AN ABSTRACT OF THE THESIS OF

Fatima A. M. Taha for the degree of Master of Science in Water Resources Policy & Management presented on May 24, 2017.

Abstract approved: Globalization of Water Resources: Examining Social Learning Using Serious Gaming

____

W. Todd Jarvis

This study examined the Water Footprint Computer Assisted Board Game (WFCABG) as a tool for enhancing the social learning of water resources issues surrounding commodities trade. The study engaged 73 students from various countries and professional backgrounds, in two academic settings in two different countries: Oregon State University (United States) and University for Peace (Costa Rica). Data were collected through pre- and post-game surveys, model outcomes, follow-up feedback sessions, and observations. The study survey design was based on the Medema, Furber, Adamowski, Zhou, & Mayer (2016) Social Learning Assessment Framework, which consists of four categories: properties of participants, properties of collaboration, properties of relationships, and properties of knowledge. The simulation was facilitated by the author and tested 12 times. The results showed a significant change in participants' perceptions and knowledge. The least change occurred in the properties of relationships. The chi square analysis revealed that individual characteristic (country of origin) was an important factor that marked the players' outcomes in the WFCABG. The game results were statistically significant and largely close among the 12 groups and across individual players from diverse demographics. The WFCABG simulation had a great effect on learning by increasing the students' familiarity and enriching their understanding of water-related management issues, enhancing their negotiation skills, and increasing the learning.

Globalization of Water Resources: Examining Social Learning Using Serious Gaming

by
Fatima A. M. Taha

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented May 30, 2017
Commencement June 2017

Master of Science thesis of Fatima A. M. Taha presented on May 30, 2017.

APPROVED:

Major Professor, representing Water Resources Policy & Management

Director of the Water Resources Graduate Program

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Fatima A. M. Taha, Author

ACKNOWLEDGEMENTS

The author would like to thank many individuals for their keen interests at various stages of this study to its conclusion.

Dr. Todd Jarvis, the Director of the Institute for Water and Watersheds, College of Earth, Ocean and Atmospheric Science (CEOAS) at Oregon State University, my research advisor who has timely guided my work. His constructive comments and unconditional assistance have helped me to a very great extent to accomplish this work.

The thesis committee members: Dr. Aaron Wolf and Dr. Mary Santelmann from CEOAS, Professor Pieter van der Zaag from IHE Delft Institute for Water Education, the Netherlands, and Dr. Jan Breitling from the University of Peace, Costa Rica for their endless support and cooperation is highly appreciated, Thank you!

Also, I would like to express my sincere gratitude to the following Oregon State University Staff: Dr. Steve Cook, Dr. Shireen Hyrapiet, Dr. Demian Hommel from CEOAS; and to Dr. Desiree Tullos from the College of Agricultural Sciences - Biological & Ecological Engineering; and to Dr. Kelly Biedenweg from the College of Agricultural Sciences - Department of Fisheries and Wildlife for allowing me to recruit their undergrads and graduates' students in this study. Their generous contributions and cooperation brought massive assistance during the data collection stage.

Million thanks for Dr. Jamon Van Den Hoek from CEOAS, my Graduate Council Representative, his invaluable ideas have kept the study on focus.

I also would like to acknowledge Professor Olivia Sylvester, Assistant Professor in the Department of Environment and Development and Professor Manish Thapa from the University for Peace in Costa Rica for their help in the early phase of the project (approval of the Institutional Review Board at the University for Peace).

ACKNOWLEDGEMENTS (Continued)

I am deeply indebted to all of whom who made this dissertation possible: Oregon State University and University for Peace students, Dr. Ross Ryan and Mr. Esteban Gutierrez from the University for Peace for their participation. Their contributions are greatly appreciated and sincerely acknowledged for bringing the research into existence.

My deep appreciation goes to Sarah Burch, a Ph.D. candidate from the Water Resources Engineering at Oregon State University for her consistent advice while testing the game and answering my endless inquiries. Mr. Joel Gorder from the College of Science, Statistics Department at OSU for providing statistical advices. Also, I would like to extend my sincere gratitude to Ms. Caterina Tadlock from The English Language and Cultural Institute, Monmouth, Oregon and Ms. Caryn Davis from Cascadia Editing, Philomath, Oregon for editing the manuscript.

Above all, this thesis is dedicated to my parents Amira Kamil and Abdelbagi Taha, my siblings and my love Abubakr Ahmed. Without their patient and support, the completion of this work could not have come to fruition.

Shukran Jazeelan!
Fatima Taha

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Page

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

GLOBALIZATION OF WATER RESOURCES: EXAMINING SOCIAL LEARNING USING SERIOUS GAMING

CHAPTER 1 - INTRODUCTION

1.1 Background

Freshwater is vitally important not only to human life and well-being but also to the environment. As the human population increases, however, the scarcity of this resource may reach crisis levels (Hanjra & Qureshi, 2010). Water is used daily in many activities, namely drinking, cooking and washing as well as in the production of many commodities such as food, beverages, clothes, paper, leather and many others. For example, to make a standard cup of coffee (125 ml) requires more than 1,100 drops (55 ml) of water to produce one drop of coffee. This means requiring 36.9 gallons of water to grow the coffee beans (Chapagain & Hoekstra, 2003) as well as the energy required to ship, roast the coffee beans and heat to brew the coffee. However, in recent years, concerns about the water requirements of ecosystems have not been carefully assessed (Smakhtin et al., 2004).

Researchers tend to examine environmental quality issues after a water crisis (Work Group for Community Health and Development, 2016). However, other scholars argue that there is a considerable change in the nature of the international discussions about the requirement of water for the environment towards achieving both economic development and environmental sustainability (Gleick, 1996). Hence, water requirements for ecosystems have been discussed at length but much less has been carried out to protect the water needs of the environment.

Moreover, the growing demand for water from various sectors, e.g. domestic (drinking and sanitation), industry (food production and services), power (electricity), agriculture (crop irrigation and watering of livestock), and the environment (wetlands and floodplains) leaves this precious resource subject to scarcity and the systems that depend on it to water stress (Hanjra & Qureshi, 2010). Furthermore, the hierarchal structure and the asymmetry of interests and power among stakeholders have added another level of challenges in the management of water resources.

Given the current gravity of problems (population growth) and the potential global crises such as climate change (flood and droughts), it's predicted that the number of people living in water-stressed regions will increase (IPCC, 2008) putting concerns about increasing the risk of wars over this finite resource (Buhaug, Gleditsch, & Theisen, 2008). The above factors have been challenging the sustainability of water resources at all scales (nationally, regionally, and internationally).

1.2 Problem Statement

Disputes over water resources are primarily due competition over resources, illegitimate/ineffective water governance institutions, and unclear role of law over water rights (USAID, 2014); disagreement over data, relations problems, lack of understanding of interests, structural power asymmetry, and competing values (Delli Priscoli & Wolf, 2009).

“Serious games” have been used as conflict resolution tools to provide a shared platform for understating, as well as for training and learning in many water resources negotiations (Medema et al., 2016; Rumore, 2010; Savic, Morley, & Khoury, 2016; Zielke et al., 2009). With the increased use of these types of exercises, there is a need to address their usefulness as tools in increasing social learning.

Many studies have been carried out to address different types of learning impact that emerge from the different serious games; transformative learning by measuring changes in understandings, beliefs, and behaviors (Rumore, 2010); social learning is transboundary water resource management, case study: St. Lawrence River Basin (Medema et al., 2016); interactive learning in the application of serious gaming in the field of water systems management and planning (Savic et al., 2016); and active incremental learning “step-by-step” by making trials and errors using the Ravilla game (Evers, 2017).

However, this study considers addressing the learning directly by linking the geography of the game (e.g. the characterizes of the participants; where it is played, and who is playing? what is their country of origin? what is their level of education? gender? age/experience? and other attributes) with the simulation outcomes. In this study, the context in which the game was tested is University staff and students (undergraduate and graduate levels) playing in two different universities; Oregon State University in the United States (OSU) and University for Peace in Costa Rica (UPEACE).

1.3 Research Questions

- Research Question #1 (RQ1): The process of the Globalization of Water Management game is designed to influence the negotiation strategies of the participants during later rounds in the game. Throughout the playing process, did the game influence the negotiations in later rounds? Did the game make a significant social learning impact?
- Research Question #2 (RQ2): What is the relationship between the participants' background and social behaviors that derive the outcomes of the game?
- Research Question #3 (RQ3): Which of the options, the game outcomes or the baseline situation represents the best scenario?

1.4 Significance of the Research

With the increased use of serious gaming in the field of conflict resolution, there is a need to better understand the learning impact of playing serious games. This study investigates the metrics of participants learning by examining four metrics of participant learning (Medema et al., 2016) namely:

- Properties of participants: the participants' characteristics: educational background, water culture (country of origin), age, gender, and the professional background.
- Properties of collaboration: communication, interactions, and collaboration within the group members and between the groups.
- Properties of relationships: the negotiation style, conflict resolution skills, and barriers to interaction.
- Properties of knowledge: the pre-requisite knowledge and the developed shared understanding.

The learning is tested using computer-supported board games trials conducted in two different countries.

- Pre- and post-game surveys of knowledge of facts e.g. specific terms and water use patterns.
- Changes in participant strategies during course of play.

Why use board games to study learning through playing serious games? Because board games permit participants to talk to each other and have discussions about issues that emerge during the game, as opposed to other types of games, such as role plays or web-based games. Although role plays allow role-playing participants to talk, the participants' actions are restricted to following their role description. For example, the negotiations experts Lawrence Susskind and Shafiqul Islam (2012) points out that in Indopotamia role-play simulation, all players could possibly reach an agreement if they modify their options, however, these options should be consistent with their mandates. This restriction imposed by adhering to the role can limit a successful implementation of potential joint solutions.

1.5 List of Hypotheses

Only one board game, the Water Footprint Computer Assisted Board Game (WFCABG) (sometimes it's referred to as the Globalization of Water Management game) was used for the game trials in this study. This single game was selected in order to keep the scope of the project within the bounds of feasibility and to focus on a specific research question - how the perspective of participants from different geographic regions and different groups might influence participant experience and outcomes of playing the game. The game was developed by the University of Twente in the Netherlands, based on the theoretical framework of Hoekstra & Chapagain (2008) in their book "Globalization of Water: Sharing the Planet's Freshwater Resource," by with the support of the World Bank Institute (Hoekstra et al., 2009).

In this study, participants were recruited purposively from different groups to play the game, in order to investigate and understand the process and the outcomes reached by individuals with different technical and geographical backgrounds and water cultures (according to their country of origin; water-rich vs. water-poor). However, the participant's country of origin might not entirely best represent the participant's water culture. For instance, within one country the scale of water availability varies (urban vs. rural, wet vs. dry). Due to this limitation, it's not true to generalize the water culture for the individuals from the same country. In this study, this limitation is not fully addressed, and the term water culture is defined and determine as from where the participant is from.

The game and the survey responses were tested against three sets of null hypotheses. This assessment helped to determine whether to accept or reject the hypotheses. In response to each question, the following list of hypotheses was tested against the observed outcomes, as shown in Table 1.1.

Table 1.1 List of multiple alternative hypotheses for each research question and predictions

Research Question		Null Hypothesis	Alternative Hypotheses
RQ1	Did the perception of the participants change?	H_1: Hypothesize seeing no pattern.	$H_{1,a}$: Hypothesize seeing pattern.
RQ2	Are the people from water-rich countries water-profit driven?	H_2: water-rich country variable and WFP_i variable are independent.	$H_{2,a}$: water-rich country variable and WFP_i variable are not independent.
RQ2	Are the people from water-poor countries focused more on negotiations gains?	H_3: water-poor country variable and DI_i variable are independent.	$H_{3,a}$: water-poor country variable and DI_i variable are not independent.

1.6 Research Objectives

The main objective was to address the impact of serious gaming in enhancing the learning of people coming from different geographic settings (e.g. rainforest vs. arid regions) over water negotiations. The specific objective of the study was to explore the important components of the strategic choice process in the negotiation over water management.

1.7 Scope

This research describes the application of serious games for social learning in two academic settings: Oregon State University in the United States and University for Peace in Costa Rica. The study does not debate the concept of "water footprint" vs. "virtual water", but rather the concept of serious gaming in improving the negotiation training and learning using quantitative analysis methods. However, the evaluation of the data can also be determined using qualitative analysis techniques based on intangible and unquantifiable information such as unstructured observations, interviews, and descriptions in order to understand the findings rather than measure it. In this study, the analysis is conducted in a quantitative manner rather than a qualitative one. Comparison with the social learning impact of other types of serious games is beyond the scope of this study.

1.8 Structure

The following section provides a literature review of three concepts: serious gaming, water footprint, and social learning in water resources management. It also describes the different types of serious games available in the field of water resources management. Following this literature review, there is a section describing the methodology used in this study to achieve the research goal: *to improve our understanding of the impact of serious gaming in enhancing the learning of people coming from different geographic settings*. Next, data are analyzed, and the results are presented in three parts, mainly by looking at the results in light of the research questions. This thesis concludes with a discussion of the study results and the findings and how the outcomes compare with those expected under the different alternative hypotheses relate to each research question.

CHAPTER 2 – LITERATURE REVIEW

2.1 The Concept of Serious Games

The time-honored term "serious gaming" was introduced by Clark Abt in his 1970 work: "Games may be played seriously or casually. We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not, or should not be, entertaining" (Abt, 1970). The idea behind is to bring both the simulation and the gaming aspects into one single activity (Rusca, Heun, & Schwartz, 2012). A Google search on the term "serious games" provides about 2,130,000 results (04/14/2017).

Serious games have been developed and are increasingly played to serve as educational interactive learning tools and to inform the dialog in a variety of sectors including Health (Wattanasoontorn et al., 2013), Education (Ulicsak, 2010; Hamdaoui et al., 2015), Social Change (Ritterfeld et al., 2009), Market and Corporation (Susi et al., 2007), Modeling and Programming (Gintis, 2000), Business (Werbach & Hunter, 2012) and Water Resources Management (Barreteau et al., 2000; Castella et al., 2005); Salen & Zimmerman, 2003; Boissau et al., 2004).

The primary function of these games is to allow the participant to think outside the box. Susi et al. (2007) stated that "serious games allow learners to experience situations that are impossible in the real world." However, Green (2002) argued that the "usefulness and realism of role-playing are often contrasted with the limitations of life decisions." Given the two perspectives, serious games proved to bridge the knowledge gap between policy and science and bring scientists and stakeholders in one negotiation table (Craven et al., 2017). Through role-plays and simulations, stakeholders may come to an agreement that is best for the people and the resource.

2.1.1 The Use of Serious Games in the Negotiation Training

The promise of role-plays and serious games is in their potential for educating, promoting social learning, modeling consensus-building, decision-making, problem-solving, catalyzing the dialogue, and informing the public as well as the stakeholder of the dimension of an issue and the possible solutions. Although the purpose is not merely entertainment (Hamdaoui et al., 2015), players will also have fun while playing the game. However, the term "serious" reminds the participants that the initial objective is learning and informing the dialogue.

The main aim is to have a "meaningful" act where "players make sense of the relation between actions and outcomes during the game, rather than to what players might learn from the game about anything other than the game itself" (Salen & Zimmerman, 2004). Connolly and others (2012) identified more than 129 papers on the learning impact of serious gaming. The most frequently occurring impact was "knowledge acquisition/content understanding."

In the field of Natural Resource Management and Environmental Policy, system thinking techniques (e.g. serious games) proved to provide a better understanding of the systematical complexity of resource conflicts where participants offer to find mutual solutions (Daniels & Walker, 2012). This kind of collaborative learning tools can help to fill the knowledge gap and narrow the differences in values between individuals (Innes & Booher, 1999). Thus, participants get to recognize the importance of consensus building particularly in the initial stages of the game to change players' actions e.g. build new relationships and ideas (Innes & Booher, 1999). Shubik (1975) stated that "an extremely valuable aspect of operational gaming is the perspective gained by viewing a conflict of interests from the other side."

With the increased use of transdisciplinary teaching approaches in the field of water management, many serious games offer to create a safer environment in which students can develop a better understanding of various aspects such as collaboration, capacity building, leadership, and conflict resolution among others.

One benefit of using serious games, as pointed out by Squire and Jenkins (2003) is to introduce new concepts. For example, computer-supported game such as "The Globalization of Water Role Play" (Hoekstra, 2012) brings participants from different disciplines to experience national water management decisions in the trade of commodities that may in a way or another affect national water scarcity and domestic demands. The game allows the participants to get involved in a life simulation of negotiation processes and make clear decisions by performing the role of individuals (representing a country vs. the globe) as well as examining the water footprint concept.

It is very important to acknowledge the vital role of "debriefing" to generate and reinforce the learning that emerges from playing serious games (Connolly et al., 2012). To a large extent, many measurements addressed the potential effects of serious games. For instance, Baldaro et al. (2004); Durkin & Barber (2002); and Squire et al. (2005) pointed out to the effectiveness of serious gaming as a tool to enhance the social learning, e.g. negotiations, engagement, and collaboration. Others purposes of serious games include:

- To support policy analysis (Bots & Daalen (2007); Innes & Booher (1999); Mayer et al. (2013)) where the game is the driver to come up with possible solutions.
- For training and as educational tools (Hoekstra (2012); Rusca et al. (2012)), and for research (Barreteau & Page, 2003).
- To embrace unfamiliar conditions and retain theoretical concepts in an experiential learning environment (Kaufman et al. 2015).

2.1.2 Types of Serious Games

There are many types of serious games such as role plays simulations, computer-assisted games, board games, fully computerized games, and web-based games. These games have been developed and advanced using methods ranging from dramatic representation to discussion groups (Farolfi et al., 2013) to allow and empower people engaged in real life negotiation and problem-solving to come up with creative, innovative, and imaginative resolutions.

Raiffa (1982) pointed out that in some of the games he played, a considerable variability occurred among the different groups of participants. In the future, these types of experiences are anticipated to pay off their usefulness and offer very valuable key lessons. To illustrate, and as pointed out by Rusca et al. (2012), in the field of water management there is a changing demand for skills such as team building, consensus building, and negotiations. Thus, serious games offer ways to develop the aforementioned skills for water managers. Table 2.1 summarized some examples of serious games in the field of water management.

