a certain degree.

Next, to question 2: "Did you feel that the CLD (used at workshop 4) effectively helped your discussion, in terms of generating ideas and organizing your thinking?," a total of 52% of respondents answered "5: Yes, very much" or "4: Yes, somewhat." Thus, about half of respondents recognized the effectiveness of CLDs. Since there was limited time for discussion with the use of CLDs, it is possible that changing the discussion conditions would increase the recognition of its effectiveness.

## 4 | DISCUSSION

This section summarizes the results of this study and the effectiveness of adopting IFGs and CLDs. First, as shown in Section 3.1, the contents of discussions on the "future state of society in 2050" and "social issues and needs," as well as the results of decision-making for policy selection were significantly different, depending on whether discussions were conducted from the standpoint of the current generation or an IFG. For example, when an IFG standpoint was assumed, discussions on social issues and needs focused more on the need for a longer-term response, as indicated by emphasis on R&D and basic research (Groups 1 and 4). IFG-based discussions also focused on social issues that were not explicitly recognized in discussions from the current generation standpoint, such as disparity (Groups 2 and 4) and failure to fulfill the SDGs. There was also a marked difference between the two standpoints in the results of discussions on the selection of five main policies that should be taken. Previous studies have suggested that adopting IFGs changes the way people envision the future, tending to increase risk perception and moderate excessive optimism about the future (Hara et al., 2021; Nishimura et al., 2020; Saijo, 2020). The results of the present study are consistent with these findings. Most notably, by expanding the discussion to include social issues and needs, this study clearly shows that the adoption of IFGs adds new perspectives to the perception of these issues, changing the scope and focus of the considerations of participants.

The results of our questionnaire surveys clearly indicate cognitive changes between workshop 1, where discussions were held from the standpoint of the current generation, and workshop 3 and later workshops, where discussions were held from an IFG standpoint. At the same time, between workshops 3 and 4, when we analyzed the effectiveness of applying CLDs, the mean response scores for most of the questions in question categories 1 and 2 tended to increase. This, together with the findings from previous Future Design studies, suggests that CLDs can be effectively introduced into discussion and decision-making processes without any loss in the empathy for future generations. In question category 3, we focused on the effectiveness of applying CLDs; the mean response scores for the questions "Were you able to generate opinions and ideas from a variety of viewpoints?" (question 3), "Were you able to connect the generated opinions and ideas together while discussing them?" (question 4), and "Were you able to have concrete discussions relevant to your group theme?" (question 5) increased, indicating the effectiveness of CLDs. Note however that although the mean response scores for the questions "Were you able to express your opinions and ideas adequately?" (question category 1) and "Were you able to generate creative opinions and ideas?" (question category 2) decreased from workshop 3 to workshop 4, probably due to the difference in discussion conditions. Particularly in Session 2 of workshop 4, where CLDs were used, the participants had a lot of time for analytical discussion as they examined the CLD. These conditions were considerably different to those in the discussion process at workshop 3, in which the participants exchanged opinions freely with each other; thus, the decrease in the mean response scores may well be due to this difference. These results suggest that CLDs can effectively be used to promote systems thinking without any loss in the "future generation" perspective. The finding that the adoption of IFGs to activate "futurability" could be compatible with the application of systems thinking is a first in the field of Future Design research. This also shows that IFGs and systems thinking can function without losing their effectiveness. An accumulation of case studies is needed to further substantiate this point and to provide a basis for the development of methods to support sustainable decision-making in the face of complex future issues.

We also noted some differences in cognitive change trends between participants of different categories (i.e., students and working adults). This finding implies that the effectiveness of Future Design practice varies according to the conditions of discussions and differences in participant attributes, yielding suggestions for further research topics. Previous studies investigated the relationships between attributes of individuals and the activation of futurability by adopting the perspectives of future generations (Hara et al., 2021; Hiromitsu et al., 2021; Kuroda et al., 2021; Nakagawa et al., 2019). We argue that generation of futurability may also be influenced by other factors in an international context, including culture and urban–rural conditions (Shahrier et al., 2017; Timilsina et al., 2022). To clarify the reasons for the differences observed in this study, we will need to undertake more case studies and compare the finding to these studies.

