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Serious Games for Just Energy Transitions: Theoretical Framework and Application to Enhance Decision-Making for Sustainability

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Abstract

Just energy transitions require diverse voices to be considered, but appropriate tools are still lacking. This study aimed to identify a tool by which diverse views could be considered in decision-making for climate change and energy transitions. Specifically, a literature review was conducted to understand the current status and gaps in the use and the application of Serious Games (SGs) in the field of sustainability. This was further used to construct a framework of criteria for selecting SGs that can enable diversity in decision-making. A specific Serious Game was selected using the framework criteria and applied in qualitative analysis that investigated a gameplay and method of data collection and analysis to assess the impact group diversity has on collective decision-making for sustainability and the quality of outcomes produced. The New Shores game was used within the context of sustainability and resilience to climate disasters. A more diverse and a less diverse group (age, ethnicity, gender, and professional role) were recruited in winter 2021, to play the game in online workshops and make decisions to sustainably develop an island while balancing personal and community wellbeing. The way each group engaged with each other and addressed the challenges of the gameplay were qualitatively evaluated to scrutinise levels of collaboration; collective decision-making and the final status of the island was quantitatively analysed to assess quality of outcomes produced by each group. Positive findings indicate that heterogenous groups demonstrated stronger collaboration, prioritised collective goals, and achieved more socially equitable and resilient outcomes compared to homogenous groups. While small scale and exploratory, the positive findings of this study indicate the need for further sustained research into use of Serious Games for sustainability decision-making, to better understand how diverse groups make decisions in game playing contexts and the extent and conditions needed for these patterns' transfer to real-world contexts.

Keywords: serious games; decision-making; diversity; homogenous group; heterogenous group; climate change

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1. Introduction

Climate change represents an unparalleled global challenge that necessitates both technological innovation and behavioural transformation. Ensuring these solutions are equitable and deliver benefits across all societal groups is essential for a Just Transition [1]. Achieving a carbon-neutral world has emerged as a critical global policy priority in addressing climate change. In this context, the United Kingdom has set an ambitious target to

reach net-zero emissions by 2050. The UK's Net Zero Strategy outlines the government's plans and key policies through which to achieve this by 2050, considering itself as a pioneer in green innovation [2]. Part of these plans must involve a just energy transition, ensuring no one is left behind and the diverse needs of the population are met [3]. The International Labour Organization (ILO) defines a Just Transition as a process that promotes inclusive and green growth "by contributing to the goals of decent work for all, social inclusion and the eradication of poverty", while costs and benefits are fairly distributed [3]. To realise these objectives, it is critical that communities have both the resources and the authority to impact decision-making and drive change [4]. Thus, transdisciplinary collaborations are important to define and address sustainability problems collectively. It is important that this process is managed through participatory approaches to allow the perspectives of diverse local stakeholders, scientists, and policymakers to be heard in the move towards just energy transitions [5].

Multiple tools that enable effective decision-making exist, but they have been found to have low effectiveness in producing high-quality outcomes [6]. Although high-quality outcomes are difficult to define as they can be contextual, they should broadly maximise the environmental and social benefits while at same time minimise economic trade-offs ensuring no one is left behind. Thus, effective decision-making (DM) tools should at least enable diverse perspectives on the problem's definition and clear articulation of values with respect to the decision to be made so that they are just and inclusive [7]. Research indicates that heterogeneous groups tend to generate more effective brainstorming outcomes [8], demonstrate stronger critical evaluation [9], and are more likely to foster breakthrough innovations [10,11]. Within organisational decision-making teams, diversity enhances innovation efficiency by delivering both informational and social advantages throughout the process [12]. Incorporating diverse perspectives in decision-making is vital to produce solutions that are both highly innovative and aligned with the varied needs of the populations they serve.

Increasing diversity among decision-making groups has the potential to yield solutions that are better aligned with complex and varied needs. One way to do that is by increasing participation of the public in deliberative DM using digital platforms for e-participation [13]. Another way is to engage the public in the co-production of decisions pertaining to sustainable management of resources. Moreover, the creation of clear, user-friendly decision-making tools developed through inclusive processes is essential. Such tools should facilitate well-informed choices and deliver outcomes that are meaningful and applicable across diverse DM contexts [6]. To address this need, this study examines DM for sustainability in a game context.

Serious Games (SGs), games or simulations that have a purpose beyond entertainment, emerged as promising methods to enable inclusive DM processes for sustainability as they are increasingly being used in enabling sustainability transitions [14]. SGs have been used as a tool for balancing the complexity of multi-stakeholder DM in land-use change, resource extraction and climate change applications to enable safe participatory experimentation that could lead to diversified solutions that are applicable in context [15]. However, previous studies have not investigated how diverse stakeholders make decisions and how their personal characteristics may have impacted the final outcomes produced. Crucially, prior work seldom connects in-game decision dynamics to diversity-sensitive outcome measures (e.g., equity, resilience), limiting our understanding of whether SGs can operationalise "Just Transition" principles in practice.

This study was developed as exploratory research on the basis that certain SGs can be used as DM tools in a game context and that there can also be a research design to assess the diversity of thinking amongst players and how that in turn impacts the quality of the

collective decisions made whilst playing a game through an appropriate qualitative analysis. While the theoretical contributions of this study are rooted in the current literature, it should be noted that since the qualitative analysis presented is small-scale, the generalisability of the findings is limited and more studies need to be conducted to uncover any underlying patterns. To better understand the interconnections between sustainability, SGs and DM, we explored the theoretical foundations of these concepts by conducting a literature review.

This study also aligns with the Sustainability Special Issue "Achieving Sustainability: Role of Technology and Innovation", which emphasises the need for innovative approaches to address complex sustainability challenges. By examining Serious Games as socio-technical tools that support inclusive, participatory decision-making, our work contributes to understanding how digital innovations can enhance just and effective sustainability transitions. In doing so, it speaks directly to the Special Issue's call for multidisciplinary insights into the ways technology and innovation can drive more sustainable futures.

2. Theoretical Underpinnings and Framework Construction

2.1. Diversity Matters for Sustainable Just Transitions

A 'Just Transition' is now widely regarded as a core framework for sustainable development, grounded in the notion that social justice and equity are essential components of the move toward decarbonisation [16]. A just energy transition aims to achieve emissions reductions, while at the same time improve peoples' lives through better work opportunities, living conditions and policy outcomes [17]. The latter stresses the importance of social and economic considerations of sustainability that interplay with the environmental targets. One such consideration is about including diverse stakeholder voices in decisions that guide transitions as they may be impacted financially or otherwise (e.g., reduced employment opportunities due to lack of green skills) and should have a say. There is urgency to revise DM procedures for sustainability and ensure that those who are typically excluded such as women, minority ethic groups and young people [18,19], are offered opportunities to feed into DM processes, thus diversity plays a major role in ensuring that no one is left behind [7]. It was shown that increasing the participation of women, who have often been excluded from conservation programmes, in sustainability decisions, may mitigate greenhouse gas emissions from deforestation, and at the same time contribute to more effective adaptation to global climate change [20].

Research [21,22] confirms that diverse groups outperform more homogeneous groups and are more successful in completing tasks not merely because they generate new ideas as they see things from different perspectives, but because diversity creates the conditions for a more thorough examination of the information provided. While the positive impact of diversity on DM has been documented in organisational environments, both in terms of diversity of leadership and of workforce and has been shown to contribute to effective solutions and innovation [23], assessment of the impact of diversity on DM for sustainability issues is lacking. A recent meta-analysis [24] showed that diversity, whether demographic, professional, or cognitive, does show a positive association with team outcomes but with a very low effect. This shows that although diversity may be beneficial, its benefits are conditional and not guaranteed. Since the magnitude of this relationship is small, there are moderators that may enhance or diminish this positive relationship. Among the most prominent positive moderators highlighted are that of the teams that engage in tasks of high complexity, perform problem-solving of open-ended problems that require a degree of creativity or innovation to produce outcomes, and show low authority differentiation. On the other hand, the benefits of diversity diminish or reverse when tasks are simple, authority is centralised, cultural contexts discourage dissent, or when subgroup faultlines emerge, such as by social identity divisions, reduced cohesion, and communication breakdowns.