Table 2.1 List of water-related serious games (adapted from Hockaday, Jarvis, & Taha, 2017)

Type of Game	Available games	Example of a game	Scenario
Board game & Role Play	• River Basin Game (Lankford, Sokile, Yawson, & Lévite, 2004)	River Basin Game	A physical representation of catchment management strategies, river flow intakes, and irrigation systems in which involves dialogue and coordination between water users and decision makers (Lankford et al., 2004).
Role Play	• Science-Based Role-Play Simulation Exercises (Rumore et al., 2016) • Indopotamia (Islam & Susskind, 2012) • Dueling Experts (Jarvis, 2014) • Pandal River Basin (Watson, 2015) • Sandus River Basin (Wolf, 2010)	Science-Based Role-Play Simulation Exercises	A climate change adaptation simulation to enhance the understanding of the associated risks of climate change and ways to adapt to these changes through face-to-face decision-making simulations (Rumore et al., 2016).
Role Play Computer Assisted (Spreadsheet)	• Globalization of Water Management (Hoekstra & Chapagain, 2008) • Ravilla (Fantini, 2017) • Tragedy of the Groundwater Commons (Isaak, 2012)	Globalization of Water Management	A game designed to depict the link between the national water self-sufficiency and the global water dependencies from the consumption of natural fibers, food, and bioenergy. It is based on the framework of Hoekstra & Chapagain (2008) to assess the impact of the global food consumption, production, water resources use and its management.
		Ravilla	A transboundary river basin management role play simulation game supported with a complex spreadsheet in which human behaviors are included in the management decisions when dealing with many uncertainties and incomplete information (Fantini, 2017).
Board Game	• California Water Crisis (Twu, 2014) • Santiago (Pelek & Hely, 2003)	California Water Crisis	A game to find solutions to California's drought based on past, present, and future scenarios. In the game, there are three regions with different resources, weaknesses, and strategies. Best reputation wins.
Online Game	• Aqua Republica (Chew et al., 2015) • River Balancer Game (The Omaha District US of Army Corps of Engineers, 2017)	Aqua Republica	A water allocation game that combines both real-time modeling (MIKE HYDRO) with real-life data. This unique type of game can help stakeholders to make realistic decisions (Chew et al., 2015).

The challenge in each of the above-listed games lies in the demands the game places on the game user in terms of setting up the game, ensuring the objectives are achieved, ensuring the delivery of information, experience and knowledge about the inherent concepts in the game model setting (Rusca et al., 2012). However, each game facilitates the learning by integrating various aspects of water and allowing the creation of knowledge.

2.2 The Globalization of Water Management

The introduction of the globalization of water management paradigm by Hoekstra and Chapagain (2008) for the use of water in commodity production (the link between national water consumption and international trade, how domestic water depletion and environmental burdens are often closely tied to global trade) began a debate of how water resources should be managed to ensure the sustainability of the resource.

Scholars argue that for efficient water use, there is an intrinsic link between national water resources management decisions, as well as environmental policies, and the global conduct of other nations in terms of how they manage their resources (Hoekstra & Chapagain, 2008). However, the water footprint concept is imperfect, and many scholars have their own reservations (Chenoweth, Hadjikakou, & Zoumides, 2013; Perry, 2014; Wichelns, 2015; Mcmanus & Haughton, 2006; Launiainen et al., 2014; Jia, Long, & Liu, 2017).

The concept has been described as "problematic" when it's applied at various scales as it best be used at the national levels (Mcmanus & Haughton, 2006) and as "an ambitious tool" to promote a sustainable water use, as it lacks the contextualization of water-related impacts and the use of water in sensitive national environmental zones (Launiainen et al., 2014). Also, the water footprint concept was labeled as being "wrong, fallacious and misleading" because it based resources allocation decisions on only the production factor while many other production factors are omitted in the theoretical basis of virtual water trade (Jia et al., 2017). Chenoweth et al. (2013) stated that "the water footprint in its conventional form solely quantifies a single production input without any accounting of the impacts of use, which vary spatially and temporally." Perry (2014) referred to the water footprint concept as "incorrectly assessed on an absolute, rather than a relative basis."

Scholars pointed that although the water footprint concept brought questions about its usefulness and the policy implications regarding international trade or national water use (Chenoweth et al., 2013; Perry, 2014), at the same time it raised awareness about the environmental impacts (Mcmanus & Haughton, 2006) and the water use in supply chains by providing an indicator of water use (Chenoweth et al., 2013).

Despite the criticisms of the water footprint concept by many scholars, the WFCABG - a serious game concerning the Water Footprint concept - was used and tested in this study. The reason behind choosing the WFCABG is to address the impact of water management strategies in water-rich/water-poor countries on the water footprint indicator.

2.2.1 The Introduction of the Water Footprint Concept

The "water footprint" concept by Chapagain and Hoekstra (2003), defined as the amount of water embedded in various products focuses only on the use of water to ensure the sustainability of the water resource. There are two important terms in the concept of the water footprint: the "internal water footprint" and the "external water footprint." The explanation of the difference between the two terms, as defined by Hoekstra and Chapagain (2007), is as follows:

- The internal water footprint (IWFP) is defined as the volume of water used (evapotranspired) to produce goods and services from domestic water resources to be consumed by its inhabitants (e.g. the sum of the crop water consumption from national resources minus the virtual water export (Fader et al., 2011)).
- The external water footprint (EWFP) is defined as the volume of water used in other countries to produce goods and services imported and consumed by the inhabitants of a country. Both IWFP and EWFP have a green water and a blue water component.

For example, California heavily depends on external water resources from outside the state borders, around 38 million acre-feet of water represents California's IWFP whereas half of this amount is used for producing goods that are then exported outside the state (see Figure 2.1 below). Also, an amount of 44 million acre-feet of water is used in the production of goods that are imported into California, representing California's EWFP (Fulton, Cooley, Gleick, Ross, & Luu, 2012).

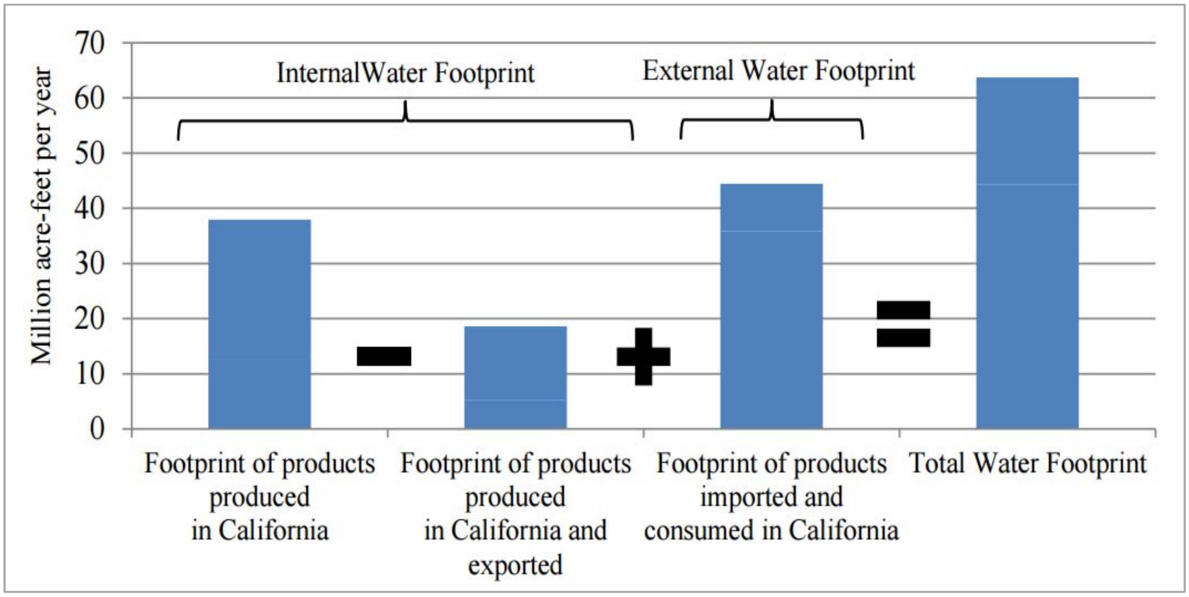

Figure 2.1 Internal and external water footprint (Fulton et al., 2012)

The water footprint is an indicator of water use, both directly (consumption, evaporation, and pollution) and indirectly (production) (Water Footprint Network, 2016b). The water footprint comprises three uses: (1) the consumptive use of green water (rainfall/evaporation moisture stored in soil strata), (2) the consumptive use of blue water (surface water and groundwater), and (3) the use of greywater (pollution) (Hoekstra, 2008).

Hoekstra (2008) differentiates between the footprint of a consumer and a business as follows:

- The water footprint of a consumer = ∑ direct water use (e.g. drinking) + indirect water use (production and services)
- The water footprint of a business = ∑ direct water use (e.g. production) + indirect water use (supply chain)

2.2.2 Water Footprint and Virtual Water

It is important to distinguish between water footprint and the concept of "virtual water" (see Figure 2.2). Velázquez et al. (2011) expressed that there is a clear difference between the concepts of virtual water and the water footprint. The former is from the perspective of production while the latter is from the point of view of consumption. Clear definitions are needed because these two concepts are often incorrectly used as synonyms.

Virtual water has been defined by Allan (1997) as the "*water in the global trading system*." It represents the total water used (volume per time) to produce the good (e.g. drinking water, food, electricity, clothing) at the place of production or consumption. The production of the good may not contain the actual water amount.

Figure 2.2 Virtual water production plus distribution and water footprint (Velázquez et al., 2011)

One can easily perceive that element of the water footprint are also closely linked to virtual water (Water Footprint Network, 2016a). Figure 2.3 below presents the inherent linkages between national water consumption and the global water use.

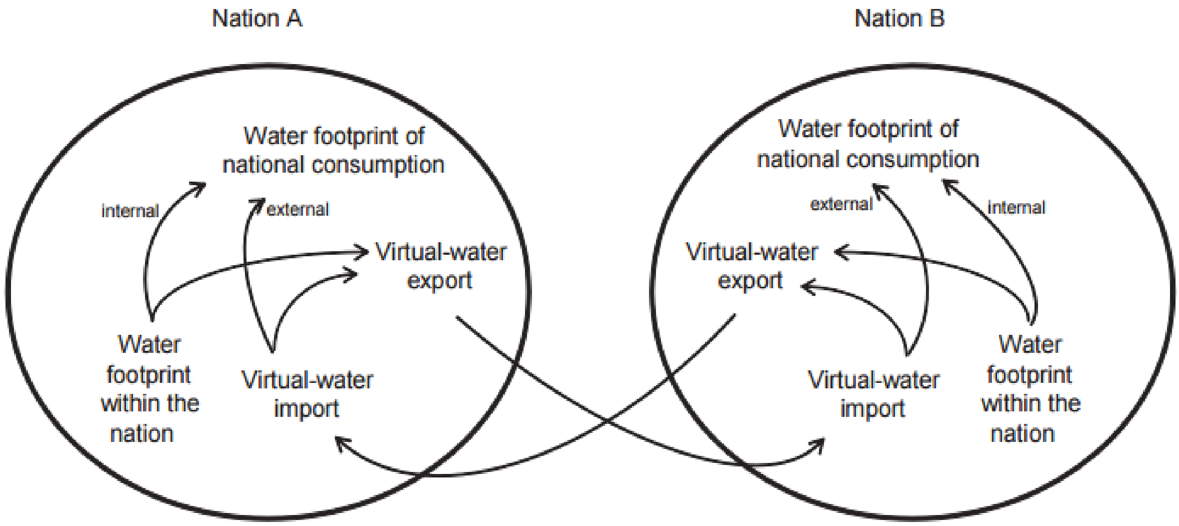

Figure 2.3 The relation between the water footprint of national consumption and the water footprint within a nation (Hoekstra et al., 2011)

This clarification also requires assigning responsibilities when adopting wise water management and production strategies. The study presented here provides a lens for game participants to better understand this linkage, tackling the issue of water footprint by playing the WFCABG. Figure 2.4 demonstrates the impact of the extra production of commodities if consumed or purchased/not purchased.

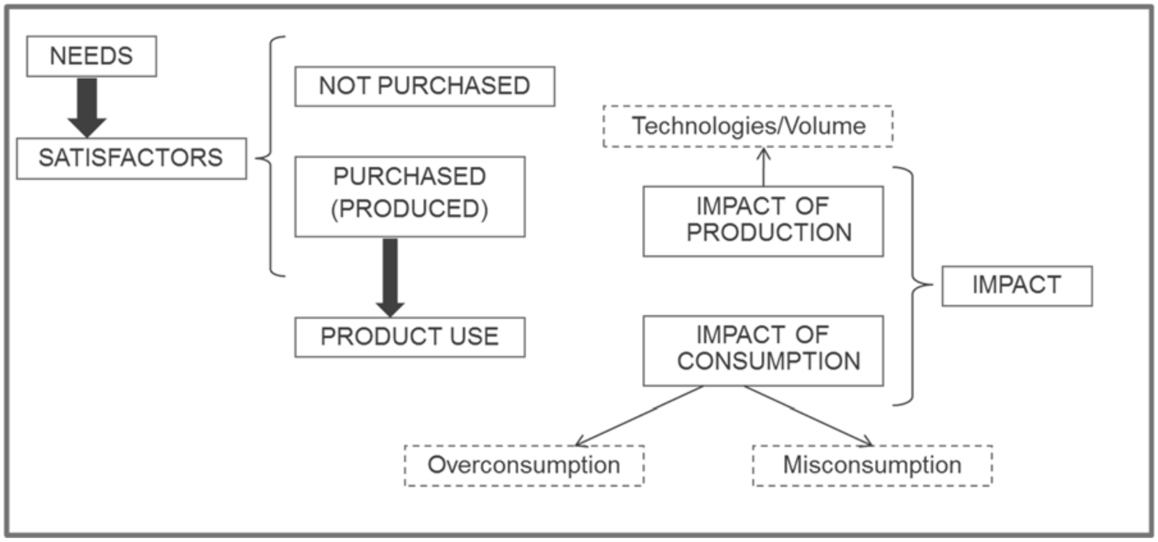

Figure 2.4 Production responsibilities (adapted from Princen, 1999)

2.3 Social Learning in Water Resources Management

2.3.1 Social Learning

One problem surrounding water resources management can come from the lack of understanding of others' interests (Delli Priscoli & Wolf, 2009). Serious games can serve as an educational learning technique as well as a platform for shared understanding. With the increased use of this kind of technique, there is a need to address the usefulness of these tools, especially if the desired impact is increasing social learning.

Social learning is defined as a "normative goal" by Medema and others (2016), and it is an important measurement to assess the impact of serious games. Many studies have explored the role of serious games in order to capture social learning (Wal et al., 2016). To do it correctly, there is a need for a mechanism to evaluate the learning. Westera (2017) suggested a "computational modeling approach" to examine learning outcomes achieved when playing serious games. The model allows exploring quantitative requirements between the outcomes and the game variables. Dent (2016) recommended making visual and analytical presentations of the negotiation/bargaining quantifiable outcomes, such as plotting the student's learning and presenting it to them. However, these kinds of data can only be meaningful if explained properly. In addition, standardization of the data can be challenging in serious games, particularly when tracking the change in learning (Serrano-Laguna et al., 2017).

2.3.2 Blending Social Learning in the Use of Serious Games

In water negotiation training, players are placed in situations comparable to real-life situations and required to respond to a specific set of conditions as they strive to resolve water-related problems. These simulations allow facilitating the learning process through practical applications of theoretical concepts (Farolfi et al., 2013). Raiffa (1982) asserted that one of the limitations in game simulations is setting all the aspects of complex negotiations issues; however, the enormous value of these types of simulations is in enhancing learning is worth the endeavor.

In preparing for serious games, some players have had time to invest in creating options and strategies between their team members as well as between the other teams. The U.S. Army Corps of Engineers Rock Island District, Institute for Water Resource carried out a "Multi-Hazard Tournament" on water-related disasters and risks. The results of the post-tournament survey showed that 71% of the participants stated that they would use the insights gained from the tournament results in future decisions (Institute for Water Resources US Army Corps of Engineers, 2016).

Moreover, computer-supported games are increasingly used to resolve complex problems in the field of natural resource management, with a subsidiary goal of “social learning” as part of the solution process. An important driver to enrich participants learning is “feedback/reflection” after the simulation (Wal et al., 2016).

CHAPTER 3 – RESEARCH METHODOLOGY

3.1 Research Design

The research methods used here constitute a mixed-methods approach, combining qualitative and quantitative methods. These include surveys, model outcomes, follow-up feedback sessions, and observations.

3.2 Research Sample

The target group for participants consisted of students and staff from water-related programs and similar natural resources programs from both OSU and UPEACE. Recruitment of participants with a solid background in water resources management was categorically unsuccessful. Reasons for declining the invitation to play the game included small numbers of enrolled students and conflicts in course-schedules.

The total enrollment number (TEN) equaled the sum of the number of users multiplied by the number of times the game was played. The initial target was to achieve a TEN of 120, which meant that the game had been played 10 times with 120 users playing (12 users in each simulation). However, in this study, 73 students were recruited to participate in the study: 14 students from UPEACE (including two staff members and one visiting professor) and a total of 59 undergraduate and graduate students from OSU. Thus, the TEN for this study was 73.

Figure 3.1 gives the sample backgrounds for research participants. Many (34.25%) of the participants had backgrounds in the biological and physical sciences. Approximately 5% of participants were from Uncategorized fields of study, such as business, human development, and accounting, among others.

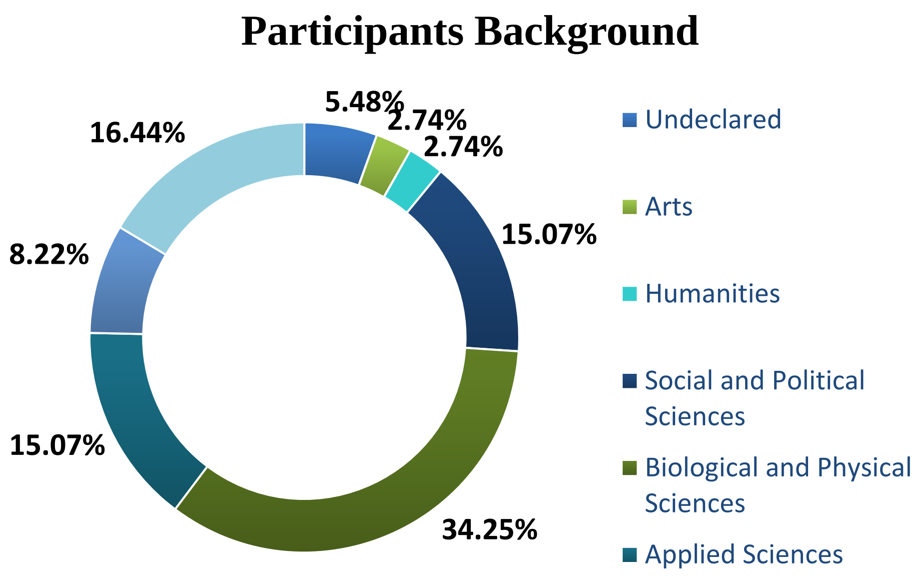

Figure 3.1 Background of participants.

3.3 Data Collection

3.3.1 Instruments for Collecting Data

The study data were collected via oral invitations, game-model simulations, pre- and before-game surveys, observations, and follow-up feedback sessions.

3.3.1.1 Oral Invitations

All participants were recruited via vocal communication/invitation and emails. During this communication, the goal and the objective of the research were described, along with how their contributions and insights would add to the study, how the data they provided would be used, and the voluntary nature of the participation process. They could decide whether to enroll in the study or not. Participants confirmed their consent at the start of each simulation. The research participants (game players) were individuals from different academic backgrounds, ages, and water cultures. Once a group of at least four people had been formed, the players were informed about the venue and time.