## 5 | CONCLUSION

In this study, we conducted a series of five debate experiments involving company employees and university students to verify the effectiveness of a method that combines systems thinking with IFGs, a method for activating "futurability," among individuals and society. Discussions were held on the themes of ensuring resilience and wellbeing, exploring a future state of society in 2050 and assessing its social issues and needs, as well as the direction of policies and measures that should be implemented in the years ahead. We analyzed the text data extracted from these discussion contents and data from questionnaire surveys administered to the debate participants. The results showed that: (1) when depicting the images of a future society and exploring its social issues and needs, the adoption of IFGs facilitates the discovery of new issues and needs that are overlooked in discussions from the standpoint of the current generation; (2) the adoption of IFGs leads to observable cognitive changes in debate participants; and (3) the IFG methodology and CLD, a systems thinking tool, could be compatible. Thus, while approaching decision-making and discussions on the future of society from the standpoints of IFGs, it is simultaneously possible to understand systematically and comprehensively the complex structure of social issues. In this way, we have been able to acquire new knowledge to help us in developing methodologies that enable more rational decision-making.

Looking ahead to further research challenges, we need to clarify whether the effectiveness of adopting IFGs and systems thinking methodologies changes under different themes and conditions, and if so, we need to clarify these influences. To achieve this aim, we need to develop more case studies.

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### CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

### DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

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## APPENDIX A: QUESTIONNAIRE SURVEY (QUESTION CATEGORIES 1 AND 2)

**Question category 1**:

We would like to ask your thoughts on the following items with reference to the matters talked about in this discussion. Please circle the applicable number for each item.

| | | Disagree | Somewhat disagree | No opinion | Somewhat agree | Agree |
|---|---|---|---|---|---|---|
| q1 | The issues in the discussion will lead to the realization of a sustainable society | 1 | 2 | 3 | 4 | 5 |
| q2 | Failure to implement the policies talked about in the discussion will lead to a serious crisis. | 1 | 2 | 3 | 4 | 5 |
| q3 | The matters discussed here must not be left to future generations. | 1 | 2 | 3 | 4 | 5 |
| q4 | The matters discussed here are the responsibility of people living in the present era. | 1 | 2 | 3 | 4 | 5 |
| q5 | The matters discussed here are issues that cannot be solved solely by people living in the present era. | 1 | 2 | 3 | 4 | 5 |
| q6 | The solution to matters discussed here is something expected by future generations. | 1 | 2 | 3 | 4 | 5 |
| q7 | What was concluded in this discussion is something that future generations would also hope for. | 1 | 2 | 3 | 4 | 5 |
| q8 | That which we enjoy today is a legacy inherited from our ancestors. | 1 | 2 | 3 | 4 | 5 |
| q9 | That which we enjoy today must be passed down to future generations. | 1 | 2 | 3 | 4 | 5 |
| q10 | The themes talked about in the discussion are important issues of the present. | 1 | 2 | 3 | 4 | 5 |
| q11 | The themes talked about in the discussion are important issues for the future. | 1 | 2 | 3 | 4 | 5 |
| q12 | The members of my group debated goals that seemed desirable for society as a whole. | 1 | 2 | 3 | 4 | 5 |
| q13 | The members of my group shared goals that seemed desirable for society as a whole. | 1 | 2 | 3 | 4 | 5 |

**Question category 2:**

We would like to ask about what you considered to be important in view of the discussion. Please circle the applicable number for each item.

| | | Not important | Not very important | No opinion | Important | Very important |
|---|---|---|---|---|---|---|
| q1 | Living an affluent lifestyle | 1 | 2 | 3 | 4 | 5 |
| q2 | Living a healthy lifestyle | 1 | 2 | 3 | 4 | 5 |
| q3 | Living a safe and secure lifestyle | 1 | 2 | 3 | 4 | 5 |
| q4 | These measures are feasible | 1 | 2 | 3 | 4 | 5 |
| q5 | These measures could bring about an ideal future | 1 | 2 | 3 | 4 | 5 |
| q6 | A society is sustainable | 1 | 2 | 3 | 4 | 5 |
| q7 | Reducing anxiety about what could occur in future | 1 | 2 | 3 | 4 | 5 |
| q8 | Reducing risks that could possibly occur in future | 1 | 2 | 3 | 4 | 5 |
| q9 | Leaving room for people in the future to be able to make choices for themselves | 1 | 2 | 3 | 4 | 5 |
| q10 | Do not impair the resources and potential of people in the future | 1 | 2 | 3 | 4 | 5 |