It seems that the right context is crucial for diverse teams to exhibit better performance and leverage their diverse cognitive resources [25] while overcoming social identity conflicts [26]. The context of sustainability therefore looks promising as it comprises 'wicked problems' that require divergent thinking and appreciation of multiple perspectives. The meta-analysis findings posit that specific behavioural patterns shown by diverse groups are related to positive outcomes. These could align with sustainability values and Just Transitions and include openness to multiple perspectives, long-term thinking, equity orientation, collaborative problem-solving, and creativity, especially evident in cognitively and professionally diverse teams.

2.2. SGs as Tools for Decision-Making in Sustainability

In our search for a new tool that could be used to enable diverse views in DM for sustainability, we considered the principles for effective environmental decision-making, which stress the importance of inclusivity, process-orientation, empowerment, and reflection [27]. SGs were promising candidates as they offer open-ended platforms in which various players can engage with sustainability issues and a safe environment (this is conceptualised as an environment in which they can fail without experiencing the adverse consequences of their decisions) in which groups can experiment with the outcomes of their decisions as well as a playful way of engaging in debate, collaboration and problem-solving and a reflective process to evaluate what was achieved [28].

SGs have been used in various sectors such as government, education, corporate and healthcare to increase the capacity of individuals and teams for effective decision-making [29]. According to a recent literature review [18], the use of SGs for sustainability is an emerging and growing field. The majority of these games focus on three key goals: (a) increasing player awareness of sustainability-related challenges, (b) delivering knowledge and understanding of targeted sustainability issues, and (c) fostering action and solution development that integrates environmental and socio-economic dimensions. The latter category is central to the purpose of this research.

2.3. Literature Review to Identify Gaps

A literature review was conducted using Scopus, limiting the search to papers published within the last decade (2015–2024) to ensure that the most up-to-date literature was reviewed. The keywords used were "serious" AND "games" AND "sustainability" AND "decision-making" with a view to capturing broad arguments, research questions and applications of SGs in DM for sustainability. The systematic search produced 51 articles, with the largest volume having been published between 2020 and 2024 (29 in total), revealing this as an emerging area of interest in sustainability science and more specifically DM for sustainability. After an initial screening, 41 papers were included for review (excluding duplicates, papers that did not include the use of SGs or conference abstract collections for which full text was not available). This search was complemented by exploratory internet search using Google for validation that important published pieces were not missed, which yielded an additional four papers for review.

The main areas of research on SGs for DM in sustainability are connected to public awareness raising and behavioural change on sustainability issues [19,30–35], learning approaches relevant for Education for Sustainable Development that aim to increase knowledge of problems and identification of solutions [14,31,36–43] and as tools for bringing stakeholders together [15,31,44–49] to collaborate. They have also been used for researching the factors that influence decisions and the tensions among decision-makers [41] for elucidating DM processes [15,42,50–53], for comparing the results among different decision-makers [54], and for explaining and justifying the design of new games for specific

sectors [55–65] and objectives [66,67]. Finally, some of the literature focuses on how SGs enable participants to interact [45,68] and how gender, values, norms, and psychological traits affect decisions under uncertainty in sustainability [46,69].

Considering the broad areas of research identified in the literature review, and the prevalent assumptions in sustainability science that bringing diverse stakeholders together and providing them with an accessible platform to make decisions will result in solutions that are more just and equitable, we identified a significant gap. Only a handful of papers attempted to investigate how stakeholders make decisions for sustainability by use of SGs with ambiguous results. This happened partly because the SGs were used to address specific sectors (such as water, land use, transport, or agriculture) in isolation, involved only a small group of stakeholders, and did not lead to learning that could be applied in practice. In some cases, the SGs were also used alongside other methods, such as Multicriteria Analysis (MCA), back-casting, or voting in order to produce results.

Limited studies sought to investigate, for example, underrepresented farmers and how they can be facilitated to make decisions on agricultural land use [15,70]. Diversity as a factor influencing decisions in sustainability has not been sufficiently researched. Only one study points out that women could be more engaged in making decisions through such SGs as a result of becoming more immersed in environmental narratives [71].

Despite their wide use for education and engagement, SGs have rarely been studied as tools for understanding how diverse groups make sustainability decisions, leaving an important gap this research aims to fill.

This novel study is an attempt to address this gap by developing a framework for SGs selection and development in terms of enabling decision processes and outcomes related with climate change/just energy transitions and use to select SGs around climate change solutions for just energy transitions to apply in a qualitative analysis of investigating how diversity influences DM in sustainability.

3. Method

3.1. Aim and Research Questions

This research set out to develop a framework for the selection and use of SGs in sustainable DM and examined research questions related to the impact of diversity on DM through a qualitative analysis application of a specific SG with two groups of differing diversity. The following research questions were examined in the study:

1. What criteria should be considered when selecting/developing and using SGs as tools to study diversity and decision-making for sustainability?
2. Is there a game set-up/method that helps assess how diversity enables groups to produce better outcomes when solving sustainability-related challenges?
3. Is there a game set-up/method that enables groups to engage in more collective and equitable decision-making processes when solving sustainability-related challenge?

The last two research questions are exploratory in the specific context of the qualitative analysis study we developed, and the conclusions drawn are limited by the amount of data we were able to collect, but they show how SGs can be used to investigate the stated purposes.

3.2. Framework for SG Review, Development and Selection

To answer the first research question, in addition to the literature review conducted previously, a review of existing studies on the conditions that enable diverse organisational teams to work well and produce innovative outcomes was undertaken [10,24,25,72] as well as considerations of inclusive and equitable participation as per the SDGs (Quality

Education), SDG 5 (Gender Equality), and SDG 10 (Reduced Inequalities) [73]. The criteria developed can be found in Table 1.

Table 1. Framework of criteria for selecting, developing and/or applying SGs to enable diversity in sustainability decision-making.

Framework of Criteria for SGs Selection and Application	
1.	Focuses on an appropriate topic that makes sense for the decision-making context (related to climate change, energy transitions or decarbonisation in our case).
2.	Requires players to work in groups and develop interaction/dialogue (interactivity).
3.	Allows participants to maintain anonymity but also be uninfluenced by tangible cues of diversity (integrity).
4.	Does not have a fixed "correct" solution but allows participants the power of decisions (open-endedness-complexity).
5.	Provides a way of recording not only the outcome of the game but also the process the groups followed to produce outcomes (outcome and process-based).
6.	Is cost-effective (financially viable).
7.	Is simple enough for the participants to engage without requiring specialist knowledge while simulating authentic challenges (authentic-realistic).
8.	Is digital, physical or low tech, played in-person or online depending on the organisational/educational requirements (ability for hybrid increases usability) (feasibility-accessibility).
9.	Provides learning that can be applied in real-world contexts (transferability).
10.	Provides a holistic view of sustainability, including environmental, social and economic considerations (holistic).

Having developed the framework, we reviewed several available SGs related to sustainability to understand which would be aligned with DM for climate change and just energy transitions. To identify suitable SGs, systematic searches were carried out online using the query "serious games" OR "social simulations" AND "climate" OR "energy". The process resulted in eight SGs (see File S1/Section 1), which were cross-checked with the outcomes of a recent systematic literature review on existing SGs related to sustainability that identified 77 such games [14]. The cross-check showed our identified games were among the most recent ones out of those reported in the publication (post-2016), and two of them were not in the literature review as they became available after 2018.

After reviewing the list of climate change/energy transition SGs, we selected the most appropriate game to apply in our qualitative analysis based on the framework criteria and specific research requirements and that was the "New Shores game: A game for democracy" (File S1/Section 2). This game was developed by the Centre for System Solutions in partnership with the Hungarian Rogers Foundation and the Slovakian organisation TANDEM n.o. as part of the EU funded project "Nauru Game for Active Citizenship of Europe". New Shores game (NSG) is a free online SG which takes players to a newly inhabited island and asks them to collectively develop the island, taking actions with consequences on the environmental, social, and economic aspects of the island, which offers a holistic view. The design of the NSG mirrors real-world decision processes by requiring players to balance competing priorities, such as resource extraction, infrastructure development, and environmental protection, while negotiating trade-offs and collaborating under conditions of uncertainty, thereby simulating the complexity and interdependence inherent in sustainability governance.