At OSU, classes with large enrollments (80 – 180 students per class) were contacted to seek volunteers, as well as international student clubs. Several OSU staff members were curious to hear more about the project and the relevance of the game to their courses. Most of the staff offered extra credits to their students for participation in the study and for writing a reflection essay after playing the game.

However, this level of interest in the game by students and staff was not the case at UPEACE. Students from UPEACE either have morning or afternoon classes; playing the game was offered only in the afternoon, given my class schedule. This limitation narrowed the sample to those who had only morning classes. Additionally, the game topic – water resources management – did not seem to be of interest to most UPEACE students. Most of whom are from fields such as media, human rights, gender, and peacebuilding.

3.3.1.2 Playing the Serious Game Simulation

3.3.1.2.1 Role Play on the Globalization of Water Management

The user license of the game was accessible from the University of Twente in the Netherlands and the Water Footprint Network, who invented the board game. They developed the game inspired by Hoekstra and Chapagain (2008) Water Footprint and Virtual Water Trade Assessment Framework. The game is a case study of the operational context of water management decisions at the national levels for domestic production as well as for global market trade. Additionally, the game provides a social toolkit to learn about several concepts related to water footprint, virtual water, and comparative advantages and disadvantages.

The game features four essential parts as follows:

Four country board-games

There are separate game boards for each country in the board game. Each game board comes with a white background representing a country. The label of each country is situated with a bold font in the right corner e.g. **Country D** as shown in Figure 3.2.

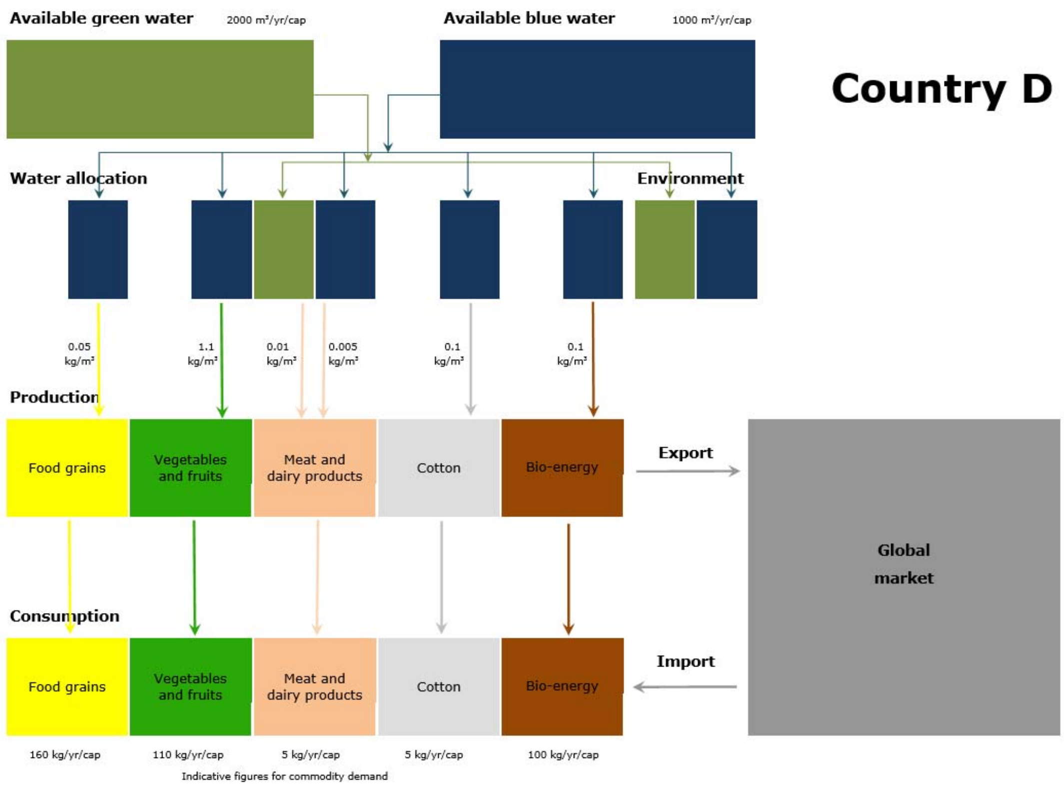

Figure 3.2 Country game-board (Water Footprint Network, 2017)

Each country varies regarding its climate, water availability, water productivity, and economic development. The countries are as follows (see Figure 3.3):

Country A: *France* (similar examples: wet parts of USA, Australia, and Japan)

Country B: *Spain* (similar examples: Western USA)

Country C: *Indonesia* (similar examples: Brazil, Southern China, and the Philippines)

Country D: *Kenya* (similar examples: Mexico, Mali, Northern China, and Sudan)

Figure 3.3 Map of board-game example countries (Credit Taha)

The model parameters are as follows in Table 3.1:

Table 3.1 Model parameters (adapted from Hoekstra, 2012)

	Country A	Country B	Country C	Country D
Climate	Temperate	Mediterranean	Tropic-Wet	Tropic-Dry
Economy	Rich	Rich	Poor	Poor
Water	Water-Rich	Water-Poor	Water-Rich	Water-Poor

In the game board, the blue rectangle refers to the amount of available blue water (both surface water and groundwater) in m^3/yr/capita. Similarly, the green rectangle refers to the amount of available green water (rainfall/evaporation) in m^3/yr/capita.

The quantities of commodities produced should be enough to meet the domestic demands. However, as it is the case in actual life, commodity production may be less than the needed domestic demands (deficit). On the other hand, these countries may also have produced a surplus of other products, which can be used for export and exchange with other commodities to meet the areas of deficit. The gray right-shaded square on the game board represents the global market in which commodities (for import or export) can be exchanged. Global negotiations can result in no/gaining commodities to fully/partially meet national demands.

Some modifications to the original game procedure were used in this study; countries could carry over their non-traded overproduction to the next round (next water-allocation year) and use it to partially meet their demand, hence making less production from that specific product(s). The goal of this modification was to ease the burden on many countries. Nevertheless, if the non-exchanged commodities were not allowed to be used, in that case, the extra production was considered “waste.” Both scenarios were taken into consideration in the analysis in Chapter 4.

Role-play sheets

There are three main role-plays for each country: (1) The Head of State, responsible for decisions based on national economic benefits, (2) the Minister of Environment, responsible for water allocation for environmental sustainability, and (3) the Minister of Trade and Foreign Affairs, responsible for the international negotiations (Water Footprint Network, 2017). The role-players are expected to represent the national interests of their respective countries at the global trade meetings. Each country's representative may differ regarding their preferences or goals in terms of meeting the environmental requirements, maintaining good relations with other countries, or meeting their domestic demand, and so forth.

A computer-assisted model

A dynamic spreadsheet was used to record each country's decision in each round to measure the six development indicators. These development indicators are shown below in Table 3.2, and they are the result of each country's individual action in each round. The calculations of these indicators were introduced at the beginning of each simulation to allow players to think of ways to improve their national development conditions by either meeting their domestic food demands or performing better actions (water saving, meeting environmental requirements, and more negotiation gains). These development indicators can be reached through the selection of the proper type and quantities of water units needed for national production.

Table 3.2 National development indicators (adapted from Hoekstra, 2012)

Category	Indicator	Unit	Calculation
Food supply	Grain supply	kg/yr/capita	C_1 = Production + Import - Export
	Vegetable and fruits supply	kg/yr/capita	C_2 = Production + Import - Export
	Meat and dairy supply	kg/yr/capita	C_3 = Production + Import - Export
Economic welfare*	Welfare	-	Welfare = 1/3 x [F + C + B]
	Food supply indicator (F)	-	$1/3\left[\left(\frac{\text{Consumption}_{\text{food-grains}}}{\text{Consumption}_{\text{food-grains,ref}}}\right) + \left(\frac{\text{Consumption}_{\text{vegetables and fruits}}}{\text{Consumption}_{\text{vegetables and fruits,ref}}}\right) + \left(\frac{\text{Consumption}_{\text{meat and dairy products}}}{\text{Consumption}_{\text{meat and dairy products,ref}}}\right)\right]$
	Cotton supply indicator (C)	-	$\text{Consumption}_{\text{cotton}}$ / $\text{Consumption}_{\text{cotton, ref}}$
	Bio-Energy supply indicator (B)	-	$\text{Consumption}_{\text{Bio-energ}}$ / $\text{Consumption}_{\text{Bio-energy, ref}}$
Environment	Meeting environmental flow requirements	%	(Water Availability – Water Use) / Environmental flow requirement) x 100
National water footprint	Green water footprint	m^3/yr/capita	WF_g= consumed products that were produced from green water
	Blue water footprint	m^3/yr/capita	WF_b= consumed products that were produced from blue water
	Water footprint % above the equal global water share	%	Share = 100 × (Total Water Footprint / Global Water Availability) per capita
Water saving	National green water saving	m^3/yr/capita	S_g= Net import of supplies produced with green water / green water productivities
	National blue water saving	m^3/yr/capita	S_b= Net import of supplies produced with blue water / blue water productivities
Dependency	Dependency on foreign resources	%	D = 100 × (External water footprint / Total water footprint)

*Cx,ref = reference consumption of the X commodity as given in the consumption figures in Table 3.3.

Other materials

The game comes with water and commodity notes, role descriptions or handouts both for the participants and for the facilitator, data sheets for each country and a PowerPoint presentation for instructions at the beginning of the game as well as for feedback at the end of the game. In the PowerPoint presentation, explanatory slides on the game sequence were added – which applied to all the countries – and slides were added on the water-related concepts inherent in the initial design of the game. These concepts were discussed, after playing the game, with the goal of solving any problems beyond the game setting and not limited to any boundaries. At the end of the game, participants were asked to debrief and reflect on the extent to which they had learned about these concepts.

Playing the game involved three rounds, with the first round taking the most time in order to accommodate learning the game. In total, the game took a maximum of three hours to complete all of the rounds. Each round consisted of three types of decisions, as outlined below.

- Stage One: Water Allocation Decision

In every round, each country had to make a water-distribution decision to produce three food-related commodities: food grains, vegetables and fruits, and meat and dairy products. In addition, cotton and bioenergy were produced for national consumption (see Table 3.3 for the national consumption for each product for each country).

Table 3.3 Indicative figures for commodity demand in kg/year/capita

Commodity demand (kg/yr/capita)	Country A	Country B	Country C	Country D	Average
Food grains	160	160	160	160	160
Vegetables and fruits	150	150	110	110	130
Meat and dairy products	80	80	5	5	43
Cotton	25	25	5	5	15
Energy crops	100	100	100	100	100

Moreover, water allocation decisions included distribution of water notes for the environment (see also Table 3.4). However, there was no penalty applied if countries did not meet their environmental requirements. The production served two purposes: for local use and for trade with other nations.

Table 3.4 Environmental flow requirements (the minimal environmental requirements as stated by the international standards; adapted from Water Footprint Network, 2017).

Green water	50 %
Blue water	40 %

- Stage Two: Global Trade Bargaining Decision

In the global trade meetings, country's representatives could import products and exchange exports with other commodities. This stage is crucial for each country, as it represents an opportunity for these nations to ask critical questions to other countries (e.g. what are your production rates?), discuss possible deals and agreements, and make future production arrangements.

- Stage Three: Performance of National Development Indicators and Feedback

After each global meeting, feedback session was given by the facilitator about the performance of each country's abovementioned six development indicators. These results were projected, interpreted, and summarized for the participants by the facilitator using the game-supported spreadsheet.

The above three steps were repeated three times (three rounds) in each game, with one new item of information provided by the facilitator in each round:

- In round 2: the facilitator released the production rates for all of the countries if the country representatives did not ask for it in round 1.
- In round 3: the facilitator introduced and explained the concept of comparative advantages and disadvantages for water production to help players make wise management choices and understand the different factors embedded in the functionality of water productivity.

Although, the target was to complete six rounds, in most of the simulations only three rounds were conducted (in a few exceptional cases consisting of four rounds were played) with an average playing time of two hours.

Ideally, the game should be played by 12 users (3 players per country). The goal was to witness the interaction between the group members and between the different groups. However, this was not the case in most of the games played. Figure 3.4 demonstrates the number of players per country in all the games.

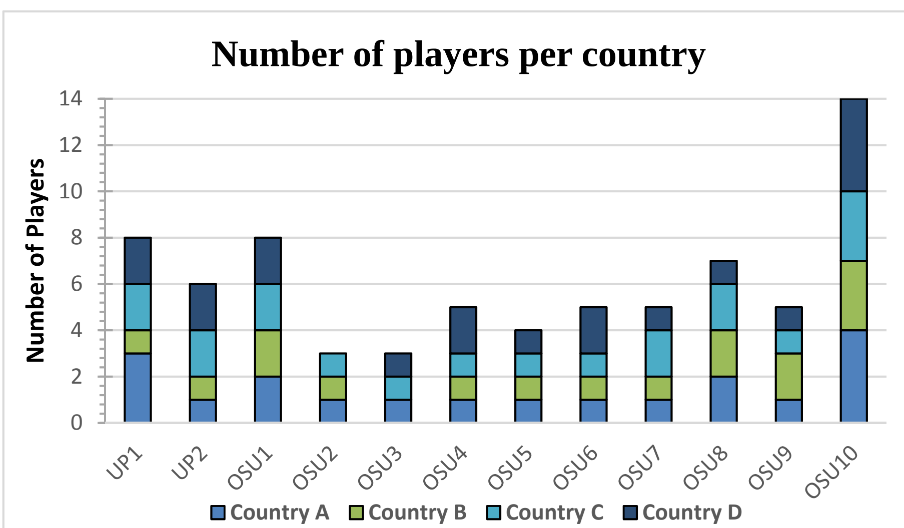

Figure 3.4 Number of players per country in each simulation.

At the beginning of the research project, one experimental game simulation was made (this was not counted in the research sample). The aim was to understand how the game works and get accustomed to it. Throughout the research duration, the game was played and tested on multiple groups (12 times).

3.3.1.2.2 Model Setting (Productivity per commodity, per type of water, and per country)

Water Productivities

Water productivities were expressed in kilograms of commodity per cubic meter of water (kg/m^3). The amount varied as a function of the following:

- Country economic category (5x higher in developed countries)
- Water availability (1.7x higher in water-abundant countries)
- Water type (1.7x higher for blue water)
- Climate (2x higher for climate suitable for commodity production)
- Commodity (see Table 3.5).

For each commodity, the actual water productivities equal:

The global average water productivity (kg/m^3) x green/blue water productivity (kg/m^3) x comparative advantage factor (dimensionless).

To calculate the actual water productivity, the global water productivity in kg/m^3 for each commodity are first recorded from the literature (Water Footprint Network, 2017) (see Table 3.5).

Table 3.5 Water productivities in kg/m^3 (rough global average per commodity) (adapted from Water Footprint Network, 2017)

Food grains	Vegetables and fruits	Meat and dairy products	Cotton	Bio-energy
0.25	1.25	0.025	0.1	0.5

Secondly, green/blue water productivity in kg/m^3 was calculated for each country as shown in Table 3.6.

Table 3.6 Productivities in kg/m^3 (adapted from Water Footprint Network, 2017)

Productivities (kg/m^3)	Country A	Country B	Country C	Country D
General productivity[1]	1.00	1.688	0.20	0.3375
Green water productivity[2]	0.75	1.266	0.15	0.2531
Blue water productivity[3]	1.25	2.109	0.25	0.4219

[1] $GP_n = GP_{n-1} * [(GW_{n-1}+BW_{n-1})/(GW_n+BW_n)]$
[2] Green water productivities = 75% the general productivity
[3] Blue water productivities = 125% the general productivity

Lastly, given the comparative advantage and disadvantage factors in Table 3.7 and the previous equation to calculate the actual water productivities, the actual green/blue water productivities data are as shown in Table 3.8 below.

Table 3.7 Comparative advantage and disadvantage factors (adapted from Water Footprint Network, 2017)

	Country A	Country B	Country C	Country D
Comparative advantage matrix for green water				
Food grains	2.0	0.5	1.0	0.0
Vegetables and fruits	0.5	0.5	1.5	0.0
Meat and dairy products	0.5	2.0	0.5	2.0
Cotton	0.0	0.5	2.0	0.0
Bio-energy	1.4	0.5	2.0	0.0
Comparative advantage matrix for blue water				
Food grains	2.0	0.5	1.0	0.5
Vegetables and fruits	0.5	2.0	1.0	2.0
Meat and dairy products	1.2	0.5	0.5	0.5
Cotton	0.0	0.5	1.0	2.0
Bio-energy	0.8	0.5	2.0	0.5

1 = Neutral
>1 = Comparative advantage
<1 = Comparative disadvantage

Table 3.8 Actual green and blue water productivities (kg/m^3) (adapted from Water Footprint Network, 2017)

	Country A	Country B	Country C	Country D
Green Water Productivity				
Food grains	0.40	0.20	0.04	0.00
Vegetables and fruits	0.50	0.80	0.30	0.00
Meat and dairy products	0.01	0.06	0.002	0.01
Cotton	0.00	0.06	0.03	0.00
Bio-energy	0.50	0.30	0.15	0.00
Blue Water Productivity				
Food grains	0.60	0.30	0.06	0.05
Vegetables and fruits	0.80	5.00	0.30	1.10
Meat and dairy products	0.04	0.03	0.003	0.005
Cotton	0.00	0.10	0.03	0.10
Bio-energy	0.50	0.50	0.30	0.10

3.3.1.3 Observations

The concepts of water footprint, virtual water, and comparative advantages and ground rules were defined during the international negotiation stage. In each round, the facilitator announced the annual rainfall forecast and the green water availability. Near the end of round one, fake news from the media was introduced intentionally — "*there is an expected drought next year*" — to test the expectations, awareness, and preparedness of the participants respond to water-related risks. However, that was not the case in the second round; there was *no drought*. The meteorological conditions (the drought conditions) remained the same in all three rounds.

3.3.1.4 Subjective Surveys

<u>Pre- and Post-Game Surveys</u>

Both before and after playing the game, players were invited to take a simple online game survey, which was developed using Qualtrics software. It contained both open-ended and close-ended questions and records on the characteristics, behaviors, and knowledge.

After the players had submitted informal consent, they proceeded to complete the pre-game survey. Moreover, by turning in the survey, they were notified of the time, date, and venue of the game. The participants received the survey with the aim of assessing the learning. The same carefully formulated key questions were asked before and after the game simulation (see Appendices A and B).

This technique has been used by many scholars (Douven et al., 2014; Rumore, 2015). It is also referred to as before-and-after surveys (Rumore, 2015). These study surveys design were based on Medema et al. (2016) social learning assessment framework, which consists of four assessment criteria; properties of participants, properties of collaboration, properties of relationships, and properties of knowledge.

Face Value and Survey Validation

Both pre- and post-game survey questions were validated. The dependability of each survey question was assessed first by establishing a face validity in which the survey questions — regarding content and structure — were reviewed and evaluated by the main thesis advisor for the Institutional Review Board submission.