## APPENDIX B: QUESTIONNAIRE SURVEY (QUESTION CATEGORY 3)

The following questions ask about your thoughts on today's discussion. Please circle the number that corresponds most closely to your answer.

| | | Yes, very much | Yes, somewhat | Undecided | No, not much | No, not at all |
|---|---|---|---|---|---|---|
| q1 | Were you able to adequately express your opinions and ideas? | 1 | 2 | 3 | 4 | 5 |
| q2 | Were you able to generate creative opinions and ideas? | 1 | 2 | 3 | 4 | 5 |
| q3 | Were you able to generate opinions and ideas from a variety of viewpoints? | 1 | 2 | 3 | 4 | 5 |
| q4 | Were you able to connect the generated opinions and ideas together while discussing them? | 1 | 2 | 3 | 4 | 5 |
| q5 | Were you able to have a concrete discussion relating to the focal point allocated to your group—either (A) "Livelihood, lifestyle, and health" or (B) "Ensuring resilience to global crises"? | 1 | 2 | 3 | 4 | 5 |

## APPENDIX C: COMPARISON OF "DIRECTIONS OF FIVE POLICIES AND MEASURES" BETWEEN THE STANDPOINTS OF CURRENT GENERATION AND IFGS

| | Discussion from current generation standpoint (Workshop 1-Session 2) | Discussion from IFG standpoint (Workshop 4-Session 1) |
|---|---|---|
| Group 1 | 1) Utilize automation and AI to promote the development of technologies that make effective use of $CO_2$<br>2) Make education free, to give all people access to education<br>3) Start discussion of ELSI (Ethical, Legal and Social Issues ) issues early<br>4) Need for a social safety net (self-help-based)<br>5) Policies to give company and employees an equal standing | 1) Reform education (e.g., introduce gap year, give students more choices from a young age, education that inspires people to live)<br>2) Promptly change polices that need to be changed (thoroughly discuss and firmly decide what needs to be reset, and establish data management frameworks and mechanisms)<br>3) Promptly promote research to maintain health<br>4) Improve financial stability<br>5) Enable voting on a policy basis |
| Group 2 | 1) Importance of education<br>➡ Review the scope of public education. Revise evaluation criteria (rather than academic ability, evaluate skills that are difficult to quantify, such as communication)<br>2) Review election system<br>➡ Change weighting of votes according to population ratio by generation, making voting methods more efficient, etc.<br>3) Rethink electricity and lifeline services<br>➡ Address higher demand due to decentralized living and system changes due to environmental issues (e.g., energy selection, undergrounding of water pipes and power lines)<br>4) Introduce behavioral restrictions<br>➡ Mechanisms to ensure harmonious concerted responses to infectious disease outbreaks and environmental issues (revive no-drive days)<br>5) Promote sharing➡ Consideration for the environment | 1) Education that accepts diversity<br>2) Personal preventive medicine and education for health promotion<br>3) Development of tools for accurately assessing mental health<br>4) Policies appropriate for the situation in Japan that can address food supply problems<br>5) A voting system that allows funds to be budgeted for next-generation needs |
| Group 3 | 1) Develop new energy sources to prepare for energy shortages in 2050. Promote national measures to develop new energy sources<br>2) Create a national system for new energy<br>3) Create a "virtual spaces law"; increase IT literacy while developing the law | 1) Use AI to optimize society and develop legal and ethical frameworks for this purpose<br>2) Enhance services, create new businesses, and establish an educational system to facilitate the transition from a consumer society to an eco-society<br>3) Develop power generation systems optimized for the characteristics of each region |

