The potential of serious games to stimulate boundary crossing learning mechanisms in higher education students

A study of MSc thesis students at Wageningen University

Julia van Ryneveld MSc Thesis in Urban Environmental Management

March 2025



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List of Abbreviations

BC: Boundary Crossing
LM: Learning Mechanism
SG: Serious Game
GE: Gaia Explorers
MRF: Master Resilient Farming and Food Systems
MUE: Master Urban Environmental Management
MIL: Master International Land and Water Management
MPS: Master Plant Sciences
MES: Master Environmental Sciences
MLP: Master Landscape Architecture and Planning
FSE: Farming Systems Ecology Group
LUP: Land Use Planning Group
ENR: Environmental Economics and Natural Resources Group
WSG: Water Systems and Global Change Group
PPS: Plant Production Systems Group
ESA: Environmental Systems Analysis Group
PAP: Public Administration and Policy Group

Summary

In the context of urgent social and environmental challenges, Boundary Crossing has been presented as a key competency needed by university graduates (Fortuin et al., 2024). Boundary Crossing literature argues that learning, knowledge creation, and innovation occur when individuals from different domains, institutes, socio-cultural backgrounds, or contexts cross the boundaries that separate their practices and knowledge (Fortuin et al., 2024; Jean et al., 2018a). Learning at these boundaries happens through different learning mechanisms, two of which – identification and Reflection – are explored in this thesis.

In order to develop Boundary Crossing Competency, students need to be exposed to learning environments which stimulate these learning mechanisms. Serious Games, or interventions with a primary objective beyond entertainment (Den Haan & Van der Voort, 2018; Laamarti et al., 2014), have been proposed as a tool to trigger these mechanisms (Jean et al., 2018a). However, no research has investigated whether Serious Games can stimulate Identification and Reflection specifically. Thus, this thesis aimed to investigate the potential of the Serious Game Gaia Explorers (Andreotti, 2025) to stimulate Boundary Crossing learning mechanisms in higher education students with a specific focus on Identification and Reflection.

This study followed an integrated mixed-methods approach to answering the question: Does playing serious games stimulate the Identification and Reflection learning mechanisms of Boundary Crossing learning in higher education students, and if so, how? After completing a Pre-Game Survey, 18 MSc thesis students from Wageningen University participated in a 1-hour Serious Game Session run by 6 trained facilitators. During the session, participants played Gaia Explorers, debriefed on their experience, and completed a Post-Game Survey. 2 weeks later, 12 participants were interviewed to gain insight into their experience of the Game Session and to investigate the learning mechanisms further.

Recordings from the Game Sessions and Interviews were transcribed, coded, and analyzed according to the literature-based operationalization of Identification and Reflection performed in this thesis. Overall, Identification and Reflection were stimulated – to different degrees – by all three methodologies used in this research, and even among the Facilitators. There were more cases of Identification than Reflection however the quantitative findings did not necessarily reflect the richness of the qualitative results. The Interviews stimulated the vast majority of Identification and Reflection.

Based on these findings, this thesis discussed that Identification and Reflection were stimulated by the combination of methods used and that debriefing is essential for stimulating learning mechanisms. That evidence of Identification and Reflection was also found between the facilitators suggested that Serious Games can stimulate learning mechanisms in more than just the participants. Importantly, however, stimulating boundary crossing learning mechanisms is not the same as boundary crossing learning. It is the role of future research to investigate how serious games can best support the latter.

1 Introduction

1.1 Boundary Crossing in Education

Amid calls for more multi-, inter-, and transdisciplinary education and research to address the wicked problems that this and future generations face (CUCo, 2024), boundary crossing (BC) has emerged as a theoretical framework (Akkerman & Bakker, 2011b; Gulikers & Oonk, 2019) that argues that learning, knowledge creation, and innovation occur when – through collaborative processes – individuals from different domains, institutes, socio-cultural backgrounds, or contexts cross the boundaries that separate their practices and knowledge (Fortuin et al., 2024; Jean et al., 2018a). As per Akkerman and Bakker (2011a), the pedagogical foundations of boundary crossing theory lie in socio-cultural learning theory, where it is argued that learning takes place in social and cultural spaces and institutions. Following Marková's (2003) claim that learning is a product of dialogicality, or the characteristic of humans to think of, create, and share social realities through dialogue with another, Akkerman and Bakker (2011a, p. 137) argue that learning requires "multiple perspectives and multiple parties." Fortuin et al. (2024) argue that learning is a change of thinking resulting from experiencing dissonance.

Where multi-, inter-, and transdisciplinary education differ in the degree to which knowledge and skills from different (academic) disciplines (Choi & Pak, 2006) is incorporated into a learning activity, boundary crossing seeks to also explicate how learning with and from those outside a scientific, professional, or cultural domain occurs (Fortuin et al., 2024). In other words, boundary crossing looks beyond discipline to take seriously the manifold boundaries that can exist in an interaction in addition to those resulting from inhabiting different academic backgrounds. Boundary crossing takes as a starting point the assumption that there exist boundaries in all forms of learning (Akkerman & Bakker, 2011a). To Kaufman and Smith (1999), a boundary is a discontinuity in action resulting from a socio-ecological or socio-cultural difference in the knowledge or domain of participants in an interaction. These boundaries are not static: they change based on the relationships of the individuals involved and the context of the situation in which the boundary arises (Akkerman, 2011; Fortuin et al., 2024).

In an educational context, boundaries are experienced when students, for example, work with other students from different academic, language or cultural backgrounds or with external stakeholders who hold different assumptions about the way a system functions. The tension resulting from encountering a boundary can hamper the cooperation or learning process (Fortuin et al., 2024), for example because the boundary remains unaddressed or because interacting individuals are unable to find common language or terms through which they can share their perspective.

However, boundaries can be transformed into spaces of learning where people are prompted to confront and reevaluate their assumptions and pre-existing knowledge (Akkerman & Bakker, 2011b). To Akkerman and Bakker (2011a), boundary crossing is the process of (re-)establishing the continuity that was disrupted by the difference. Jean et al. (2018a) expand on this definition by highlighting that boundary crossing is a generative process in which new knowledge is created by integrating diverse forms of knowledge across different domains through collaboration. The ability to cross boundaries – specifically, the ability to recognize, seek out, integrate, and use the

discontinuity that arises when different perspectives interact – is known as boundary crossing competence (Fortuin et al., 2024). This competence is increasingly being recognized as an essential quality for universities to develop in their current and future graduates (Fortuin et al., 2024).

1.1.1 Research into Boundary Crossing Learning

Research into boundaries and boundary crossing has been conducted in a wide range of domains across work, school, and life (Akkerman & Bakker, 2011a). Within work-related studies, the literature investigates how collaboration and co-creation occurs both within and across teams operating in different domains or fulfilling different functions (Akkerman et al., 2006; Akkerman, 2011; Akkerman & Bakker, 2011a; Van der Haar et al., 2013). School-based research into boundary crossing tends to focus on differing perceptions of discourses held by teachers and students (Akkerman & Bakker, 2011a), as well as boundary crossing within pedagogical frameworks (Akkerman & Bakker, 2011a; Leung, 2020). Research into the tensions between school-work-life for trainee teachers have explored the difficulty faced by new teachers when transitioning from teacher training to school-based placements in terms of identity formation (Beauchamp & Thomas, 2011; Fejes & Köpsén, 2014; Trent, 2013), the integration of boundary crossing collaborations in teacher education (Straub et al., 2021), and collaboration between schools and academic institutions (Gorodetsky & Barak, 2008).

1.1.2 Boundary Crossing Learning Mechanisms

In a review of BC literature, (Akkerman & Bakker, 2011a) argue that learning at boundaries – or learning by crossing boundaries – can occur through four learning mechanisms (LMs) briefly explained below: Identification, Coordination, Reflection, and Transformation.

1.1.2.1 Identification

Studies that find the learning potential of boundaries to be Identification argue that encountering boundaries upsets the distinctions individuals have made between social practices (Akkerman & Bakker, 2011a). At the boundary, individuals are forced to reevaluate the core identities of overlapping social worlds/the individuals in these worlds. Here, individuals need to develop an understanding of their own expertise, assumptions, values, and principles and how these facets shape their understanding of the world (Fortuin et al., 2024). A boundary can also be a place in which an individual can identify these characteristics in team members/other social groups.

1.1.2.2 Coordination

Akkerman and Bakker (2011a) argue that boundaries can be sites of learning through the potential they hold for groups with diverse backgrounds to establish modes and practices in which they can coordinate collaboration. Coordination as a learning potential of boundaries is about understanding how members of different social worlds work together effectively and collaboratively. This is about the way in which the group communicates with each other, the boundary objects they use to mediate common ground, and the methods used to make the differences between their social worlds and practices less disruptive (Akkerman & Bakker, 2011a).

1.1.2.3 Reflection

Boundaries also provide places where individuals can comprehend that they have different perspectives/understandings of an issue compared to others and also where they can formulate new perspectives based on this comprehension (Akkerman & Bakker, 2011a). In other words, Reflection as a mechanism through which learning can occur at boundaries operates through perspective making and perspective taking (Akkerman & Bakker, 2011a). Perspective making is about making clear how an individual understands an issue whilst perspective taking is about an individual being able to understand themselves through the eyes (perspective) of another.

1.1.2.4 Transformation

The new perspectives or practices encountered at a boundary can also stimulate a change in the behavior or practices of those meeting the boundary (Fortuin et al., 2024). Akkerman and Bakker (2011a) argue that boundary crossing can stimulate Transformation when collaboration stimulates the co-development of new practices.

1.2 Serious Games

To develop the boundary crossing competence outlined in Section 1.1 students need to be exposed to learning environments which "trigger" (Fortuin et al., 2024, p. 215) and allow students to practice these learning mechanisms (Section 1.1.2). One tool that has been suggested as way of triggering these learning mechanisms is serious games (SGs) (Jean et al., 2018a). Serious games are interventions with a primary objective beyond entertainment (Den Haan & Van der Voort, 2018; Laamarti et al., 2014). These games combine serious aspects like teaching, learning, cooperation, and communication with more playful aspects like rewards and role playing typical of household games (Daré et al., 2019). In natural resource management and environmental education, SGs tend to represent a simplified version of socio-ecosystem dynamics and revolve around a game objective which participants need to learn and make decisions about together (Daré et al., 2019).

SGs can capture both the techno-physical and socio-political complexity of natural resource management decisions by providing participants with room to negotiate, deliberate, and share perspectives which make them effective tools for stimulating learning in stakeholder engagement sessions and education (Den Haan & Van der Voort, 2018). In higher education, SGs have shown promise as tools to develop active learning (Bonnier et al., 2020), experimentation (Squire, 2008), and content-related (Severengiz et al., 2020) knowledge and skills, among others, whilst increasing engagement, motivation, and enjoyment of learning activities (Bakhanova et al., 2020; Bellotti et al., 2010).

Serious games have been proposed as interesting tools in the context of boundary crossing education because of the type of learning that takes place in serious games (Section 1.2.1) and how serious games can function as boundary objects (Section 1.2.2).

1.2.1 Social Learning and Serious Games

SGs have received increasing attention in the literature as effective tools to promote social learning (Bakhanova et al., 2020; Den Haan & Van der Voort, 2018; Van der Wal et al., 2016). Den Haan and Van der Voort (2018) argue that serious games facilitate social learning through social interactions. Social learning occurs when an individual experiences a change in their

understanding of a system, problem, collective action etc. through interacting and collaborating in participatory settings (Den Haan & Van der Voort, 2018). Thus, both SGs and Boundary Crossing view learning as a necessarily social process. Here, the focus is not (so much) on the vertical development of knowledge or skills by stage or level, but on horizontal learning (Engeström et al., 1997) or learning across contexts, social interaction, and forms of knowledge.

Baird et al. (2014) argue that there are three types of learning that constitute social learning:

- 1. *Cognitive Learning* refers to the acquisition of new knowledge and the restructuring of existing knowledge.
- 2. Normative Learning refers to the shift in a student's viewpoint, values, or paradigms.
- 3. *Relational Learning* refers to individuals achieving an improved understanding of others' perspectives as well as developing a sense of trust and cooperation between individuals.

Furthermore, in a review of the social learning potential of serious games, Den Haan and Van der Voort (2018) find that most research into serious games (37/42 papers) focus on the cognitive learning outcomes in serious games. Far fewer (17/42) focus on relational learning and even fewer (5/42) on normative learning. In this review, the researchers find evidence to different degrees that all three elements of social learning are stimulated by serious games.

1.2.2 Boundary Crossing and Serious Games

Veltman et al. (2019) among others highlight the importance of boundary objects in supporting boundary crossing learning. Boundary objects - often used in boundary crossing research - refer to artefacts that are meaningful within and across practices and allow for communication across boundaries (Fortuin et al., 2024; Star & Griesemer, 1989). Such objects have different meanings to individuals inhabiting different social worlds (Star & Griesemer, 1989), but they are recognizable in both as a tool to unite different domains. In their classic study of cross-domain interactions at a Zoology Museum, Star and Griesemer (1989) found that administrators, research scientists, amateur collectors and other actors were able to cross their domain, social, and disciplinary boundaries to work together despite their differences because of boundary objects. For example, identifying the state of California as a boundary object around which the different social worlds worked allowed each to create their own representations of the area. That is, they could each create their own maps - also boundary objects - of the area with the information that was relevant and interesting to the particular group (Star & Griesemer, 1989). Within the same outlines of the area of interest - the borders of the state of California - biologists created highly abstract maps of "life zones" (Star & Griesemer, 1989, p. 411) whilst amateur collectors created simple maps highlighting collection locations and campsites.

Jean et al. (2018a) found that serious games can be effective boundary objects in a watershed governance case explored by students, professionals, and other diverse stakeholders. Likewise, Terlouw et al. (2021) found that an escape room-based serious game can serve as a boundary object to facilitate cooperation and communication between high-functioning children with autism spectrum disorder. In the context of stakeholder debates over livestock stocking and environmental management practices in communities in Burkina Faso, Ethiopia, and Tanzania Morris et al. (2021) found that serious games can serve as useful tools to make visible and reconcile differing perspectives, values, and goals. However, they also highlighted that the

authorship of the game is important in that the mechanisms of the game can favor one side of a stakeholder debate or be used by stakeholders in unexpected ways. This research indicates the potential of serious games to serve as boundary objects, however there is yet to be research conducted on the potential of serious games to serve as boundary objects in an exclusively higher education setting.

1.2.3 Limitations in Serious Games Research

Despite the potential of serious games to enhance social learning, there are criticisms both in terms of the pedagogical and design underpinnings of serious games. To the former, critics of serious games argue that too little is known about whether, and if so, how learning happens in serious games (Madani et al., 2017). Aubert et al. (2019) argue that serious games research is lacking in method to assess the learning in serious games. They argue that an important avenue for future research is not just to determine *that* people are learning but *how* are they learning (Aubert et al., 2019) and according to what learning outcomes (Den Haan & Van der Voort, 2018; Jean et al., 2018a; Madani et al., 2017). It is also important to determine in which subjects SGs hold potential for learning. Young et al. (2012) when reviewing serious games in K-12 education found that SGs show some evidence for promoting learning in language and history learning, but little evidence in math and science. Jean et al. (2018a) as well as Ávila-Pesántez et al. (2017) argue that more research is needed into the relationship between the design and the learning that takes place during games.

However, as Girard et al. (2013) argue in a review of the efficacy of serious games as educational tools, it is also hard to make generalizations about the efficacy of SGs due to the vast range of subject matters, game types, and research methods used in SG research.

1.3 Knowledge Gaps

As highlighted by Veltman et al. (2019) further research into the boundary crossing learning processes that students experience during the problem-solving process is needed to gain insight into how teachers can better support boundary crossing. This builds on the argument made by Akkerman and Bakker (2011a) that many studies within the field of boundary crossing define boundaries where they are expected rather than detected. In other words, more empirical research is needed into how individuals in (potentially) boundary crossing situations actually identify boundaries, and which boundaries they identify. For that, learning environments in which learners identify and experience boundaries – such as in serious games – are needed.

Being confronted with a boundary does not mean continuity will necessarily disintegrate (Akkerman & Bakker, 2011a). However, nor does simply being exposed to boundaries mean that students will learn (Fortuin et al., 2024): diversity alone is not a sufficient condition for learning. The ability of boundaries to be spaces of potential for learning requires support and training of the capacity to engage with these differences such that they can be learnt from, as well as a learning environment in which such boundary learning is stimulated (Fortuin et al., 2024). Serious games have the *potential* to create learning environments in which these differences can be explicated and learnt from (Jean et al., 2018a), however more research is needed to understand if, and if so how, serious games can be used to stimulate boundary crossing learning.

Within serious games literature, a key shortcoming identified by various authors (Den Haan & Van der Voort, 2018; Jean et al., 2018a; Madani et al., 2017) is the difficulty of evaluating the learning outcomes of games. This calls for research with a clear definition of what learning outcomes are being investigated and how they will be identified.

1.4 Purpose of the Study

Though both boundary crossing and serious games have been receiving increasing attention in the literature individually, the above introduction has highlighted that there is a dearth of research investigating the potential of serious games to stimulate Boundary Crossing learning mechanisms among higher education students. Thus, this thesis aims to investigate the potential of serious games to stimulate Boundary Crossing learning students with a specific focus on Identification and Reflection learning mechanisms.

General Research Question (GRQ): Does playing serious games stimulate the Identification and Reflection learning mechanisms of boundary crossing learning in higher education students, and if so, how?

This GRQ will be answered through the following sub-research questions (SRQs):

- 1. SRQ1: Do serious games trigger the Identification learning mechanism, and if so, how?
- 2. SRQ2: Do serious games trigger the Reflection learning mechanism, and if so, how?

1.5 Outline of this Thesis

Following this introduction (Chapter 1), this thesis consists of 4 main chapters. Chapter 2 outlines the methodology used in data collection and analysis. Chapter 3 presents the results of this research which are then discussed in Chapter 4. Chapter 5 draws conclusions from the results and discussion and addresses the research questions this thesis aims to answer.

2 Methodology

2.1 Theoretical Framework: Operationalizing Boundary Crossing

The SRQs above result in two key concepts that needed to be operationalized: Identification and Reflection. This section outlines how, based on the literature, this study understood these terms. The operationalization of these terms shaped the way in which the other methods used in this study were constructed and how the analysis was performed (see Appendix 7: List of Codes and Subcodes for all the codes and subcodes used in this thesis).

2.1.1 Identification in this Thesis

Literature on the Identification learning mechanism suggested that a boundary's potential to facilitate learning lies in its ability to engage learners in outlining their own identities in relation to others' (Akkerman & Bakker, 2011a). Thus, Identification was operationalized as:

- 1. Recognition and definition of one's **own perspective** (Gulikers & Oonk, 2019). Perspective was further defined as the assumptions, norms, principles, and values held by an individual (Fortuin et al., 2024).
- 2. Recognition and definition of one's **own expertise** (Gulikers & Oonk, 2019). Expertise was further defined as the knowledge, skills, network, and attitudes an individual has, as are relevant to the task at hand (Gulikers & Oonk, 2019). Part of recognizing one's expertise is also recognizing the shortcomings of this expertise. Learning at a boundary can occur through Identification if the boundary serves as a space in which the individual can recognize not only what skills etc., they possess in relation to the task at hand, but also which skills etc., they still require.