The main aim of face validity is to ensure capturing the research topic. Afterward, a pilot test was carried out to review any existing errors and consistency, and check linked, skipped questions and the reliability of the surveys. The collected trial data were further discarded and not included in the results. They were only used with the aim to test the survey. Finally, the surveys were revised and distributed to the students.

Follow-up Feedback Session

At the end of the simulation, the facilitator led the debriefing and allowed students to reflect on the simulation experience and the lessons learned. Participants were encouraged to reflect for a period ranging in length from 10 to 20 minutes. The feedback session was conducted to supplement the learning.

The participants were given a list of six optional questions to use during the reflection period (see Appendix C), or they could simply reflect on the whole experience in general. The questions were related to the conceptual theories and the contextual information about trade, water resources management, and the participants' perceptions on the exercise of serious games as tools for a greater collaboration and better learning. These conversations were recorded with the permission of participants. Direct quotes were deemed especially relevant for the benefit of the research.

3.4 Data Analysis

3.4.1 Survey Analysis

3.4.1.1 Social Learning Assessment and Q-Test

The responses to the pre-game and post-game surveys were assembled and further analyzed. Each response was coded. In all of the samples, the rate of occurrence of repeated responses (frequency) was calculated. Measuring the differences in the answers from all participants reflected the knowledge or the lack thereof of the learning topic. If the participant gave the same answers to the questions before and after the game survey, then the participant did not learn anything, or the participant was already familiar with the specific information.

The changes in answers reflected the changes in the participants' knowledge and perception, which is equated to the learning. This mechanism is referred to here as the "*Q-test*" by matching pairs of pre- and post-frequencies for each participant response to determine whether the responses were significantly different from each other (see Figure 3.5).

If the responses do not match, proportional values are calculated in order to make the comparison. The results of the proportion will show if the difference between the pre- and post-survey is significant or not. Finally, each social learning assessment criterion was given a certain weight. Overall, the whole samples learning evaluation was measured.

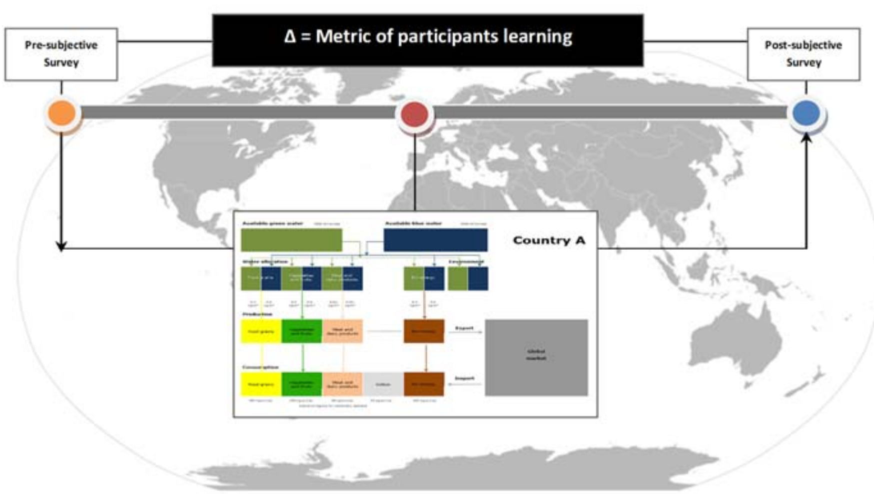

Figure 3.5 Q-test

3.4.1.2 Testing the hypotheses

The game and the survey responses were tested against three sets of hypotheses. This assessment helped to determine whether the hypotheses were accepted or rejected in response to each question. A set of working alternative hypotheses on the influence of participant attributes and philosophy of water management are as follows:

Expected Multiple Working Alternative Hypotheses

The expected outcomes under each hypothesis and how different outcomes might allow rejecting some of the hypotheses are described below:

The prediction for RQ1 is that if the participants gave the same answers in the pre- and post-game survey, then the participants' perception did not change. It's expected that the age variable will result in a significant impact on the learning. Meaning that those who are old, have a higher level of knowledge and would perform better tasks.

For RQ2, people from water-rich countries or people from countries with large water footprint would have a type of water culture that is profit driven (Curry, 1999), and would be unaware of the global water footprint because of the abundant nature of their waters. Throughout the game, if people from water-rich countries did not adopt strategies to lower their water footprint, then they did not learn about the global nature of their water use and are unaware. For the second part of the question, people from water-poor countries would relate the water management in the game to their water cultures, and due to the level of water scarcity, they would focus more on the negotiations. If the people from water-poor countries are building relations with other countries and seeking future trade agreements, then they are more focused on the negotiation gains (Curry, 1999).

However, there is great level of variability among people from different countries. The process for selection of participants did not allow to achieve a representative sample of either populations (i.e., those from water-rich and water-poor countries). Not all the people from water-rich countries (USA, Canada, England, the Netherlands, etc.) can be referred to as greedy, ignorant wasters of water and their life choices are driven only by the desire for profit. Moreover, with respect to the states attribute, the assumption of water culture varies on a state by state basis (eastern vs. western).

Similarly, not all people from water-poor countries can be referred to as highly knowledgeable about water management, understand concepts such as the water footprint and virtual water use much better than those from a water-rich country, care nothing for profit, and make water management choices based on preference for negotiation, emerging from a water culture driven only by their willingness to share water equitably with other people and the environment.

This study also anticipated that those who had high knowledge levels would perform better at tasks. For example, students actively involved in the graduate level study of water resources are more knowledgeable than those involved in the graduate study of other topics.

3.4.2 Model Analysis

3.4.2.1 Comparison between Different Worlds

A comparison was made between the different worlds (the various game samples trials) on the amount of waste (in case countries could not carry over their commodity surplus to the next round). The amount of waste was measured in kg of commodity and tested against the consumption figures in Table 3.3.

3.4.2.2 National Development Indicators

Additionally, the average performance of each development indicator (food supply, economic welfare, meeting environmental flow requirements, national water footprint, water saving, and dependency on foreign resources) were calculated for all of the 12 worlds (game samples trials) over the three rounds (water years). These figures will be further used in Chapter 4 to answer RQ2.

3.4.3 Feedback Analysis

Subsequent feedback represents valuable learning data, as it focused on reflecting on what was learned. In general, participants' feedback was recorded to provide the raw materials for the research study. These inputs were then transcribed as comments made in feedback represent useful information in interpreting the game results and drawing conclusion, specifically insightful thoughts from participants that could add to the study.

CHAPTER 4 – RESULTS

4.1 Survey Results

4.1.1 Q-Test and Social Learning Assessment

The responses on the surveys not only indicated the participants' preferences, but they also indicated the relative clarity of their preferences, as well as the level of self-expression of their preference for a particular question.

4.1.1.1 Properties of Participants

An emerging issue was bringing people to play the game. People hesitated to discuss their fears about participating, e.g. What are the game prerequisites? Are there a lot of mathematical calculations? In the first sample at UPEACE, the game was presented in a Pecha-Kucha style (Arndt & Klentzin, 2010) in one of the classes. This simple presentation style allowed me to show the research work and display the game to many students. That helped in answering many students' questions and reaching volunteers that may otherwise have been unwilling to participate. The first two groups (14 participants) at UPEACE were mostly from peace, law and human rights backgrounds. The remaining 59 participants, who played at OSU, came from several different backgrounds (see Figure 4.1).

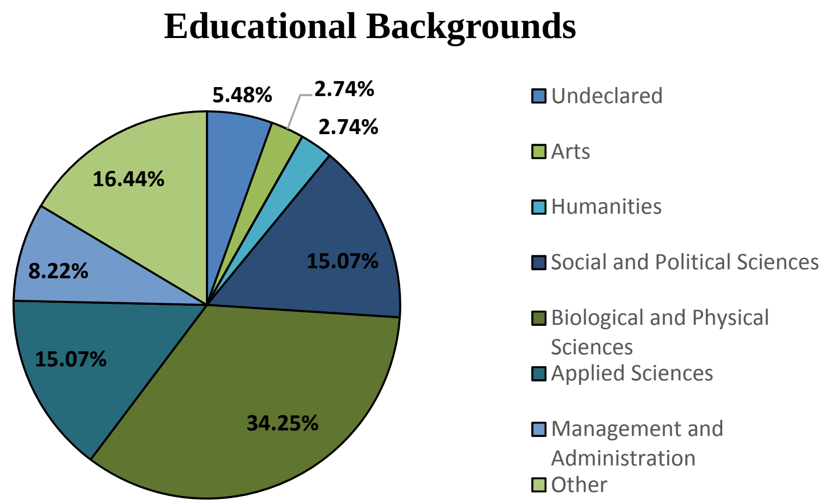

Figure 4.1 Backgrounds of UPEACE and OSU participants.

The participants were from different nationalities; 71% were from the United States, while only 29% were from other countries: China, Viet Nam, Canada, Nigeria, Malawi, Lebanon, Austria, Japan, Eritrea, Costa Rica, Indonesia, the Philippines, and the United Kingdom. The large number of American students was expected during the data collection phase since the longest sampling duration was in the U.S. and most of the enrolled students at OSU are Americans.

For the 71% American students coming from different states, these states were grouped into regions (see Table 4.1). The country/states of origin or water culture of the participants were arguably the focus of this study and were meant to be used as scales to categorize the participant's perspective on water resources management.

Table 4.1 Regions and Divisions of the United States

Regions	Divisions	%
Northeast	Massachusetts	2.3
	New York	2.3
Total		**4.6**
Midwest	Illinois	4.5
	Indiana	2.3
	Ohio	2.3
	Wisconsin	2.3
Total		**11.4**
West	California	6.8
	Kansas	2.3
	Oregon	63.6
	Utah	2.3
	Washington	4.5
Total		**79.5**
South	Florida	2.3
	South Carolina	2.3
Total		**4.6**

However, given the researcher's limited capacity to examine water management in each country or state and connect state of origin to water culture of the participant, the quality of the results does not represent the individual state's preference. Thus, the discussion of the state of origin was eliminated. Sufficient evaluation of each state regime can be investigated further in future projects.

4.1.1.2 Properties of Collaboration

The second criterion of the social learning framework was properties of collaboration. This was represented in two questions in the survey. One question consisted of multiple choices, and the other was an open-ended question. This part was reflected in the responses to the following questions:

Q: Soon you will be participating in a collaborative serious game. Do you prefer to work within a team or alone?

The responses to this question may contain the following parameters that are changing; A (response: I prefer to work alone), B (response: I enjoy Both, playing alone and teamwork), and TW (response: I prefer teamwork).

The possible logical combinations are; A→A, A→B, A→TW, B→A, B→B, B→TW, TW→A, TW→B, TW→TW. If the transition is towards individual actions, negative values were assigned for each combination of responses. Similarly, if the transition is towards collaborative actions, positive values were assigned (See Table 4.2).

If the responses are the same (same preference), which is the case of the combinations: A→A, B→B, and TW→TW, an index value of zero is given.

The scale in Figure 4.2 was used to depict the changes in the individual level of collaboration before and after the game.

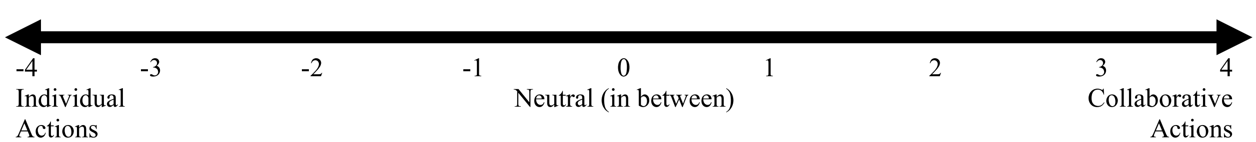

Figure 4.2 Collaboration scale

The collaboration scale demonstrates that positive values represent a change towards a more collaborative direction, while negative values represent a change towards more individual actions.

Table 4.2 Collaboration

	Index	Logical combination direction	Count	Percentage (%)
Individual actions	-4	A→A	1	2.0
	-3	TW→A	3	5.9
	-2	B→A	5	9.8
In between individual and collaborative actions	-1	A→TW	2	3.9
	0	TW→TW	18	35.3
	1	B→TW	15	29.4
Collaborative actions	2	A→B	1	2.0
	3	TW→B	0	0.0
	4	B→B	6	11.8
	Total		**51**	**100**

The above figures (see Table 4.2) are the results of the Q-test (measuring the responses before and after the game). Apparently, many participants are people who prefer both individual behaviors as well as teamwork when it comes to playing a serious game (68.6%). Only 13.8% of the whole tested population enjoyed collaborative actions, as shown in Figure 4.3.

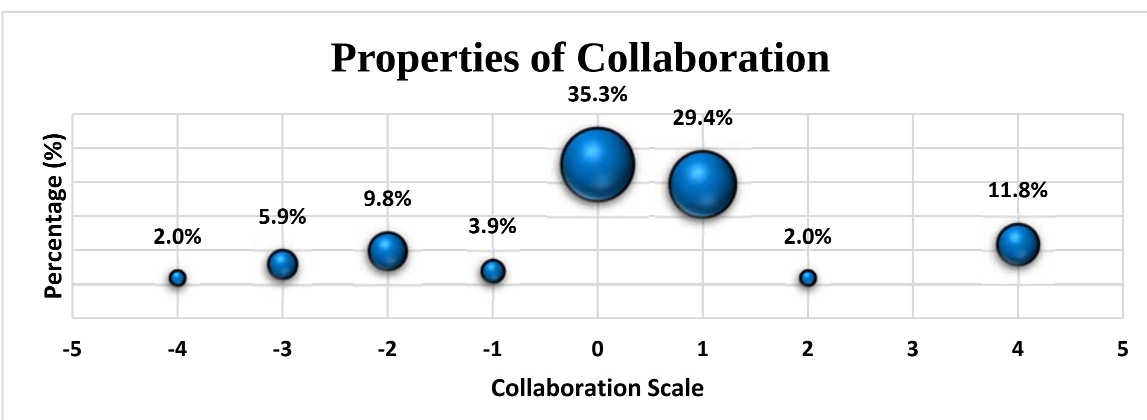

Figure 4.3 Properties of collaboration.

Q: What can be done to improve feelings of inclusiveness within your team members?

This question is the type of an open-ended question where participants express their feelings and their knowledge. All responses have been covered and coded into categories as shown in Table 4.3. These categories were developed from the data set and based on the identification of potential response categories. Some responses were very general; others were very specific. After using keywords for coding these responses, some categories were combined and narrowed down into similar responses.

As can be seen in the table, the counts in the post-survey only matched the counts for the pre-survey in the case of category "Others – Open Mind." There was no matching of responses in the remaining categories.

Table 4.3 Feeling of inclusiveness

Categories	$Count_{pre}$	$Count_{post}$
1. Listening	18	0
2. Acknowledge opinions (Making people feel heard)	23	1
3. Communication, negotiation, discussion and Participation	20	6
4. Respect	4	0
5. Asking questions	6	0
6. Others	-	-
Trust Building	1	0
Open Mind	1	1
Eye Contact	1	0
Body Language	1	0
Taking notes	1	0
Suggestions of Common Solutions	4	2
Knowledge Building	3	0
Establishment of a clear dialogues structure	2	0

4.1.1.3 Properties of Relationships

The third set of criteria in the social learning framework refer to properties of relationship. The properties of relationships were represented in a total of four questions in the survey. This evaluation for this criterion was carried out on the responses to the following questions:

Q: Before coming to the game session, what do you think are the most important things in the negotiations?

The pre- and post-responses to this question were as follows:

Table 4.4 Preparation for negotiations

Response	Pre-count	Post-count	Abs*	Pre (%)	Post (%)	Abs (%)
Preparedness to participate	24	21	3	16.22	14.89	1.32
Leadership and capacity building	16	12	4	10.81	8.51	2.3
Respecting diverse perspectives, interests, and goals	30	24	6	20.27	17.02	3.25
Developing joint solutions	23	28	5	15.54	19.86	4.32
Team building, involvement and communications	17	17	0	11.49	12.06	0.57
Knowledge exchange	24	20	4	16.22	14.18	2.03
Trust building	14	19	5	9.46	13.48	4.02
Total	**148**	**141**	**27**	**100**	**100**	**0**

*Abs: the absolute value of differences in responses before and after the game

As shown in Table 4.4, which is also plotted in a Radar diagram (see Figure 4.4), before playing the game, participants believed that by respecting diverse perspectives, interests, and goals, as well as by preparing for the negotiation they could achieve more negotiation gains. On average, only a few participants (one or two) read and understood the game handouts in each game trial.

However, after playing the game, participants indicated that investing more time in developing joint solutions was the most important thing, as well being prepared before coming into the negotiations. Adopting a strategy of respecting diverse perspectives, interests, and goals in addition to trust building and knowledge exchange also showed noteworthy differences in pre- and post-game surveys by a large amount relative to other elements.

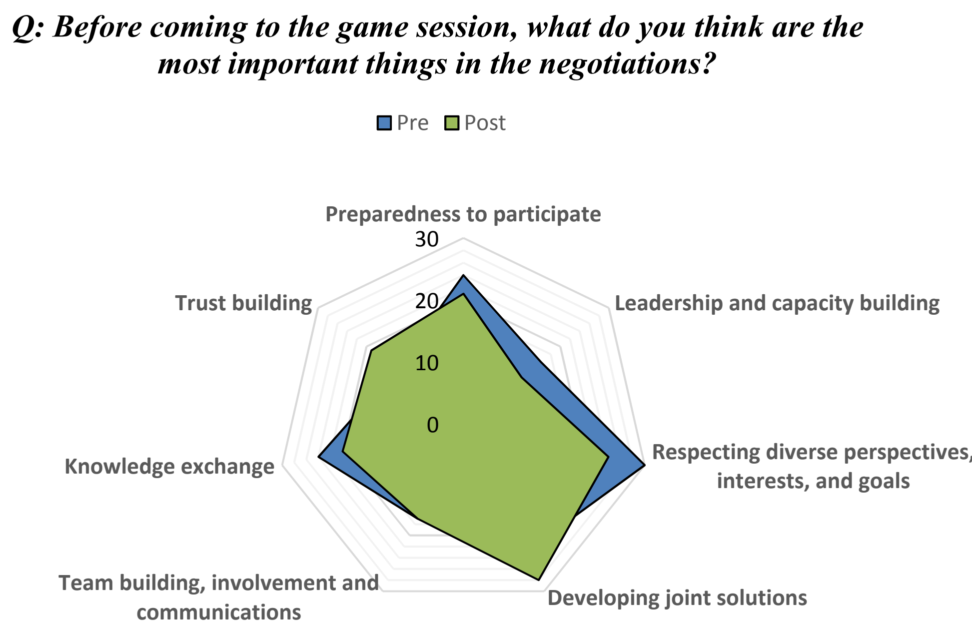

Figure 4.4 Preparation for negotiations

Q: Imagine the following scenario during the game, you are part of a team of three people representing one country. In global negotiations, your country will have only one voice. You need to talk to your team members and decide on What to do, Who will represent the country, etc. How are you planning to deal with conflict and disagreements within your team?