(Continues)

| | Discussion from current generation standpoint (Workshop 1-Session 2) | Discussion from IFG standpoint (Workshop 4-Session 1) |
|---|---|---|
| | 4) Discuss a $CO_2$ tax. Measures to boost awareness of environmental issues<br>5) Brand Japanese traditions to earn revenue. Use the money to protect traditions and regional characteristics | 4) Establish and maintain a disaster prediction system and establish a disaster response system<br>5) Maintain primary industries by advancing automation and improve food self-sufficiency through evolution |
| Group 4 | 1) To address natural disasters:<br>➢ Hazard maps and other "soft" (not "hard") measures<br>➢ Avoid using or living in high-risk areas (e.g., use for farmland)<br>➢ Enhance everyone's disaster response experience (e.g., share through national and local governments)<br>2) To address energy shortages:<br>➢ Increase energy options<br>➢ Improve infrastructure (e.g., hydrogen stations)<br>➢ Improve battery and charging technology<br>➡ promote industry-academia partnerships, technology for charging EV vehicles from the road while running)<br>3) To address declining birthrates:<br>➢ Accept the country's declining birthrate and plan accordingly (restructure current system)<br>4) To address declining R&D and industrial capacity:<br>➢ Create a Japanese Silicon Valley<br>➢ Create an environment that allows people to repeatedly take on new challenges<br>➢ Create growth industries (strengths) (e.g., development of AI and quantum computers)<br>➢ Foster people who can shape (not just predict) the future<br>5) To address people's life:<br>➢ Introduce a universal basic income | 1) Energy issues need to be tackled speedily with awareness of international competition and without being bound by vested interests<br>2) Biotechnology research needs to be continued to solve food supply problems<br>3) For the sake of national security, research and development needs to move beyond existing frameworks<br>4) Institutions need to be designed to remain viable even in the face of population decline<br>5) Development of AI and technology can lead to greater well-being, but a shared understanding and acceptance of ethics and social norms is also essential. Public discussion needs to be conducted based on such a shared understanding. |
| Group 5 | (Measures)<br>1) Natural disasters<br>2) Securing resources (food) and energy<br>3) Waste problems (especially e-waste and plastic waste)<br>(Policies)<br>4) AI: In what fields should AI be used?; how should personal information be handled?; concluding ethical agreements internationally<br>5) If diversity can be guaranteed in various areas of decision-making, the above issues can be more easily resolved | 1) Waste disposal<br>Although there will be zero emissions of $CO_2$ and nuclear waste by 2050, there will still be emissions before 2050, and even in 2050 emission countermeasures will be needed. We want to see these countermeasures adopted from 2022.<br>2) Biodiversity<br>It is necessary to improve the natural environment to enable humans to coexist with animals and plants, and to make it more comfortable for human life ("One health").<br>3) Energy<br>Promote deployment of renewable energy<br>4) Education<br>By 2050, AI will be highly advanced and there will be two types of people: those who can control AI and those who will be controlled by AI. Consequently, education will be necessary to minimize the number of people in the latter category.<br>5) Measures based on an awareness of "nexus structure"All the issues listed above are interrelated (nexus structure). In 2022, however, they were being addressed separately and without success. Consequently, the issues need to be tackled with an awareness of their nexus structure. |

## APPENDIX D: AVERAGE SCORE AND STANDARD DEVIATION FOR EACH QUESTION ITEM IN QUESTION CATEGORIES 1, 2, AND 3

See Tables D1, D2, and D3.