Although the NSG has been widely used in educational and workshop contexts, our targeted searches found no peer-reviewed publications employing it as a research tool. Existing online sources describe gameplay and learning outcomes but do not report empirical studies or evaluations. This absence likely reflects the game's origin as an Erasmus+ educational project and its dissemination through practitioner networks rather than academic channels. As a result, our study represents the first formal research application of the NSG, demonstrating how it can be used to generate empirical data on collective

decision-making, diversity and sustainability. The paper therefore provides an original contribution by bringing an established but under-researched Serious Game into scientific inquiry, offering both methodological innovation and new insights into how group diversity shapes sustainability-related decisions.

3.3. Qualitative Analysis of the Application of the Serious Game

As a next step, we applied the selected SG to examine a game set-up/method that would allow us to draw some insights on the impact of diversity on collective DM in climate change. Participants were recruited through a professional agency (Pook Fieldwork: https://pookfieldwork.co.uk/, accessed on 21 February 2026) and organised into groups based on responses to an Equality, Diversity, and Inclusion (EDI) questionnaire specifically designed for this study (File S1/Section 3). We operationalised diversity as an aggregate of gender, ethnicity, age, and professional role, supplemented by education level collected via the EDI questionnaire. These data informed the formation of a heterogenous group (greater spread across variables, higher variety) and a homogenous group (greater similarity among members, lower variety), as detailed in File S1/Section 4. Categorical scoring was used to construct the differing diversity groups, and the Blau index was calculated for each category. Across all five categories examined, the value of the index was >0 for the heterogeneous group. For the homogenous group, the value was >0 for only two categories signifying lower diversity (the value of 0 equals to all members of the group being similar). This approach treats diversity as distinct categories (e.g., gender: male/female; ethnicity: white/non-white; professional role: manager/non-manager). Each category of protected or other characteristics was counted without assigning numerical values beyond presence/absence. Variety as a proxy for measuring diversity has been found to have a more positive relationship with team performance in a recent meta-analysis [74]. For example, the "heterogenous" group included multiple categories across variables.

The heterogenous group, with high diversity of protected and other characteristics (age, gender, ethnicity, professional role, caring responsibilities), will be referred to as Group 1 hereon, and the homogenous group, which was low diversity in terms of the same characteristics and will be referred to as Group 2 (File S1/Section 4). Recruitment criteria were provided to ensure representation across targeted demographic profiles (File S1/Section 5). The participants were provided with financial incentives to participate in the workshops, and their participation was a pre-requisite for being reimbursed.

The EDI questionnaire was developed with The Equal Group, experts in workplace EDI, to ensure diversity data was captured in a sensitive and equitable manner. Collected data covered protected personal characteristics alongside socio-economic status, educational background, professional experience, neurological factors, and social context.

Two online workshops were organised in December 2021 to facilitate the game. Each workshop initially included ten invitees; however, due to absences, Group 1 comprised seven participants (heterogenous), while Group 2 included eight (homogenous). Participants received guidance on game procedures in advance. A moderator from the project team ran the workshops and three other researchers observed the virtual game and took notes. The moderator was a trained facilitator for the NSG and was experienced in the gameplay. The structure of the game started with a welcome from the moderator, followed by an overview and purpose of the game and a few housekeeping rules. The game was played online, and the players were given pseudonyms (Latin plant names, which was the only option offered by the game in terms of naming the players) for anonymity, and all communication occured through virtual chat. After completing two trial rounds, the game proceeded through ten standard rounds, culminating in a reflective discussion guided

by questions from the moderator (File S1/Section 6). Both workshops received the same introductory material and question sets to ensure uniformity. The game offered a collection of quantitative data through the island status dashboard, individual player data and final report statistics as well as chat text generated by the players while discussing and agreeing on actions to move through the rounds.

3.4. Data Collection and Analysis

In order to answer the two remaining questions about the impact of diversity on DM, a mix of quantitative and qualitative datasets were used. The first quantitative dataset was the final report produced by the SG after the end of gameplay, which showed the state of the island (in terms of environment, economy, and society) and individual player statistics (wealth, wellbeing, actions, and sanctions/placed to monitor players' use of action points). Data were extracted from the report and analysed quantitatively using MS excel. This was used to capture the outcomes produced by the players.

The second was a qualitative dataset from the chat transcript of the SG. This included the written conversations of participants of the two groups throughout the gameplay (available in Zenodo, see end of manuscript) and captured the process the players used to reach the final outcomes. These were analysed qualitatively using reflexive thematic analysis that involved inductive coding to develop our understanding of how well the two groups worked together and made decisions while playing the game. This analysis was coupled with the researchers' observations during the gameplay so the data could be meaningfully grouped into themes and the analysis of the post-game reflection from the chat transcripts for triangulation.

3.5. Reflexive Thematic Analysis of Participant Interactions During the SG

Reflexive thematic analysis [75] was used to analyse the chat conversations produced by participants during the ten rounds of the NSG for both groups to gain insight into group interaction and decision-making. The choice of this analysis was made due to the need for the researchers to interpret participant dialogues that happened completely online where written text was the only means of communication among group members. This entailed a heavy reliance on the interpretive ability of the research group to identify meaningful responses to the research questions and establish clear links with the theoretical assumptions of the study [76]. Underpinning this approach are assumptions related to a constructionist approach to text interpretation [77] meaning that the dialogues analysed contained language that not only reflected what the participants were experiencing as players in that specific moment but also reflected underlying social factors and meanings indicative of participants' personal characteristics/understandings/social status and constructed social realities. As our underlying assumption was that diversity influences DM and interactions among players, we used a critical approach [78] in the sense that what participants captured in text and how they responded to each other's prompts while playing the game was not only directed by the underlying social factors but was also constructed while the players were actively engaging with the game. The analysis used was primarily inductive as the data directed the identification of codes and themes [75]. The researchers wanted to capture and interpret meaning as it was generated by the participants' chat interactions without missing any emerging dimensions in the data rather than trying to adhere to an existing theoretical model of collective decision-making. A mix of semantic and latent coding [76] was used as we wanted to descriptively capture participant dialogues and convey their interactions in an accessible way but also uncover hidden meaning that could be directed by underlying factors such as those linked with diversity of characteristics and experiences that come from different gender roles, ethnic backgrounds, or professional duties. Data

analysis was undertaken using MS word and excel to record, identify and group themes present in the chat transcripts.

Three of the researchers (VK, MC and ZMH) individually familiarised themselves with the chat transcripts of the two workshops to identify interpretive themes in the data. These were then discussed among the research group and collectively consolidated. Notes shared by the research group from the chat transcripts analysis, and during the observation of the groups playing the game, indicated silence of Group 2 (homogenous) in the reporting element of the game, the lack of meaningful interactions among its members during the operations phase of the game and the ways in which they avoided direct confrontation by being sarcastic or using humour. Thus, the interpretive themes focused on prioritising personal versus collective aims and the degree of openness and transparency about values, actions, and strategies, making individual versus collective decisions and having lower versus higher interaction as a group. They were then used as guidance to generate the initial codes from the data. Each line of the two chats was coded by the lead researcher (VK). Sentences which were not relevant for the research questions were also coded, e.g., referring to technical difficulties or instructions from the moderator as they could serve in later interpretations. Then, the codes were semantically analysed to develop initial themes. Thirty-five themes were developed as part of the analysis (Table 2 and Zenodo). The initial themes were reviewed by the other researchers so they could add to the interpretation of the data and interrogate whether they could be further grouped into higher level themes that would make sense for analysing the DM processes of the groups.