The responses to this question were coded based on Thomas-Kilman conflict mode instrument (Thomas & Kilman, 1974), as shown in Table 4.5 below.

Table 4.5 Coding conflict management styles

Response	Code
Fight back and enforce your opinion	Competing
Avoid conflict and accept any suggestions	Compromising
Argue until we all reach consensus	Avoiding

Of interest was that the "conflict management style within the group" most often selected by the participants before and after the game was *compromising*. Secondly, comes *other* modes such as:

- Individualism (not part of a team, therefore, decisions were made *individually* with no disagreement with any team member)
- Facilitation of discussion (playing the role of a *facilitator* within the group)
- Reasoning options and solutions
- Reworking suggestions
- Listeners

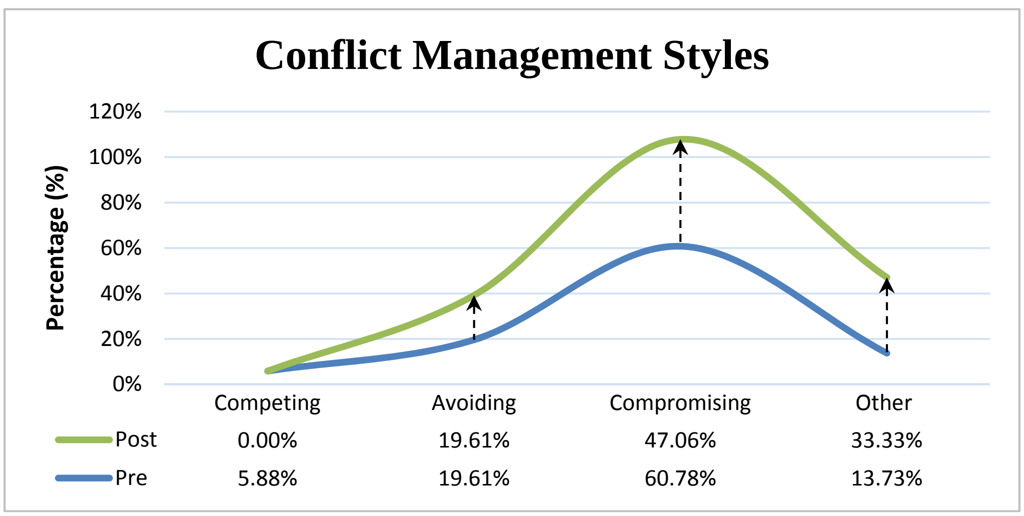

Figure 4.5 Conflict management style within the Group

The same number of participants who employed a particular type of avoiding behavior remained the same before and after the game (see Figure 4.5). The relative proportions were closely similar. However, the overall percentages were higher in the post-game survey than in the pre-game survey. As mentioned earlier, the number of players who were willing to compete and compromise decreased after playing the game whereas the number of players who were willing to adopt another type of strategies increased. Only, the number of players who adopted a strategy of avoiding to conflict remained the same (19.61%).

Q: When negotiating with other teams, what strategy(s) will you adopt?

Pre-Game Responses

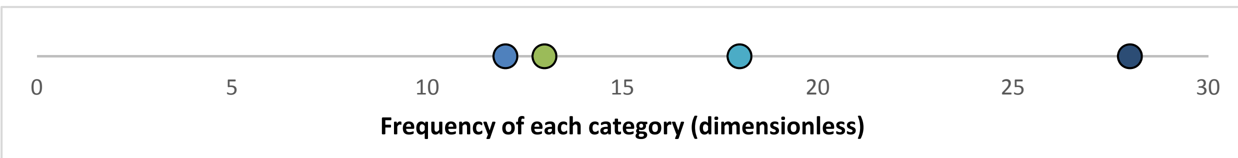

Figure 4.6 Pre-game negotiation strategies with other groups

Post-Game Responses

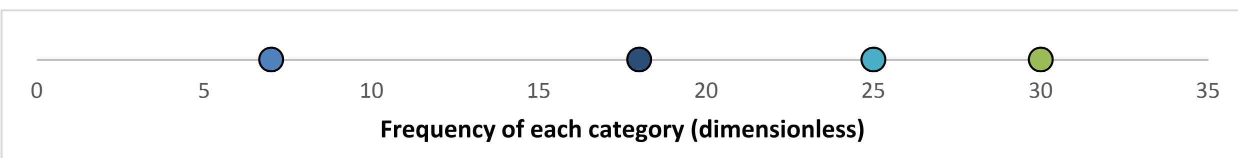

Figure 4.7 Post-game negotiation strategies with other groups

- **Be prepared for the worst and best scenario outcomes**
- **Give and Take**
- **Build relations and good reputation**
- **The team strategy will keep changing using a combination of the above strategies"**

As shown in the above figures 4.6 and 4.7, it is clear that participants changed their strategies after playing the game. They appeared to have learned that in the negotiations, adopting a "give and take" strategy is imperative to have fruitful discussions. Moreover, building relations and good reputation are an essential strategy when it comes to the negotiations over water-related problems. Before playing the game, students had a tendency of ignoring valuable aspects of negotiations such as relationships, trust, and respect.

Q: What could be the barrier(s) for collaborative working with your counterparts?

Given four optional barriers for the participants to choose from as listed in Table 4.6 below, the main barrier for many of the participant was the "the lack of coordination and communication." Even after playing the game, participants acknowledged that this barrier represented the greatest obstacle during the negotiation (see Figure 4.8).

Table 4.6 Collaboration barriers

Barriers	Count		Percentage (%)	
	Pre	Post	Pre	Post
No trust	26	23	26	28.75
Language barriers	20	6	20	7.5
No respect	16	7	16	8.75
Lack of coordination and communication	38	44	38	55
Total	**100**	**80**		

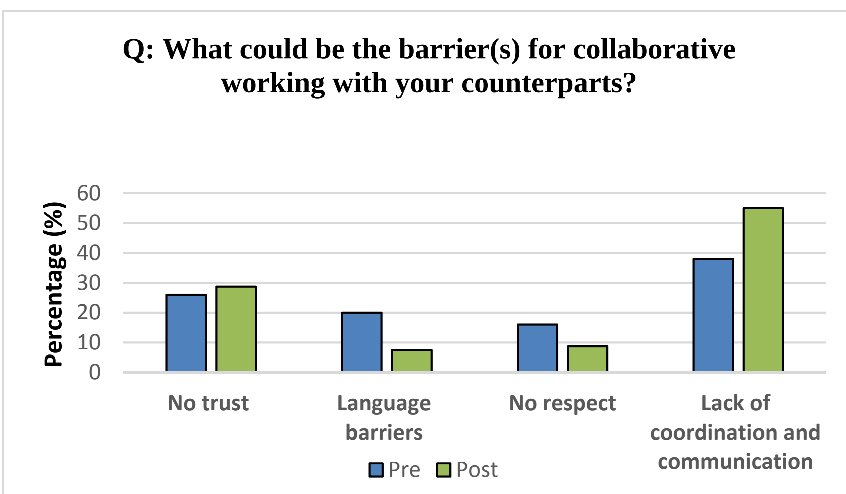

Figure 4.8 Collaboration barriers

4.1.1.4 Properties of Knowledge

With respect to the four criteria associated with the social learning framework, the properties of knowledge received much of the survey questions. This criterion was evaluated through the responses to the following questions:

Q: In real life scenario, whom do you think is more prepared in the negotiations over international water disputes?

Interestingly, 34% of the participants believe that water-rich countries come more ready to the water negotiations than water-poor countries or even the private sector (see Figure 4.9). This number even increased to 65.31% after playing the game. In the game, the private sector was not represented. This lack of representation may explain why no single response to the private sector was not selected after playing the game. Participants limited their answers to the initial design of the game and did not transfer the game situation to a hypothetical real-life scenario.

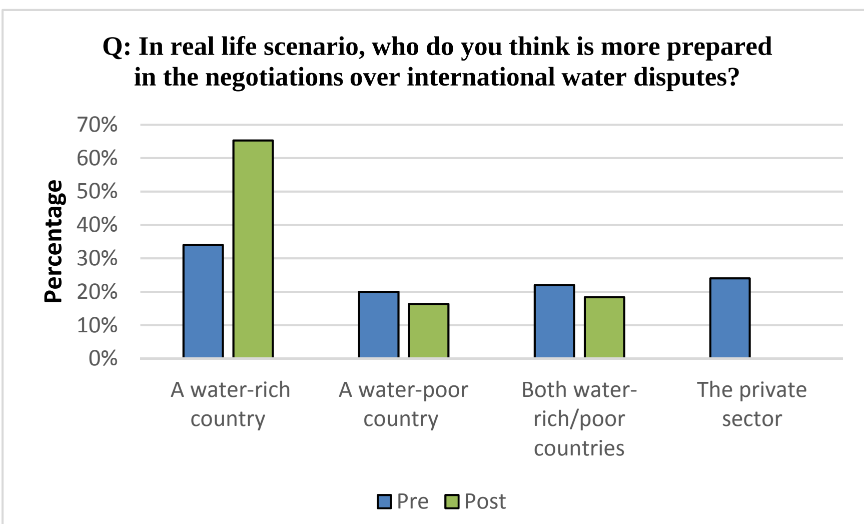

Figure 4.9 Countries preparation to international water disputes

Another interesting finding is that almost the same number of participants hold the idea that both water-rich and water-poor countries came prepared to the meetings over water-related disputes, even after experiencing this idea in the game.

Q: Countries vary in terms of the quality, quantity, and use of their national water resources. According to your country's water culture, what is considered a wise water management?

Countries vary regarding how they manage their water resources. A list of options of what was seen as wise water management to many nations was provided. These options are as shown in Figure 4.10. Around 8% of the participants were not able to identify what is considered wise water management; the emerging pattern was "I don't know." This percentage can generally be related to their background and field of expertise as 64.39% of the research participants had Biological and Physical Sciences, Applied Science, and Social and Political backgrounds while the remaining 35.61% are from other educational backgrounds.

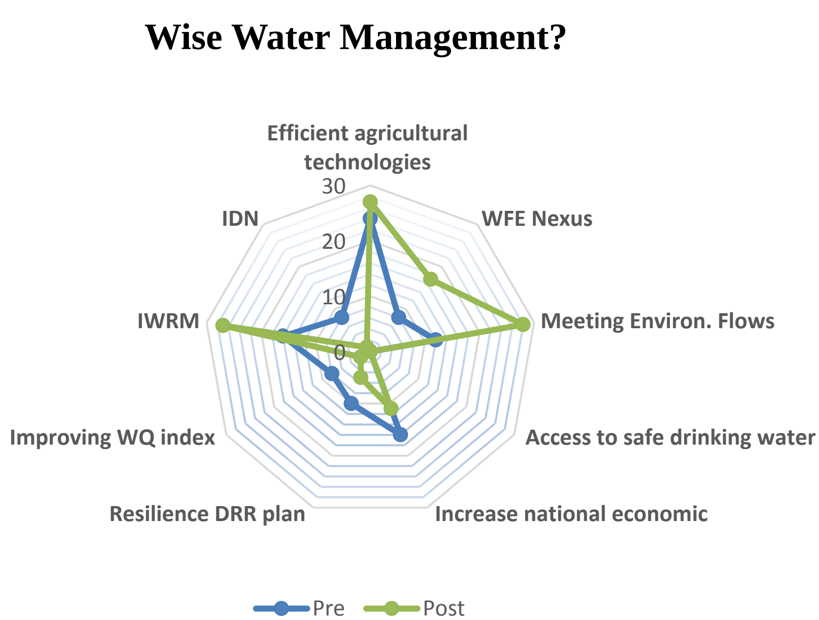

Figure 4.10 Wise water management

In the game, participants aimed primarily to produce agricultural products thus considering the use of efficient agriculture techniques ought to be of importance to have a wise management system. However, it seems that participants agree that “meeting the environmental flow requirements” is important to have in a sustainable water management system. The environment is voiceless in the game, though recognizing the substantial importance to consider the environment as part of the water management system was crucial.

Q: Given the uncertainties associated with climate change, countries are encouraged to reduce their water use consumption by adopting effective management strategies in order to mitigate the negative impacts of climate change. How do you think we can achieve efficient water use?

According to Figure 4.11, the responses to the surveys depict that efficient water use can be achieved by either using water saving techniques or reducing the global water footprint. Remarkably, the percentage of participants who believed that capping environmental requirements then trade is one way to achieve water efficiency have increased significantly after playing the serious game.

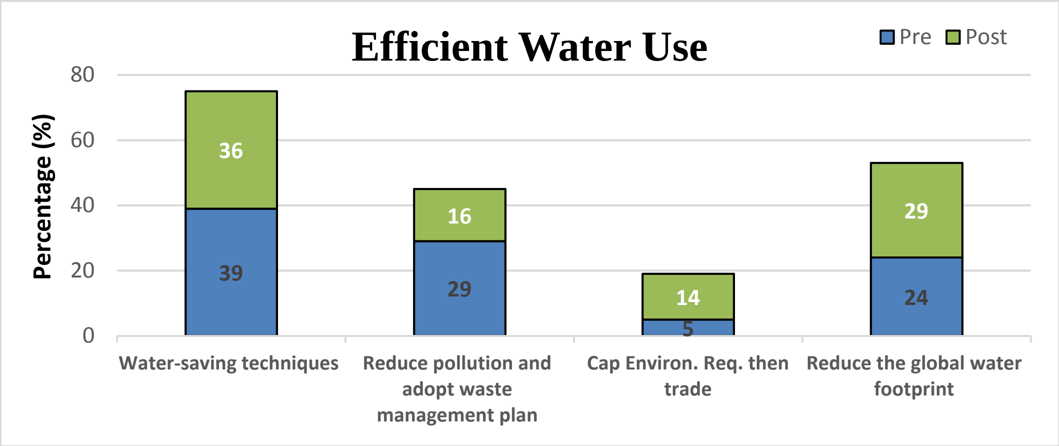

Figure 4.11 Efficient water use

Q: Water-scarce countries have low water productivity while water-abundant countries have high water productivity?

Referring to the game model setting in Chapter 3, water productivities vary as a function of five factors including country economic category, water availability, water type, climate, and commodity type. The correct answer to this question is "*maybe*." The statement can be true or false depending on the above five aspects (see Figure 4.12). In the game, players were allowed to choose the option "maybe", however, the selection of the option "maybe" decreased from 19 to 17 after playing the game.

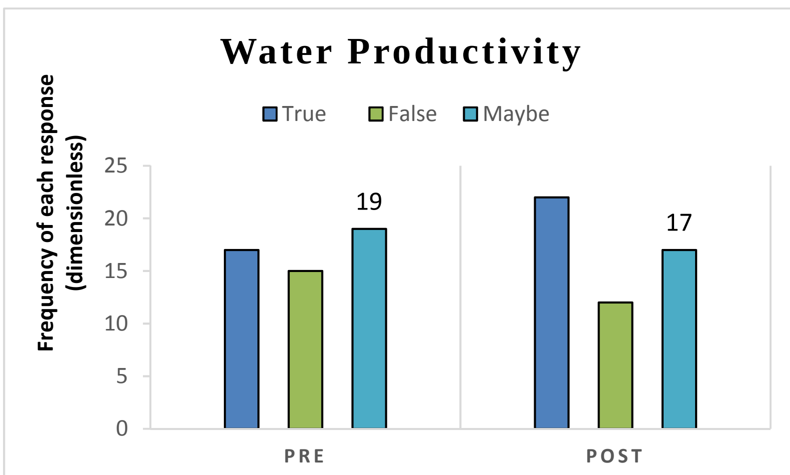

Figure 4.12 Water productivity

Q: How much do you support global trade?

Participants came to an agreement, even after playing the game, that trade is crucial to achieving food self-sufficiency. Some participants managed to make their countries reach a self-sufficiency status. However, this was not the case for most of the counties since their resources (e.g. water, climate, and land) were limited. Only a few participants opposed the idea of trading commodities as can be seen in Figure 4.13.

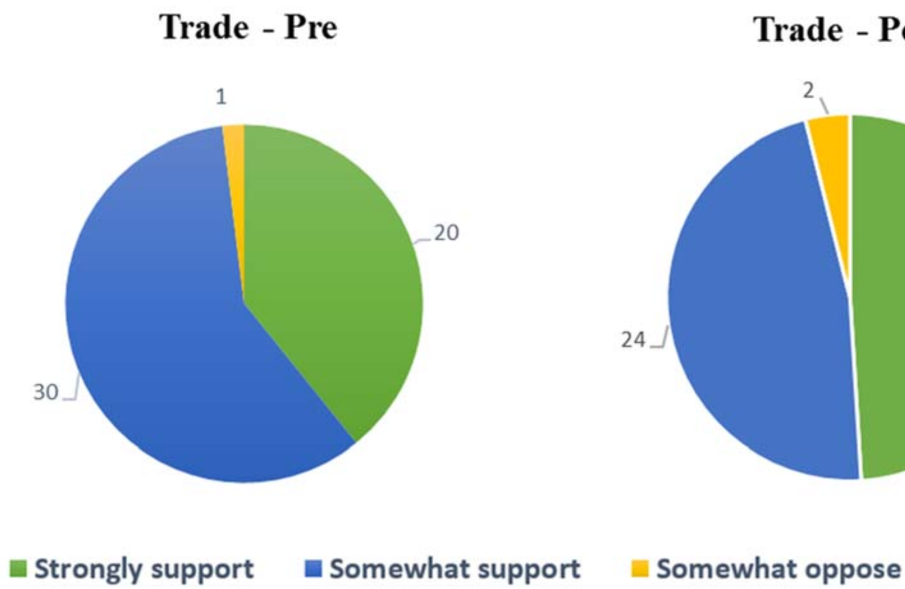

Figure 4.13 Global trade

Q: Globally, trade is a mechanism to exchange water-embedded goods, capital, and services across borders to obtain national needs (food, energy, industrial products, etc.). How much do you know about the theory of "Comparative Advantage" in international trade?

With respect to the economic theory of comparative advantage and disadvantage in water productivity, this concept was part of the hidden objectives in the game. The concept was further elaborated to the participants at the end of each game. In brief, each country was capable of having a maximum value of production (see also Table 4.8 in Chapter 4) that could be achieved when they get to specialize in the commodities for which they have a comparative advantage (export goods in which have a comparative advantage, and import goods in which they have a comparative disadvantage). This key understanding is important as it reduced pressure on domestic resources and can result in more national water saving. Players learned a lot about this theory after the simulation as shown in Figure 4.14 below.