These two characteristics referred to the ability of an individual to define the boundaries of their practices and knowledge.

- 3. Recognition and definition of the **perspectives** and **expertise of others** (Gulikers & Oonk, 2019).
- 4. Ability to **relate one's own** perspective and expertise **to that of others** (Gulikers & Oonk, 2019). This captured the idea that the Identification learning mechanism is concerned with establishing the defining features (Akkerman & Bakker, 2011a) of one perspective or practice *in relation* to another. Akkerman and Bakker (2011a) define this as a process of *othering*, or being able to outline how one practice/perspective is distinct from another. Relatedly, Akkerman and Bakker (2011a) argue that once the distinction between practices/perspectives/expertise has been made clear, individuals are then in the context of a project or group task able to start *legitimizing their coexistence*. By this they mean that individuals can construct their identities such that it is clear how and why they add value to the activity in relation to the other participants.

2.1.2 Reflection in this Thesis

Where the Identification learning mechanism focused on the ability of the student to outline their knowledge/perspective in relation to those of other students, the Reflection mechanism

captured how boundary crossing can stimulate individuals to take on new perspectives and possibly construct new identities. Reflection was thus deconstructed as follows:

- 1. Ability to **understand a different perspective** from one's own (Fortuin et al., 2024). This is a step beyond Identification in that it requires recognition of *what* makes one perspective different from another, and *how* these differences came to be.
- 2. Openness to **learning from differing perspectives** (Gulikers & Oonk, 2019). This means that students can recognize what they can and have learnt from others (Fortuin et al., 2024) and are actively seeking opportunities to learn from others. Likewise, they create learning moments for other students (Fortuin et al., 2024; Gulikers & Oonk, 2019).
- 3. **Perspective taking**: the ability of the student to see themselves and their practices/knowledge/expertise/skills from the perspective of another. This means that the student can take on a different perspective and reflect on how they may be understood by someone from that perspective.

Together, as Veltman et al. (2019) argues, Identification and Reflection learning mechanisms stimulate the ability to understand the overlap and differences between individuals as well as to navigate the multiple understandings between them.

2.2 Mixed Methods Introduction

This thesis used a mixed methods approach with both pre-, in-, and post-game elements, as is common in SG research (Mayer et al., 2014), to generate qualitative and quantitative data to answer the exploratory questions addressed in this research. The participants were MSc thesis students at Wageningen University. Quantitative data was used to summarize and structure the qualitative data rather than to generalize the findings. Importance was given to understanding the quantitative findings through the qualitative data.

A mixed methods approach was chosen for several reasons. First, the results of one method alone would have been inadequate for answering this study's research questions: multiple methods were needed to corroborate the findings of, and in some cases elicit findings from, another (Creswell & Plano Clark, 2018). Relatedly, the initial results from the Game Session needed further explanation and investigation (Creswell & Plano Clark, 2018) which was not possible without further discussion with participants. Third, using quantitative data to structure qualitative findings, and qualitative data to explain and contextualize quantitative data allowed for a more robust understanding of the findings than had one been used alone (Creswell & Plano Clark, 2018).

Figure 1 provides an overview of the order in which different data collection events took place and the methods used. The surveys, debriefing, and Interview questions were designed to stimulate Reflection on BC learning according to Gulikers and Oonk (2022) and to flow into each other (Figure 3 in Appendix 1: Flow of BC-Stimulating Questions). These methods, as well as the methodology used to analyze their results are discussed in the remainder of the chapter.

	Recruiting & Training Phase (two weeks before)	Game Session	Event	Interview Phase (two weeks after)	Processing and Analysis Phase
Activity	Pre-Game Survey (n=21) Facilitator Training (n=6)	Game Play & Debriefing Gaia Explorers (n-18) Debriefing (n=18)	Just After Post-Game Survey (n=18) Facilitator Debrief (n=3)	Interview (n=12)	Data Processing and Analysis
Aim	Gain insight into participant expertise to establish Game Session configuration. Participant consent. Material for interview questions. Train facilitators to run the game.	Immerse participants in Gaia. Stimulate collaboration. Collect data on any BC stimulated during Game Session. Game Session. Game Session. Give room for participants to process game experience to turn it into learning (Baker et al., 1997).	Gain insight into participant and facilitator experience of the game sessions. Generate data for interviews and analysis.	Gain insight into participant experience of BC learning drawing on data from surveys and Game Session and questions from Gulikers and Oonk (2022).	Process, analyze, and consolidate findings on BC LM stimulation in/from surveys, Game Session, and interview data.
Data	Qualitative, quantitative	Qualitative	Qualitative, quantitative	Qualitative	Qualitative, quantitative summary of qualitative data
? Method	Open- and closed-ended questions through online survey. In-person training.	Audio recordings of Game Play and Debriefing at 3 Game Sessions. Pictures.	Survey: Open- & closed- ended questions in written survey. Debrief: audio recording of semi- structured debrief	Audio recordings of semi- structured interviews.	Transcription, inductive and deductive thematic coding.
Who	Researcher + Supervisors	Facilitators + Resear	cher	Researcher	Researcher + Supervisors

Figure 1 Research Timeline and Methods Used (adapted from Daré et al. (2019))

This figure provides an overview of the research timeline and methods used in this thesis. It outlines the activity, the aim of the activity, the type of data collected, the method used, and who was responsible for this. It is separated into 4 periods starting after the initial research orientation phase.

2.3 Pre-Game Survey

2.3.1 <u>Design</u>

Pre-game surveys are commonly used in SG research to get a better understanding of who the participants are and initial results on concepts relevant to the study at hand (Jean et al., 2018a; Mayer et al., 2014; Zhou, 2014). The aim of the pre-game online survey was to gain basic data (Jean et al., 2018a) on the participants' study background and self-identified expertise as well as consent to being audio recorded in the Game Session. This information was necessary to gain insight into who the participants were, whether they met the selection criteria to participate in the study, and for constructing Game Sessions with participants from mixed backgrounds. The questionnaire included 12 short closed-ended questions aimed at establishing participants' basic data and academic background which was used as a proxy for their expertise (see Section 2.1). The one open-ended question was designed to elicit their self-defined expertise to validate the expertise proxied by their academic background (Creswell & Plano Clark, 2018). See Appendix 2: Pre-Game Survey for a copy of the survey.

2.3.2 Participants

The inclusion criteria for participants were 1) MSc student currently writing their MSc thesis, 2) enrolled at Wageningen University, and 3) available for the November 28, 2024, Game Session. MSc thesis students were recruited via invitations sent by thesis coordinators, thesis ring coordinators, word of mouth, and directly by me two weeks before the Game Session. The decision to sample from the whole population of Wageningen University MSc thesis students was motivated by the need for coverage and diversity: for students to collaborate in interdisciplinary and international teams as is a core tenet of BC (Fortuin et al., 2024), students from a wide background of study areas needed to be recruited. In practice, 56% of students came from either the same degree program as me or chair group as my one supervisor (FSE) due to ease of access, indicating that convenience sampling was used.

Participants were pre-informed of which Game Session they would play in to ensure that there was a mix of academic backgrounds and expertise present at each Session. Game Session 3 was an exception as one participant dropped out just before the Session started and another (P5) joined with a friend (P4) without being allocated a Game Session. Table 1 provides an overview of the Game Session Configuration and the background of each participant as reported in the Pre-Game Survey. Most (39%) of the 18 participants were Urban Environmental Management (MUE) students. Resilient Farming and Food Systems (MRF) students represented the next largest proportion (22%) followed by Plant Sciences (22%). One participant each followed Environmental Sciences (MES), International Land and Water Management (MIL), and a double masters in Land Use Planning (MLP) and MRF. Figure 4 in Appendix 4: Self-Identified Expertise provides an overview of participants' self-identified expertise.

Game Session	Participant	MSc Program	Thesis Chair Group	Interview
	P13	MRF	FSE	Yes
	P14	MUE	LUP	Yes
1	P15	MRF	FSE	No
F1 and F2	P16	MUE	ENR	Yes
	P17	MUE	LUP	Yes
	P18	MIL	WSG	Yes
	P10	MPS	PPS	No
	P11	MUE	LUP	Yes
2	P12	MPS	PPS	No
F3 and F4	P7	MUE	LUP	Yes
	P8	MUE	ESA	Yes
	Р9	MUE	WSG	No
	P1	MRF	PAP	Yes
	P2	MES	ENR	Yes
3	Р3	MRF	FSE	Yes
F5 and F6	P4	MPS	Plant Breeding	Yes
	Р5	MPS	Plant Breeding	No
	P6	MLP, MRF	LUP	No
Total Participants	18			12

Table 1 Game Session Configuration and Participant Background

This table depicts which facilitators ran each Game Session and which participants played in which Session. The 2nd and 3rd columns give an overview of the MSc Programs followed by each participant and the chair group in which they are writing their MSc thesis, respectively. The abbreviations are expanded upon in the List of Abbreviations (Page 6). The 4th column indicates whether the participant agreed to be Interviewed.

2.4 Game Sessions

2.4.1 Facilitator Training

As noted by Jean et al. (2018a), facilitators enhance and enable interactions between participants and play a large role in shaping the way the game is played through the way it is introduced and the debriefing between rounds. Not only do facilitation skills – managing the game and the debriefing – need to be learnt (Crookall, 2010), it was also important that the three Game Sessions were introduced and run in the same way to reduce (facilitator-driven) variation between sessions. Thus, the 6 students who volunteered to facilitate the SG used in this research, Gaia Explorers (see Section 2.4.3), were invited to attend a 1 hour 15-minute training session on November 19, 2024, to learn how the game works and the different facilitation teams before getting an in-depth training into how to manage the game. Each facilitator was provided with a Training and Facilitation Guide (Appendix 5: Gaia Explorers Training and Facilitation Guide) that outlined game management, and the script used to introduce and run the game. They were also provided with worked examples to practice managing the game. The training also (briefly) covered how to run the debriefing as research has shown that learning is a product of the debriefing, not the game itself (Crookall, 2010).

2.4.2 Research Setting and Data Collection

The 1 hour and 15-minute Game Session took place on Wageningen Campus on November 28, 2024. Three Game Sessions were set up in a large conference room, each with a game board set up on the table and 8 chairs placed around the board (see Figure 2). Each Game Session was played simultaneously by 6 participants facilitated by 2 trained volunteers. Each Game Session was recorded using an audio recorder. Video recordings of the Game Sessions were considered but ultimately not taken as the analysis methods chosen for this study were not fit for analyzing non- Figure 2 Research Setting verbal interactions.



2.4.3 Gaia Explorers

After a brief introduction to this thesis, all participants played all 5 rounds of the game Gaia Explorers (GE) developed by Andreotti (2025) (See Appendix 5: Gaia Explorers Training and Facilitation Guide for an overview of the rules and mechanisms). Each game lasted an average of 47 minutes (SD=7.04 minutes). GE is an adaptation of the ReHab game developed and used by Le Page et al. (2016). The game's narrative is based on the work of McGreevy et al. (2022) on postgrowth approaches to sustainable agrifood systems. The scientific backing for the planetary boundary and regeneration mechanics comes from the work of Richardson et al. (2023) on planetary boundaries, Singh et al. (2021) on science-policy interfaces for food system transformations, and Gerten et al. (2020) on feeding the global population whilst remaining within planetary boundaries. GE's aim is to explore tradeoffs and synergies at a global level between food production and planetary boundaries (Andreotti, 2025). The game focuses on land use and biodiversity boundaries which participants can affect by implementing different land use management strategies. The objective of the game is for participants to produce enough food for their community whilst staying within the planetary boundaries of the system.

This game was chosen for several reasons. First, it can be played in less than one hour. This was necessary to reduce the time commitment from participants and facilitators alike. Second, the mechanics were relatively simple. This was important because what was interesting for this thesis was not whether students understood the underlying system and mechanisms but how trying to discover these mechanisms could stimulate BC learning mechanisms. Third, whilst it is a game about food systems, having a background in food systems was not a requirement for understanding the mechanisms of the game. This was relevant because the students participating in this study came from different (environmental studies-related) backgrounds but had not necessarily completed the same depth and breadth of food systems classes. A game that revealed these differences but did not make them barriers to play was thus necessary for students to engage in conversation about what they knew and how.

2.4.4 Participant Debrief

Immediately following the conclusion of GE, facilitators started the debriefing according to the Facilitation Guide. Debriefing is argued to be one of the most important elements of SGs (Crookall, 2010), essential for, among other reasons, participants to consolidate and reflect on their experience of the game (Daré et al., 2019), turning their experiences into learning (Baker et al., 1997), validating findings across methods (Kara, 2024), and evaluating the effects of participation (Daré et al., 2019). Thus, the debriefings were intended to last 20 minutes however in practice they lasted an average of 9 minutes (SD=4.6 minutes).

The design of the debriefing guide was inspired by the ComMod SG process (Daré et al., 2019) and some of the debriefing phases presented by (Kriz, 2010). The guide outlined 5 key questions that should have been asked and a series of extra questions in case time allowed. In the first phase (Q1), participants were asked to step back from the game and reflect on how they were feeling now that the game was finished. Next, in Q2-4, they were asked to discuss what happened (Kriz, 2010), or the events of the game (Daré et al., 2019). These questions also allowed participants to explore what Daré et al. (2019, p. 42) refer to as "explanations," or their different interpretations on the game events. Q5 invited the participants to reach conclusions (van den Hoogen et al., 2016) about what they had learnt during the game (Kriz, 2010).

Due to the Game Sessions running longer than expected, the debriefings ended up being much shorter than planned and facilitators did not manage to ask all the main questions in any of the Game Sessions. The consequences of this are discussed in Section 4.1.2.

2.4.5 Post-Game Debrief with Facilitators

Immediately after the game, 3 facilitators (F1, F2, and F6) participated in a 24-minute debriefing. Like the participant debriefing, the aim of the facilitator debriefing was to consolidate what the facilitators had experienced and gain insight into how the pairs had experienced facilitating together. Facilitators knew the questions they would be asked from both the facilitator training and the Facilitation Guide. The debriefing was audio recorded.

2.5 Post-Game Survey

Following the ComMod process described by Daré et al. (2019) (see also Mayer et al. (2014)), a hard copy of the post-game survey (PGS) was distributed to and filled out by all 18 participants immediately after the debriefing to gather insights into their individual experience of playing in Gaia Explorers (Jean et al., 2018a). Participants filled out the PGS in the research setting and handed it to their Session facilitators before leaving.

The PGS had the specific aim of getting participants to identify and reflect on any 'tensions' they may have experienced (see Section 2.1). Whereas the debriefing provided participants with the room to collectively discuss their experiences, the PGS was important in that it allowed participants to individually reflect on their experience. The word 'tensions' was used as a proxy for 'boundaries' based on the assumption that the former is more tangible and recognizable to participants than the latter: it was important to use language that was understandable to all participants in roughly the same way (Becker, 2007). The PGS contained 3 closed-ended questions (2 Likert-scale), 4 short open-ended questions which were used to shape the questions

asked in the Interview, and a question asking whether the participant would be willing to participate in the Interview. The PGS can be found in Appendix 3: Post-Game Survey.

2.6 Interviews

Two to three weeks after the Game Session in December 2024, a total of 12 semi-structured Interviews were conducted (see Table 1 for participants interviewed). According to Hennink and Kaiser (2022), the literature suggests that a sample size of between 9-17 Interviews is necessary for saturation. A down-time between game and Interview of two weeks was chosen such that the game was still fresh in the participants' memories but had also settled in participants' minds. 9 Interviews were in person on Wageningen campus and 3 were online. The Interviews lasted on average 28 minutes and were all conducted in English. With the consent of the participants, all Interviews were recorded using an audio recorder.

Semi-structured Interviews are often used in SG research (e.g. Liu et al. (2023), Kara (2024), Guala et al. (2024)) to further investigate ideas that participants felt were relevant in the game (McConville et al., 2023) without being bound to a strict guide. Thus, a semi-structured interview method was chosen over a stricter, structured method to allow for participant-specific questions to be asked and for themes that came up during the Interview to be explored. This method was also chosen over a focus group because participants had already participated in a group debrief (albeit shorter than planned), this research was interested in individual BC outcomes rather than group BC outcomes, and (though less important) it was deemed to be too logistically challenging to coordinate a time given the participants' conflicting schedules. Furthermore, especially considering the brevity of the Post-Game debriefings the Interview was intended to serve as another (debriefing) moment for participants to reflect on their experience.

The Interviews were conducted according to the Interview Guide included in Appendix 6: Interview Consent and Guide. As per the guidelines written by Knott et al. (2022) on constructing semi-structured interview guides, the Guide was designed to start with 2 broad opening questions followed by 3 more BC-specific questions and finally 2 closing questions. The Guide included probes and prompts for each question to make the content more concrete to participants (Knott et al., 2022). The questions were kept broad to prevent a situation where participants disagreed with a question or its premise (Knott et al., 2022; McConville et al., 2023).

The Guide was designed to incorporate elements from both the Pre-Game and Post-Game surveys for several reasons. First, and most importantly, this allowed for the further exploration of themes that were interesting to the participant (as they had written it in their survey answers) and interesting to the research (as selected from the survey answers). Second, this was done to make the value of these surveys clear to the participants: by reusing their own words they could see that their answers were taken seriously. Third, this was done to ground the Interview questions in the participants' experiences to make the questions more understandable and relatable.

2.7 Processing and Analysis

2.7.1 <u>Transcription</u>

The audio recordings of the Game Sessions (game + debrief), facilitator debriefing, and the 12 Interviews were first transcribed using the AI transcription tool Notta.ai. This software generated a graphic representation (Kowal & O'Connell, 2014) of only the vocal behavior of the participants. Non-vocal movements (e.g., nodding) and non-linguistic activities (e.g. placing an explorer on a plot) were not included in the transcription as only audio data was collected (Kowal & O'Connell, 2014). In the Game Session transcript, filler words or utterances such as uhm, like, or uh were often left in the transcription whilst in the one-on-one Interviews the AI software removed much more of this content. In the second step, I listened to each recording alongside the AI generated transcription to, to the best of my ability, correct mis-transcriptions and to attribute quotes to the correct speakers. The notation [inaudible] was used when the audio recording could not be understood.