These initial themes were then grouped into four higher-level themes (themes) to reflect the levels of collective DM employed by the two groups. There were initial themes that had nothing to do with actual decision-making, such as sentences about data reporting in the results phase, or making observations (Theme: no DM/no interaction-DMT0). But there were also themes that showed some basic processes of decision formation such as simply agreeing to a suggestion or asking questions to the group (basic DM-low interaction-DMT1), to more advanced processes, such as considering trade-offs and consequences, sharing intentions, and justifying an action (advanced DM-higher interaction-DMT2). The final theme included strategies for addressing collective goals that the participants discussed during the results phase and agreed to pursue and acts of altruism and self-sacrifice (collective DM-high interaction-DMT3). The four themes of decision-making (DMT) were discussed among the researchers, the raw codes were consulted and reviewed to make sure the generated themes were reflective of the group discussions, and views of the researchers (Table 2). This analysis served to answer the third research question. The outcomes of this process were triangulated by analysing the responses of players of the two groups during the post-game discussion.

Reflexivity was ensured throughout the coding process by engaging multiple researchers with diverse backgrounds in independent familiarisation and theme generation, followed by iterative discussions to challenge assumptions and interpretations. Researchers maintained reflexive journals to document decision-making during coding, and all themes were critically reviewed against raw data to minimise bias and ensure transparency.

Table 2. Decision-making themes (DMT) resulting from the reflexive thematic analysis of the two groups' chat transcripts.

Themes (35 in Total)	DMT	Example from Transcript [sic]
* Personal/money	DMT0	. . .same as *ulmus*. Lot wealthier though
Data reporting/DR	DMT0	CO_2 concentration 53 to 56, coal use 0 to 4, forest 288 to 256
Technical questions	DMT0	Is the forest condition the number of trees?
Express environmental concern	DMT0	You obviously don't want to just chop down all the trees
Observation	DMT0	Everything increased moderately
Disapproval	DMT0	Not looking good
Surprise-panic	DMT0	ooh the uni is finished!
Regret	DMT0	Sorry
Being funny/humour	DMT0	who has moolah?
Emoticon use	DMT0	☹
Risk reporting	DMT1	there is a tv room on the edge of the island that i feel is at risk
Generate hypothesis	DMT1	There will be 37 new trees in the next round
Asking questions/views/initiates dialogue	DMT1	dont we need a hospital?
Criticising others/challenging	DMT1	*Castanea*, all for improving your live but need some of your savings for the school and health centre;)
Agreement	DMT1	Agreed
Personal/experimenting	DMT1	we are allowed to make mistakes
Personal/justification	DMT1	my funds are very low as i am investing so if anyone with more coins is happy contribute, please do
Personal/condition-promise	DMT1	if i cut i will invest
Personal/benefit	DMT1	Planting also takes less action points
Positive comment/encouragement-approval	DMT1	lets all get it built!!
Personal/informing	DMT1	im all out of goes
Personal/request	DMT1	I don't have much money. Can anyone finish it?
Outcome/Consequence of action or inaction	DMT2	*acer* i think if we cut too many trees in our area we are more than likely to get flooded
Balance personal/collective aims	DMT2	I did plant as I cut
Sustainability/balancing actions/trade-offs	DMT2	Its a trade off—need to compromise
DR/comparison with previous rounds	DMT2	Forest condition went down but not as bad as in the first round
* Collective/justification of action	DMT2	because if disaster hits we can have inhabitants and rebuild. Education should be second i believe so we have highly skilled inhabitants
Collective/prompting others/suggesting action	DMT2	Can everyone donate some to protect the current public buildings too?
Collective/informing of action/intention	DMT2	im happy to help with forest regeneration
Collective/future benefit	DMT2	all i have done is plant. think it will take 2/3 rounds to see the benefit of planting
Collective/establish priorities/conditions for action	DMT2	i think we should protect the health centres as top priority
Collective/request	DMT2	Can anyone cutting try to replant too please
Collective/altruistic	DMT3	*laurus* sent you some money
Collective/strategy	DMT3	Done good on trying to rebuilt when we were going wrong and had to be done collectively
Personal/sacrifice	DMT3	i think you want have been a little more selfish, but when there is a greater goal you can sacrifice

* Personal theme refers to codes that promote personal wellbeing and goals in the SG and collective refers to codes that promote community wellbeing and goals.

4. Results

Firstly, we report the outcomes of the EDI questionnaire that was used to divide the workshop participants into the two groups, Group 1 (homogenous) and Group 2 (heterogenous). Then, the game outcomes (status of the island reports) are compared between the two groups to understand what level of sustainability each achieved. In Section 4.3, the results of the reflexive thematic analysis are reported and compared to identify differences in the DM processes employed by each group. In the final section, insights from the post-game reflection are discussed to validate the results of the thematic analysis in terms of how the two groups worked together, prioritised goals, and uncover their overall learning from the game.

4.1. Diversity

The diversity of each group was a key variable to be manipulated during gameplay. We examined diversity in terms of gender, ethnicity, age, and professional role to create two groups; one designed to be more diverse than the other. These are however relative measures, and diversity is an aggregate measure in this instance as we wanted the groups to reflect the UK general public (heterogenous) and policymakers (homogenous) [79,80] (File S1/Section 7). Group 1 was made up of four females and three males, and Group 2 was made up of seven males (Figure 1). All participants identified as the same sex as registered at birth. Group 1 consisted of slightly younger members, but Group 2 was specifically recruited to be older to reflect UK policymakers [81].

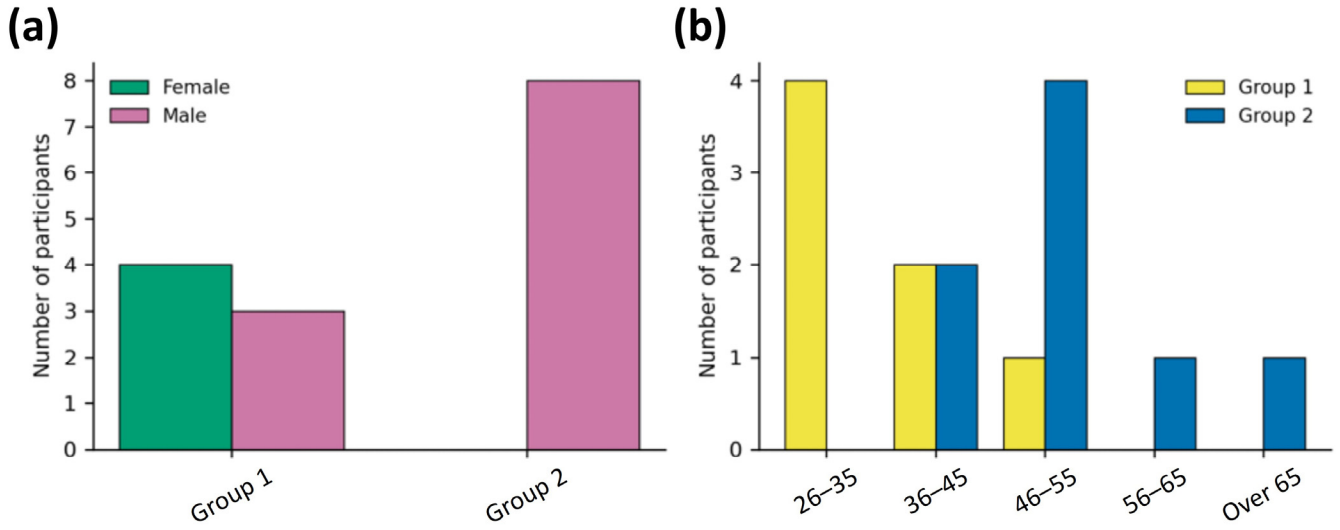

Figure 1. Workshop participant demographics: (**a**) gender and (**b**) age range (Group 1: heterogenous, Group 2: homogenous).

Group 1 represented a mix of ethnicities, in contrast to Group 2, which consisted solely of white participants (Figure 2), consistent with earlier criteria. Within Group 1, one individual who selected 'other' indicated 'Indian Caribbean.' Among white participants, three provided further detail: one in Group 1 identified as 'British,' and two in Group 2 specified 'British' and 'Jewish.' Professionally, all Group 2 participants were managers, whereas none of Group 1 participants held managerial roles.