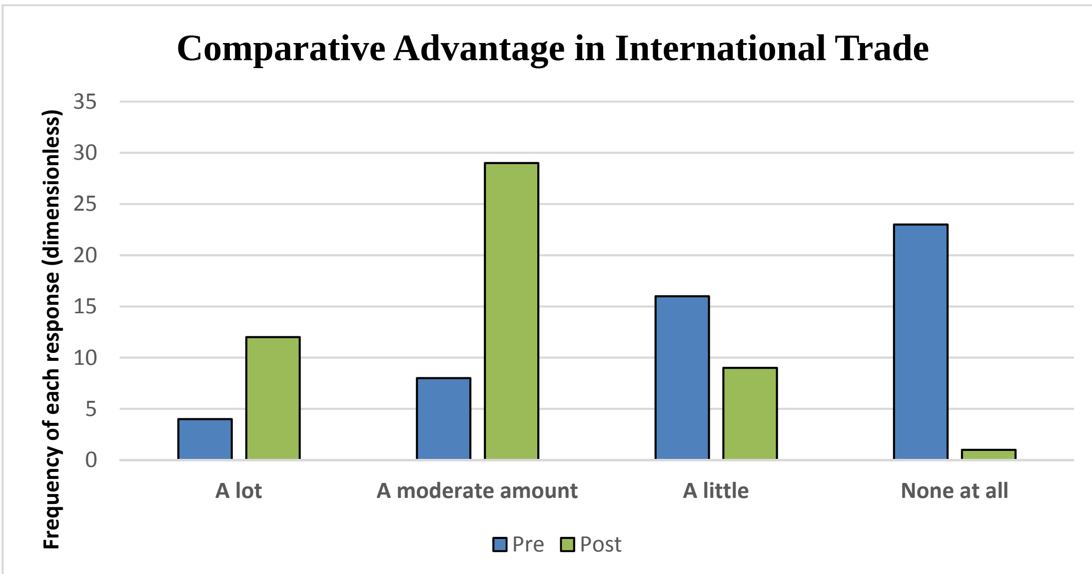

Figure 4.14 Comparative advantage in international trade

Q: In the field of water resources management, there are many conceptual frameworks such as virtual water and water footprint to name a few. Do you know the difference between the two concepts?

There is a significant difference between the two concepts of virtual water and water footprint (see section 2.2.2). In each game, the two concepts are further explained after playing the game.

As shown in Figure 4.15, it appears that 43% of the participants understood the difference between the two concepts in the post-game survey while only 4% did not.

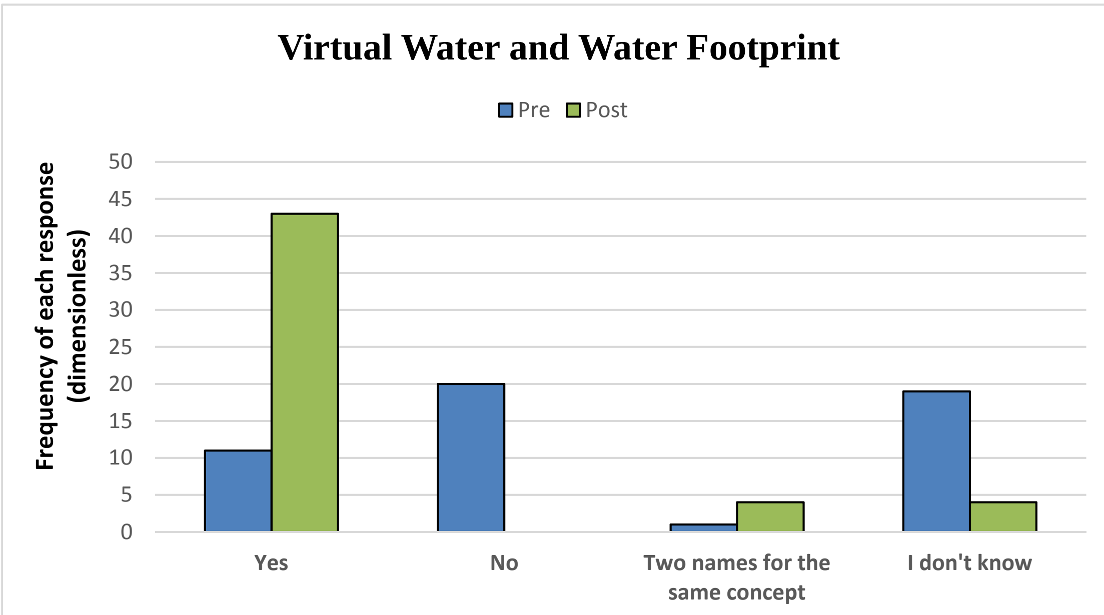

Figure 4.15 Difference between virtual water and water footprint

Q: There is an ongoing debate about the conflict between 'water for economy' versus 'water for nature.' What do you think of the role of global trade in this issue?

Water is a potential resource for conflict as it is used by different sectors including economy, nature, agriculture, domestic, among other sectors. Global food security was founded to bring together the global water distribution through trade (Rosegrant, Cai, & Cline, 2002).

Participants responses vary with respect to the role of global commerce as a mechanism to settle the conflict between water for nature or water for economy. However, prior to playing the game, most participants considered trade as more or less as an economic mechanism to increase the national GDP than a way to achieve sustainability. This proportion decreased slightly over the course of playing the game, while the proportion which viewed trade as an efficient mechanism to reduce conflict between water for nature or water for economy increased by 10%.

Also, there was a drop of 8.21% in the responses in which trade was thought to be damaging to the environment as can be seen from Figure 4.16. However, the game simplifies real environmental concerns related to trade. The game does not consider the several attributes such as the income per capita, level of investment, the number of population and many others. Thus, adding the above scenarios could have an impact on the participant perception on the role of trade especially after playing the game and witnessing it.

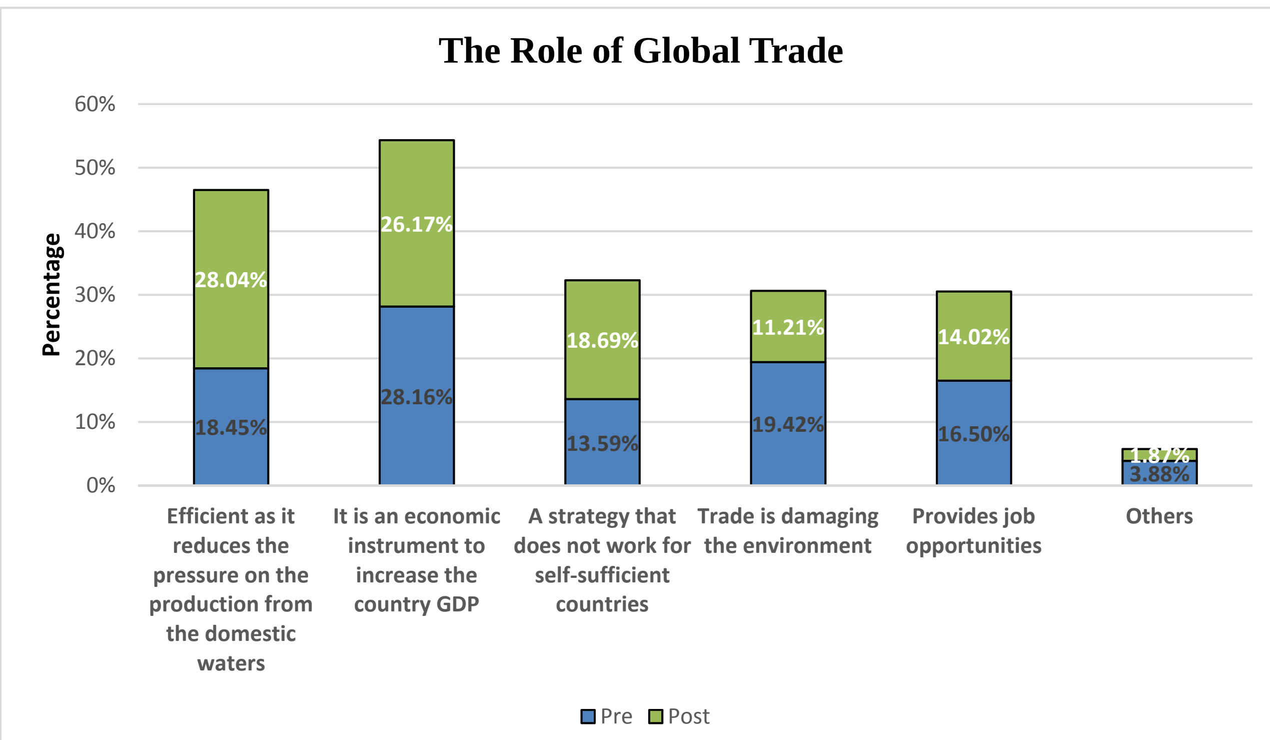

Figure 4.16 The role of global trade

4.2 Model Results

4.2.1 National Development Indicators

Each game ran for three rounds. The average (mean) of each development indicator was calculated for each of the four game-countries. Table 4.7 displays the average of the six national development indicators for each of the four-represented countries in the 12 samples. As mentioned earlier, these results are further used in Chapter 5 to answer RQ2.

Table 4.7 Model average results: national development indicators

Sample	Country	Food supply	Economic development	Environment	Water footprint	Water saving	Dependency
UP1	A	286.44	1.76	88.41	45.23	187.38	15.88
	B	122.11	0.84	91.67	n/a	330.98	13.46
	C	86.40	0.60	84.06	37.26	1899.40	11.50
	D	82.33	0.33	42.86	n/a	-336.69	7.42
UP2	A	286.44	1.76	88.41	45.23	187.38	15.88
	B	122.11	0.84	91.67	n/a	330.98	13.46
	C	86.40	0.60	84.06	37.26	1899.40	11.50
	D	82.33	0.33	42.86	n/a	-336.69	7.42
OSU1	A	115.56	0.94	75.12	49.53	453.92	36.31
	B	107.56	1.05	43.33	46.09	66.81	38.77
	C	105.61	0.70	85.51	23.10	3834.93	31.16
	D	76.39	0.46	52.38	n/a	795.26	36.80
OSU2	A	179.92	0.90	39.13	86.45	-68.31	15.00
	B	109.67	0.92	62.62	n/a	-362.37	6.26
	C	90.11	0.59	79.71	14.90	991.64	18.17
	D	39.72	0.11	n/a	n/a	287.86	100.00
OSU3	A	118.00	0.90	100.00	16.64	-131.07	13.59
	B	n/a	n/a	n/a	n/a	n/a	n/a
	C	89.67	0.59	65.22	65.16	2261.66	11.46
	D	48.44	0.34	100.00	n/a	162.72	33.17
OSU4	A	114.11	0.88	49.28	48.75	-840.00	32.90
	B	116.00	0.93	59.52	7.82	-146.15	9.86
	C	81.56	0.56	55.07	58.54	1568.44	7.58
	D	74.67	0.56	57.14	n/a	743.24	28.83

Table 4.7 Model average results: national development indicators (Continued)

Sample	Country	Food supply	Economic development	Environment	Water footprint	Water saving	Dependency
OSU5	A	118.67	0.88	100.00	21.83	-76.25	30.25
	B	94.67	0.89	100.00	n/a	-93.70	9.79
	C	67.33	0.55	100.00	n/a	1373.05	11.43
	D	75.00	0.56	95.24	n/a	182.40	32.65
OSU6	A	113.67	0.87	100.00	20.84	428.79	51.03
	B	93.11	0.83	100.00	0.49	261.10	31.09
	C	47.44	0.48	82.61	4.16	-788.01	1.16
	D	40.00	0.37	71.43	n/a	-659.98	18.41
OSU7	A	124.78	0.89	43.48	127.53	1491.48	33.43
	B	130.00	1.00	41.67	9.34	68.49	6.00
	C	91.44	0.58	51.78	63.05	2207.69	9.73
	D	73.11	0.38	28.69	n/a	39.69	19.99
OSU8	A	127.78	0.88	66.67	69.82	207.38	9.96
	B	123.89	0.97	44.29	10.54	-82.57	5.88
	C	71.89	0.56	75.36	50.98	1672.71	8.04
	D	58.33	0.29	88.10	n/a	-282.26	18.66
OSU9	A	125.56	0.80	59.42	69.58	22.71	4.77
	B	128.67	0.97	26.19	29.07	48.57	7.26
	C	73.44	0.48	47.83	64.92	807.74	6.71
	D	50.56	0.28	95.24	n/a	-362.94	15.10
OSU10	A	125.56	0.98	39.10	133.61	684.70	43.70
	B	112.78	0.91	92.86	4.36	-31.69	12.04
	C	67.56	0.35	20.29	54.86	-230.18	5.49
	D	84.44	0.58	92.86	n/a	862.65	49.34

The shaded figures indicate when the outcomes of the game (needs) were outside the desirable ranges in Table 4.8.

The range of these the desirable outcomes for each national development indicator is as follows:

Table 4.8 Range of each national development indicator

National Development Indicator	Range
Food supply	Country A and B: a value of 390 means fully satisfying the national food supply demand from the three categories namely: food grains, vegetables and fruits, and meat and dairy products. Any value less than 195 means meeting less than half of the national food demand. Country C and D: a value of 275 means fully satisfying the national food supply demand from the three aforementioned food categories namely. Any value less than 137.5 means meeting less than 50% of the national food demand.
Economic development	Economic development depends on the supply of three commodities: food, cotton, and bio-energy. For all the four countries, a value of 3 represents meeting this indicator (an equal value of 1 for food, cotton, and bio-energy). Similarly, a value of less than 1 shows meeting some of the indicator requirements.
Environment	This indicator can be fully met by allocating 40% of the available blue water and 50% of the available green water. The same applies to each country. Thus, a value of 100 represents maintaining healthy aquatic ecosystems. Any value less than 50% means meeting less than half the desired environmental flow requirements.
Water footprint	This values of this indicator are percentages of water footprint above the equal global water share. The higher numbers, the more global water share (Global Water Availability = 2150 m3/yr/capita) (adapted from Water Footprint Network, 2017).
Water saving	Positive values mean domestic water saving. The higher number, the more water saving. Negative values mean national water loss. The higher negative value, the more water loss.
Dependency	This indicator represents the percentage of external water footprint over the total national water footprint. Thus, the values are a percentage of dependency on foreign resources. The higher value, the more dependency. Similarly, the lower value, the less dependency and more self-sufficiency.

4.2.2 Amount of Waste

Table 4.8 shows the maximum value of production when countries specialize in the commodities for which they have a comparative advantage.

Max production = Water Productivity x (Euro/kg) x [Water Availability – Environmental Requirements]

Where,

Water Productivity : kg/m^3

Water Availability : m^3/yr/cap

Table 4.9 Maximum production (adapted from Water Footprint Network, 2017)

	Country A	Country B	Country C	Country D	Total
Green Water	394	633	84	127	
Blue Water	750	633	150	127	
Total	1144	1266	234	253	2897

Because in the simulations, players could carry over their surplus to the next year, no waste was considered, however, at the end of the game or the third round results of surplus or waste could occur. Taking into consideration that consumption equals imports minus exports (limited to the national cap), the following Figure 4.17 shows the amount of waste for each sample.

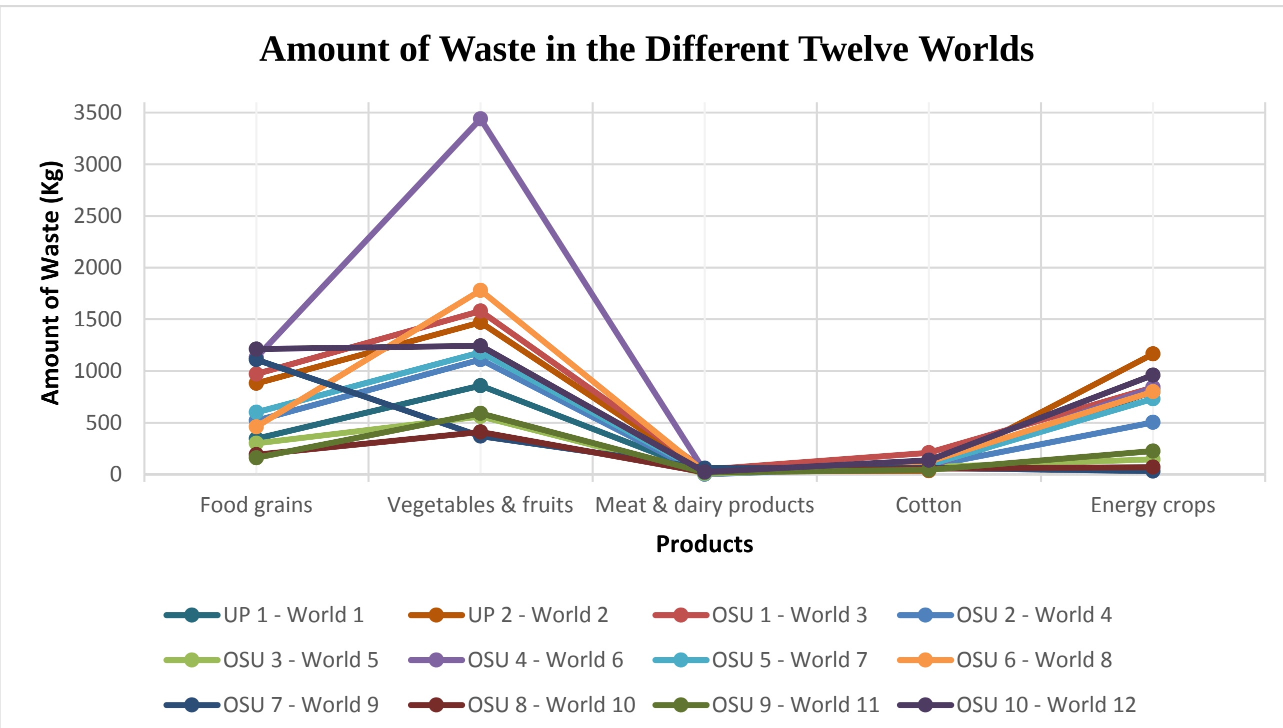

Figure 4.17 Amount of waste (kg)

Referring to Figure 2.4 in Chapter 2 clearly, the production of the five commodities (specifically vegetable and fruits) resulted in a massive amount of global waste from these products. Surprisingly, meat and dairy products had zero waste in all the 12 groups. Thus, adopting wise production strategies with deep consideration to the potential of the theory of comparative advantages for crop production can replace the need for imports and allow for food self-sufficiency in many countries. However, if land, water, and yields limit the production, then imports become a necessity. In the end, several limitations are inherent in the game, and the game world cannot be compared with reality.

4.3 Observations Results

Due to time limitation, only three-year simulations were played in all the games. The dynamics of each round were different from one round to another as well as from one game to another.

During the simulation, it was noticed that when the crisis was introduced to the players at round two (the drought) a dramatic change in the room atmosphere happened. Players had made pre-agreement with other countries thinking that next year they will have the same scenario, the same available water. Only, in one game (UP2), one player expected a drought is coming based on a prior experience in a similar game design. However, the drought called for more agreement and cooperation amongst the players. The emergent property of having a drought suggested to the players to cooperate to overcome the food crisis as a result of the drought.