2.7.2 Thematic Analysis: Inductive and Deductive Coding

Thematic analysis is a qualitative method for identifying, analyzing, and categorizing patterns within data (Fereday & Muir-Cochrane, 2006; Knott et al., 2022; Vaismoradi et al., 2013). Following the work of Fereday and Muir-Cochrane (2006), this research took a hybrid approach to thematic analysis using both inductive and deductive coding. An inductive approach to coding allows the code categories to emerge from the analysis of the data (Bingham, 2023; Hsieh & Shannon, 2005; Knott et al., 2022) whilst a deductive approach develops the codes a priori based on a pre-existing framework (Bingham, 2023; Fereday & Muir-Cochrane, 2006). Such a hybrid approach was taken to allow Boundary Crossing to be defined/operationalized within the context of the study as well as to ensure that the data could be tested against the literature-supported operationalization (Section 2.1).

First, the transcripts were skimmed, and initial inductively determined boundary and LM codes were applied to quotes in ATLAS.Ti 24. Boundary codes referred to instances where participants identified a boundary – or difference – between themselves and another participant. The purpose of this was to briefly analyze whether GE stimulated boundaries and if so, what kind (see Table 7), but was not the main focus of this research.

Next, these LM subcodes were categorized within the deductively determined LM codes. These codes represented the sub-elements of the BC operationalization outlined in Section 2.1: for example, "Recognition and Definition of One's Own Expertise" or "Perspective Taking". Third, the inductive subcodes in the deductive categories were supplemented by the remainder of the deductively determined subcodes, or the elements of each code (e.g., the code "Expertise" was further operationalized into the subcodes 'knowledge', 'skills', 'attitudes', etc.). Forth, the data was reevaluated and coded according to the final code list (see Appendix 7: List of Codes and Subcodes). For examples of quotes coded according to this method, see the tables in Section 3.

Though this process is described linearly, it was – as in Fereday and Muir-Cochrane (2006) – an iterative process and (sub)codes were merged, re-categorized, added, and deleted throughout the process until the final code list emerged. This list was similar to the operationalization above – indeed, the codes correspond completely to the sub-elements of each LM. However not all the

sub-elements from the literature-based operationalization were found to be relevant in the context of the Game and likewise some new subcodes were generated based on the inductive coding.

LM Codes were applied with the same meaning across all methods except for the subcode "Expertise: knowledge" which differed between Game Sessions and Interviews. In the Game Sessions, the subcode was applied to instances where participants applied their knowledge whilst in the Interviews this was applied to instances where participants actively recognized and defined what that knowledge was. This was based on the assumption that in the Game Session setting participants were implicitly recognizing and defining the knowledge that was relevant to the situation and explicitly using the knowledge due to the fast-paced nature of the game. Meanwhile, in the Interview they could step back and explicate the foundations of their expertise.

After the data was coded, a quantitative summary of the code usage was generated to provide an overview of the patterns identified in the data. This provided a structure, but did not capture the depth and nuance of participants' experiences. Thus, the qualitative data underlying this quantitative data provided a richer and more in-depth picture of the participants' learning (McConville et al., 2023) and was the main determinant of this research's conclusions.

3 Results

The following section details the findings from the various methods used in this study. After presenting results on the coding of the learning mechanisms, the results are presented in terms of method and conclude by presenting the findings on the latter part of the SRQs: and if so, how?

3.1 BC in the Context of a Serious Game: Results of Coding

3.1.1 Codes Used

Table 2 Frequency of Codes and Key Subcodes Used Per Method

Koy Codec		Method							
	Rey Codes	Game S	ession	Post-Gam	e Survey	Inter	view	To	tal
	Key Subcodes	% Game Session	N	% Post-Game Survey	N	% Interview	N	% Total Count	N
	Own Perspective	63%	147	34%	10	25%	114	38%	271
	Own Perspective: understanding of mechanisms	48%	112	17%	5	8%	38	22%	155
	Expertise	15%	35	3%	1	19%	86	17%	100
ion	Expertise: knowledge	13%	30	3%	1	14%	62	13%	93
cat	Rec. & Def. Missing	0%		7%	2	4%	16	3%	18
tif	Rec. & Def. Others	2%	5	14%	4	19%	85	13%	94
Ider	Red. & Def. Other's Perspective/Expertise: Understanding of Mechanisms	2%	5	10%	3	8%	36	6%	44
	Relating Perspective and Expertise	7%	17	3%	1	4%	18	5%	36
	Understanding a Different Perspective	1%	2	10%	3	6%	26	4%	31
	Understand a Different Perspective: what makes perspectives different	0%	1	10%	3	4%	16	3%	20
c	Openness to Learning	10%	24	21%	6	15%	66	14%	96
ce fle c tio	Openness to Learning: rec. of what has been learnt from others	3%	6	7%	2	5%	24	5%	32
Ľ	Openness to Learning: seeking opportunity to learn from others	70/	17	1.49/	4	99/	26	99/	57
	Perspective Taking	7 % 20 /	17	70/	4	8%	30	8%	57
	Perspective Taking	2 /0	4	1 70	2	0 %	37	0%	43
	from perspective of another	2%	4	7%	2	6%	29	5%	35
	Total Count	270	234	1 /0	29	0,0	448	070	711

This table depicts all the Codes (light blue highlight) and a selection of Key Subcodes found in this research. The table depicts the frequency that each code/subcode was found in each method as well as the proportion of all codes found in that method represented by a code/subcode. The final two columns indicate the total proportion and count of each code across methods.

Appendix 7: List of Codes and Subcodes presents a full list of the inductively and deductively determined LM codes found in this research. Table 2 presents a summary of the key codes and subcodes. Table 2 depicts the frequency with which each code and a selection of key subcodes were found in quotes from the Game Sessions, Post-Game Surveys, and Interviews. The table illustrates that there were substantially more instances of Identification than Reflection across the 3 methods (541 vs 170). Identification was relatively more prevalent in the Game Sessions than in the other methods. 87% of the codes applied to the Game Session transcripts were Identification-related compared to 71% of the Interview codes and 62% of the PGS codes. In

other words, Reflection was more important in the Interviews than in the Game Sessions in both relative and absolute terms.

Of the codes found in the Game Session transcripts, 78% referred to participants recognizing and defining their own perspective or expertise. That is, during the Game Session participants expressed their own understanding and knowledge far more frequently than they recognized, defined, or reflected on the perspective/expertise of others. This is particularly striking in the case of 'Rec. & Def. Others' and 'Understanding a Different Perspective' where there are only 5 and 2 instances, respectively, of these codes in the Game Sessions. In the Interviews, on the other hand, 48% of codes referred to participants recognizing and defining their own perspective/expertise and 19% to recognizing and defining the perspective/expertise of others. This indicates that participants recognized, defined, and understood other perspectives more in the Interviews than in the Game Sessions.

The most frequently found code across all methods was "Own Perspective" (271 instances) of which 155 cases of the subcode "Understanding of Mechanisms" were found. Interestingly, there are disproportionately more cases of this subcode being found in the Game Session than in any other method, despite there being 2.5 times more minutes of Interview recordings than Game Session recordings (346 vs 140 minutes, respectively).

3.2 Results of Game Sessions and Debriefing

Because the debriefing followed the Game Session, and in most cases was short, this section will explore the two together. Analysis of the Game Sessions revealed that Identification LM codes were most frequently found, specifically codes related to participants expressing their own expertise and perspectives (i.e., not recognizing that of other participants). There was limited evidence of Reflection taking place, and most instances thereof were participants expressing an Openness to Learning.

3.2.1 Identification

87% of the codes found in the Game Sessions were Identification LM subcodes, the vast majority of which came from participants recognizing and defining their own perspective, specifically in relation to their understanding of how specific game mechanisms worked. In terms of the Expertise element of the Identification LM, there is some evidence that the participants expressed their expertise – specifically their knowledge – to justify why they were advocating for certain positions. However, it seemed that the process of recognizing that their expertise was relevant to the game was an implicit process: participants did not explicitly outline what knowledge they had and how it was relevant, but rather applied their expertise as it was determined to be relevant to the game. Whilst participants demonstrated that they were willing to collaborate with each other and were generally open to hearing each other's thoughts, there is little evidence in the Game Session transcripts that participants went a step further to recognize, define or relate to the perspectives and expertise of others. Where participants did, it was to agree or disagree with an argument made by a co-participant.

3.2.1.1 Expertise: Knowledge

In the Game Sessions it was found that expertise was implicitly identified as being relevant and explicitly applied. To the former, this required that participants recognized the mechanisms on the Gaia (e.g., pollution, biodiversity loss, harvesting etc.) and defined them as being similar to Earth, or at least similar enough that their Earth-based knowledge was 'relevant'. Thus, all instances in which the subcode 'Expertise: knowledge' was found in the Game Session transcripts involved participants using subject-specific information/terminology to justify why they were making certain decisions.

At Game Session 1, for example, there were several instances of participants – MRF students and otherwise – using agricultural terminology to justify their decisions. For example, P13 and P15 discussed ideas of leaving land fallow, land sparing vs land sharing, and crop rotation which P16 explained to the facilitator. P13 also discussed how animal-based diets are more 'unsustainable' than plant-based diets in Quote 3.1 (Table 3) whilst P18 had insight into the relationship between pollution and climate change and the effects that this may have on harvesting:

"But I'm just thinking, like, if the pollution increases and the climate change effects go up, what if we have, like, one year where we're not able to harvest? Then do we want to leave more, like, 20% for livestock or two resources for livestock?" (P18, Game Session 1)

In Quote 3.2 from Game Session 3 (Table 3) participants were confused about why they were getting 2 units of pollution. P6 argued that it could be due to the amount harvested – drawing the

connection between harvesting practices and pollution output – whilst P4 argued that it was to do with the differential impacts of animal vs. plant-based diets.

In the examples illustrated above, participants applied their knowledge without expressly explaining why it was relevant or how this knowledge came to be. Thus, the way knowledge was coded in the Game Sessions was different to the way in which knowledge was recognized and defined in the Interviews where participants took a more reflective approach, and explicated *which* knowledge was relevant and useful and *how* it was used in the game.

3.2.1.2 Own Perspective

'Own Perspective: understanding of mechanisms' was the most used subcode in the Game Sessions (indeed, across all methodologies). Analysis of quotes coded with this subcode revealed that participants recognized and defined their own perspective in two main ways: either to simply explain how they understood an element or to go a step further and explain why they were supporting an action or. In all cases where this code was found, participants were making specific reference to elements or moments in the game, not in 'real life'.

In Quote 3.3 (Table 3) for example, P13 detailed the perspective they had on the activists: plots where the activists were standing were inaccessible, like how 'business as usual' work is blocked during some Extinction Rebellion protests. At Game Session 1, the City was not provided with 8 resources in the first round, so the facilitators placed a Sad Face on the board. In response to this, P7 expressed how they understood the meaning of the Sad Face as follows:

"Now the city will die, right, because we don't have any of... Yeah, the city is starving guys." (P7, Game Session 3)

In the examples listed above, participants had not yet decided to take an action – they were still considering how to proceed but were still using the discussion period between rounds to share their perspectives. In the following examples, participants expressed their perspective to support an action such as P13 in Game Session 1 (Quote 3.4, Table 3) or P1 in Game Session 3 who stated:

"So, I don't know what you guys are thinking, but I think it would be also interesting just to try it out, to place one on one of the fields where the protesters are on, to just like see what happens. So maybe also one where a lot of resources are in this one. So, I'll just place this one there and then do nothing more." (P1, Game Session 3)

In both instances, the participants stated both what they wanted to do, and why they believed this action was important. P13 decided to harvest because they identified that this was necessary for their group to be able to provide the City with 8 resources (their Session's goal). P1 justified their decision to place their explorer on a plot also inhabited by an activist by explaining their perspective on learning more about the activists. Thus, the participants used their perspectives to explain why they were taking a decision (see also Quote 3.5, Table 3).

Relatedly, it was also found that participants explicated their perspective on the mechanisms to convince other participants to adopt a particular strategy. For example, at Game Session 3, P1 tried to convince the other participants that they needed to invest in a mix of feed and food (the strategy) as insurance against a winter period in which they may not be able to grow:

P1: And I would be a bit concerned to put everything in food in terms of that we don't know the weather or whatever. So, I don't know, maybe it's also winter at some point. And then we need like...

P4: Yeah, but we can store our food. We don't need to have animals.

P5: I mean we do inter-galaxy travel. I mean, we can store it, you know? I hope so.

P1: Maybe it's just like safe to say we use, I don't know, like six for food and two for feed or even like seven to one or something. So, I have like a bit of security in that.

(P1, P4, P5, Game Session 3)

P4 and P5, however remained unconvinced of P1's reasoning by counterarguing with their understanding that the explorers would be able to store food. This example illustrated how – whether successful or not – participants used their perspectives to convey what they felt the group needed to do.

Table 3 Selected Examples of Identification in Game Sessions

Code	Sub-code	Participant(s)	Quote	Additional Code: Sub-code
Expertise	Knowledge	P13	(3.1) "I think personally that we have to feed less to	Own Perspective: Understanding of
		(Game Session	the animals because animal proteins are normally	mechanisms
		1)	quite unsustainable"	
		P1, P2, P4, P5,	(3.2) P3: But look at that, we're getting two pollution.	
		P6	Even though we didn't do any animal feed.	
		(Game Session	P5: So, we can do one feed next time If we get	
		3)	two But maybe isn't it	
			P6: I think about the amount of how much we	
			harvest. Rather than	
			P1: Maybe it's also about	
			P4: No but the feed should be worse than food.	
Own	Understanding	P15, P13	(3.3) P15: But these, I think these we cannot use	Openness to Learning: Seeking
Perspective	of mechanisms	(Game Session	because of the activists, right? Where the activists	opportunities to learn from others
		1)	are, you cannot use, right?	
			P13: They're blocking it. I'm seeing it as like	
			Extinction Rebellion.	
		P13	(3.4) "Because first I thought of leaving one resource	
		(Game Session	on each plot for some reason but then we won't	
		1)	reach eight so I think I'll just harvest everything I	
			can."	
		P9	(3.5) "He said eight harvest, so this is already too	
		(Game Session	much for my reasoning. So, I'm going to put both of	
		2)	mine here."	

This table depicts selected examples of Identification found in the Game Sessions. "Code" refers to the element of the BC LM operationalization the Quote applies to. "Sub-code" refers to the specific part of the operationalization the quote applies to. "Participant(s)" refers to which participant(s) from which Game Session was quoted. "Quote" refers to the example of the BC LM exhibited by the participant, preceded by the reference number. "Additional Code: Sub-code" refers to any other codes found in relation to the quote.

3.2.2 Reflection

There is limited evidence of Reflection taking place during the Game Session, both quantitatively and qualitatively, but when it did take place, it tended to be in the form of participants expressing openness to learning. There were 4 instances of Perspective Taking which took the form of participants demonstrating that they understood why participants took particular actions.

3.2.2.1 Openness to Learning

24 instances of Openness to Learning were found across the Game Sessions, most of which were students explicitly asking questions to either gain insight into how other participants understood a particular mechanism or into how other participants wanted to approach exploration. Importantly, the quotes included in the section cannot be interpreted as 'Openness to Learning' without understanding the wider context in which they were expressed.

To the former, participants saw learning how the game mechanisms functioned as a collaborative process, where their understanding of the game developed not just after each round when the consequences of their actions were revealed but also through learning from what the other participants understood or thought about an action (see Quote 4.1, Table 4). For example, when trying to establish a plan on where to place explorers, P1 made a proposal and asked the others what they think:

P1: Or we occupy the other three fields and harvest them empty because like why not?

P4: But then people will be everywhere.
P3: And animals will not have anywhere to go.
P1: But they can also eat from the activists, right?
P4: No.
P5: No.

P4: They also count like as humans.

Here, P1 continued to seek out the other participants' understanding by asking follow-up questions.

To the latter, participants attempted to understand how the other participants were approaching the game so that they could adjust their own actions. This was evident in Game Session 3, for example, in the last round. In this round where the participants had opposing understandings of City Happiness, P2 and P3 were aligned in wanting to provide at least 8 resources for the city. Because P1, P4, and P5 chose not to harvest in the last round, P2 and P3 needed to align on how to reach their collective goal. Throughout the discussions in this last round, there are several instances of P2 and P3 trying to learn what the other was going to do such that they could align:

P3: So, are you planning to harvest anything like from both plots or...?

P2: Yeah, I was thinking I'd harvest

P3: One from each?

P2: At least one from each, yeah.

(P2 and P3, Game Sessions)

Here, the participants were not per se trying to learn content knowledge from each other, but to get a better understanding of how they planned on acting in the round demonstrating that in the context of this game, 'learning' also needed to be defined in relation to strategy.

3.2.2.2 Perspective Taking

Of the 4 instances of Perspective Taking, 3 took place during the game and 1 during the debriefing. In all cases, the participants demonstrated how they understood what another participant's perspective was and then outlined how this aligned with their actions. For example, during the debriefing at Game Session 3 P6 (Quote 4.2, Table 4) expressed that they did not understand the City Happiness mechanism in the same way as some of the other participants. To P6, the city did not 'die' if it did not receive all 8 resources. However, they also expressed an understanding of why those who believed it would die found it so important to harvest more to ensure that the city was happy. This illustrated that P6 could recognize the reasoning of the other participants – even if it contradicted their own – and explain how this shaped their actions.

Table 4 Selected Examples of Reflection in Game Sessions

Code	Sub-code	Participant(s)	Quote	Additional Code: Sub-code
Openness to	Seeking	P7, P8, P12	(4.1) P7: And for what do we need feed again? What is the	
Learning from	opportunity	(Game Session	feed for?	
Others	to learn from	2)	P8: For animals.	
	others		P7: But why do we need that?	
			P10: Maybe for the meat to like, you know, for the cows.	
Perspective	Actions from	P6	(4.2) "But it was also a bit of context, because we did not	Expertise: Knowledge
Taking	perspective	(Game Session	really agree or understand what implications were like. I	
	of another	3)	didn't think of people dying, or like either, but then it makes	Openness to Learning: Rec. of what
			sense that that could be, and then if someone else is	has been learnt from others
			thinking of that, they will make a certain decision."	

This table depicts selected examples of Reflection found in the Game Session. "Code" refers to the element of the BC LM operationalization the Quote applies to. "Sub-code" refers to the specific part of the operationalization the quote applies to. "Participant(s)" refers to which participant(s) from which Game Session was quoted. "Quote" refers to the example of the BC LM exhibited by the participant, preceded by the reference number. "Additional Code: Sub-code" refers to any other codes found in relation to the quote.

3.3 Results of Post-Game Survey

3.3.1 Identification in the Post-Game Survey

There was some evidence of Identification in the Post-Game Survey, particularly in relation to participants recognizing and defining their own perspective (Table 5). Of the 18 Identification subcodes found the 10 quotes, 10 fell under the code "Own Perspective." Quote 5.1 (Table 5) for instance demonstrated that the participant – an MRF student – applied their knowledge on crop rotation to the game but also acknowledged that they were missing recognition of relevant information on corridors. In Quote 5.2 (Table 5) P3 referred to the disagreement at Game Session 3 about whether failing to provide the city with 8 resources would result simply in unhappiness or in the death of the city. Here, they explained their understanding of the mechanism and at the same time demonstrated how they understood the other participants' perspectives.