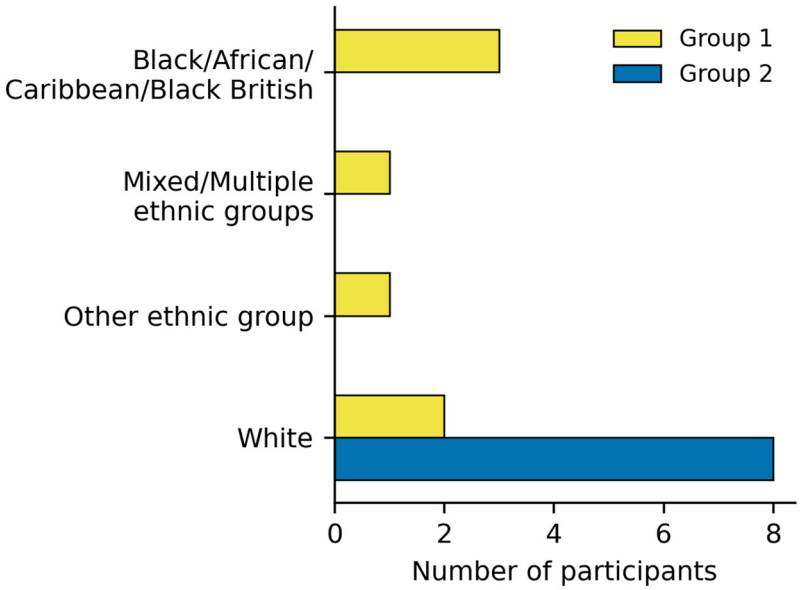

Figure 2. Ethnicity of participants by group.

Group 2 lacked participants with caregiving roles, whereas nearly 50% of Group 1 reported these responsibilities, predominantly among part-time employees. All members of Group 1 were in full-time employment. Educational qualifications were broadly equivalent across groups (Figure 3).

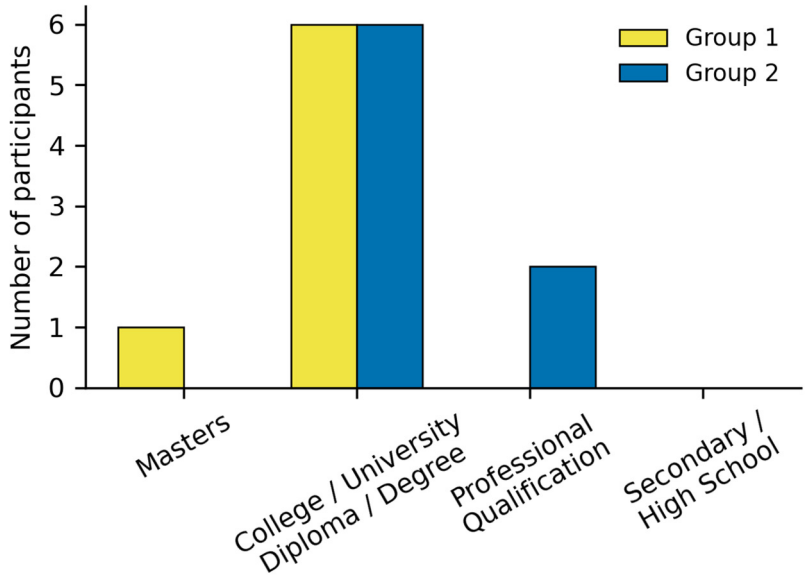

Figure 3. Highest qualification of participants, by group.

4.2. Status of the Island

As part of the qualitative analysis, we wanted to evaluate the quality of sustainability outcomes (environmental, social and economic) produced by groups of differing diversity. Both groups played the SG during online workshops and used chat to communicate. They started the game on islands that were identical in terms of existing resources, were given the same instructions, had two test rounds to familiarise themselves with the gameplay and then played for ten rounds in total. They made choices in each round according to their decisions and strategies to develop on the island. Figure 4 shows a visual graphic of the state of the island at the end of the game in round 10, each icon has been labelled.

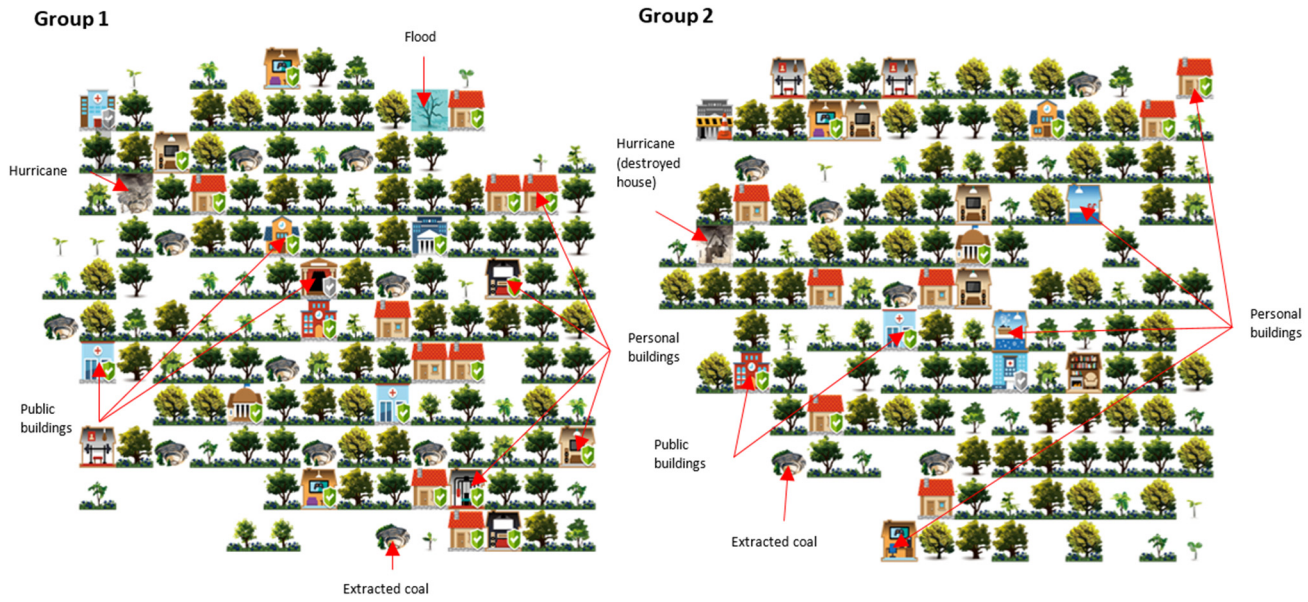

Figure 4. The completed island layouts for Groups 1 and 2 are shown with cell type labels. Buildings marked with a green shield are protected, those with a silver shield remain unprotected owing to inadequate funding, structures without shields are unprotected, and traffic cones identify buildings in progress.

Analysis of environmental indicators revealed that carbon dioxide (CO_2) concentration in Groups 1 and 2 progressed similarly, showing a consistent rise over ten rounds and converging at similar end values. Despite this, Group 1 encountered more flooding events and a markedly higher incidence of hurricanes (File S1/Section 8). Coal extraction patterns were alike in both groups, displaying growth over time and mirroring CO_2 concentration curves. Forest health was equivalent on both islands (File S1/Section 8).

Regarding social outcomes, Group 1 (scored 7 and 3) outperformed Group 2 (scored 3 and 1) in education and cultural indicators, while both groups achieved comparable health scores. Development levels were broadly similar; however, Group 2 prioritised private rooms over public buildings, unlike Group 1 (File S1/Section 9). Additionally, Group 2 exhibited significantly lower resilience, with inadequate protection against disasters (File S1/Section 9), resulting in the loss of two private homes to climate-related events. The total level of resilience for the island of Group 1 was 2.5 times higher than Group 2, and the positive impact of Group 1 on their island was 1.5 times higher than that of Group 2.

Economic performance diverged sharply between groups. Group 2's total income at the end of the game was 13 times higher than Group 1's, and its wealthiest participant was also 13 times richer than the richest in Group 1 (File S1/Section 9). Group 2 exhibited severe inequality: two participants achieved living standards 18 and 11 times above the lowest, while two became homeless (File S1/Section 9). In Group 2, three participants maintained their initial standard of living and three improved, whereas in Group 1, two remained unchanged and five improved. Although Group 1's highest living standard was 2.6 times lower than Group 2's, income distribution was more balanced, and no participants became homeless (File S1/Section 9).