4.4 Feedback Results

Participants were excited during the game rounds. The following list of quotes in Table 4.9 depicts the most common comments by participants during the feedback session at the end of the game (after the third round):

Table 4.10 Feedback quotes

"At one point, when the global market opened, it got very complicated."
"I appreciate what stakeholders do."
"I was confused; I needed to sacrifice something."
"I find it difficult for water-poor countries to survive and meet their environmental requirements."
"It is difficult to hit all the six development indicators. This is a hard game."
"It is a very complex game."
"Next time, I would have done better deals."
"This was fun!"
"Time passed so fast."
"We were afraid to bring the wrong crop to the market."
"We did not prioritize any of our goals."
"We liked the game, and we want to go for another hour."
"Next time, we need to know more about other countries demands before we get into the global market. We just exculpated what they are trying to do."

It is worth mentioning that only a few participants were unable to answer the feedback questions because there were tired after playing for more than two and half hours. In the future, in order to change the way the post-game survey was administered given the problem of participant fatigue, after a period of time (maybe one week), participants can be reminded on the importance of their participation in the research and asked to fill an open-ended prompt (e.g. what did you learn from the exercise? Please share your experience).

Moreover, some OSU staff offered writing a reflection essay after playing the game for extra credits. Here are some of the statements from students (participants from the U.S.) reflecting on the experience:

Table 4.11 Reflection quotes

"The game made me realize how the environment is always the first place to suffer when water managers allocate water. When the decision is made whether to take water for food production or leave it for the environment, the human element will always win. We were able to see this first hand in the game."
"The game was very effective in introducing the complex nature of water negotiations."
"The game provided unique insight into the importance of trust, communication, and compromise during negotiations."
"Role-playing is a powerful tool to help teach water conflict resolution strategies."
"The game provides an insight into real life water decision making. Playing the game was a challenge, we hardly represent the true difficulties in water negotiations."
"Sending trade representatives in the game and coming together as an international body allowed us to achieve mutually beneficial agreements."
"In the game, negotiations were non-predatory as we strived to generate trade alliances."
"The game highlighted examples of benefits and shortcoming of difficulties in negotiation styles."
"There was never a way to make each requirement. There was always some detriment or failure to the economy, products, the environment, etc. no matter how much communication, compromise or manipulation there was; just as would be in the real world. Though it was important to see how each of the lessons were useful and culminated into the skills required in resources management."

CHAPTER 5 – DISCUSSION

5.1 Discussion

RQ1: The process of the Globalization of Water Management game is designed to influence the negotiation strategies of the participants during later rounds in the game. Throughout the playing process, did the game influence the negotiations in later rounds? Did the game make a significant social learning impact?

RQ1-1: Throughout the playing process, did the game influence the negotiations in later rounds?

The main aim of the game was to simulate semi-real situations and problems that stakeholders face at the global scale in order to educate and train the participants on how to react at the national levels and on how to interact with others per a specific set of conditions. However, the game does not depend upon the prior diagnosis of the problem; participants only need to come prepared for the negotiation.

The game was designed so that participants could draw on their own resources to analyze the situation at hand by examining the potential of comparative advantage theory in international trade and what applied to their country. The learning portion occurred during the facilitation of the negotiation, as well as through the practical application of and critical thinking about basic water resources management theories.

The first game trial was played in August 2016 with 11 MSc students playing at OSU, in the United States. The second and third samples were played at UPEACE in Costa Rica. The remaining samples (10 games) were collected at OSU. In total, the game was played 12 times. It was tested on multiple numbers of students from different backgrounds. Each game was facilitated by the facilitator and the language used during the game was English. The game instructions were also distributed in English.

During the first round in most of the games, many of the players respected the international obligations to meet the environmental requirements; however, from the second round forward, a few participants began to pay less attention to the environment and instead directed their focus toward commodity production. This may indicate that although people are aware of environmental issues, their commodity production interests take priority over the voiceless environment.

Consequently, at year two, players adopted a strategy to allocate less water for the environment and use more water for commodity production.

At year three, after observing that these strategies were not sufficient to resolve the national development problems, most (but not all) of the players accepted the international obligation to meet the environmental requirements (e.g. $\text{OSU4}_{\text{Coutry C}}$ and $\text{OSU8}_{\text{Coutry D}}$) as shown in Table 5.1. Exceptional is the game samples $\text{OSU3}_{\text{Coutry A and Country D}}$, $\text{OSU5}_{\text{Coutry A and Country B}}$, and $\text{OSU6}_{\text{Coutry A and Country B}}$) who met the water requirements for the environment in all the three rounds.

The choices participants made when playing the game does not reflect their own resource management philosophies. However, the participants use a game experience to "play" with other persona's and make choices that they might never make in real life.

The second and third simulations were played at the UPEACE in Costa Rica in December 2016. The participants were MSc students in natural resources and environmental development, internal law and human rights, security and governance, and gender and peace education programs; one visiting professor; and two UPEACE staff.

They were split into four teams. Three simulated years were played. Hit by the fear of drought on year two, all players adapted their strategies to reduce their water use. They also met to discuss possible shared future trade arrangements to increase their national water availability.

After two rounds of unsuccessful negotiations, the theory of comparative advantages and disadvantages in international trade was introduced. This introduction strongly influenced game play: it markedly affected players' strategies and outcomes and pushed them towards saving water and also toward less competitive activities. This allowed all players to enjoy high performances regarding the improvement of their national development indicators at the end of the round.

This same scenario was very similar in all 12 games played. The table below shows the results of each of the six development indicators for each sample for year 1, year 2 and year 3.

Table 5.1 Model results for three water years

Sample	Development indicator*	Country A yr1	Country A yr2	Country A yr3	Country B yr1	Country B yr2	Country B yr3	Country C yr1	Country C yr2	Country C yr3	Country D yr1	Country D yr2	Country D yr3
UP 1	FS	238.33	331.67	289.33	165.33	80.00	121.00	65.40	98.80	95.00	41.17	43.33	162.50
	ED	1.59	1.76	1.91	0.82	0.72	0.97	0.56	0.69	0.55	0.26	0.26	0.48
	E	86.96	86.96	91.30	100.00	100.00	75.00	78.26	73.91	100.00	100.00	14.29	14.29
	WFP	39.53	33.95	62.19	0.00	0.00	0.00	48.84	44.19	18.77	0.00	0.00	0.00
	WS	0.00	-182.50	744.64	0.00	570.00	422.94	0.00	1600.00	4098.21	0.00	-700.00	-310.07
	D	0.00	16.67	30.97	0.00	16.04	24.35	0.00	6.45	28.04	0.00	6.45	15.81
UP 2	FS	238.33	331.67	289.33	165.33	80.00	121.00	65.40	98.80	95.00	41.17	43.33	162.50
	ED	1.59	1.76	1.91	0.82	0.72	0.97	0.56	0.69	0.55	0.26	0.26	0.48
	E	86.96	86.96	91.30	100.00	100.00	75.00	78.26	73.91	100.00	100.00	14.29	14.29
	WFP	39.53	33.95	62.19	0.00	0.00	0.00	48.84	44.19	18.77	0.00	0.00	0.00
	WS	0.00	-182.50	744.64	0.00	570.00	422.94	0.00	1600.00	4098.21	0.00	-700.00	-310.07
	D	0.00	16.67	30.97	0.00	16.04	24.35	0.00	6.45	28.04	0.00	6.45	15.81
OSU 1	FS	113.33	116.33	117.00	96.00	130.00	96.67	128.50	91.67	96.67	45.83	91.67	91.67
	ED	0.93	0.94	0.95	0.90	0.97	1.26	0.63	0.60	0.86	0.17	0.60	0.60
	E	26.09	100.00	99.26	21.43	57.14	51.43	56.52	100.00	100.00	100.00	28.57	28.57
	WFP	16.32	64.39	67.88	90.95	13.95	33.39	62.33	0.00	6.98	0.00	0.00	0.00
	WS	-1299.07	944.18	1716.65	-639.68	236.44	603.68	1750.00	3421.45	6333.33	-671.46	1073.90	1983.33
	D	10.00	49.27	49.67	66.50	16.19	33.63	14.04	38.86	40.58	10.10	54.21	46.08
OSU 2	FS	-424.25	352.62	611.40	110.33	110.33	108.33	90.00	90.33	45.83	36.67	36.67	45.83
	ED	0.70	1.03	0.98	0.92	0.92	0.91	0.59	0.59	0.17	0.08	0.08	0.17
	E	21.74	43.48	52.17	50.00	64.29	73.57	60.87	78.26	0.00	0.00	0.00	0.00
	WFP	36.48	105.49	117.38	0.00	0.00	0.00	15.97	15.01	0.00	0.00	0.00	0.00
	WS	-1565.77	417.95	942.89	-504.74	-336.42	-245.96	506.60	1055.09	592.98	135.29	135.29	592.98
	D	6.00	20.31	18.69	0.00	18.78	0.00	9.09	24.51	100.00	100.00	100.00	100.00
OSU 3	FS	118.33	115.67	120.00	0.00	0.00	0.00	97.00	89.67	28.67	71.67	45.00	28.67
	ED	0.80	0.94	0.96	0.00	0.00	0.00	0.61	0.60	0.13	0.39	0.49	0.13
	E	100.00	100.00	100.00	0.00	0.00	0.00	69.57	65.22	100.00	100.00	100.00	100.00
	WFP	19.23	9.63	21.07	0.00	0.00	0.00	63.99	78.96	0.00	0.00	0.00	0.00
	WS	-136.57	-159.67	-96.97	0.00	0.00	0.00	1583.39	3246.03	19.96	282.13	186.06	19.96
	D	9.10	20.03	11.64	0.00	0.00	0.00	7.35	13.99	16.86	48.58	34.07	16.86

* FS: Food Supply, ED: Economic Development, E: Environment, WFP: Water Footprint, WS: Water Saving, and D: Dependency

Table 5.1 Model results for three water years (Continued)

Sample	Development indicator*	Country A			Country B			Country C			Country D		
		yr_1	yr_2	yr_3	yr_1	yr_2	yr_3	yr_1	yr_2	yr_3	yr_1	yr_2	yr_3
OSU 4	FS	109.00	113.67	119.67	102.67	115.33	130.00	61.67	91.33	40.67	91.67	91.67	40.67
	ED	0.65	0.67	1.34	0.86	0.94	1.00	0.49	0.60	0.49	0.60	0.60	0.49
	E	73.91	43.48	30.43	64.29	64.29	50.00	100.00	30.43	100.00	42.86	28.57	100.00
	WFP	0.00	25.70	120.56	0.00	2.25	21.21	0.00	106.40	0.00	0.00	0.00	0.00
	WS	-1962.88	-1297.45	740.34	-553.15	-49.81	164.52	627.88	1742.02	181.32	1295.71	752.71	181.32
	D	7.62	36.11	54.98	5.16	10.14	14.30	5.58	5.24	13.03	29.22	44.24	13.03
OSU 5	FS	115.33	118.67	122.00	71.67	89.00	123.33	47.67	64.33	41.67	91.67	91.67	41.67
	ED	0.73	0.95	0.97	0.83	0.86	0.97	0.51	0.54	0.50	0.60	0.60	0.50
	E	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	85.71	100.00	100.00	85.71
	WFP	0.00	29.24	36.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	WS	-617.65	78.61	310.30	-345.98	-251.06	315.94	-335.29	2371.11	-430.15	1500.00	-522.65	-430.15
	D	29.95	18.82	41.97	5.96	7.54	15.87	1.12	21.39	11.00	41.56	45.40	11.00
OSU 6	FS	114.33	106.67	120.00	71.67	111.33	96.33	46.00	49.00	41.67	6.67	71.67	41.67
	ED	0.73	0.90	0.96	0.77	0.90	0.83	0.42	0.51	0.31	0.25	0.56	0.31
	E	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.96	100.00	60.71	53.57	100.00
	WFP	1.56	0.00	60.96	0.00	0.00	1.46	0.00	0.00	0.00	0.00	0.00	0.00
	WS	383.58	160.90	741.88	-140.84	309.35	614.77	-210.00	-972.22	-540.00	-1116.37	-323.58	-540.00
	D	31.88	66.01	55.21	13.35	46.39	33.53	0.19	3.29	5.66	11.62	37.94	5.66
OSU 7	FS	123.33	124.67	126.33	130.00	130.00	130.00	91.00	91.67	91.67	46.00	91.67	81.67
	ED	0.91	0.78	0.98	1.00	1.00	1.00	0.56	0.57	0.60	0.30	0.40	0.42
	E	26.09	43.48	60.87	17.14	64.29	43.57	43.48	27.52	84.35	57.50	7.14	21.43
	WFP	95.30	144.37	142.93	19.63	4.64	3.73	77.45	93.20	18.51	0.00	0.00	0.00
	WS	-201.14	1698.48	2977.09	-187.85	386.06	7.26	1375.63	2042.09	3205.34	-872.51	473.48	518.10
	D	10.62	43.56	46.12	0.00	10.51	7.49	4.77	7.72	16.70	16.81	17.93	25.22
OSU 8	FS	130.00	128.00	125.33	130.00	119.00	122.67	64.00	71.67	80.00	48.33	58.33	68.33
	ED	0.73	0.91	0.98	1.00	0.96	0.96	0.54	0.56	0.57	0.29	0.24	0.36
	E	47.83	73.91	78.26	9.29	73.57	50.00	86.96	69.57	69.57	100.00	78.57	85.71
	WFP	75.18	81.33	52.94	26.05	3.26	2.31	30.03	58.14	64.77	0.00	0.00	0.00
	WS	-133.57	616.17	139.56	-159.88	0.00	-87.84	1672.79	1200.00	2145.35	-66.82	-606.36	-173.59
	D	1.33	18.85	9.70	0.00	13.51	4.13	9.38	8.82	5.91	11.20	18.55	26.24

* FS: Food Supply, ED: Economic Development, E: Environment, WFP: Water Footprint, WS: Water Saving, and D: Dependency

Table 5.1 Model results for three water years (Continued)

Sample	Development indicator*	Country A			Country B			Country C			Country D		
		yr_1	yr_2	yr_3	yr_1	yr_2	yr_3	yr_1	yr_2	yr_3	yr_1	yr_2	yr_3
OSU 9	FS	120.00	126.67	130.00	130.00	129.33	126.67	64.33	69.00	87.00	46.67	48.33	56.67
	ED	0.64	0.77	1.00	1.00	0.95	0.96	0.31	0.55	0.59	0.24	0.26	0.33
	E	52.17	69.57	56.52	7.14	42.86	28.57	21.74	82.61	39.13	100.00	92.86	92.86
	WFP	28.59	67.98	112.16	28.77	34.16	24.28	49.74	44.85	100.15	0.00	0.00	0.00
	WS	-235.21	241.88	61.48	-131.38	258.46	18.62	-279.51	414.29	2288.43	-351.67	-312.14	-425.00
	D	0.51	8.08	5.73	0.00	16.79	4.99	5.99	3.21	10.92	12.01	7.66	25.62
OSU 10	FS	130.00	116.67	130.00	103.33	105.00	130.00	46.00	78.33	78.33	70.00	91.67	91.67
	ED	1.00	0.94	1.00	0.85	0.90	1.00	0.47	0.19	0.41	0.55	0.60	0.60
	E	17.35	43.43	56.52	100.00	100.00	78.57	39.13	21.74	0.00	100.00	100.00	78.57
	WFP	221.10	56.95	122.79	0.00	0.00	13.09	18.76	12.26	133.56	0.00	0.00	0.00
	WS	2294.56	-863.79	623.33	-334.41	-316.67	556.00	-1466.67	409.47	366.67	602.95	1608.34	376.67
	D	72.18	29.34	29.58	4.50	9.35	22.26	0.78	15.25	0.44	28.02	54.12	65.88

* FS: Food Supply, ED: Economic Development, E: Environment, WFP: Water Footprint, WS: Water Saving, and D: Dependency

To measure the level of influence in the game negotiations from one round to another (water years), the proper statistical method is calculating the deviation from the maximum positive value as follows:

$$\text{Dev.} = x_{i,j} - MPV_i$$

Where,

$x_{i,j}$: the value of development indicator i at year j for each sample

MPV_i : the maximum positive value (strong influence) of development indicator i for each sample (refer to Table 4.8 in Chapter 4)

The smaller the deviation (difference), the stronger influence and the larger difference depicts no influence (negligible, see Table 5.2).