3.3.2 Reflection in the Post-Game Survey

Table 2 illustrates that there was some evidence of all three elements of the Reflection LM in the Post-Game Survey responses, with the majority (6/11 codes on 9 quotations) of the Reflection codes related to "Openness to Learning from Different Perspectives." Here, participants indicated that including multiple views matters (Quote 5.4, Table 5) and is valuable to the learning process (Quote 5.3, Table 5). Quote 5.5 (Table 5) illustrated that through participating in the serious game P14 – an MUE student with a background in architecture – was able to learn about crop conservation and how to set up a serious game. This demonstrated that the Post-Game Survey gave P14 the space to not only recognize what they learnt from their peers at Game Session 1 but also what they learnt about the methods used in the Game Play setting.

Table E Salastad E	vomplog of Identification	and Dofloation in t	ha Doot Cama Survava
Table 5 Selected E	<i>xamples of identification</i>		le Fusi Gaine Suivevs

Code	Sub-code	Participant	Quote	Additional Code: Sub-code
Recognition	Understanding	P13	(5.1) "I focused instantly on crop rotation, while I	Rec. Def. Missing
and	of mechanisms	(Game	never thought of corridors."	Expertise: Knowledge
Definition of		Session 1)		
One's Own		P3	(5.2) "It is important to discuss values beforehand	Own Perspective: Values
Perspective		(Game	and also if we are on the same ground regarding how	
		Session 3)	we understand the different mechanics. E.g. I thought that the city will die without food, while other participants thought that the people are just 'unhappy'."	Rec. Def. Other's Perspective/Expertise: Understanding of mechanisms
Openness to	Seeking	P1	(5.3) "There is always something to learn from the	
Learning from	opportunity to	(Game	views of others."	
Different	learn from	Session 3)		
Perspectives	others	P8	(5.4) "All views, all stakeholders' participation	
		(Game	matters"	
		Session 2)		
	Recognition of	P14	(5.5) "I learned some new insights on crop	
	what has been	(Game	conservation and how to [set] up a serious game."	
	learnt from	Session 1)		
	others			

This table depicts selected examples of both Identification and Reflection found in Post-Game Surveys. "Code" refers to the element of the BC LM operationalization the Quote applies to. "Sub-code" refers to the specific part of the operationalization the quote applies to. "Participant" refers to which participant from which Game Session was quoted. "Quote" refers to the example of the BC LM exhibited by the participant, preceded by the reference number used in the text. "Additional Code: Sub-code" refers to any other codes found in relation to the quote.

3.4 Results of Post-Game Debrief with Facilitators

The Post-Game Debriefing demonstrated that facilitators also experienced and could explain boundaries, both between themselves and the game and between each other. There was evidence of both Identification and Reflection, specifically in relation to recognizing and understanding the perspective of others.

3.4.1 <u>Results on Boundaries</u>

The 3 facilitators who participated in the Post-Game Debrief discussed experiencing challenges in the 'new' role they had to fulfil as well as between themselves and other facilitators. Their role in the game itself rather than (the relationship/an interaction with) another individual served as the source of tension because it put facilitators in a 'system' that functioned differently – and in which they had to function differently – than what they were used to. F6, for example, felt that facilitating posed a challenge resulting from not knowing exactly how to keep from revealing too much information to the participants:

"... it was hard for me to not give too much information. Being in like the position of power where I know everything and they're like, 'I wonder how this works' and I was just kind of like... 'uhhh'." (F6, Post-Game Debrief with Facilitators)

To the latter, the debriefing revealed that facilitators experienced and could explicate boundaries between themselves. In the following exchange F1 expressed disagreement with the way that F2 led the debriefing at their table:

F1: ... And that's like, for me, the opposite for me of what a scientist should do. Like you should... like as a social scientist you always go with zero bias and like say 'duhbuhbuhbuh... This is the question' and then...For me that was like 'no, no, no, don't tell them! Don't tell them! Like, let, let it come from them!' Like, I was, in that point I was also tense.

F2: That probably that comes from... this is like my third or fourth experience being like a facilitator/mentor/leader in any sort of student thing, and I guess, unfortunately, I'm just used to asking people questions and then getting back like silence. And having to be like "okay, you need a little nudge, let's go!" But, no, yeah ideally silence is best.

F1: No, no, no... I'm just yeah...It's not that this is right or wrong. I was just tense at that point. I'm not saying that you did it correctly or incorrectly or anything... For me it was a bit tense because I have a different approach.

This exchange illustrated several elements related to boundary crossing. First, the game setting enabled a difference like this between facilitators to be experienced: F1 recognized their own perspective on how debriefings should be conducted related this how F2 was conducting the debriefing (Identification). Second, the debriefing setting gave F1 the space in which to express that they experienced this difference and for the two parties to understand how and why they acted in the way they did/have the perspectives they have (Reflection). For F2, their facilitation style was attributed to their experience in a similar role and being in a position where participants need to be prompted to answer questions (Identification). Third, F2 recognized the perspective (Reflection) of F1 – "ideally silence is best" (F2, Post-Game Debrief with Facilitators).

3.4.2 Results on Recognizing and Taking the Perspective of Others

The debriefing revealed evidence of facilitators being able to recognize and take the perspective of the participants, particularly in relation to how the participants understood the mechanisms of the game and why they made the decisions they made. Selected examples are displayed in Table 6.

Code	Sub-code	Facilitator	Quote	Additional Code: Sub-code
Rec. & Def.	Understanding	F1	(6.1) "The difference was they thought they were collaborating	Perspective Taking: Actions
Other's	of mechanisms	(Game	with the activists. When the activists came, they thought, 'oh,	from perspective of another
Perspective/		Session 1)	let's go where the activist goes.'"	
Expertise				
Perspective	Actions from	F1	(6.2) "I saw all of them collaborating in terms of strategy, trying	Rec. &. Def. Other's
Taking	perspective of	(Game	to save the animals. And they were all trying to reduce pollution,	Perspective/Expertise:
	another	Session 1)	they were all trying The only thing was city happiness, the two	Understanding of
			people had a different strategy."	mechanisms
		F6	(6.3) "So, two people didn't harvest, and then two people ended	
		(Game	up harvesting. But I thought it was, again, it's the different ways	
		Session 3)	that they interpret it. And again they're values. 'Why do you	
			want to have the city happy, but no animals?'"	

Table 6 Selected Examples of Identification and Reflection Debrief with Facilitators

This table depicts selected examples of both Identification and Reflection found in the debrief with facilitators. "Code" refers to the element of the BC LM operationalization the Quote applies to. "Sub-code" refers to the specific part of the operationalization the quote applies to. "Facilitator" refers to which facilitator from which Game Session was quoted. "Quote" refers to the example of the BC LM exhibited by the facilitator, preceded by the reference number used in the text. "Additional Code: Sub-code" refers to any other codes found in relation to the quote.
Most of the Identification and Reflection codes found in the Post-Game Debriefing were either subcodes of "Recognizing and Defining Other's Perspective/Expertise" or of "Perspective Taking", as is reflected in the quotes 6.1-6.3 in Table 6. Here, facilitators discuss (their perspective on) participants' perspectives on how different mechanisms worked (e.g., the impact of the activist, harvesting) as well as their strategy. Interestingly, in almost all coded instances of F2 and F6 talking about the participants' decisions/discussions they adopted the first-person 'voice' of the participants to illustrate (their understanding) of the participants' perspectives. This is illustrated in Quote 6.3 (Table 6), for example, where F6 embodies the (perceived) perspectives of P4 and P5 in asking "Why do you want to have the city happy, but no animals?" or in the quote from F6 about P18's risk preferences:

"She was kind of like 'I wish I went more extreme. Like I wish I went both like full sides of each spectrum.'" (F6, Post-Game Debrief with Facilitators)

Consequently, there was overlap (11 instances of overlap in 20 quotations) between recognizing and taking the perspective of others. Facilitators 'became' the participants to illustrate how they understood participants' actions, indicating that understanding (Identification) and taking on (Reflection) a perspective may be interconnected.

3.5 Results of Participant Interviews

The participant Interviews provided a richer understanding of what happened during the Game Session and demonstrated a broader range of both Identification and Reflection.

3.5.1 Boundaries

Though the explication of boundaries was not per se investigated in this thesis, it is useful to have an overview of which boundaries were stimulated by Gaia Explorers (see also Section 1.3). In the 12 Participant Interviews, there were 53 Boundary codes found in 47 quotes. As summarized in Table 7, 20 related to participants identifying a difference in understanding and 19 to participants identifying that they approached the game differently to another participant.

Table 7 Number of Times Boundary Codes were Found in Participant Interviews

Boundary Code	Count
Boundary: 'no' disagreement	8
Boundary: difference in approach	19
Boundary: difference in understanding	20
Boundary: unaddressed difference	6
Total	53

This table illustrates the number of times boundary codes were applied to Participant Interviews. Column 1 depicts the boundary code found, and column 2 depicts the frequency that the boundary was found in the Interviews.

Participants who discussed having a difference in understanding most often referred to instances where they understood the game's mechanisms or elements differently to their co-participants. Often, participants from the same table independently brought up the same differences. All the Interviewees from Game Session 3 (n=3), for example, highlighted the difference in understanding about the City Happiness mechanism. P1, for instance, attributed this to the way in which participants understood the game's timescale:

"So, I thought ... like the whole thing is one year... And then when someone else was like 'no, that's like years, like each year and if we like don't give them enough food a year, then they will die,' you know? And it was like this contentious (sic) about like will they die, or will they just be unhappy?" (P1, P1 Participant Interview)

Even though Game Session 1 spent over two minutes in the last round alone and more in the debriefing discussing this, the participant Interviews revealed that they also did not have a unified understanding about what happened. In the quote above, P1 understood the debate to be about timescale. P2, however, understood the debate to be about whether participants were willing to prioritize biodiversity over humans:

"And some of us were like, 'oh, what if we make the city unhappy and just try to preserve the biodiversity?' And then the rest of the team was like, 'no, we want to make the city happy'. And they just made their own decisions." (P2, P2 Participant Interview)

This illustrated that even though participants may have recognized the same instance of a difference in understanding, they did not necessarily agree on what they (mis-)understood or why.

3.5.2 Identification

As outlined in Table 2, Identification-related codes represented 71% of the BC codes found in Interview transcripts. These results were driven by Identification of 'Own Perspective', 'Expertise', and 'Rec. & Def. Others' and revealed that participants identified that pre-existing knowledge shaped the way they played the game and that participants identified how others understood the game almost as frequently as they understood it themselves. Table 8 presents a selection of quotes coded with Identification subcodes from the Post-Game Interviews.

3.5.2.1 Recognition and Definition of One's Own Perspective

The Interviews allowed all participants to recognize and define their perspectives and indeed, this code was the most frequently found BC code in the Interviews. Analysis of these instances revealed that participants tended to recognize their perspective in two ways: 1) in relation to their understanding of a specific mechanism (e.g., pollution, biodiversity loss, etc.) or 2) in relation to how they explored the workings of the mechanisms in the game.

To the first, as depicted in Table 2, 'Own Perspective: understanding of mechanisms' was the most frequently found subcode of the 'Own Perspective' subcodes. These were instances where participants highlighted specific examples of how they understood a game element to work. This was illustrated by the following quote from P2 where they explain their understanding of the City Happiness Mechanism and how it affected how they interacted with their teammates:

"I was trying to convince people that that's what that would mean. Like that people would die if they didn't have the resources." (P2, P2 Participant Interview)

To the second, participants had no knowledge of how the mechanisms worked before starting to play the game so alongside 'having to' meet the requirements of the city they needed to determine how the different mechanisms worked. For most of the participants, this prompted Identification of how much 'risk' they were willing to take, or how 'extreme' they were willing to go in experimentation. Like P18 in Quote 8.1 (Table 8), P14 was in favor of a riskier approach:

"I think we should, in that game and in general in games like these, we should take a more extreme position while we were more balancing our choice." (P14, P14 Participant Interview)

The game also created an environment in which participants could explore without real world consequences. P1, for example, identified that the game setting allowed them to suspend their 'real-life' risk aversion and be a little bit more experimental than usual:

"...I was much more like explorative in the game. Just like, 'yeah, let's do that!' ... And I think that's like something I wouldn't do in a real life, and I was also very cautious in real life you know like not take risks and stuff like that, so it was also interesting to like see this difference." (P1, P1 Participant Interview)

Table 8 Selected Examples of Identification in Post-Game Interviews

Code	Sub-code	Participant	Quote	Additional Code: Sub-code
Rec. Def.	Risk	P18	(8.1) "I thought "oh let's just have fun and let's just be maybe crazy, try to, to have	Boundary: difference in approach
Own	Preference	(Game	crazy solutions or experiment a little bit with like the maximum minimal outcome	
Perspective		Session 1)	that you can have". But then when I noticed that people were trying to approach it	Expertise: attitudes
			in the "let's find a solution and let's save it and not have fun for ourselves but have,	Rec. & Def. Perspective and Expertise
			a have the best outcome possible" then I thought "okay so I think if this is a	of Others: Risk preferences
			collaborative game so let's, let's have one strategy" And that yeah that changed the	
			way I approached it later."	
Rec. Def.	Knowledge	P13	(8.2) "I got really hung up on what I knew from my studies I'm doing resilient	
Own		(Game	farming. I got super focused on rotation of cropping schemes and leaving land	
Expertise		Session 1)	fallow vs. putting crops on the land and it was this whole theory that I had in mind."	
	Skills	P14	(8.3) "Yeah, I mean as considering now myself maybe as a planner maintaining a	
		(Game	quiet approach it's something that I can relate with like planners and like try to	
		Session 1)	balance the decisions within certain solutions, situations."	
Rec. Def.	Rec. Def.	P16	(8.4) "I think if there would have been someone who is specifically a specialist in	
Expertise	Missing	(Game	animal sciences or something like that, maybe they would have caught this point	
One Still		Session 1)	because they might be dealing with green corridors more than we do this also has	
Requires			always made me think that when we plan cities and regions ecologists are not	
			there, I think, unless it's a plan for the nature conservation or something."	
Rec. Def.	Understan	P2	(8.5) "I you think people are going to die because you don't harvest, you're like,	Perspective Taking: actions from the
Perspective	ding of	(Game	'well, that's the top priority for me then.' Yeah. But otherwise, you're like, 'well, they	perspective of another
& Expertise	Mecha-	Session 3)	can be a little unhappy.' And that's fine. So, we won't harvest as much."	Understand a Different Perspective:
of Others	nisms			how does a difference arise

This table depicts selected examples of Identification found in the Post-Game Interviews. "Code" refers to the element of the BC LM operationalization the Quote applies to. "Sub-code" refers to the specific part of the operationalization the quote applies to. "Participant" refers to which participant from which Game Session was quoted. "Quote" refers to the example of the BC LM exhibited by the participant, preceded by the reference number. "Additional Code: Sub-code" refers to any other codes found in relation to the quote.

3.5.2.2 Recognition and Definition of One's Own Expertise

All participants recognized and defined their expertise in relation to the game in the Interviews. Results on two sub-codes – Knowledge and Skills – are discussed below.

3.5.2.2.1 Knowledge

'Knowledge' was the most frequently found a sub-code in all 12 participant Interviews (72% of 'Expertise' subcodes were 'Expertise: knowledge'). Participants recognized how their knowledge (typically from their studies) affected their gameplay in a wide range of situations including shaping their priorities and how much they could apply their 'Earth-knowledge' to the planet.

First, a key finding from the Interviews was that participants explained why they prioritized certain elements – particularly in relation to Biodiversity and City Happiness – over others through their academic background. P16 – an MUE student with a background in architecture and urban planning – for instance argued:

"I come from a comparatively social sciences background... So, when I was playing the game, most of my thinking was based [on] the people side." (P16, P16 Participant Interview)

This quote demonstrated that having a social sciences background primed P16 to focus on the more human-related elements of the game, but also highlighted how P16 was able to relate their own expertise to that of other participants (specifically, identifying the distinction between their fields of expertise).

Second, "you work with what you know" (P13 Participant Interview). All participants (except P16 [P16 Participant Interview] who proposed to their Game Session that Gaia could represent a "utopian world" where anything was possible) when asked how they approached Gaia stated that if not already by the beginning, then at least by the end of the game they were playing with the assumption that Gaia's systems mimicked Earth's with varying results. In Quote 8.2 (Table 8) P13 identified how their background in resilient farming led them to focus on two (Earthly) farming practices, assuming the mechanisms of Gaia mirrored those on Earth. Because they were so sure that these practices were the same on Gaia, they applied them throughout the game only to find out by the end that they were "completely on the wrong track" (P13, P13 Participant Interview). Similarly, P17's background in land use planning did not help them uncover the Biodiversity Corridor mechanism, much to their disappointment:

"I overlooked the biodiversity, the path, because it's so simple and I was honestly a bit disappointed in myself that I didn't notice it, because that's half my bachelor's right there." (P17, P17 Participant Interview)

In the case of P13, their Earth knowledge did not end up being 'helpful' for discovering how Gaia worked in part because their "tunnel vision" (P13, P13 Post Game Survey) prevented them from exploring other possibilities. On the other hand, P17's Earth knowledge may have been helpful if only the game had triggered them to think about it.

3.5.2.2.2 Skills

There are only 3 instances where the code 'Expertise: skills' was found, suggesting that this subelement of Identification was not important in the Interviews. However, the instances in which it was found stood out because they were so similar. Two participants recognized and defined how their skills – specifically, their training as (urban) planners shaped the way they approached collaboration during the game. Both participants mentioned that mediating and engaging with different perspectives are essential skills for planners. In Quote 8.3 (Table 8), P14 argued that their training as a planner explained why they prioritized finding a middle-ground in perspectives. This was substantiated by P17 who was initially surprised to conclude that their background did, in fact, shape the way they played the game:

"I think at least academic background ... it could have played a bigger role, it should have played a bigger role because then I probably figured it out much sooner, but no. Yeah, I just try to see the way of thought of others: 'okay, you go that direction, you want to go that direction. Okay, how can we meet in the middle?' Well, now that I think about it, it's also quite a big part of being a planner, is just to mediate. So, yeah, in that sense, I think it did play a role." (P17, P17 Participant Interview)

This quote is interesting as it illustrated how prompting a participant to think about their background revealed to them something they had not thought about before.

3.5.2.3 Recognition and Definition of the Expertise One Still Requires

Across the methods, the Interview was the most common pathway through which participants were able to identify the expertise that they were missing to understand the mechanisms and to define what they would have needed. For instance, in Quote 8.4 (Table 8), P16 argued that neither they nor their co-participants had the expertise deemed to be missing. This quote was also interesting because it demonstrated that P16 could relate the expertise missing in the game setting to the expertise missing in their professional life as well: ecologists are also (usually) missing from urban planning discussions.