Despite similar income generation, Group 1 directed substantially greater investment—1.6 times higher—into public infrastructure and safeguarding measures than Group 2 (Table 3). The total number of trees Group 1 planted to balance CO_2 concentration and regenerate the forest was 2.7 times higher than that of Group 2; however, Group 2 collected 1.6 times more berries than Group 1 but showed similar figures of coal extraction and cut trees as Group 1 (Table 3). Despite experiencing a higher frequency of hurricanes

and floods, Group 1 incurred no losses from these events. In contrast, Group 2 sustained considerable damage, including the destruction of buildings and the loss of private homes due to climate-related disasters (Table 3). Additionally, Group 1 participants refrained from imposing sanctions, whereas Group 2 enforced penalties on two members to regulate their behaviour on the island.

Table 3. Summary of key economic interventions and property losses resulting from disasters (arbitrary game units).

	Group 1	**Group 2**
Money invested in public infrastructure	1892	1217
Income generated	4100	4506
Trees planted	64	24
Coal extracted	43	31
Trees cut	318	291
Berries collected	262	418
Sanctions placed	0	−4
Flood loss	0	−85
Hurricane loss	0	−30

In conclusion, while both groups had a similar impact on the environmental conditions of the island (measured by CO_2 concentration, coal extraction and forest condition), Group 1 faced more climate disasters but managed to build a more socially developed and economically equitable island, with higher resilience to climate change. Group 2 failed to develop the island socially at the same level as Group 1 except for health infrastructure. The wealth inequalities in Group 2 were severe, as two participants became extremely wealthy and two became homeless. Group 2 suffered many consequences from the fewer climate disasters due to low climate change resilience of the built infrastructure as their aim was to increase personal, over community, wellbeing.

In terms of interpreting this outcome, coupled with participant observations during the gameplay, it seems that social capital and infrastructure resilience are interconnected. Heterogenous groups show more regard for collective aims, values and priorities, which results in higher resilience towards climate, whereas homogenous groups prioritise personal goals which results in increased vulnerability to climate disasters as each actor acts on their own.

4.3. Reflexive Thematic Analysis (RTA)

Regarding the DM process, the most notable differences between the two groups were that Group 1 players engaged in more interactions. They tried more frequently to engage others in action through prompting and suggesting actions or strategies to take throughout the gameplay, discussing priorities and conditions for acting, providing justifications for their actions and through being more open and transparent about their intentions and actions. Another striking difference is that members of Group 1 engaged in altruistic actions of transferring money to other players to complete common goals, while Group 2 members never engaged in it, although there were open requests by some players. It is also notable that the players of Group 1 never asked for money to be sent to them openly, but other players took the initiative of doing so, while in Group 2 the most frequent personal requests were about money to be sent to them because they had run out of it.

Group 1 players talked about risks and future outcomes; benefits and consequences of actions taken during the game, with one occasion of a participant comparing data from previous rounds to justify the suggestions for action to be taken. Group 1 also talked frequently about how they could balance their personal aims with the collective goals

of developing on the island. In addition, they focused on how to balance trade-offs that arise when faced with the challenge of developing an island sustainably, while using its natural resources. In some cases, Group 1 showed their environmental concern by opting for specific actions such as planting trees or collecting berries which they justified as minimising the climate disaster risk. Group 2, on the other hand, never discussed any of these aspects and did much more data reporting in each round without taking it further. Although they agreed on observations and on random action suggestions, they rarely implemented concrete actions and strategies. Group 2 used humour and emoticons to communicate with others and managed confrontation indirectly, while Group 1 members were critical and more directly challenging of other players for their suggestions and actions, though this was done in a respectful way.

Heterogenous groups would seem to have less commonalities in terms of goals and outcomes to pursue; however, this exploration shows that their members show higher accountability towards achieving the final aims of the game and capacity of transferring learnings to the real-world, and because of their differences, they scrutinise their actions openly to achieve a common vision. The homogenous group, while hypothetically sharing similar aims, acted with hidden agendas, no common strategy, and no connections to real-world DM. More in-depth discussion of the qualitative analysis of the chat transcripts for Groups 1 and 2 is included in File S1/Sections 10 and 11 using specific examples from the "conversations" held in each workshop and coding analysis, notes and annotated transcripts are available in Zenodo (see end of manuscript).

Using the four themes of decision-making shown by the two groups and calculating the number of initial themes in each revealed the difference in DM processes shown by the two groups (Figure 5).

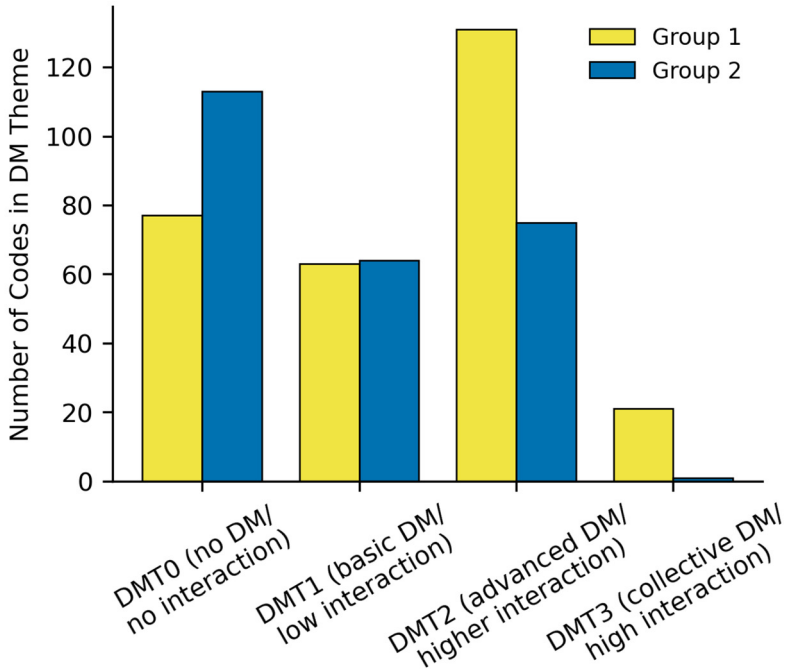

Figure 5. Decision-making themes (DMT) utilised by the two groups (Group 1: heterogenous, Group 2: homogenous) playing the SG using codes categorisations; (Theme: no DM/no interaction—DMT0; basic DM/-low interaction—DMT1; advanced DM/higher interaction—DMT2; and collective DM/high interaction—DMT3).

Group 1 showed capability in working collectively, devising strategies, building consensus around common goals and taking action to develop sustainably on the island, and even when they were following personal goals, they justified how they would balance

these goals by taking further action to improve conditions for all on the island, while Group 2 members avoided open discussions about collective goals or priorities on the island and chose to purse mostly personal goals.

The reflexive thematic analysis showed clear qualitative differences between the homogenous and heterogenous groups that can be understood through well-established theories of group behaviour. These mechanisms also illuminate why the two groups diverged in their approaches to sustainability-related decisions during the game.

The homogenous group displayed patterns characteristic of groupthink [82]. Members tended to agree quickly, avoided open disagreement, and relied on humour or brief remarks instead of challenging one another. This is consistent with social identity theory [83], which suggests that similarity increases cohesion and conformity pressures. Combined with the common knowledge effect [84], the group focused on shared and familiar information, such as immediate game events, while neglecting unique insights or long-term consequences. In sustainability decision-making, these processes are limiting because sustainability challenges require confronting uncomfortable trade-offs, questioning default assumptions, and integrating information that is uncertain or unevenly distributed. Groupthink and reliance on shared knowledge therefore could have steered the homogenous group toward short-term, individually oriented choices with insufficient attention to public goods or future risks.