**TABLE D1** Average score and standard deviation (SD) for each question item (question category 1).

| | Workshop 1 ($n$ = 20) | | Workshop 3 ($n$ = 20) | | Workshop 4 ($n$ = 20) | | Workshop 5 ($n$ = 20) | |
|---|---|---|---|---|---|---|---|---|
| | Average | SD | Average | SD | Average | SD | Average | SD |
| q 1 | 4.25 | 0.43 | 3.75 | 0.99 | 4.20 | 0.87 | 3.95 | 0.86 |
| q 2 | 4.05 | 0.67 | 3.70 | 0.90 | 4.05 | 0.92 | 4.05 | 0.80 |
| q 3 | 4.40 | 0.49 | 3.95 | 0.86 | 4.25 | 0.77 | 4.30 | 0.64 |
| q 4 | 3.85 | 1.01 | 4.05 | 0.74 | 4.05 | 0.74 | 4.25 | 0.62 |
| q 5 | 3.75 | 0.94 | 3.60 | 0.97 | 3.65 | 0.91 | 3.65 | 0.91 |
| q 6 | 4.40 | 0.80 | 3.85 | 0.73 | 4.30 | 0.64 | 4.10 | 0.89 |
| q7 | 3.90 | 0.62 | 3.50 | 0.92 | 4.25 | 0.62 | 4.00 | 0.84 |
| q8 | 3.95 | 0.86 | 3.80 | 0.87 | 3.75 | 0.99 | 4.20 | 0.81 |
| q9 | 3.80 | 1.17 | 3.50 | 0.97 | 3.85 | 0.73 | 4.15 | 0.85 |
| q 10 | 4.45 | 0.59 | 4.20 | 0.87 | 4.16 | 0.67 | 4.30 | 0.71 |
| q 11 | 4.50 | 0.59 | 3.95 | 0.86 | 4.25 | 0.77 | 4.25 | 0.83 |
| q 12 | 4.40 | 0.66 | 4.00 | 0.77 | 4.10 | 1.14 | 4.45 | 0.59 |
| q 13 | 4.25 | 0.62 | 4.00 | 0.77 | 4.10 | 0.89 | 4.15 | 0.79 |

**TABLE D2** Average score and standard deviation (SD) for each question item (question category 2).

| | Workshop 1 ($n$ = 20) | | Workshop 3 ($n$ = 20) | | Workshop 4 ($n$ = 20) | | Workshop 5 ($n$ = 20) | |
|---|---|---|---|---|---|---|---|---|
| | Average | SD | Average | SD | Average | SD | Average | SD |
| q 1 | 2.95 | 1.36 | 2.65 | 1.06 | 3.30 | 0.84 | 3.30 | 1.14 |
| q 2 | 3.90 | 1.45 | 4.35 | 0.91 | 4.60 | 0.49 | 4.45 | 0.74 |
| q 3 | 3.90 | 1.45 | 4.40 | 0.80 | 4.40 | 0.58 | 4.35 | 0.85 |
| q 4 | 3.05 | 1.36 | 3.25 | 0.89 | 3.65 | 0.96 | 3.80 | 0.98 |
| q 5 | 3.55 | 1.40 | 3.80 | 0.81 | 4.20 | 0.87 | 4.10 | 1.04 |
| q 6 | 3.65 | 1.42 | 4.35 | 0.65 | 4.15 | 1.01 | 4.40 | 0.80 |
| q7 | 3.60 | 1.50 | 3.80 | 0.93 | 4.25 | 0.62 | 4.05 | 0.97 |
| q8 | 3.60 | 1.39 | 3.70 | 1.00 | 4.25 | 0.70 | 4.00 | 1.00 |
| q9 | 3.45 | 1.50 | 3.55 | 1.07 | 4.10 | 0.70 | 3.95 | 0.74 |
| q 10 | 3.80 | 1.33 | 4.10 | 0.83 | 4.45 | 0.67 | 4.20 | 0.68 |

**TABLE D3** Average score and standard deviation (SD) for each question item (question category 3).

| | Workshop 3 ($n$ = 17) | | Workshop 4 ($n$ = 17) | |
|---|---|---|---|---|
| | Average | SD | Average | SD |
| q1 | 4.41 | 0.77 | 4.29 | 0.82 |
| q2 | 3.88 | 0.83 | 3.71 | 0.96 |
| q3 | 3.65 | 0.84 | 3.88 | 1.02 |
| q4 | 3.94 | 0.73 | 4.06 | 0.87 |
| q5 | 3.71 | 0.89 | 4.12 | 0.83 |

## APPENDIX E: AVERAGE SCORE AND STANDARD DEVIATION FOR EACH QUESTION BY STUDENTS AND COMPANY EMPLOYEES (QUESTION CATEGORIES 1, 2, AND 3)

See Tables E1, E2, and E3.