Some participants also highlighted that it was not only expertise that was missing, but also perspectives. For example, P2 raised the point that perspectives outside of the 'Wageningen Bubble' – typically left-leaning, educated, and sustainability-minded – were missing from all tables. Here, they argued that the perspectives people held that their table – particularly in relation to what they wanted to prioritize – were very similar and if the game was played in a different context the outcomes may have been different:

"Like, uh, maybe if you played it, um, outside of Wageningen it, you would have people who had different priorities, but in Wageningen, it's like, you know, we're kind of like-minded, I think. Uh, yeah, I, I think we're... on the same page." (P2, Participant Interview)

To P18, even perspectives from their own Game Session were missing:

"I think they had other perspectives to bring to the table that I would have loved to listen to. But we didn't have the time for that also with the decision making." (P18, P18 Participant Interview)

This quote illustrated that it was not just the participants who were invited to participate that shaped the kinds, depths, and quantities of perspectives that were shared but also more practical elements about how long participants had to complete the game that dis-/enabled different voices.

3.5.2.4 Recognition and Definition of the Perspective and Expertise of Others

There was also strong evidence of participants being able to recognize and define the perspective and expertise of other participants during the Interview (27% of Identification codes were 'Rec. & Def. Others' subcodes). Indeed, participants recognized and defined how other participants understood the mechanisms (36 instances) almost as frequently as they recognized and defined their own understanding (38 instances). Two key findings are discussed below: first, although analysis of the Game Sessions revealed almost no evidence of participants directly recognizing the expertise of others, the Interviews demonstrated that the expertise of others played an important role in how participants approached the game; second, there is an overlap between this element of the Identification LM and the element 'Perspective Taking' of the Reflection LM.

First, whilst analysis of the Game Sessions yielded no discrete instances of participants recognizing and defining the expertise of others, the Interviews revealed that participants were very aware of each other's expertise and that this shaped whose ideas they listened to, and which participants 'directed' the way the game was played. For example, at Game Session 1, P18's argued that they and the other non-MRF students listened to the P13 and P15 because they sounded credible, convincing, and had a background that was perceived to give them expertise in the game's subject matter:

"I think we mainly listened to people who have like a more agriculture background ... we're like 'oh this sounds smart. Why not? Let's do that.' Also, because ... the people with an agricultural background seemed the most convincing ones." (P18, P18 Participant Interview)

Indeed, P14 agreed (see also the quote from P16 below):

"They were from, ah, farming ecology, yeah. And they mentioned this, and they were so convincing... so [we] thought, okay, 'they know what they're saying, so let's follow them." (P14, P14 Participant Interview)

From P13's perspective, the non-MRF participants went along with what P13 and P15 argued for because the two were confident about the relationship between the game and what they knew from their degrees:

"We were kind of sharing what we knew from our studies and the rest of the group kind of took it from us because they were like, "oh, they know what they're saying...it was just funny to see that kind of dynamic of people following when you say something in a determined way." (P13, P13 Participant Interview)

Thus, there is a disconnect between what was found during the Game Sessions and what participants reported during the Interviews.

Second, of the 85 instances of 'Rec. & Def. Others' identified in the analysis, 15 were also coded with a 'Perspective Taking' subcode. The Interviews thus demonstrated that recognizing and defining the perspective/expertise of other participants was an important first step for participants to be able to further explain why their co-participants took particular actions or had particular priorities. In terms of perspective, for example, P2 identified in Quote 8.5 (Table 8) the two understandings of the City Happiness mechanism at their table and explained how holding these two views determined the resulting action: participants who felt that the City would die

without all 8 resources harvested more to compensate for those who felt the City would simply be unhappy and thus did not harvest in the last round of the game. Likewise with expertise, Interview participants defined instances where the background of others shaped the way they approached the game (see also Section 3.5.2.1). P11 (P11 Participant Interview), for example, argued "there's a girl, I think she's doing environmental science, I'm not sure, but I'm not sure, but yeah she concerns the forest a lot" ("forest" here referred to the biodiversity corridors).

There were also instances where participants recognized and defined the perspective of others without necessarily extending this Perspective Taking. For example, P16 argued:

"There were insights from others who were from the land, I mean, the nature side, the forest and conservation people. There were some people who were talking from the animal side... they knew the specifics of what is needed for an animal or what is needed for nature to thrive." (P16, P16 Participant Interview)

Here, P16 identified the perspective of participants at their table ('the animal side') and defined what this brought to the game (knowledge about what was necessary for the animals/nature to 'thrive'), without going the step further to take on this perspective. Thus, whilst recognizing and defining other's perspective/expertise often took place in the context of taking on that perspective, it was not always sufficient for Perspective Taking to occur.

3.5.3 Reflection

As outlined in Table 2, the majority of Reflection-related codes were found in quotes from the participant Interviews. These results were largely driven by instances of 'Openness to Learning,' but as the results discussed in this chapter highlight, the comparatively (to Identification) low frequency of Reflection codes found masked the depth of Reflection demonstrated by participants. Instead, the results highlighted that the Interviews provided ample opportunity for the participants to demonstrate the Reflection LM, but also that there is a strong overlap between Identification and Reflection (see also Section 3.5.2.4).

3.5.3.1 Ability to Understand a Different Perspective

Quantitatively it seemed that there was (relatively) limited evidence that participants understood what made perspectives different and how these differences arose (only 26 instances), however a deeper look into the quotes revealed that participants demonstrated strong understanding of each other's perspectives and that in part, this was facilitated by Identification of other participants' perspective and expertise.

One way in which participants reflected on what made perspectives different was through discussing differences in narratives about the game elements. To do so, participants referred to how they understood specific game elements and the narratives they constructed around them and compared this to the understanding and narratives of the other participants. For example, in Quote 9.1 (Table 9) P1 argued that differences arose in the narrative participants constructed around the explorer tokens and the fields. Here, P1 explicated what differed between the perspectives by comparing that of others to their own understanding – indeed the quote was also coded with the Identification subcode 'Relating Perspective and Expertise' – highlighting an overlap between Reflection and Identification.

The overlap between Reflection and Identification arose again in the case of participants explaining how their backgrounds shaped how their differences came to be. At Game Session 1, for instance, P16 mentioned that it may be important to send all explorers to the fields each round to ensure that they are fairly represented. In their Interview, P13 (Quote 9.2, Table 9) stated that this was not a perspective that they shared and recognized and defined P16's social science background – particularly in stakeholder engagement – as an important driver behind P16 wanting to move all the explorers to the field. Thus, P13 argued their difference in perspective arose because of (what they identified to be) P16's background. Likewise, P14 noted that the differences in priorities in their Game Session were due to differences in each other's backgrounds: those with a more agricultural education were focused on "fields and crop rotation" whilst the environmental planners at the table were "thinking more about like air pollution production" (P14, P14 Participant Interview). Here, P14 explained how the difference in background and defining how these backgrounds shaped priorities.

Table 9 Selected Examples of Reflection in Post-Game Interviews

Code	Sub-code	Participant	Quote	Additional Code: Sub-code
Understanding	What makes a	P1	(9.1) "I had in mind, it was just like people that were	Openness to Learning: Rec. of what has been
a Different	perspective	(Game	occupying the field, and we can't use them anymore. Then	learnt from others
Perspective	different	Session 3)	someone else: 'oh, I thought they were just like farmers, they	Relating Perspectives & Expertise: Differ
			were harvesting," and I thought "interesting' I didn't even	Rec. & Def. Other's Perspective/Expertise:
			[think] about it and it's just like something that's I think	Understanding of mechanism
			inspiring how you can look differently at the same thing."	
	How does a	P13	(9.2) "She was talking about the people all the time, and	Perspective Taking: Actions from perspective of
	difference	(Game	about whether all people should be in, and on the one hand	another
	arise	Session 1)	it could just be small things you think while you're playing a	Rec. & Def. Other's Perspective/Expertise:
			game. But it could also of course be because you're saying,	Knowledge
			'I'm from a bit more of a social backgroundI thought was	Rec. & Def. Other's Perspective/Expertise:
			interesting. Because I didn't think of it, and then when she	Understanding of mechanism
			said it, I was like, 'oh yeah, actually maybe.'"	
Openness to	Recognition	P14	(9.3) "I think the relationship within and but also like	
Learning from	of what has	(Game	knowledges in terms of like crop rotation, that's something	
Others	been learnt	Session 1)	that doesn't come first in my mind when I start like playing	
	from others		that game."	
	Seeking	P1	(9.4) "You have these different viewpoints on the same thing,	
	opportunity to	(Game	and I think that also means that you will always only see like	
	learn from	Session 3)	a bit of a fraction right from the reality and someone else	
	others		sees a different fraction and if you bring them together,	
			sometimes they are of course also [contesting] but like	
			sometimes together they build something new."	

This table depicts selected examples of Reflection found in the Post-Game Interviews. "Code" refers to the element of the BC LM operationalization the Quote applies to. "Sub-code" refers to the specific part of the operationalization the quote applies to. "Participant" refers to which participant from which Game Session was quoted. "Quote" refers to the example of the BC LM exhibited by the participant, preceded by the reference number. "Additional Code: Sub-code" refers to any other codes found in relation to the quote.

3.5.3.2 Openness to Learning from Different Perspectives

Most instances of Reflection in this thesis came from participants expressing an openness to learning from different perspectives. Table 2 indicates that this was driven by participants recognizing what they learnt from each other and seeking opportunities to learn from each other. Analyzing the qualitative results yielded two key findings: first, 'learning' was for the most part game-specific: participants largely reflected on how they learnt more the game's mechanisms through interacting with the other participants without necessarily connecting this to the world beyond the game. Second, whilst in the Interview participants could not *actively* seek opportunities to learn from others, they did express willingness to hear from other perspectives.

3.5.3.2.1 Recognition of What Has Been Learnt From Others

Much like with recognizing and defining perspectives, what participants learnt from each other was predominantly game-specific: participants recognized what others had taught them about the game mechanisms.

Some participants recognized learning by indicating what did not come 'naturally' to them. For example, in Game Session 1, the MRF students brought up the idea of land sharing vs land sparing which was new to the other participants at the table. P15 argued that a land sparing approach or trying to harvest a lot from only a few plots would be best, whilst P13 argued that the group needed to consider harvesting fewer resources from each plot so as not to deplete the land. P16 referred to these concepts in their Interview two weeks after the Game Session and contextualized them within in the game:

"... somebody from the agriculture or the land and forest, something ecological background... They suggested how now not to crowd something on one plot, because the resources are limited. It can't really suffice everyone on that one plot. So then that's, that became like our shaping point for nicely distributing the explorers into different... different plots and not overcrowd just one plot. That wouldn't have very naturally come to me." (P16, P16 Participant Interview)

In this quote, P16 demonstrated what they had understood from the debate between the MRF students and could still apply these concepts to a situation from the game. They also recognized that this was something that didn't come naturally to them, indicating that it was learnt during the Game Session. This notion was repeated in Quote 9.3 (Table 9) where P14 reflected on how the idea of 'crop rotation' was unfamiliar to them. Again, the MRF students explained this idea to the group because not everyone understood how it worked or how it could be applied in the game. In their Interview, P14 could explain how it was used in the game demonstrating that they had learnt from this interaction, at least in the context of applying crop rotation in Gaia Explorers.

3.5.3.2.2 Seeking Opportunities to Learn From Others

Throughout their Interviews, and in most cases multiple times within the Interview, all participants expressed a willingness to learn from other perspectives. For some, like P17, this was because they themselves felt that they were lacking the knowledge to be able to make informed decisions themselves:

"I didn't really feel like I knew all that much and if I feel that way I just try and learn from others. So that's pretty much what I did." (P17, P17 Participant Interview) Here, P17 reflected on how when faced with uncertainty, they sought out the perspectives of others who were (perceived to be) more qualified. For others, openness to learning from others was prioritized to ensure that a better understanding of the 'whole picture' was achieved: focusing only on their own perspective or expertise would result in blind spots and they were motivated to work towards a holistic and representative understanding of what everyone wanted in or understood from the game. P11, for instance, highlighted that they needed to be open to hearing from other experts to get a better understanding of what the collective goal was:

"I think for me, an urban planner, I shouldn't be so insistent about, "oh, we want to make a city happy." Also, we have to listen about ecologist or, I don't know, economist, I would say. And we have to discuss about the common goal of the city." (P11, P11 Participant Interview)

This quote mirrors what P1 argued in Quote 9.4 (Table 9): learning from others was necessary because one person only understands a small fraction of the bigger picture. As P2 summarized, "if you had any chance of finding out anything about the planet you needed to collaborate" (P2, P2 Participant Interview).

Lastly, 4 participants also expressed an openness to being exposed to a greater diversity in perspectives and backgrounds, arguing that this may stimulate more learning and new insights. P12 for instance argued that "starting at different places and having different backgrounds definitely creates different ideas in people's head and creates contention" (P12, P12 Participant Interview). The idea of creating contention to stimulate learning was also addressed by P14 who claimed that "it would be interesting, at least on one table, to have a big conflict between someone. Because from conflicts, you can have a lot of new insights or understand how the game works" (P14, P14 Participant Interview) and by P7 who highlighted that "if everyone just agrees then … you don't really hear something else than what you believe is the truth or believe is right or whatever" (P7, P7 Participant Interview).

3.6 And if so, how? Results on Game Elements

Table 2 gives quantitative insight into which methods most likely stimulated BC learning. Interpreting Table 2 in light of the question 'and if so, how?' revealed that there were many instances of both Identification and Reflection being stimulated by the methods used in this research. The Game Sessions predominantly stimulated Identification – largely in terms of participants explicating their understanding of the game mechanisms – but did little to stimulate Reflection or Identification of the perspectives of others. The Interviews also stimulated many instances of Identification but on a broader spectrum: unlike in the Game Sessions where participants mainly identified their own perspective, the Interviews yielded quotes coded with a broader spread of the BC subcodes. Most importantly, however, more than 75% of the quotes coded with a Reflection subcode came from the Interviews.

Whilst the quantitative findings presented one side of the story, the qualitative data underlying this quantitative data was richer and presented a more nuanced understanding of how participants experienced BC learning through these methods. In other words, the quantitative results did not fully capture the learning experience of participants. The findings presented below show that participants valued the Game Session for stimulating discussion about viewpoints and the Interviews for allowing them to consolidate their experience, but also that there were other experiences outside of the methods used in this thesis that were important.

3.6.1 Game Sessions

As demonstrated by the quantitative findings, participants felt that the game was effective in stimulating discussion about perspectives and differences. From P8's point of view:

"We are really good at [communicating] our thinking, so the differences became something good, which is something that can help us understand the role of the game." (P8, P8 Participant Interview)

This sentiment was mirrored by P4 at Game Session 3 who argued that the game environment allowed them to identify and address their differences and viewpoints. P17 at Game Session 1 found that the discussions between rounds were most important for getting to understand the other participants, however as P13 stated the mid-game conversations were more focused on understanding the game than consolidating what happened between the participants, what their views were, and how they as a team ended where they did. For that, the debriefing was important:

"Definitely the debrief, I think, was important, because during the game you're just concerned with figuring out how the game works, so you're not thinking about it too much, and then indeed because we got the time to talk, we did maybe point it out [to] each other, like, 'hey, you always thought this and you thought this'... Yeah, so I do think the debrief was important for that." (P13, P13 Participant Interview)

3.6.2 Interviews

Indeed, for some participants, the Interview allowed them to think back on the game in a way they would not have otherwise and to consolidate what they learnt. As per P18, the Interview was necessary to prompt them to think about what happened during the game:

"Yeah, I don't think I would have thought about it much... I don't think it would have come up unless maybe I'm asked, like, yeah. I'm stimulated with this question." (P18, P18 Participant Interview)

Here, P18 noted that without being re-stimulated to think about the game they would not have revisited their learnings/behaviors/actions from the Game Session. Similarly, they were the only participant who mentioned the PGS as being an important stimulus for them to "restructure ... and untangle [their] thoughts" (P18, P18 Participant Interview). The same was true for P1 who felt that the Interview setting – having a "conversation partner" with whom to "go back and forth" on the game (P1, P1 Participant Interview) – allowed them to gain new insights about their Game Session experience:

"I'm actually super happy that I participated now in the Interview because it was for me also like, I feel like I take more out of this experience now than I did before." (P1, P1 Participant Interview)

Thus, the Interviews prompted participants to think back on the Game Session in a way they otherwise would not have done.

3.6.3 Informal Discussions

For some participants (P4, P8, P14, and P18) the informal discussions they had outside of the game allowed them to debrief on what happened during their experience. P4, P8, and P18 mentioned the importance of being able to discuss their experience with their flat mates or partners as a way of debriefing on what happened, whilst P14 discussed the differences between their Game Sessions and co-participants with P7. These interactions are of course not captured by the methods used in this thesis but may have been just as important for the BC learning process (if not more) than those used.

3.6.4 Conclusion

Thus, the quantitative and qualitative data do not contradict each other, but rather independently provide incomplete pictures of what participants took away from the Game Sessions. Overall, findings highlighted that whilst the Game Session was of course essential for stimulating Identification and Reflection (at later points), the additional debriefing moments after were necessary for allowing participants to think back on what happened and demonstrate the Reflection LM.

4 Discussion

4.1 Discussing the Key Findings

This thesis has contributed to both the serious game and the boundary crossing literature by providing a methodology through which SGs can be used to stimulate BC LMs and by demonstrating through this methodology how SGs can stimulate these learning mechanisms. In this section the key findings of this research are discussed, along with their limitations and implications for further research.

4.1.1 Identification and Reflection were Stimulated by the Combination of Methods

Overall, Identification and Reflection were stimulated – to different degrees – by all three methodologies used in this research, and even among the Facilitators. Across the board, there were more cases of Identification than Reflection – specifically, Recognition and Definition of Own Perspective – however the quantitative findings do not necessarily reflect the richness of the qualitative results. The Interviews stimulated the vast majority of Identification and Reflection. This section will further elaborate on this key finding by exploring the interdependence of the methods used, the interdependence and distribution of codes across methods, and the implications of Facilitator BC for further use of SGs for BC.

4.1.1.1 Interdependence of Methods

Each of the methods used in this research were designed to build upon one another – the Interview was possible only because the Game Session had been played and the post-game survey shaped the questions asked in the Interview. Whilst it is clear both in quantity and complexity of the qualitative data that the Interview provided more room for Identification and Reflection than any other method, it was only because of the previous methods (namely, the Game Session) that this was possible. As further discussed in Section 4.2.3, Interviews allowed for the explication of important evidence on the role of expertise in shaping game play that was not detected during the game. Thus, this research provides exploratory evidence that GE can stimulate the Identification and Reflection learning mechanisms, but only when complemented by surveys and Interviews.