In contrast, the heterogenous group demonstrated dynamics aligned with information elaboration theory [85]. Members brought diverse backgrounds and experiences, which required them to clarify assumptions, justify proposals, and integrate different viewpoints. This behaviour was reinforced by cognitive diversity and distributed cognition [86,87]. The group collectively pooled varied knowledge and perspectives, enhancing their ability to recognise ecological interdependencies, anticipate systemic impacts, and evaluate long-term trade-offs. They also displayed stronger perspective-taking and empathy [88,89], reflected in cooperative behaviours, willingness to support vulnerable players, and attention to equity and collective wellbeing.

These mechanisms played directly into sustainability decision-making. Sustainability problems are inherently complex, multidimensional, and characterised by interdependent socio-environmental outcomes. Effective decisions therefore depend on questioning assumptions, considering diverse stakeholder impacts, weighing short- and long-term consequences, and integrating value-based reasoning. The heterogenous group was able to do so because diversity disrupted groupthink, broadened the range of considerations, and supported deeper deliberation. By contrast, the homogenous group's conformity pressures and narrow information focus constrained their ability to engage with sustainability's complexity. In this way, diversity acted as a cognitive and social resource, enabling more reflective, inclusive, and resilient sustainability-related decisions.

4.4. Post-Game Reflection and Triangulation

Following the conclusion of the NSG, the moderator posed identical questions to both groups (File S1/Section 12), beginning with a general reflection on the island's performance. These discussions served to triangulate the RTA findings. Group 1 expressed overall satisfaction, attributing success to collaborative decision-making. Responses demonstrated evidence of knowledge transfer to real-world contexts, as participants articulated connections between in-game actions and real-life implications. For instance, one participant noted the importance of protecting essential infrastructure, while another highlighted the challenge of balancing competing priorities. In contrast, Group 2 exhibited limited reflection, with comments primarily focused on game mechanics or final statistics. Although one participant acknowledged the need for cooperation, subsequent exchanges devolved into

humorous accusations of selfishness, reinforcing an individualistic outlook. Sustainability considerations were largely absent from Group 2's discussion. When asked about the type of community formed, Group 1 emphasised collective goals despite inherent tensions between development and conservation, with participants openly admitting occasional self-interest within a cooperative framework. Conversely, Group 2's responses centred on interpersonal conflicts and resistance to collaboration, underscoring a fragmented approach. Overall, post-game reflections revealed stark differences: Group 1 prioritised collective decision-making and acknowledged the complexity of balancing competing objectives, whereas Group 2 largely affirmed individualistic values, with only isolated recognition of the benefits of cooperation.

This suggests that most members of Group 2 shared the view that people mainly act out of self-interest, which they saw as a defining characteristic. This dominant view was strong enough to persuade the one dissenting member to accept that, given differing opinions, groups should rely on expert knowledge when making decisions.

This could further imply that Group 2 did not allow space for discussing views, considering trade-offs and then making decisions as they did not function as a community. For Group 1 (heterogenous) agreement of collective aims came first (resulting from diverse views that are given space), and the satisfaction of personal aims/individuality was then possible in such a community. The post-game evaluation survey and its findings can be found in File S1/Sections 13 and 14.

5. Discussion

5.1. Implications of the Use of SGs in Sustainability Policy-Making and Research

Addressing sustainability challenges, such as climate change and decarbonisation of the energy sector, requires innovative, realistic, and equitable solutions that can come from diverse minds [90,91]. Fortunately, recent research in organisational diversity supports that heterogenous groups "make smarter" decisions compared to homogeneous groups [73,92]. Sustainability solutions are rarely one-size fits all. The findings of this research suggest that SGs can be used as tools to study diversity and DM for sustainability, provided they are selected or developed according to specific criteria, which have to do with aligning the topic in focus, allowing open-endedness, interactivity, cost-effectiveness, feasibility, accessibility, transferability to the real world and enabling authenticity of the experience for the players. For example, the qualitative analysis findings showed that an SG selected with the identified criteria allowed users to play in a simple interface, with clear rules and data visualisation and "low stakes" but also with a realistic format that enabled them to engage in making decisions and taking actions for sustainability holistically. This set-up also allowed the researchers to study the collective decision-making of the two groups. This can have some practical implications for real life policy-making. For example, SGs can support policymakers in real-world settings by simulating complex scenarios such as flood risk management, enabling them to experiment with resource allocation strategies, explore trade-offs between infrastructure investment and nature-based solutions, and understand diverse stakeholder perspectives in a safe, interactive environment before implementing policies.

SGs, such as the ones suggested by our framework, can be selected or developed and used in sustainability science and policy-making to enable, for example, stakeholders, such as researchers investigating low- and zero carbon transitions, to co-produce actions with local communities [93] that are aligned with their priorities and realities or bring policymakers and local community members together to co-produce decisions in matters that affect them such as flood risk reduction due to climate change [53] or making smarter agricultural choices. They could also enable diverse stakeholders such as scientists, policy-

makers, local community organisations and businesses to make decisions on appropriate nature-based solutions to increase resilience to climate change, regenerate nature in an urban area or manage resources effectively [42,63,94]. Lastly, SGs could be developed that offer minoritised (due to ethnicity) or marginalised (due to gender, age, societal status) groups the opportunity to have a say in terms of actions to pursue more just climate futures. SGs can be developed with functions that allow for the quantification of the diversity of players, but organisers of SGs should view diversity as a crucial component of the game in advance of setting up the groups of players participating.

5.2. Implications of the Use of SGs for Research in Decision-Making for Sustainability

This paper suggested a methodology by which to analyse SGs results in terms of the process of collective DM as well as its outcomes. The analysis of the data dashboard, final report and the chat transcripts generated during the gameplay and the subsequent quantitative comparisons and RTA offered mixed methods insights into how the two groups made decisions and the type of sustainability outcomes they produced. A heterogenous group was capable of achieving a more just and prosperous development outcome by prioritising collective over personal goals and this was evident in the final report figures (in terms of environmental, social and economic parameters) as well as in the discourse produced. Specifically, the volume of talk was one of the indicators used to assess collective DM as the heterogeneous group used it to enable transparency and commitment to communicate openly and challenge and explain their positions. This resulted in conversations during the gameplay and on reflection after the game that were deeper in that they tackle issues, such as tensions between conservation and development, trade-offs, community wellbeing and future impact, which were not addressed either in the game or during reflection by the homogeneous group. Another indicator used to assess DM was the ability to transfer learning to the real world, as the heterogeneous group in this instance rationalised choices and effectively opened the discussion to the group transferring learning to the real world as evidenced by the post-game reflection. These transfers were not evident in the homogenous group. Another indicator was the degree of social capital ("the ability of people to work together for common purposes in groups and organisations" [95]) shown by members of each group. The heterogenous group prioritised common goals above personal goals, and this resulted in increased resilience towards climate disasters. In contrast, there was discourse in the homogenous group indicating moves that maintain the status quo (e.g., individualism prevails) in terms of fewer inter-group challenges and rationalisation for not taking actions through deference to "experts". Previous research has found similar results when comparing groups of policymakers from the same department versus from multiple government departments [53], but our findings offer a set of qualitative indicators/themes by which the quality of collective DM for sustainability can be analysed. These indicators can be applicable in DM through having them built-in new SGs or for analysing DM in real-world cases.

5.3. Implications for the Use of SGs in Education for Sustainability

In recent years, Serious Games addressing sustainability and climate challenges have become increasingly prevalent [18]. Research has largely concentrated on their educational value for grasping theoretical aspects of these topics [96–98], with limited focus on how they cultivate transversal sustainability skills like systems thinking, critical thinking, and decision-making [99], which are vital for addressing real-world sustainability problems. Our use of the NSG contributes to educational research and showed that participants of both groups became aware of the sustainability challenges posed by development, but only the heterogenous group considered the trade-offs involved in DM for sustainability

as well as the future impact and climate risks associated with extraction of fossil fuels, and made connections with real-world DM, which is an important competence for achieving sustainability transitions [100,101]. This has implications for learning and leadership training programmes as it does not suffice to use the appropriate SG as per our framework to explore the complexity of a given sustainability challenge, there is need to align it with real-world challenges for transfer to occur as well as enable appropriate group learning dynamics among the learners so they can challenge each other, explore deeper dimensions and pursue common goals. Similar results were presented using low-tech SGs to stimulate students' higher-order thinking by using appropriate pedagogies to enable students to participate in challenging hands-on group work [73]. Recent research also shows greater perceived cultural diversity was found to promote behavioural and cognitive engagement in group learning as well as better learning outcomes in Higher Education contexts [102]. Recognising diversity in learning contexts adds an important layer to the rationale for employing SGs as experiential tools in education. Evidence suggests that individuals who appreciate diversity within their groups tend to achieve more favourable outcomes, whereas those who prioritise similarity over diversity often experience fewer positive results [103–105].