**TABLE E1** Average score and standard deviation (SD) for each question item (question category 1).

| | | Workshop 1 | | Workshop 3 | | Workshop 4 | | Workshop 5 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Average | SD | Average | SD | Average | SD | Average | SD |
| q1 | Students | 4.45 | 0.50 | 4.36 | 0.64 | 4.73 | 0.45 | 4.36 | 0.48 |
| | Employees | 4.00 | 0.00 | 3.00 | 0.82 | 3.56 | 0.83 | 3.44 | 0.96 |
| q2 | Students | 3.91 | 0.67 | 3.91 | 0.67 | 4.36 | 0.64 | 4.36 | 0.64 |
| | Employees | 4.22 | 0.63 | 3.44 | 1.07 | 3.67 | 1.05 | 3.67 | 0.82 |
| q3 | Students | 4.27 | 0.45 | 4.36 | 0.48 | 4.55 | 0.50 | 4.64 | 0.48 |
| | Employees | 4.56 | 0.50 | 3.44 | 0.96 | 3.89 | 0.87 | 3.89 | 0.57 |
| q4 | Students | 3.64 | 0.98 | 4.27 | 0.62 | 4.18 | 0.57 | 4.36 | 0.64 |
| | Employees | 4.11 | 0.99 | 3.78 | 0.79 | 3.89 | 0.87 | 4.11 | 0.57 |
| q5 | Students | 3.91 | 1.00 | 3.91 | 0.79 | 3.55 | 0.89 | 3.55 | 0.89 |
| | Employees | 3.56 | 0.83 | 3.22 | 1.03 | 3.78 | 0.92 | 3.78 | 0.92 |
| q6 | Students | 4.27 | 0.96 | 4.18 | 0.57 | 4.64 | 0.48 | 4.45 | 0.66 |
| | Employees | 4.56 | 0.50 | 3.44 | 0.68 | 3.89 | 0.57 | 3.67 | 0.94 |
| q7 | Students | 3.82 | 0.57 | 3.64 | 0.77 | 4.45 | 0.50 | 4.36 | 0.64 |
| | Employees | 4.00 | 0.67 | 3.33 | 1.05 | 4.00 | 0.67 | 3.56 | 0.83 |
| q8 | Students | 3.91 | 0.79 | 4.09 | 0.67 | 4.18 | 0.57 | 4.36 | 0.64 |
| | Employees | 4.00 | 0.94 | 3.44 | 0.96 | 3.22 | 1.13 | 4.00 | 0.94 |
| q9 | Students | 4.00 | 1.21 | 3.73 | 0.96 | 3.91 | 0.79 | 4.64 | 0.48 |
| | Employees | 3.56 | 1.07 | 3.22 | 0.92 | 3.78 | 0.63 | 3.56 | 0.83 |
| q10 | Students | 4.55 | 0.50 | 4.64 | 0.48 | 4.18 | 0.72 | 4.64 | 0.48 |
| | Employees | 4.33 | 0.67 | 3.67 | 0.94 | 4.13 | 0.60 | 3.89 | 0.74 |
| q11 | Students | 4.64 | 0.48 | 4.45 | 0.50 | 4.55 | 0.66 | 4.64 | 0.64 |
| | Employees | 4.33 | 0.67 | 3.33 | 0.82 | 3.89 | 0.74 | 3.78 | 0.79 |
| q12 | Students | 4.55 | 0.66 | 4.18 | 0.57 | 4.36 | 0.64 | 4.64 | 0.48 |
| | Employees | 4.22 | 0.63 | 3.78 | 0.92 | 3.78 | 1.47 | 4.22 | 0.63 |
| q13 | Students | 4.27 | 0.62 | 4.18 | 0.57 | 4.36 | 0.64 | 4.18 | 0.72 |
| | Employees | 4.22 | 0.63 | 3.78 | 0.92 | 3.78 | 1.03 | 4.11 | 0.87 |