As has been demonstrated in the literature (see Jean et al. (2018a), Liu et al. (2023), Kara (2024)) a mixed methods approach to using Gaia Explorers in this research allowed for a more complete understanding of the participants' experience. Alone, Gaia Explorers was limited in the degree of Reflection and breadth of Identification it stimulated but when prompted with other methods, participants demonstrated evidence of wider Identification and Reflection abilities. One reason for this could be that the SG itself served as an effective boundary object (Jean et al., 2018a) for stimulating Identification and Reflection, but that additional methodologies were needed to explicate these LMs. In research on using SGs to understand decision making among health care professionals, Jackson and Iacovides (2022) found that SGs could be used as elicitation tools in Interviews because of their ability to prompt Reflection through simulation. These findings suggested that SGs can be useful in providing a context and scenario around which to interact,

but that other methods in which participants can explain/explore how and why they made the decisions they did are necessary to capture the extent of participant experience (Jackson & Jacovides, 2022).

Whilst there is insufficient evidence (and indeed, it is not the aim of this research) to draw a causal relationship between any method used and BC LM stimulation, nor is it possible to pinpoint exactly how each method contributed to the outcome, it is clear that the combination of methods used did stimulate participants to engage with the BC LMs.

4.1.1.2 Interdependence and Distribution of Codes Across Methods

Much like how the methods used in this research cannot be seen as independent, the learning mechanisms were also found to be interdependent. As demonstrated in the results tables in Section 3, several quotes were coded with more than one subcode, not just within the same learning mechanism but also across learning mechanisms, particularly in the case of recognizing and defining and understanding/taking the perspective or expertise of others. As demonstrated in Sections 3.5.2.4 and 3.5.3.1, for example, there was an overlap between quotes coded with the Identification and Reflection codes. Here, in order for participants to see their knowledge/actions from the perspective of other participants, they needed to understand *what* the other participants' knowledge and action were.

Codes that were found frequently during the Game Session tended to also be found frequently during the Interview, though a wider range of codes were found in the Interviews data. That is, the Interview allowed for a greater and more comprehensive breadth of BC LM stimulation than the Game Session. Indeed, the Interview allowed participants to discuss topics not explored at all during the game (e.g., recognizing and defining their skills as were relevant to the game) and stimulated far more instances of Reflection. This is further explored in Section 4.1.2.

4.1.1.3 BC LMs and Facilitators: Implications for use of SGs for BC

Perhaps the clearest example of how boundaries provided room for Identification and Reflection came from the interaction between F1 and F2 in the post-game debrief with facilitators (Section 3.4). Though the facilitators were not the intended sample (all were MSc students, but not all were MSc thesis students) of this research, the findings from this debriefing revealed that Facilitators themselves identified boundaries and were able to use these boundaries to express their knowledge/understanding and see the situation from each other's perspective. These findings suggest that SGs also have potential to stimulate BC LMs through the facilitation thereof, not just game play. The role that peer facilitation can play in enhancing teamwork, communication, content understanding, and confidence has long been explored in various educational programs including anatomy (Krych et al., 2005), mathematics and chemistry (Parkinson, 2009), nursing (Svellingen et al., 2021), and distance education (Baran & Correia, 2009), among others. This literature suggests that peer facilitation is beneficial not just to the students but the student facilitators as well. Further research should investigate the role that peer facilitation of SGs can play in stimulating BC LMs and should focus more on the experience of the facilitators than done in this study.

4.1.2 Debriefing is Essential for Stimulating BC LMs in SGs

The importance of the debriefing in SG research has been long-defended in the literature as discussed in Section 2.4.4 (Bonnier et al., 2020; Crookall, 2010; Le Page et al., 2016; van den Hoogen et al., 2016), and indeed this thesis adds to the literature supporting this argument. Due to the (unintended) brevity of the collective debriefings in this research (see Section 2.4.4), the other methods (survey, Interview) provided participants with the necessary room to debrief on their experiences. This is illustrated by the depth and breadth of both Identification and (especially) Reflection subcodes found in the Interview transcripts compared to the Game Session: almost no Reflection codes were found in the Game Session transcripts – including the short debriefing – and Identification was largely limited to understanding the game mechanisms. Conversely, the Interviews revealed that participants had much more to say about how they experience the game, how they interacted with others, how their and their teammates' knowledge affected the game, and that they could demonstrate a deeper understanding of their teammates than was evident during the game. Without the Interview serving as a debriefing moment, this study would likely have concluded that serious games (alone) do not do much to stimulate BC LMs.

This study also made it clear how important preparing facilitators to run debriefings is. As noted by Jansen and van Zelst (2021), facilitators are essential in SGs particularly during the debriefing phase where they can focus on reflecting to draw out learning and experience from the game Whilst the Facilitation Guide outlined an adapted version of the Kriz (2010) debriefing process, it was clear from the results that simply listing the questions was not enough to provide structure to the debriefing. The majority of the facilitator training was focused on understanding how the game mechanisms worked and practicing this and not on the debriefing. Despite mentioning that the debriefing was important the training did not allow sufficient time to prepare facilitators to lead these debriefings and this possibly contributed to the very short and rather unstructured debriefings after the Game Sessions. As found by Baalsrud Hauge et al. (2021) facilitator competencies are a key driver of learning outcomes in serious games. Thus, if a particular element of the Game Session is deemed to be important – e.g., the debriefing – then facilitators should receive sufficient training to be able to run the element effectively. Thus, future researchers using this thesis's approach or using debriefings should ensure that their facilitators receive sufficient training in running all elements of the Game Session (Mayer et al., 2014), not just the game.

4.1.3 <u>Stimulating BC LMs ≠ BC Learning</u>

The aim of this research was to determine whether serious games *stimulate* BC LMs and indeed evidence was found to suggest that SGs in combination with more reflective methods can stimulate these LMs. However, two important factors need to be considered when interpreting this finding. First, *stimulating* BC LMs should not be read as *learning* at the boundary per se. As Fortuin et al. (2024, p. 215) argue, the BC LMs are simply ways in which "boundaries can be used as learning opportunities." Although LMs were provoked by the methods used in this study it cannot be concluded that BC *learning* – as defined in Section 1.1 – took place. As noted by Fortuin et al. (2024), developing the ability to learn at boundaries does not occur in a single learning

activity, but by practicing the competency in a range of learning settings and situations. Further analyzing the results through the Boundary Crossing Rubric designed by Gulikers and Oonk (2019) could explore whether these methods stimulated not just BC LMs, but participants to become "Good Boundary Crosser[s]" (Gulikers & Oonk, 2019, p. 969). Thus, further research is necessary to investigate if these methods, beyond simply stimulating a mechanism, can support learning.

Second, due to the limited scope of this study there was no medium-term (let alone long-term) follow up with participants on their experience of the Game Session or Interviews. As such, the BC LMs may be stimulated by the methods used, however no conclusions can be drawn about whether this extends beyond the limited time period and scope of this research. As Mayer et al. (2014) argue, the limited investigation into the long-term effects of SGs is a limitation of SG research in general. However, as identified by Den Haan and Van der Voort (2018), there is initial evidence on methods used to elicit and evaluate longitudinal social learning benefits of SGs in the literature (see Ducrot et al. (2015)). Within BC research, further investigation into the long-term effect of SGs on BC competencies is needed.

4.2 Limitations

4.2.1 Exploratory Study

No other studies have investigated the Identification and Reflection LMs specifically in relation to SGs. Jean et al. (2018a) and Jean et al. (2018b) both investigate BC in SGs, however, where they are focused on determining whether SGs can serve as an effective boundary object in getting participants to acknowledge boundaries, this study was interested in exploring the BC LMs more directly. As such, there is little comparative evidence that can be drawn upon to compare or evaluate the findings in the study. In that sense, this study is comparable to other SG research: SG research is limited by the lack of comprehensive, comparable, and widely used frameworks to assess the efficacy of the games in achieving their desired outcomes (Mayer, 2012; Mayer et al., 2014). Whilst the findings cannot be compared to that of other SG studies, the methodologies used – surveys, the Game Session, debriefing, Interviews – are common across SG research (Mayer et al., 2014) and will be discussed below. As such, this paper serves as an exploratory study into stimulating BC LMs in SGs but recognizes that more research is essential before drawing hard conclusions or giving recommendations on how SGs can (or cannot) be used as BC tools.

4.2.2 <u>Sample</u>

The convenience sampling method used in this study means that the findings cannot be generalized to the entire population of MSc thesis students at Wageningen University (Stratton, 2021). The sample may be biased because the (majority LUP) thesis students who signed up to participate may not be representative of the population (see Table 1) (Sousa et al., 2004). This is not just because of their academic background, but also because of the possibility of motivation bias (Stratton, 2021). Indeed, I knew 12/18 participants before the study, and it is (highly) possible that they were motivated to help (however they perceived helping) me with my research. This was

likely not representative of the motivations of the general population and may also be a concern in terms of demand characteristics, or when participants adjust their behavior after knowing the aims of the research (Nichols & Maner, 2008). Despite the bias-related issues of this sampling method, it was a useful method given the resources available for this research. Indeed, as found by Kara (2021) in a systematic review of serious games research in science education, convenience sampling is the most common sampling method in SG research for this reason. Furthermore, this study did not aim to generate generalizable findings, however it is nonetheless important to note that if this study's methodology is replicated with a different sample, the results may be different.

4.2.3 Data Collection in Game Sessions

The Interviews revealed more Recognition and Definition of the Perspective/Expertise of others than was detected during the Game Sessions. In the Interviews, participants expressed a sensitivity to the expertise of others that was not explicit during the Game Session. These findings suggest that the methods used to analyze the Interviews may not be the most appropriate methods to analyze the Game Sessions. In the Game Sessions, for instance, it could be that the meaning units were too narrowly defined to capture the more long-lasting interactions that develop between participants as the game goes on, and thus that coding transcripts failed to capture the complexity of the interactions. As such, the methodology for evaluating BC in Game Sessions may need to be adapted to identify the more subliminal and longer-term interactions than the current approach.

Jean et al. (2018a) provide an alternative approach to understanding interactions between participants. In addition to game play and a post-game survey, Jean et al. (2018a) performed an interaction analysis on the audio-visual recordings of the game. Here, they proxied the quantity and quality of participant interactions with directed (any interaction between two participants in which there is direct eye contact and communication e.g., a question, response, etc.) and team interactions (interactions not directed towards one specific participant, but to the group) to generate interaction maps. They argue that such an approach helps them evaluate the ongoing and social process of knowledge co-creation within a SG setting (Jean et al., 2018a). In the context of the analysis in this thesis, such an approach could be used to explore the longer-term development in participant interactions *during* the game assuming that this instrument is carefully validated for the BC LM behavior it is measuring.

More intensively, digital games research has presented various game-based assessment or stealth assessment methods used to collect data on participant learning/performance (Ke & Shute, 2015; Udeozor et al., 2024). As Ke and Shute (2015) argue, most analysis of learning in SGs has historically been indirect and post hoc (as in this study). Finding ways to integrate authentic assessment of learning – and in the case of this research, of BC – real-time into games is a task for current and future research (Udeozor et al., 2024) and takes place during the game design phase (Udeozor et al., 2023). Whereas the analysis of BC in this game was focused on what participants *say* (verbally and written), a game-based assessment approach would be focused on what participants *do* during the game (Udeozor et al., 2023). Importantly, as Ke and Shute

(2015) warn, any such assessment framework must be rigorously validated to ensure the measurement validity of the instrument.

4.2.4 Methodological Limitations

4.2.4.1 Coding and Reliability

As discussed in Section 4.3, my subjectivity played a large role in shaping the outcomes of this study. Due to the time and resource limitations of this study, I was the only coder in this research. This has implications for the reliability of the coding in terms of stability and reproducibility (Campbell et al., 2013). Stability refers to whether the same codes were applied in the same way over time. As noted in Section 2.7.2, the subcode 'Expertise: knowledge' was applied differently in Game Session transcripts than it was in Interview transcripts due to the differences in the way knowledge was used in these two settings. I chose to keep the two under the same subcode as explained in Section 2.7.2, but also recognize that in doing so the same codes are not applied in the same way over time (though they are applied differently consistently). This did not affect the results presented above, however, because I was aware of the difference when interpreting and writing about the qualitative findings.

Reproducibility is concerned with whether another coder – familiar with the background of this research and with a clear understanding of the code book – would assign the same subcodes to the same quotes that I did (Campbell et al., 2013). This raises the issue of intercoder reliability, a topic that is considered to be good practice within qualitative research (O'Connor & Joffe, 2020), but is nonetheless controversial with some researchers arguing that it improves the rigor of qualitative research and others arguing that it is unnecessary (Armstrong et al., 1997; O'Connor & Joffe, 2020) (or infeasible due to e.g., lack of funding/resources (Campbell et al., 2013)). To ensure that the codes used in this research were consistently applied and that the code book was clear and well developed, another researcher could have coded some of the Interviews/Game Sessions and an analysis could have been performed on how consistently we coded. As argued by Burla et al. (2008), ensuring that coding is consistent is crucial when presenting qualitative data quantitatively as done in this study. Thus, this study could have been improved by performing an intercoder reliability assessment.

4.2.4.2 Quantitative Summaries of Qualitative Data

The qualitative findings of this study were quantified to provide a structure to the vast number of quotes coded in this research. However, due to both methodological limitations and the lack of nuance provided by quantitative findings, qualitative data needs to be analyzed to understand the nuance and complexity of participants' experience and understanding (James, 2012). The former relates to the argument made Burla et al. (2008) above that particularly when qualitative data is quantified it is good practice to have another coder use the same code book on the same data to ensure that coding was done reliably and consistently. To the latter, as Braun and Clarke (2006) argue, more instances of a specific theme – or code – does not necessarily mean that the code is more important (and vice versa), nor does it mean that the quantities are comparable (is one instance of Reflection 'equal' to one instance of Identification?). There are 'fewer' instances of Reflection, but those that there are show that participants were stimulated to think deeply about

their own and other's (inter)actions/expertise/perspectives. Likewise for Identification, quantitative evidence revealed few instances of Recognition and Definition of One's Skills, but qualitative evidence demonstrated that the 3 cases were rich with evidence for this Identification element. The quantification of the qualitative data in this research should not be understood as an attempt to generalize or make more rigorous the research (James, 2012), but rather as an indicative (and flawed) tool to structure the complexity.

4.3 My Role as Researcher: A Reflection

My view point and the actions I took as a researcher in all stages of this research – from choosing the theoretical framework to data collection, analysis, writing – impacted the outcomes of this study and myself (Mackieson et al., 2018). Recognizing and addressing this is part of a reflexive approach to research, or a continuous and collaborative process that is essential to enhancing the rigor and transparency of qualitative research (Olmos-Vega et al., 2023). Reflexivity is not, as Olmos-Vega et al. (2023) and Mackieson et al. (2018) argue, an attempt to apologize for the role my subjectivity – alternatively, my lack of objectivity – played in this research but rather to acknowledge how it contributed to the outcomes of this study. My subjectivity and position impacted data collection, analysis and writing, as briefly discussed here.

To the first, I was the sole interviewer and knew many of the participants beforehand. Whilst the semi-structured Interview method allowed for further exploration into topics that came up during the Interview, that was also up to me to decide what was relevant to delve into. On the one hand, this meant that because I had been immersed in BC literature I could adapt and ask questions that were relevant to the topic. On the other hand, this meant that I also may have focused too much on a particular element of BC that was perhaps not relevant to the participant. Furthermore, as mentioned in Section 4.2.2, it is also possible that participants were more inclined to say what they thought I wanted to hear, particularly because I was sitting right in front of them during the Interview.

To the second, because of my theoretical commitment to the boundary crossing framework and the thematic analysis approach used in this thesis, I read the transcripts with the framework in mind and created a final code list that largely reflected what already existed. I (consciously or unconsciously) already had in mind the kinds of themes I was expecting to find in the data when I performed the inductive coding: that is, the codes/subcodes were created (Braun & Clarke, 2023) within a context where I was researching BC LMs and not in an "epistemological vacuum" (Braun & Clarke, 2006, p. 84).

Last, but certainly not least, not only was I the only coder of the work, but I also further selected key quotes from these coded quotes to illustrate the points I was making during the writing process. As Braun and Clarke (2006) argue, choosing which quotes to use in the written report following thematic analysis involves selecting the parts of specific quotes that I want to use, choosing where to place them (of course, not in the context in which they were said), and using them to support an argument that I want to make. Thus, participants' say (their voice) was instrumental to my arguments: I emphasized their voice when it supported my arguments and chose not to include quotes when I thought they were irrelevant.

These factors are an integral part of research; however, they are not inevitable but rather (the product of) conscious choices influenced by my assumptions and aims.

4.4 (More) Further Research

The discussion above has identified areas for further research within the various limitations of this study design. One area for future research is the feasibility of SGs in educational settings. This research demonstrated that boundary crossing was stimulated in individual elements of this study, but the BC LMs were more comprehensively stimulated through the combination of methods – surveys, a game, and an Interview. This was time-intensive and thus may pose a challenge to the integration of SGs into the time- and resource-restricted higher education curriculum as a means of stimulating boundary crossing. However, as found in this study and in Jean et al. (2018a) and Jean et al. (2018b), SGs provide ample opportunity for participants to identify and learn from the boundaries that exist between themselves and others. This is important in the context of higher education where, as Leung (2020) and Veltman et al. (2019) argue, meaningful boundary objects to support BC learning are essential. Thus, further research is needed into the role that SGs can feasibly play in supporting BC in higher education.

Another area for future research could be an investigation into the type of boundaries experienced in different serious games and how this shapes (if at all) the extent to which BC LMs are stimulated. The kinds of boundaries experienced during Gaia Explorers – as outlined in Table 7 – are mainly about differences in understanding of or approach to playing the game. The boundaries were very game-specific, whilst other SGs stimulated participants to contend with more personal (Cheong et al., 2015) or societal/political (Medema et al., 2016) boundaries. Investigation into the role that the type of boundaries experienced during a SG plays in shaping BC outcomes would be useful in both creating and using games to best facilitate BC learning.

5 Conclusion

This research has demonstrated that the serious game Gaia Explorers can stimulate the Identification and Reflection learning mechanisms of Boundary Crossing in MSc thesis students at Wageningen University when supported by methods that allow participants to debrief on their experience of playing the game and interacting with others. Thus, the game served as a tool to create discussion and be discussed, but additional methods that made space for debriefing allowed for more and richer instances of both Identification and Reflection. In terms of Identification (SRQ1), the Game Session itself stimulated several instances of Recognition and Definition of One's Own Perspective (specifically of 'Understanding of Mechanisms') but it was only through the Interviews that participants were able to elaborate on the full spectrum of the Identification mechanism. In terms of Reflection (SRQ2), almost all instances of Reflection came from the Interviews where participants were able to demonstrate all elements of the learning mechanism. The post-game survey revealed instances of both Identification and Reflection, however these were brief and needed further elaboration in the Interviews (as intended). Thus, Gaia Explorers was necessary but not sufficient to stimulate the Identification and Reflection learning mechanisms of Boundary Crossing.