5.4. Implications for Managing Diversity in Organisations

Our results, showing that heterogeneous groups engaged more openly in trade-offs, prioritised collective aims, and produced more equitable and resilient outcomes than homogeneous groups, indicate that the performance benefits of diversity are realised when organisations enable high-quality interaction, creative problem-solving and shared ownership of goals rather than merely assembling demographically varied teams. This aligns with recent research [106] from an organisational perspective that diversity must be managed as part of organisational identity in a balanced way. Insufficient emphasis invites cynicism and threatens legitimacy among under-represented groups, while excessive emphasis can trigger backlash or perceptions of unfairness among others. Thus, organisations should move beyond symbolic commitments to diversity and intentionally design decision environments, especially those related with departments that deal with complex issues, that balance diversity identity with other factors, such as common goal setting, low authority differentiation, and structured interaction and interdependent cooperation [25,98], thereby preserving internal legitimacy while unlocking the collective problem-solving advantages we observed in our heterogeneous group.

5.5. Limitations and Future Research

This study has some limitations which need to be acknowledged. For the qualitative analysis we set out to compare compared two small groups of ten players each. Due to last minute no-shows/cancellations, one of the groups had seven while the other had eight participants. The small scale of this study was useful to demonstrate the selected SG's applicability in terms of investigating diversity and DM, but the results of this study should not be extrapolated. The observed differences may be due to other reasons than the diversity of participants selected to play the game in the two workshops, and we acknowledge that because of compounding effects, the impact of each protected or other characteristic in the results observed cannot be discerned. Alternative reasons for the observed results, may be due to values differences in Group 2 participants and more alignment of values in Group 1 participants or due to the more competitive nature of participants in Group 2 and the more collaborative nature of participants in Group 1 attributed to chance. However, something can be said about the use of Serious Games as educational platforms for sustainability. The outcomes of the games are influenced by who

the participants are (diversity, values, professional role, traits) and despite the best efforts of the educators/organisers who design the learning experience, positive sustainability action behaviours and outcomes cannot be guaranteed. On the other hand, they make good platforms for examining decision-making for sustainability exactly because the outcomes are influenced by the participant characteristics and interactions, which reflects real-world environments. More SG experiments are needed to validate whether SGs enable better collective decisions, and diverse groups generate more sustainable outcomes. This could be an avenue for future research using the selected, or new SGs according to the criteria presented. In addition, the qualitative analysis was reflexive meaning that it was subject to the interpretation ability of the group of researchers. However, all the researchers, who have diverse ethnicities, expertise, and professional backgrounds, engaged in this and discussed all data and themes to ensure many conceptualisations were explored. In future games, the function of assessment of DM could be built-in the game using our suggested indicators to minimise biases.

The study operationalised diversity as an aggregate of five demographic variables, which constrains interpretation regarding the mechanisms through which diversity shaped group interactions and which dimensions exerted the strongest influence on collaborative performance. Additionally, we acknowledge the limitations related to categorical classifications of the diverse characteristics of the participants, the reliance on self-reported identification of diversity, which is subjective, as well as the absence of continuous measures for diversity.

Future studies could explore the design of interregional comparative studies, analyse the differential impact of specific demographic variables, or conceptualise SGs that directly address the different demographics or other diversity characteristics related to sustainability decision-making. When determining which diversity dimensions to emphasise in future studies, the existing literature provides stronger evidence for gender's influence on decision-making compared to ethnicity or socio-economic status. Research on board composition and corporate social responsibility consistently highlights gender as a key factor, with findings suggesting that achieving a critical mass of women on boards is associated with improved outcomes, while the effects of ethnicity and other protected characteristics remain underexplored [107]. Further research into the entangled and discrete impacts of gender and diversity in DM is required for the benefit of global sustainability agendas such as the UN Sustainable Development Goals (SDGs) which posit that the transition to a more sustainable world should be done leaving no one behind and the IPCC [108] who promote energy transitions that are fair and equitable. SGs could assist as DM tools and ensuring gender inequality and other social inequalities are addressed [109]. Future research should concentrate on investigating the interplay between game design features and diversity-related outcomes. For example, examining whether mechanisms such as resource limitations or cooperative incentives intensify or reduce diversity's influence on decision-making quality. In addition, conducting cross-cultural assessments is vital to establish the framework's validity in non-Western and varied institutional contexts, thereby clarifying how cultural dimensions affect decision-making and strengthening the model's generalisability and practical utility [110].

6. Conclusions

This exploratory study examined how group composition shapes sustainability decision-making within a structured Serious Game environment. The findings show that group diversity influences how participants engage with the game's challenges, but not in a uniformly positive or negative manner. Instead, both heterogenous and homogenous

groups demonstrated distinct strengths and limitations that are valuable for understanding decision-making processes in sustainability contexts.

The heterogenous group engaged more frequently in explicit reasoning, discussion of trade-offs and future risks, and coordination of collective actions. These behaviours were associated with more equitable and resilient outcomes in the game scenario. However, this does not imply that diverse groups inherently produce better decisions. The collaborative dynamics observed here may reflect the specific composition, values, or interaction styles of this group rather than diversity alone.

The homogenous group exhibited faster agreement, smoother surface-level coordination, and more individual initiative in certain types of development activities. These patterns illustrate that similarity among members can support efficiency and rapid task execution in some contexts. At the same time, the group's tendencies toward limited deliberation and a focus on individual rather than collective outcomes highlight potential vulnerabilities when addressing problems, like sustainability transitions, which require integrating multiple perspectives, balancing competing priorities, and anticipating long-term risks. Importantly, these dynamics should not be seen as inherent to homogenous groups but as reflections of how this specific group interacted within the game environment.

Across both groups, the Serious Game proved a useful tool for making decision processes visible, generating authentic interactions, and revealing how players navigate uncertainty, resource constraints, and interdependence. Rather than privileging one type of group over another, the study suggests that the value of diversity in sustainability decision-making depends strongly on contextual factors: the nature of the task, the design of the decision environment, the incentives for cooperation, and the facilitation structures that support meaningful exchange among participants.

Given its small scale and exploratory design, the study does not aim to generalise the effects of diversity but to illustrate how Serious Games can offer a controlled yet realistic setting for examining the conditions that support thoughtful, inclusive, and context-sensitive decision-making. Future work should involve larger, more varied samples, test the interaction between different forms of diversity and specific game design features, and investigate how insights generated in game environments translate to real-world governance. By viewing diversity as a contextual resource, researchers, educators, and policymakers can use Serious Games to design decision environments that are more adaptive, equitable, and reflective of the complexities inherent in sustainability transitions.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/su18052382/s1, File S1: sustainability-4080444-supplementary.

Author Contributions: Conceptualization: V.K., M.C. and Z.M.H.; Methodology: V.K., Z.M.H. and M.C. Formal analysis and investigation: V.K., Z.M.H., M.C. and G.O.; Writing—original draft preparation: V.K.; Writing—review and editing: V.K., M.C., G.O. and Z.M.H.; Funding acquisition: Z.M.H., V.K., M.C. and G.O. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This study was given ethics approval by the University of Surrey research ethics committee on 21 July 2021 (FEPS 20-21 018 EGA). Informed consent was received from all workshop participants using an online consent form, participants provided consent to participate in the workshops, their data and quotes from playing the SG be used in publications and be shared in open access data repository provided anonymity is maintained and quotes are pseudonymised. The data controller of this study is the University of Surrey, and the Data Protection Officer can be contacted at dataprotection@surrey.ac.uk.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are openly available in Zenodo at https://zenodo.org/records/18174533, accessed on 21 February 2026, reference number: Version 2 and in Supplementary Materials File S1.

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