**TABLE E2** Average score and standard deviation (SD) for each question item (question category 2).

| | | Workshop 1 | | Workshop 3 | | Workshop 4 | | Workshop 5 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Average | SD | Average | SD | Average | SD | Average | SD |
| q1 | Students | 2.82 | 1.47 | 3.09 | 1.16 | 3.36 | 0.98 | 3.64 | 1.07 |
| | Employees | 3.11 | 1.20 | 2.11 | 0.57 | 3.22 | 0.63 | 2.89 | 1.10 |
| q2 | Students | 4.09 | 1.44 | 4.91 | 0.29 | 4.82 | 0.39 | 4.64 | 0.48 |
| | Employees | 3.67 | 1.41 | 3.67 | 0.94 | 4.33 | 0.47 | 4.22 | 0.92 |
| q3 | Students | 4.00 | 1.41 | 4.82 | 0.39 | 4.45 | 0.66 | 4.45 | 0.78 |
| | Employees | 3.78 | 1.47 | 3.89 | 0.87 | 4.33 | 0.47 | 4.22 | 0.92 |
| q4 | Students | 3.09 | 1.38 | 3.55 | 0.89 | 3.91 | 1.00 | 4.09 | 0.67 |
| | Employees | 3.00 | 1.33 | 2.89 | 0.74 | 3.33 | 0.82 | 3.44 | 1.17 |
| q5 | Students | 3.91 | 1.31 | 4.27 | 0.45 | 4.64 | 0.64 | 4.64 | 0.48 |
| | Employees | 3.11 | 1.37 | 3.22 | 0.79 | 3.67 | 0.82 | 3.44 | 1.17 |
| q6 | Students | 4.09 | 1.38 | 4.55 | 0.50 | 4.55 | 0.50 | 4.73 | 0.45 |
| | Employees | 3.11 | 1.29 | 4.11 | 0.74 | 3.67 | 1.25 | 4.00 | 0.94 |
| q7 | Students | 3.64 | 1.55 | 4.18 | 0.72 | 4.55 | 0.66 | 4.27 | 0.96 |
| | Employees | 3.56 | 1.42 | 3.33 | 0.94 | 3.89 | 0.31 | 3.78 | 0.92 |
| q8 | Students | 3.73 | 1.29 | 4.18 | 0.72 | 4.45 | 0.66 | 4.27 | 0.86 |
| | Employees | 3.44 | 1.50 | 3.11 | 0.99 | 4.00 | 0.67 | 3.67 | 1.05 |
| q9 | Students | 3.45 | 1.50 | 4.00 | 1.04 | 4.27 | 0.75 | 4.18 | 0.57 |
| | Employees | 3.44 | 1.50 | 3.00 | 0.82 | 3.89 | 0.57 | 3.67 | 0.82 |
| q10 | Students | 3.91 | 1.31 | 4.36 | 0.64 | 4.73 | 0.45 | 4.55 | 0.50 |
| | Employees | 3.67 | 1.33 | 3.78 | 0.92 | 4.11 | 0.74 | 3.78 | 0.63 |

**TABLE E3** Average score and standard deviation (SD) for each question item (question category 3).

| | | Workshop 3 | | Workshop 4 | |
|---|---|---|---|---|---|
| | | Average | SD | Average | SD |
| q1 | Students | 4.40 | 0.92 | 4.20 | 0.98 |
| | Employees | 4.43 | 0.49 | 4.43 | 0.49 |
| q2 | Students | 3.90 | 1.04 | 3.70 | 1.10 |
| | Employees | 3.86 | 0.35 | 3.71 | 0.70 |
| q3 | Students | 3.60 | 1.02 | 3.90 | 1.14 |
| | Employees | 3.71 | 0.45 | 3.86 | 0.83 |
| q4 | Students | 3.90 | 0.94 | 4.20 | 0.98 |
| | Employees | 4.00 | 0.00 | 3.86 | 0.64 |
| q5 | Students | 3.80 | 0.98 | 4.30 | 0.78 |
| | Employees | 3.57 | 0.73 | 3.86 | 0.83 |