These findings reaffirmed what has been argued in the literature that a debriefing moment is an integral part of using serious games in both research and education. It is through debriefings that participants are able to consolidate their experience and examine what they have taken from their participation, as was confirmed by participants in this research. In this study, the key debriefing moments were the Post-Game Debrief with the facilitators and Interviews with the participants. Evidence of both Identification and Reflection were also found in the former suggesting that serious games can be boundary crossing tools for both facilitators and participants if given sufficient space to debrief on their experience. Importantly, however, stimulating boundary crossing learning mechanisms is not the same as boundary crossing learning. It is the role of future research to investigate how serious games can best support the latter.

In the context of needing to find new ways to prepare students to address the wicked problems that we currently face, serious games show potential in allowing participants from different backgrounds to explore new environments, debate, discuss, and work together to solve problems. In this way, they can be one part of a wider educational effort to develop boundary crossing competency in higher education students, but this remains under-researched in the literature. This research presented one approach of using a mixture of different participant-input methods to explore the potential of serious games in stimulating boundary crossing learning mechanisms. It calls for a further investigation into how these fun and engaging tools can go beyond *stimulating* learning mechanisms to best support boundary crossing *learning*.

6 References

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b	Pre-survey (academic background/ expertise)	Debriefing (group dynamics)	Post-survey (which boundaries were experienced)	Interview (were the BC LMs experienced)
1. 2. 3. 4. 5. 6.	What is your master's study program? What chair group are you writing your thesis in? Are you part of a Master's thesis ring? If yes, which? What was your Bachelor's study program? What was your specialization in your Bachelor's? In a few words, how would you define your area(s) of	 How do you feel? Did you prioritize one outcome over another? Why this outcome (R)? Did you agree with this decision ()? Would you have prioritized something else if you were playing alone? Were you cooperative? Were there any barriers to cooperation? How did this work? How did you as an individual or group figure this out (R)? Based on your experience is this realistic ()? What did you learn about others (R)? 	 Did you experience tensions (e.g., differences in opinions, language, perspective, priorities, understanding, etc.) in your group? In a few words, can you give an example of a tension that you experienced in this game ())? Do you feel that this boundary was addressed (i.e., discussed or otherwise made explicit) during the game or did it remain implicit ()? In a few words, what if anything, happened when you experienced this tension (R)? In a few words, did this tension affect the outcome of the game (I, R)? In a few words, what do you take away from this game (I, R)? 	 Warm up questions What did you take away from the game session (), R)? Boundaries You mentioned in the post-game survey that one of the tensions - or differences - you experienced in your game was Could you tell me a bit more about this experience (), R)? Identification questions How did your knowledge/academic background/skills/attitudes/values shape the way you played the game? And your coplayers' ()? Reflection Questions You mentioned in your post-game survey. Could you elaborate a bit more on this for me (R)? Beyond There were different parts of this research. You filled out a pre-survey, played a game, participated
	experuse ?	 Debrief w How did your games g Did you notice any 'bo' Did the game give play perspectives? Were players open to working together to ur What is your takeaway 	vith Facilitators (o? Anything surprising? bundaries' between players? yers room to discuss their hearing each other's opinions and iderstand the game? y from this (I, R)?	 a deprinting, completed a post-survey, and are now participating in an interview. How, if at all, do you think these different moments encouraged you to think back on this game? 6. Closing How do you feel about having participated in this research? Would you play the game again? Is there anything else you would like to add?

7 Appendix 1: Flow of BC-Stimulating Questions

()) = Identification **R**= Reflection

Figure 3 Flow of BC-Stimulating Questions

This figure depicts the flow of BC-Stimulating Questions between the different methods. It outlines the questions asked in the different elements and identifies whether they were intended to stimulate Identification or Reflection. This figure thus shows how the different elements were designed to connect with each other.

8 Appendix 2: Pre-Game Survey

Note: The survey below was administered over Microsoft Forms. As such, it was presented differently to participants, but the content is the same.

Come Play A Serious Game

You are invited to come play a serious game about land use change and biodiversity loss on **Thursday 28 November** from 15:00-16:15 at Lumen 1!

This Game Session is part of the data collection for an MSc thesis supervised by Federico Andreotti (FSE) and Karen Fortuin (ESA) exploring Boundary Crossing Learning and Serious Games. No prior experience with games is necessary. Plenty of snacks will be available.

Please fill out this form (13 short questions) if you are interested in taking part. There are limited spaces available!

If you have any questions, please contact Julia van Ryneveld (julia.vanryneveld@wur.nl). Hope to see you there!

Note: you need to be an MSc thesis student to participate in this event.

Name*					
Email Address*					
Are you currently writing your Master's Thesis?*					
The case study us	ed in this thesis is students writing their Master's	thesis. If this	YES	NO	OTHER
is not you then un	fortunately you will not be able to participate in t	he game. But			
if you'd like to obs	erve then you're more than welcome!				
Are you able to	participate in a Game Session Thursday 28,	YES	NO	MA	/BE
November 2024 f	from 15:00-16:15 in person at Lumen 1?*				
(If Yes) What is yo	ur Master's study program?*				
Which chair group	o are you writing your thesis in?*				
Are you part of a N	Master's Thesis Ring?*	YES	NO	I DON'T	KNOW
(If Yes) Which The					
What was your Bachelor's study program?*					
What was your specialization in your Bachelor's?					
In a few key wo					
expertise?					
Do you consent to being recorded (audio and visual) during the event?*					
Audio and visual recordings will be analyzed for the purposes of this the			will be safely	YES	NO
stored on the WUR OneDrive. You have the right to withdraw this consent at any time.					
Do you consent to your data being used in this thesis?					
Data from the Game Session may be used in this thesis in the form of quotes or pictures from					
the event. Any identifying characteristics (name, face, etc.) will be anonymized if used in the YES NO					NO
final report. Your email address listed above may be used by me (Julia van Ryneveld) to					
contact you before and after the Game Session. You have the right to withdraw this consent					
at any time.					

9 Appendix 3: Post-Game Survey

4

3

Name:		
Question 1		
Did you experience tensi	ons (e.g. differences in opinions, language, perspective, priorities	s, understanding etc.) in your
group? Please circle:		
No tension	Some tension	Lots of tension

Question 2

1

2

In a few words, can you give an example of a tension (e.g. differences in opinions, language, perspective, priorities, understanding etc.) that you experienced in this game?

6

7

8

9

10

5

Question 3

Do you feel that this tension was addressed (i.e., discussed or otherwise made explicit) during the game or did it remain									
implicit? Please circle:									
Mainly	Implicit	Somewhat addressed Mainly Addres				ldressed			
1	2	3	4 5 6 7 8 9 10					10	
Questio	n /								

Question 4

In a few words, what, if anything, happened in the game when you experienced this tension?

Question 5

In a few words, did this tension affect the outcome of the game?

Question 6

In a few words, what do you take away from this game?				

Question 7

Would you be open to participating in a 30 minute				
follow up Interview about your experience of this	Yes	No	Maybe	
game?				

Thank you!

Post-Game Survey Justification

Objective

The goal of this survey is to 1) make explicit a boundary that the participant experienced whilst playing, 2) give the participant room to reflect on how they contributed to the team's understanding of the game and vis versa, 3) recruit Interview participants. If participants agree to an Interview, the results from this survey can also be helpful in shaping the Interview.

Justification for Key Questions

Question 1

The facilitation of this game aims to promote cooperation between participants, at least in relation to the goal of providing 8 blobs to the city. However, disagreements may of course still arise in terms of prioritizing other objectives (e.g., pollution, how to test different mechanisms, how to handle biodiversity loss). Thus, this question seeks to set the theme for the rest of the survey which is focused on boundaries/barriers. At the same time, it seeks to determine how participants identify cooperation/conflict in relation to the existence of boundaries/barriers: is a cooperative process necessarily boundary-free?

Question 2.1

Gulikers and Oonk (2019) argue that boundaries need to be explicitly identified for them learners to cross them. This question prompts participants to both reflect on what boundaries they experienced during the game and to attempt to make them explicit. Explicating the differences that are experienced – specifically, defining differences in expertise, perspective, priorities, etc. – is a form of Identification. Thus, the goal of this question is to stimulate Reflection on the game such that participants can identify boundaries within their group.

Question 2.2

The goal of this thesis is to explore whether serious games can trigger boundary crossing learning. This question is a step towards addressing this goal by identifying whether the game facilitates the explication/discussion of boundaries or whether they go noticed, but unaddressed.

Questions 3 and 4

These questions aim to prompt the Reflection mechanism which is concerned with whether participants are open to learning from others and contributing to the learning process of others. These questions encourage participants to reflect on the knowledge they identified other participants as having and themselves to be lacking and vice versa.

Question 5

This is an open question which aims to capture any learning or thoughts or opinions that participants take away from the game. It is related to questions 3 and 4, but more open in the sense that it isn't explicitly about 'learning' with others. If the participant agrees to a follow up Interview in which this question will be asked again, it can be interesting to see how the answer to this question in the survey immediately following the game compares to the answer after some time has passed.

10 Appendix 4: Self-Identified Expertise

Though academic background can give insight into what the participants' area of expertise was, the Pre-Game survey also gave participants the option to self-identify or further specify their expertise. The tree map below (Figure 4) represents the words that were most used in these descriptions and how frequently these words were used. Often several areas of expertise were listed. Only key terms with a minimum count of 2 were included so as to limit the size of the figure. A deeper look into 'management' reveals expertise in landscape, water, project, crop, and stakeholder management. 'Planning' captures expertise in spatial, urban, and landscape planning. Four participants listed their expertise as 'food'-related, specifically focusing on food policy and food systems. Two participants identified their expertise as 'systems analysis' and one as 'data analysis'.



Figure 4 Tree Map of Word Frequencies in Participants' Self-Identified Expertise

This figure depicts a tree map of word frequencies from participants' self-identified expertise in their Pre-Game Surveys. Each rectangle is proportional in size to the number of times the word was mentioned. It provides insight into the type of expertise present at the Game Sessions.

11 Appendix 5: Gaia Explorers Training and Facilitation Guide

Gaia Explorers Training Guide

The objective of the training session is to prepare facilitators (game facilitator + calculator) to run the game during the data collection period.

Training Session Outline (Tuesday 19, 14:15-15:30ish, Radix Nova Summer Room)

- 1. 5 min: Introduction
- 2. 25 min: Game Play

Objective of Game Play: For participants to get experience playing the game

3. 10 min: Game Debrief

Objective of Debrief: For participants to reflect on their understanding of the mechanics of the game and the narrative told. Unlike during the data collection event where the debrief is focused on perspectives and how participants learnt with/from each other, the debriefing during the training session is focused on how the game itself works.

30 min: Game Narrative and Mechanics Overview and Examples
 Objective: to run through the facilitation of the game including the narrative, the mechanics, and examples of how the mechanics work. There will also be an overview of how to debrief the game.

Data Collection Day Outline (Thursday 28, 14:40-16:30, Lumen 1)

On the day of the event, please arrive 20 minutes before the session to go over any last-minute questions or concerns regarding the game itself. Everything should be set up by the time you arrive, but good to check that the table works for you and that you have everything you need. We will then have a roughly 15 min debrief as a facilitation team afterwards to talk about what happened during the session.

- 1. 20 min: Set up and answering questions
- 2. 10 min: Introduction to participants
- 3. 40 min: Game Play with participants
- 4. 20 min: Game Debrief with participants
- 5. 5 min+: Exit Survey and Food with participants
- 6. 15 min: Facilitator Debrief

Facilitator Debrief

After Playing we will have a quick debrief as the facilitation team. We'll touch on some of the questions below so keep them in mind!

- 1. How did your games go? Anything surprising?
- 2. Did you notice any 'boundaries' between participants?
- 3. Did the game give participants room to discuss their perspectives?
- 4. Were participants open to hearing each other's opinions and working together to understand the game?
- 5. What is your takeaway from this?

Gaia Explorers Facilitation Guide

Thank you!

Thank you for agreeing to help facilitate Gaia Explorers as part of the data collection for my thesis! I really **could not** do this without you and appreciate so much that you have taken the time to not only facilitate in the event itself, but to attend the training session and learn how this game works.

This Guide

Along with instructions on how this game works, the game narrative, and the debriefing, this pack will also include a game board and some examples to work through to help you practice facilitating/calculating. You can also always contact me (Julia, +31 6 57 48 73 94) if you have any questions. Text in green is a facilitator note. Text in purple is to help with narrative and is the only information that participants should receive.

Roles

You will work in pairs with one person acting as the facilitator and the other as the calculator. The roles of each are as follows:

Facilitator	Calculator
The facilitator is responsible for managing the flow of the	The calculator supports the facilitator by doing all the
game, with a specific focus on establishing and maintaining	calculations and adjustments during the game. They are
the narrative, redirecting questions, explaining the	responsible for keeping track of the game elements (e.g.
mechanisms within the context of the narrative, and keeping	regeneration, pollution) and changing them on the board so
time. Additionally, the facilitator leads the debriefing session.	that the facilitator can focus on the flow of the session.
Before the game	During each round
 Set up the board according to the facilitation guide 	 Keep notes of interesting dynamics/quotes
(should already be done, but just check!)	At the end of each round, calculate
 Split participants into pairs (if enough) 	 Resource (blob) regeneration
During the game	 Food vs Feed emissions
 Structure the flow of the game according to the 	 Pollution accumulation
facilitation guide	 City happiness
 Calculate/adjust biodiversity loss and activist 	Before the start of the next round
presence	 Adjust the board to reflect the changes in
 Keep time 	regeneration, emissions, and city happiness
 Flip 'hint' cards when necessary 	Before the debriefing
During the debriefing	 Highlight any interesting dynamics to the facilitator
 Facilitate the debriefing outlined in this guide 	(e.g., was the city happy? How many animals
After the debriefing	remain? How much pollution?)
 Hand out and collect the post-game survey 	

This may seem like a lot – and maybe even more so after we work through the game mechanics! But what is important for this thesis is **not** that the game mechanics function 100% smoothly/'accurately'. What matters is the conversations that are stimulated by the game itself. If (when!) a mistake is made, it is okay!! If the group notices, prompt them to discuss why they think it is a mistake (turn the conversation towards the learning that led them to this realization) or weave it into the storyline.
The Game (Adapted from Andreotti (2025))

Objective

The objective of the *game* is for explorers to *collectively* produce 8 blobs (resources) for the city each round. The challenge is to produce enough resources whilst maintaining biodiversity and minimizing land use change and emissions. The objective of the *session* is to collect data for my thesis investigating whether (and if so how) serious games can trigger participants to examine their and others' own perspectives and reflect on what/how they learnt during the game. On the day of the event, these objectives will be explained by me to participants before the games start.

Components

- 1 map
- 80 resource tokens
- 10 animal tokens
- 4x10 participant puppets (4 different colors)
- Post-game Survey for each participant
- 5 'X' tokens to cross off plots

Initial Set Up

- 5 happy/unhappy city tokens
- 30 pollution tokens (or pen to cross off circles)
- 16 activist tokens
- Hint Cards
- Dice and hour timer (if necessary)

At the beginning of the game, 4 sets of 10 differentcolored participant puppets are outside the planet. 10 animals are in the biodiversity area. 4 activists are in the city. 'Hint cards' are facedown. Pollution Cloud City Happiness Biodiversity Area-Ariacent Plot Biodiversity Area Biodiversity Corridor Sector Biodiversity Loss

Figure 1 Initial Board Set Up



Each sector is initially set up as left. The final set up may differ in each subsequent round based on the decisions made in the previous round.

Figure 2 Initial Sector Set Up

Game Play (5x rounds)

Steps 1-4 are played 5 times. Each round should last 7-8 minutes. 2-3 minutes for Steps 1-3 and 5 minutes for Step 4.

Step 0: Welcome to Gaia and Establishing Narrative Start Recording Here!

You are explorers who find yourself on a new planet because decades of unsustainable practices on your previous planet, Earth, rendered it uninhabitable. On this new planet, your objective is to **collectively** work together to produce 8 blobs, or resources, for your city each round. At the same time, you are challenged to manage your food system to reduce pollution and biodiversity loss. To do so you must learn how things work on this planet over the next 5 rounds.

Step 1: Place Explorers on the Board

Start in Sector 1. Teams can choose to place none, one, or two of their puppets on one of the 8 plots in sector 1 (max. 8 explorers in each sector). There is no minimum number of explorers per plot.

We will start in sector 1 (point to sector 1). Each round I will ask you to place up to two of your puppets on the plots in this segment. Go ahead and place your tokens.

Step 2: Harvest

Now that you have placed your tokens, you can harvest the resources from the plots if you like. (Go from team to team until each team has harvested what they would like. Put the resources in the yellow dots next to the sector number) Now we can see what the consequences of this are for Gaia.

Step 2.1: Biodiversity

Biodiversity is represented by the animals (max 10) in the Biodiversity Area at the center of the board and is affected by the presence of explorers close to the biodiversity area. The Biodiversity Area is connected to each of the sectors by a Biodiversity Corridor.

- Participant visits Biodiversity Area-adjacent plot: remove 1 animal and place it in Limbo
 - It seems that your exploration has had an impact on [name of animal], and it no longer wants to (or it no longer can) live here. For now, it disappears from Gaia to Limbo.
- Unvisited Biodiversity Area-adjacent plot with no blobs: no change in animals
- Unvisited Biodiversity Area-adjacent plot with blobs: retrieve 1 animal from Limbo and put it in the Biodiversity Area
 Huh, it looks like something has happened to make [name of animal] return from Limbo.

Step 2.2: Activists

Activists are concerned if biodiversity declines or increases and come from/return to the city. The activist is placed on one of the internal plots in the next sector (r+1) and there is a maximum of 4 activists (one for each plot) in each round. Note that there are no consequences of having an activist on the board. They represent peaceful protest against the explorers.

- Loss of 1 animal: add 1 activist to one of the Biodiversity Area-adjacent plots in the next sector
 - An activist from the city has noticed that an animal has disappeared from Gaia. They will now occupy one of these plots.
- Reintroduction of animal: remove the activist from the Biodiversity Area-adjacent plot and return them to the city
 o An animal has returned from the Limbo, so the activist can return to the city.

Step 2.3: Blob Regeneration

Blobs regenerate depending on how explorers acted in each round. At the beginning of the game, each sector is set up with 12 blobs. This is the initial set up, but each round can be affected by the actions in the previous round. There is a maximum of 3 blobs per plot (so if in a round there are more than 24 blobs, the excess is just not placed on the plots).

It is now harvesting time. (Pointing at the top left most plot) Would you like to harvest any blobs from this plot? (Remove the desired number of blobs from each plot and place them in the yellow circles at the top of each sector)

- All harvested: remove 1 blob from the next segment starting from the external plots and then moving inward (5-8) if the external plots are completely depleted
- Partial harvest: add 2 blobs to the next segment starting with adding blobs to the external plots (1-4) and then moving inward (5-8) if the external plots reach their maximum.
- Unvisited plot: add 1 blob to the next segment starting with adding the blob to the external plots (1-4) and then moving inward (5-8) if the external plots reach their maximum.

Regeneration takes place depending on your harvesting decisions. You can see the outcome of this in the next segment.

Step 2.4: Land Use

The number of plots occupied by explorers during each round determines the amount of land available **only** in the next round. This mechanic introduces a challenge for balancing or reducing land use. Maximum occupation represents land degradation due to overuse and 'restoring' the plot introduces a balance between resource collection and sustainable land management.

- >7/8 plots occupied: cross out 1 plot in next round only
 Something has happened which means that you now only have 7 plots instead of 8 to occupy in the next round.
- 4/7 plots occupied: remove the cross from the plot in the current round
 o It seems like Gaia has recovered from your previous decisions and the lost plot can is open again.

Step 3: Blob Use

Once all harvested blobs have been placed in the 8 yellow circles on top of the sector, participants can collectively decide whether to use the blobs as food for the community or feed for the animals. If they choose feed, mark the resource or put a sticker on it to indicate that it is not food.

Step 3.1: Pollution

Whether explorers choose to use their blobs for food or feed has a different impact on pollution. Note that the ratios are exact: if you have only 3 blobs of food, for example, there is no pollution recorded.

• For every 4 blobs (exactly) allocated to food: cross out 1 pollution circle on the cloud

• For every 1 blob allocated to feed: cross out 2 pollution circles on the cloud

The way you use your blobs – whether for food or feed – has had an impact on the amount of pollution that has accumulated on your planet as you can see here (point to pollution cloud).

Step 3.2: City Happiness

Explorers must collectively give 8 blobs to the city. It doesn't matter if the blobs are food or feed.

- If the city receives 8 blobs: place a smiley face in the corresponding number by the city

 You have provided 8 blobs to the city, so it is happy this round!
- If the city receives <8 blobs: place a sad face in the corresponding number by the city

 You haven't provided 8 blobs to the city, so it is sad this round

Step 4: Debriefing Between Rounds

After you have calculated and displayed the results of each round participants have 5 minutes to debrief on what happened in that round and what their plan is for the next round.

End Debriefing

Once the Game Session is over, there is 20 minutes for a short debrief on the game. The first part (roughly 5 minutes) should be focused on how participants feel and transitioning from the game environment back to the 'real world'. Next, the focus of the debriefing will be on the focus of the thesis, namely Identification and Reflection mechanisms.

Now that the gaming part of the session is over, I'd like to invite you to reflect on how you feel and what happened during the game. I'll ask some guiding questions to keep our debriefing focused on how you expressed and perceived perspectives during the game, but we will also just see where the conversation goes. To start off, let's talk about how you feel now.

Feelings Questions

- 1. How do you feel?
- 2. Did you as a group prioritize one outcome over another? Why this outcome? Did you agree with this decision? Would you have prioritized something else if you were playing alone?

Boundary Crossing Questions

- 3. Were you cooperative? Were there any barriers to cooperation?
- 4. (in reference to a dynamic/token) How did this work? How did you as an individual or group figure this out? Based on your experience, is this is realistic?
- 5. What did you learn about others (their thoughts, perspectives, knowledge)? About yourself?

Extra Questions

- How did your understanding of this element change over time?
- What was important for others in this game?
- What expertise (if any) was necessary for the game?
- How do you think you contributed to the team's understanding of the game? How does your background knowledge contribute to your understanding of the game's mechanisms?
- How did others contribute to the team's understanding of the game?
- Were there decisions that you strongly agreed or disagreed on? Why? How did you resolve this?
- How did you help others understand your perspective/knowledge/thought process? Did it work?
- How did others help you understand their perspective/knowledge/thought process? Did it work?
- What systems was this game exploring? (This game was designed to explore the tradeoff between food production and planetary boundaries.)
- Did you have a say in the group? Do you think everyone got to express their perspectives?

End Recording here! Hand out Exit Survey.

Game Cheat Sheet and Scoresheet

Objective: Explorers *collectively* need to produce 8 blobs (resources) for the city each round.

Challenge: Produce enough resources whilst maintaining biodiversity and minimizing land use change and emissions.

Initial Board and Sector Set Up:



At the beginning of the game, 4 sets of 10 different-colored participant puppets are outside the planet.10 animals are in the biodiversity area. 4 activists are in the city. 'Hint cards' are facedown.



Each sector is initially set up as above. The final set up may differ in each subsequent round based on the decisions made in the previous round.

Introduction: You are explorers who find yourself on a new planet because decades of unsustainable practices on your previous planet, Earth, rendered it uninhabitable. On this new planet, you are trying to manage your food system and biodiversity in more sustainably, but to do so you must learn how different systems work on this planet.

Rounds (repeated 5x):

- 1. Place explorers on the board: Explorers can visit a plot or stay home. Max 3 minutes.
- 2. *Harvest: Changes are calculated at the end of each round (r) and are implemented in the set-up of the board/segment for the following round (r+1).*

Blob Regeneration (max 3 blobs per plot)	Activists (max 4 per sector)
 All harvested: -1 blob from plot Partial harvest: +2 blob (starting with external plots) Unvisited plot: +1 blob 	 -1 animal: +1 activist (on internal plots) +1 animal: -1 activist
Biodiversity (max 10 animals)	Land Use
 Participant visits biodiversity-adjacent plot: -1 	 7/8 plots occupied: -1 plot in next round
animal	 4/7 plots occupied: +1 plot in the next round
 Unvisited plot with no blobs: 0 change in animals 	
 Unvisited plot with blobs: +1 animal 	
3. Blob Use: Changes are calculated at the end of each ro	und (r) and are implemented in the set-up of the board/segment

for the following round (r+1).

Pollution Accumulation	City Happiness				
4 food = 1 pollution units	 City has 8 blobs: happy 				
1 feed = 2 pollution units	 City has <8 blobs: sad 				

4. *Debriefing*: Explorers given room to discuss the outcome of the previous round and plan for the next. Max 5 min.

Closing Debriefing: Now that the gaming part of the session is over, I'd like to invite you to reflect on how you feel and what happened during the game. I'll ask some guiding questions to keep our debriefing focused on how you expressed and perceived perspectives during the game, but we will also just see where the conversation goes. But to start off, let's talk about how you feel now.

Round 1

	5				3 0 0	
	6 0 0	Biodiversity Corridor	8			
Blobs: +,		Animals: +,		Activists: +,		
Total Δ:		Total Δ:		Total Δ:		
Blobs to city:© or ⊗		Feed: (1 feed = 2 pol)	Food: (4 food = 1 pol)		Pollution: (from feed + from food)	
Land Use Change:			•			
(7/8 occupied = -1 in r+1	; 4/7 occupied = +1 in r)					

Round 2

	5		7		3 O O		
	€ 00	Biodiversity Corridor	8		4		
Blobs: +,		Animals: +, –		Activists: +	Activists: +,		
Total Δ:		Total Δ: Total Δ:		Total ∆:			
Blobs to city:© or 🛞		Feed : (1 feed = 2 pol)	Food : (4 food = 1 pol)		Pollution: (from feed + from food)		
Land Use Change:			1				
(7/8 occupied = -1 in r+1	; 4/7 occupied = +1 in r)						

Round 3

	5		7		3 0 0	
	6 () ()	Biodiversity Corridor	8			
Blobs: +,		Animals: +, –		Activists: +,		
Total Δ:		Total Δ: Tota		Total ∆:	۵:	
Blobs to city:© or 🔅		Feed : (1 feed = 2 pol)	Food : (4 food = 1 pol)		Pollution: (from feed + from food)	
Land Use Change:						
(7/8 occupied = -1 in r+1	; 4/7 occupied = +1 in r)					

Round 4

	5		7		3 O O	
	6 () ()	Biodiversity Corridor	8			
Blobs: +,		Animals: +,		Activists: +,		
Tetel A		Takal A		Tabal A		
Iotal Δ:				Ιστάι Δ:		
	0					
Blobs to city:©	or 🕲	Feed:	Food:		Pollution:	
		(1 feed = 2 pol)	(4 food = 1	pol)	(from feed + from food)	
Land Use Change:						
(7/8 occupied = -1 in r+1	; 4/7 occupied = +1 in r)					

Round 5

	5		7		³ OO		
	€ 00	Biodiversity Corridor	8		4		
Blobs: +,		Animals: +, –		Activists: +,			
Total Δ:		Total Δ: Tota		Total ∆:	ι <u>Δ</u> :		
Blobs to city:© or 🛞		Feed: (1 feed = 2 pol)	Food: (4 food = 1 pol)		Pollution: (from feed + from food)		
Land Use Change:		,	<u> </u>		· · · · ·		
(7/8 occupied = -1 in r+1	; 4/7 occupied = +1 in r)						

12 Appendix 6: Interview Consent and Guide

Introduction and Consent

Thank you for participating in the Game Session and for agreeing to do this Interview. Both are part of my MSc research into the role that serious games can play in triggering boundary crossing learning in MSc students. I asked you to participate in this Interview because I would like to get a bit more insight into your experience of, and learning during, the Game Session.

This Interview will take approximately 30 minutes. It will consist of a few introductory questions, then some questions about boundary crossing before concluding with your perspective on learning in this Game Session and Interview.

I would like to ask if this Interview can be recorded and if quotes can be used in my report. The recording will be transcribed and coded and quotes may be used in this thesis report and related presentations/publications. If you agree, your name and answers will be anonymized, and you have the right to withdraw your consent at any time. You will be sent a copy of the transcript as soon as the transcription has been finalized.

Do you consent to being recorded?

□ Yes

🗆 No

Do you consent to quotes being used in my thesis report and/or related presentations/publications?

□ Yes

🗆 No

If there is anything you would like to have removed from the recording or if you would like the recording to be stopped at any time, please tell me.

Name: ______

Signature: _____

How to Use This Guide

This guide is for a semi-structured Interview of participants in a serious game. The aim of this Interview is to get a better understanding of whether participants felt that the Identification and Reflection learning mechanisms of boundary crossing were stimulated by playing a serious game. This guide has several elements as detailed below:

- <u>Objective</u>: Each section has an objective which is outlined at the top. This is for the Interviewer to know what the goal of the questions in the section is.
- **Question X**: Main theme questions are found in bold. These questions should be asked by the Interviewer in the order they appear in in this guide.
- Prompt: Prompts should be asked to ensure that the topic is covered. They are intended to encourage the Interviewee to say as much about the topic as possible.
- Probe: Probes should be used as follow-up questions. The guide lists examples of questions but probes can also arise during the Interview depending on where the discussion goes.
- *Scripted Text*: Italicized text is a script to introduce questions or a section and should be read in the order that it is presented in the guide.

Warm up Questions and Follow up

<u>Objective</u>: To ease the participant into the Interview by following up on the Game Session and giving them a chance to share a bit about their own experience.

Thank you for agreeing to participate in this Interview. I will start the recording now if that is okay with you? First, I will ask some questions about the Game Session itself.

Question 1: What did you take away from the Game Session?

Prompts:

- What did you understand the game to be about?
- What was your experience of cooperating with other participants to play this game?
- How did you feel at the end of the Game Session?
- This could be, for example, something about the relationship between different mechanisms (biodiversity or resource regeneration or activism), your feelings on how realistic this was, group dynamics or an interaction with one of the participants/facilitators that was memorable.

Probes:

 How – from whom, during which interaction, through what part of the game – did you take this away?

Boundary Questions

<u>Objective</u>: To gain insight into whether participants identified and reflected on boundaries within the game.

In the post-game survey, you were asked about a tension, or some sort of difference in perspective, language, assumptions, priorities, understanding, goals etc. that may have affected your group work or collaboration. In the next question, I wanted to follow up on this.

Question 2: You mentioned in the post-game survey that one of the tensions – or differences – you experienced in your game was ______. Could you tell me a bit more about this experience?

Prompts:

- Did you as a group of participants agree on what you wanted to prioritize? On how you wanted to play more experimentally or more conservatively? Did you agree on what each of the mechanisms represented?
- How did you address this, if you did?
- Did you notice any differences between the facilitators?
- What made it difficult to address tensions?
- Did you feel like there was room in the game setting to address this or any other tension that arose between you and other participants?

Probes:

- When did this arise? Was it throughout the game or just at one point?
- Were any of the other participants involved in this?
- How did this make you feel?
- Were there other tensions that you encountered?

Identification Questions

<u>Objective</u>: To address the question 'do serious games trigger the Identification learning mechanism, and if so, how?'

Next, I want to ask you a bit about how your norms, assumptions, principles, values and your knowledge, skills, network, attitudes, as well as those of your co-participants affected your experience of the game. You were at a table with people from different backgrounds – both academic and social and cultural and language etc. – and each with different ways of approaching an unfamiliar situation.

Question 3: How did your knowledge/academic background/skills/attitude/values shape the way you played the game? And your co-participants'?

Prompts:

- Were there any surprises for you? This could be something like a statement from another participant that was unexpected or something you noticed that surprised you?
 - \circ Moments of realization?
- You may not have had expertise in land use planning or planetary boundaries and biodiversity protection, but you did bring with you other knowledge that impacted the way you played the game. What knowledge/skills/attitudes/values did you bring to the game?
- What knowledge/skills/attitudes/ did your peers bring to the game?

- How did you work as a team?
- How did you figure out how crop regeneration worked?
- What did you as a team prioritize? Why?
- Was it important to you that biodiversity was protected? That the city was happy? Why?
 - Did the facilitator prompt you to look closer at any of the elements?
 - Looking at the game board again, what do you notice?

Probes:

- Do you think you worked well as a team?
- Did playing this game give you a better understanding of your teammates?

Reflection Questions

<u>Objective</u>: to address the question 'do serious games trigger the Reflection learning mechanism, and if so, how?' This question will be quite open in the Interview and will draw on something that stood out in the post-game survey of each individual participant.

Next, I'd like to ask you about something I found interesting in your post-game survey and how you look back on the game.

Question 4: You mentioned ______ in your post-game survey. Could you elaborate a bit more on this for me?

Prompts:

- Why was this important to you?
- What did you talk about in the debriefing? What stood out to you?
- How did the game stimulate you to notice this?

Beyond

<u>Objective</u>: To bring the Interview to a close and to answer the 'how' part of the research question.

Finally, I wanted to take a step back and look at this research, looking at all the elements that were included before, in, and after the Game Session.

Question 5: There were different parts of this research. You filled out a pre-survey, played a game, participated in a debriefing, completed a post-survey, and are now participating in an Interview. How, if at all, do you think these different moments encouraged you to think back on this game?

Prompts:

Do you think this triggered you to think back on the game because of the type of method
 – e.g., game, survey, Interview, a combination of methods – or because of the questions
 asked?

Probes:

• Now you've participated in all these elements, you've mentioned that you've taken [this] away from the game. What now? Can you apply this to your everyday life?

Closing

<u>Objective</u>: To get any final insights into how the participant experienced the Game Sessions/Interview, how these can be improved in the future, and any final thoughts they may have on the topic.

Thank you again for participating in this Interview and in the Game Session. Before you go, I have two short questions about your experience of participating in this research.

Question 6: How do you feel about having participated in this research? Would you play the game again?

Prompts:

 Is there anything you would have changed about the Interview? About any part of the Game Session?

Question 7: Is there anything else you would like to add?

Prompts:

- About the game?
- About what you took from this research?
- About group work/collaboration?
- About the Interview?

Thank you for taking the time to answer these questions. Once I have transcribed the Interview, I will send you a copy of it and you can let me know if there's anything you'd like changed. I will stop the recording now

13 Appendix 7: List of Codes and Subcodes

Table 10 List and Frequency of Codes and Subcodes

Key Codes	Method							
	Game Sess	sion	Post-Game Si	urvey	Interview		Total	
Key Subcodes	% Game Session		% Post-Game Survey		% Interview		% Total Count	N
Own Perspective	63%	147	34%	10	25%	114	38%	271
Own Perspective: perspective on what happened	5%							
Own Perspective: principles	0%	11	10%	3	5%	22	5% 1%	36
Own Perspective: risk preferences	3%	6	0%	0	3%	12	3%	18
Own Perspective: understanding of	48%	110	170/			20	22%	455
Own Perspective: values	8%	112	7%	2	8%	36	8%	56
Expertise	15%	35	3%	1	19%	86	17%	122
Expertise: assumptions	1%	3	0%	0	1%	3	1%	6
Expertise: attitudes	0%	1	0%	0	3%	14	2%	15
Expertise: knowledge	13%	30	3%	1	14%	62	13%	93
Expertise: not impaction	0%	1	0%	0	1%	4	1%	5
Rec. & Def. Missing	0%	0	7%	2	4%	16	3%	18
Rec. & Def. Others	2%	5	14%	4	19%	85	13%	94
Rec. & Def. Other's Perspective/Expertise:	0%		001		10/		10/	
Roc & Dof Othor's		0	0%	0	1%	4	1%	4
Perspective/Expertise: attitudes	0%	0	3%	1	5%	22	3%	23
Rec. & Def. Other's								
Perspective/Expertise: feelings	0%	0	0%	0	1%	4	1%	4
Rec. & Def. Other's								i i
Perspective/Expertise: knowledge	0%	0	0%	0	2%	11	2%	11
Rec. & Def. Other's								
Perspective/Expertise: risk preferences	0%	0	0%	0	2%	8	1%	8
Rec. & Def. Other's Perspective/Expertise: understanding of	2%	_						
Relating Perspective and	7%	5 17	3%	3 1	<u>8%</u>	36 18	5%	36
Relating Perspective and								
Expertise: differ Relating Perspective and	3%	7	3%	1	2%	10	3%	18
Expertise: similar	4%	10	0%	0	2%	8	3%	18
Understanding a Different Perspective	1%	2	10%	3	6%	26	4%	31
Understand a Different								
difference arise	0%	1	0%	0	2%	10	2%	11
Understand a Different Perspective: what makes	0%	4	1.09/	2	49/	10	20/	20
Openness to Learning	10%	24	21%	3 6	4%	66	3% 14%	96
Openness to Learning: creating learning moments for	0%							
others		1	0%	0	1%	6	1%	7
Openness to Learning: rec. of what has been learnt from others	3%	6	7%	2	5%	24	5%	32
Openness to Learning:		0	170		570	27	570	52
seeking opportunity to learn	7%					~ ~		
Perspective Taking	2%	17	14% 7%	4	8% 8%	36	8% 6%	57
Perspective Taking: actions	2%	4		2	0 %		E 0/	
Perspective Taking:		4	/%	2	6%	29	5%	35
knowledge from perspective of another	0%	0	00/	0	2 0/	Q	10/	p
Tatal Ocum	I	004	0%	0	↓ 2%	0	1%	d

This table depicts all the Codes (light blue highlight) and Subcodes found in this research. The table depicts the frequency that each code/subcode was found in each method as well as the proportion of all codes found in that method represented by a code/subcode. The final two columns indicate the total proportion and count of each code across methods.