Table 5.2 Influence levels for three water years

		Country A				**Country B**				**Country C**				**Country D**			
Sample	**DI**	**MPV**	**yr_1**	**yr_2**	**yr_3**	**MPV**	**yr_1**	**yr_2**	**yr_3**	**MPV**	**yr_1**	**yr_2**	**yr_3**	**MPV**	**yr_1**	**yr_2**	**yr_3**
UP 1	FS	390	151.67	58.33	100.67	390	224.67	310.00	269.00	275	209.60	176.20	180.00	275	233.83	231.67	112.50
	ED	3	1.41	1.24	1.09	3	2.18	2.28	2.03	3	2.44	2.31	2.45	3	2.74	2.74	2.52
	E	100	13.04	13.04	8.70	100	0.00	0.00	25.00	100	21.74	26.09	0.00	100	0.00	85.71	85.71
	WFP	0	-39.53	-33.95	-62.19	0	0.00	0.00	0.00	0	-48.84	-44.19	-18.77	0	0.00	0.00	0.00
	WS	5000	5000.00	5182.50	4255.36	3000	3000.00	2430.00	2577.06	5000	5000.00	3400.00	901.79	3000	3000.00	3700.00	3310.07
	D	0	0.00	-16.67	-30.97	0	0.00	-16.04	-24.35	0	0.00	-6.45	-28.04	0	0.00	-6.45	-15.81
UP 2	FS	390	151.67	58.33	100.67	390	224.67	310.00	269.00	275	209.60	176.20	180.00	275	233.83	231.67	112.50
	ED	3	1.41	1.24	1.09	3	2.18	2.28	2.03	3	2.44	2.31	2.45	3	2.74	2.74	2.52
	E	100	13.04	13.04	8.70	100	0.00	0.00	25.00	100	21.74	26.09	0.00	100	0.00	85.71	85.71
	WFP	0	-39.53	-33.95	-62.19	0	0.00	0.00	0.00	0	-48.84	-44.19	-18.77	0	0.00	0.00	0.00
	WS	5000	5000.00	5182.50	4255.36	3000	3000.00	2430.00	2577.06	5000	5000.00	3400.00	901.79	3000	3000.00	3700.00	3310.07
	D	0	0.00	-16.67	-30.97	0	0.00	-16.04	-24.35	0	0.00	-6.45	-28.04	0	0.00	-6.45	-15.81
OSU 1	FS	390	276.67	273.67	273.00	390	294.00	260.00	293.33	275	146.50	183.33	178.33	275	229.17	183.33	183.33
	ED	3	2.07	2.06	2.05	3	2.10	2.03	1.74	3	2.37	2.40	2.14	3	2.83	2.40	2.40
	E	100	73.91	0.00	0.74	100	78.57	42.86	48.57	100	43.48	0.00	0.00	100	0.00	71.43	71.43
	WFP	0	-16.32	-64.39	-67.88	0	-90.95	-13.95	-33.39	0	-62.33	0.00	-6.98	0	0.00	0.00	0.00
	WS	5000	6299.07	4055.82	3283.35	3000	3639.68	2763.56	2396.32	5000	3250.00	1578.55	-1333.33	3000	3671.46	1926.10	1016.67
	D	0	-10.00	-49.27	-49.67	0	-66.50	-16.19	-33.63	0	-14.04	-38.86	-40.58	0	-10.10	-54.21	-46.08
OSU 2	FS	390	814.25	37.38	-221.40	390	279.67	279.67	281.67	275	185.00	184.67	185.00	275	229.17	238.33	238.33
	ED	3	2.30	1.97	2.02	3	2.08	2.08	2.09	3	2.41	2.41	2.41	3	2.83	2.92	2.92
	E	100	78.26	56.52	47.83	100	50.00	35.71	26.43	100	39.13	21.74	0.00	100	100.00	100.00	100.00
	WFP	0	-36.48	-105.49	-117.38	0	0.00	0.00	0.00	0	-15.97	-15.01	-13.70	0	0.00	0.00	0.00
	WS	5000	6565.77	4582.05	4057.11	3000	3504.74	3336.42	3245.96	5000	4493.40	3944.91	3586.76	3000	2407.02	2864.71	2864.71
	D	0	-6.00	-20.31	-18.69	0	0.00	-18.78	0.00	0	-9.09	-24.51	-20.91	0	-100.00	-100.00	-100.00
OSU 3	FS	390	271.67	274.33	270.00	390	390.00	390.00	390.00	275	178.00	185.33	192.67	275	246.33	203.33	230.00
	ED	3	2.20	2.06	2.04	3	3.00	3.00	3.00	3	2.39	2.40	2.42	3	2.87	2.61	2.51
	E	100	0.00	0.00	0.00	100	100.00	100.00	100.00	100	30.43	34.78	39.13	100	0.00	0.00	0.00
	WFP	0	-19.23	-9.63	-21.07	0	0.00	0.00	0.00	0	-63.99	-78.96	-52.54	0	0.00	0.00	0.00
	WS	5000	5136.57	5159.67	5096.97	3000	3000.00	3000.00	3000.00	5000	3416.61	1753.97	3044.44	3000	2980.04	2717.87	2813.94
	D	0	-9.10	-20.03	-11.64	0	0.00	0.00	0.00	0	-7.35	-13.99	-13.04	0	-16.86	-48.58	-34.07
OSU 4	FS	390	281.00	276.33	270.33	390	287.33	274.67	260.00	275	213.33	183.67	183.33	275	234.33	183.33	183.33
	ED	3	2.35	2.33	1.66	3	2.14	2.06	2.00	3	2.51	2.40	2.40	3	2.51	2.40	2.40
	E	100	26.09	56.52	69.57	100	35.71	35.71	50.00	100	0.00	69.57	65.22	100	0.00	57.14	71.43
	WFP	0	0.00	-25.70	-120.56	0	0.00	-2.25	-21.21	0	0.00	-106.40	-69.23	0	0.00	0.00	0.00
	WS	5000	6962.88	6297.45	4259.66	3000	3553.15	3049.81	2835.48	5000	4372.12	3257.98	2664.59	3000	2818.68	1704.29	2247.29
	D	0	-7.62	-36.11	-54.98	0	-5.16	-10.14	-14.30	0	-5.58	-5.24	-11.92	0	-13.03	-29.22	-44.24
OSU 5	FS	390	274.67	271.33	268.00	390	318.33	301.00	266.67	275	227.33	210.67	185.00	275	233.33	183.33	183.33
	ED	3	2.27	2.05	2.03	3	2.17	2.14	2.03	3	2.49	2.46	2.41	3	2.50	2.40	2.40
	E	100	0.00	0.00	0.00	100	0.00	0.00	0.00	100	0.00	0.00	0.00	100	14.29	0.00	0.00
	WFP	0	0.00	-29.24	-36.27	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00
	WS	5000	5617.65	4921.39	4689.70	3000	3345.98	3251.06	2684.06	5000	5335.29	2628.89	2916.67	3000	3430.15	1500.00	3522.65
	D	0	-29.95	-18.82	-41.97	0	-5.96	-7.54	-15.87	0	-1.12	-21.39	-11.79	0	-11.00	-41.56	-45.40
OSU 6	FS	390	275.67	283.33	270.00	390	318.33	278.67	293.67	275	229.00	226.00	227.67	275	233.33	268.33	203.33
	ED	3	2.27	2.10	2.04	3	2.23	2.10	2.17	3	2.58	2.49	2.49	3	2.69	2.75	2.44
	E	100	0.00	0.00	0.00	100	0.00	0.00	0.00	100	0.00	13.04	39.13	100	0.00	39.29	46.43
	WFP	0	-1.56	0.00	-60.96	0	0.00	0.00	-1.46	0	0.00	0.00	-12.47	0	0.00	0.00	0.00
	WS	5000	4616.42	4839.10	4258.12	3000	3140.84	2690.65	2385.23	5000	5210.00	5972.22	6181.82	3000	3540.00	4116.37	3323.58
	D	0	-31.88	-66.01	-55.21	0	-13.35	-46.39	-33.53	0	-0.19	-3.29	0.00	0	-5.66	-11.62	-37.94

Table 5.2 Influence levels for three water years (Continued)

		Country A				Country B				Country C				Country D			
Sample	**DI**	**MPV**	**yr_1**	**yr_2**	**yr_3**	**MPV**	**yr_1**	**yr_2**	**yr_3**	**MPV**	**yr_1**	**yr_2**	**yr_3**	**MPV**	**yr_1**	**yr_2**	**yr_3**
OSU 7	FS	390	266.67	265.33	263.67	390	260.00	260.00	260.00	275	184.00	183.33	183.33	275	229.00	183.33	193.33
	ED	3	2.09	2.22	2.02	3	2.00	2.00	2.00	3	2.44	2.43	2.40	3	2.70	2.60	2.58
	E	100	73.91	56.52	39.13	100	82.86	35.71	56.43	100	56.52	72.48	15.65	100	42.50	92.86	78.57
	WFP	0	-95.30	-144.37	-142.93	0	-19.63	-4.64	-3.73	0	-77.45	-93.20	-18.51	0	0.00	0.00	0.00
	WS	5000	5201.14	3301.52	2022.91	3000	3187.85	2613.94	2992.74	5000	3624.37	2957.91	1794.66	3000	3872.51	2526.52	2481.90
	D	0	-10.62	-43.56	-46.12	0	0.00	-10.51	-7.49	0	-4.77	-7.72	-16.70	0	-16.81	-17.93	-25.22
OSU 8	FS	390	260.00	262.00	264.67	390	260.00	271.00	267.33	275	211.00	203.33	195.00	275	226.67	216.67	206.67
	ED	3	2.27	2.09	2.02	3	2.00	2.04	2.04	3	2.46	2.44	2.43	3	2.71	2.76	2.64
	E	100	52.17	26.09	21.74	100	90.71	26.43	50.00	100	13.04	30.43	30.43	100	0.00	21.43	14.29
	WFP	0	-75.18	-81.33	-52.94	0	-26.05	-3.26	-2.31	0	-30.03	-58.14	-64.77	0	0.00	0.00	0.00
	WS	5000	5133.57	4383.83	4860.44	3000	3159.88	3000.00	3087.84	5000	3327.21	3800.00	2854.65	3000	3066.82	3606.36	3173.59
	D	0	-1.33	-18.85	-9.70	0	0.00	-13.51	-4.13	0	-9.38	-8.82	-5.91	0	-11.20	-18.55	-26.24
OSU 9	FS	390	270.00	263.33	260.00	390	260.00	260.67	263.33	275	210.67	206.00	188.00	275	228.33	226.67	218.33
	ED	3	2.36	2.23	2.00	3	2.00	2.05	2.04	3	2.69	2.45	2.41	3	2.76	2.74	2.67
	E	100	47.83	30.43	43.48	100	92.86	57.14	71.43	100	78.26	17.39	60.87	100	0.00	7.14	7.14
	WFP	0	-28.59	-67.98	-112.16	0	-28.77	-34.16	-24.28	0	-49.74	-44.85	-100.15	0	0.00	0.00	0.00
	WS	5000	5235.21	4758.13	4938.52	3000	3131.38	2741.54	2981.38	5000	5279.51	4585.71	2711.57	3000	3351.67	3312.14	3425.00
	D	0	-0.51	-8.08	-5.73	0	0.00	-16.79	-4.99	0	-5.99	-3.21	-10.92	0	-12.01	-7.66	-25.62
OSU 10	FS	390	260.00	273.33	260.00	390	286.67	285.00	260.00	275	229.00	196.67	196.67	275	205.00	183.33	183.33
	ED	3	2.00	2.06	2.00	3	2.15	2.10	2.00	3	2.53	2.81	2.59	3	2.45	2.40	2.40
	E	100	82.65	56.57	43.48	100	0.00	0.00	21.43	100	60.87	78.26	100.00	100	0.00	0.00	21.43
	WFP	0	-221.10	-56.95	-122.79	0	0.00	0.00	-13.09	0	-18.76	-12.26	-133.56	0	0.00	0.00	0.00
	WS	5000	2705.44	5863.79	4376.67	3000	3334.41	3316.67	2444.00	5000	6466.67	4590.53	4633.33	3000	2397.05	1391.66	2623.33
	D	0	-72.18	-29.34	-29.58	0	-4.50	-9.35	-22.26	0	-0.78	-15.25	-0.44	0	-28.02	-54.12	-65.88

As shown in Table 5.2, the game did influence the negotiations from one round to another. For example, in sample OSU1 (first sample at OSU), the change in each development indicator can be seen as follows:

- Food supply: participants of Country D changed their water allocation strategies from year 1 through year 3 striving to partially meet their national food demand (MPV_D = 275 kg), from meeting 45.83 kg in year 1 (229.17 kg deficit) to 91.67 kg in year 2 and year 3 (183.33 kg deficit).

- Economic Development: the MPV for this indicator is 3 for all the four country board-games. Participants of Country B succeed to annually increase their national economic growth from the production of food, cotton, and bio-energy. The economic development indicator increased from 0.9 (Dev_1 = -2.1), 0.97 (Dev_2 = -2.03) to 1.26 (Dev_3 = -1.74), from year 1, year 2 to year 3 respectively.

- Environment: through the game, participants of Country C became aware of the importance of meeting the environmental requirements (for all the countries, the target or the MPV is

100%). In year 1, only a percentage of 56.52 of the environmental requirements was met (43.48% was remained) to fully meeting the environmental requirements (100%) in year 2 and year 3 ($Dev_{2,3} = 0$).

- Water footprint: the MPV for this indicator is zero percent for all the countries. Participants of Country C minimized their share from global water resources from 62.33% in year 1 to a share of 0% and 6.98 % from global water availability in year 2 and year 3 respectively.

- Water saving: participants of Country B adopted a strategy to save more water from one round to another (given $MPV_B = 3000$ m^3/capita/year); from a water loss of 639.68 m^3/capita in year 1 ($Dev_1 = -3639.68$) to a water saving of 236.44 m^3/capita ($Dev_2 = -2763.56$) in year 2 to 603.68 m^3/capita ($Dev_3 = -2396.32$) in year 3.

- Dependency: the MPV for this indicator is zero percent for all the four countries represented in the game. The percentage of dependency on foreign resources for the participants of Country B showed less dependency and more self-sufficiency throughout the game; from 66.5% dependency on foreign resources in year 1 to 16.19% and 33.63% dependency on foreign resources in year 2 and year 3.

The above analysis shows a considerable degree of influence in negotiation in later rounds by changing strategies to either improve one or more development indicators or in some cases worsen one or more development indicators.

RQ1-2: Did the game make a significant social learning impact?

To numerically examine the degree of change in perceptions (social learning) in all of the games, the survey data were first coded, categorized and then the changes in the pre-game and post-game surveys were calculated, as per the Q-test method:

$$\text{Q-Test} = f_{post} - f_{pre}$$

Where,

f_{post} : post-response frequency

f_{pre} : pre-response frequency

Since each category is seen to contribute a proportion of the total, the frequency for each category was divided by the total frequency. However, the Q-test scores are only valid if the number of responses was the same in the pre-and post-surveys. In case responses are not the same, the proportional values were calculated for the each category. The equation used was:

$$\text{Proportion (p)} = f_{post} / f_{pre}$$

In the same criterion, to address the relative size of each category, it was calculated by:

$$\text{Ratio} = \text{Number in the largest category} / \text{Number in the smallest category}$$

These steps were carried out for the three social framework criteria, as shown below in Tables 5.3, 5.4, 5.5 for the properties of collaboration, relationships, and knowledge, respectively.

Table 5.3 Q-Test: Properties of collaboration

Criteria	Questions	Responses	Coding	f_{pre}		f_{post}		Q-Test	Proportion	Ratio
Properties of Collaboration	Collaboration	I prefer working alone	1	Q9	9	Q4	4		0.44	8.357
		I prefer teamwork	2		7		26		3.71	
		I enjoy both	3		35		21		0.60	
	Feelings of Inclusiveness	Listening	-	Q12	18	Q6	0	0	0.00	0.000
		Acknowledge opinions	-		23		1		0.04	
		Communication, Negotiation, Discussion, and Participation	-		20		6		0.30	
		Respect	-		4		0		0.00	
		Asking questions	-		6		0		0.00	
		Others	Trust Building		1		0		0.00	
			Open Mind		1		1		-	
			Eye Contact		1		0		0.00	
			Body language		1		0		0.00	
			Taking notes		1		0		0.00	
			Suggestions of common solutions		4		2		0.50	
			Knowledge building		3		0		0.00	
			Establishment of clear dialogue structure		2		0		0.00	

Table 5.4 Q-Test: Properties of relationships

Criteria	Questions	Responses	Coding	f_{pre}		f_{post}		Q-Test	Proportion	Ratio
Properties of Relationships	Preparation for Negotiations	Preparedness to participate	1	Q10	24	Q9	21		0.88	0.000
		Leadership and capacity building	2		16		12		0.75	
		Respecting diverse perspectives, interests, and goals	3		30		24		0.80	
		Developing joint solutions	4		23		28		1.22	
		Team building, involvement, and communications	5		17		17	0	-	
		Knowledge exchange	6		24		20		0.83	
		Trust building	7		14		19		1.36	
		Other	8		0		1		0.00	
	Conflict Management Styles	Fight back and enforce your opinion	1	Q11	3	Q5	0		0.00	0.000
		Avoid conflict and accept any suggestions	2		10		10	0	-	
		Argue until we all reach consensus	3		31		24		0.77	
		Other	4		7		17		2.43	
	Negotiation Strategies with other Groups	Be prepared for the worst and best scenario outcomes	1	Q13	12	Q7	7		0.58	3.956
		Give and Take	2		13		30		2.31	
		Build relations and good reputation	3		18		25		1.39	
		The team strategy will keep changing using a combination of the above strategies	4		28		18		0.64	
	Collaboration Barriers	No trust	1	Q14	26	Q8	23		0.88	13.333
		Language barriers	2		20		6		0.30	
		No respect	3		16		7		0.44	
		Lack of coordination and communication	4		38		44		1.16	
		Other	5		1		4		4.00	

Table 5.5 Q-Test: Properties of knowledge

Criteria	Questions	Responses	Coding	f_{pre}		f_{post}		Q-Test	Proportion	Ratio
Properties of Knowledge	Serious Gaming	0	0	Q16	0	Q10	0	0	-	0.000
		1	1		0		0	0	-	
		2	2		0		0	0	-	
		3	3		0		0	0	-	
		4	4		0		1		0.00	
		5	5		2		3		1.50	
		6	6		6		2		0.33	
		7	7		5		7		1.40	
		8	8		3		14		4.67	
		9	9		3		9		3.00	
		10	10		3		15		5.00	
	Countries Preparation to International Water Disputes	A water-rich country	1	Q17	17	Q11	32		1.88	0.000
		A water-poor country	2		10		8		0.80	
		Both water-rich/poor countries	3		11		9		0.82	
		The private sector	4		12		0		0.00	
		Other	5		1		2		2.00	

Table 5.5 Q-Test: Properties of knowledge (Continued)

Criteria	Questions	Responses	Coding	f_{pre}		f_{post}		Q-Test	Proportion	Ratio
Properties of Knowledge	Wise Water Management	The use of efficient agricultural technologies and practices	1	Q18	24	Q12	27		1.13	0.000
		Water_Food_Energy Nexus Strategy	2		8		17		2.13	
		Meeting the environmental flows	3		12		28		2.33	
		Access to safe drinking water	4		0		0	0	-	
		Increase national economic status	5		16		11		0.69	
		Implement resilience and disaster risk reduction plan	6		10		5		0.50	
		Improving the water quality index	7		8		2		0.25	
		Integrated Water Resources Management Plan	8		16		27		1.69	
		I do not know	9		8		1		0.13	
		Other	10		0		0	0	-	
	Efficient Water Use	Using water-saving techniques	1	Q19	39	Q13	36		0.92	0.000
		Reduce pollution and adopt waste management plan	2		29		16		0.55	
		Cap environmental requirements then trade water-embedded products	3		5		14		2.80	
		Reduce the global water footprint	4		24		29		1.21	
		Is there a climate change? I do not think so!	5		0		0	0	-	
		Other	6		1		0		0.00	

Table 5.5 Q-Test: Properties of knowledge (Continued)

Criteria	Questions	Responses	Coding	f_{pre}		f_{post}		Q-Test	Proportion	Ratio
Properties of Knowledge	Water Productivity	True	1	Q20	17	Q14	22		1.29	1.618
		Maybe	2		15		12		0.80	
		False	3		19		17		0.89	
	Global Trade	Strongly support	1	Q21	20	Q15	25		1.25	0.000
		Somewhat support	2		30		24		0.80	
		Somewhat oppose	3		1		2		2.00	
		Strongly oppose	4		0		0	0	-	
	Comparative Advantage in International Trade	A lot	1	Q22	4	Q17	12		3.00	83.375
		A moderate amount	2		8		29		3.63	
		A little	3		16		9		0.56	
		None at all	4		23		1		0.04	
	Difference between Virtual water and Water Footprint	Yes	1	Q23	11	Q18	43		3.91	0.000
		No	2		20		0		0.00	
		Two names for the same concept	3		1		4		4.00	
		I do not know	4		19		4		0.21	
	The Role of Global Trade	Efficient as it reduces the pressure on the production from the domestic waters	1	Q24	19	Q16	30		1.58	3.158
		It is an economic instrument to increase the country GDP	2		29		28		0.97	
		A strategy that does not work for self-sufficient countries	3		14		20		1.43	
		Trade is damaging the environment	4		20		12		0.60	
		Provides job opportunities	5		17		15		0.88	
		Other	6		4		2		0.50	

The analysis results show that there was a change in three social learning properties. The results were expected because of inherent bias due to the following:

(1) The two criteria that represent the individual personality and behaviors are as follows:

Properties of Collaboration: this criterion was represented in two survey questions. One question was an open-ended question (qualitative data), which permits self-expression in the response. Although the responses were coded and categorized, individuals differed in terms of their level of expression. That created a great gap between what was mentioned before and after the game.

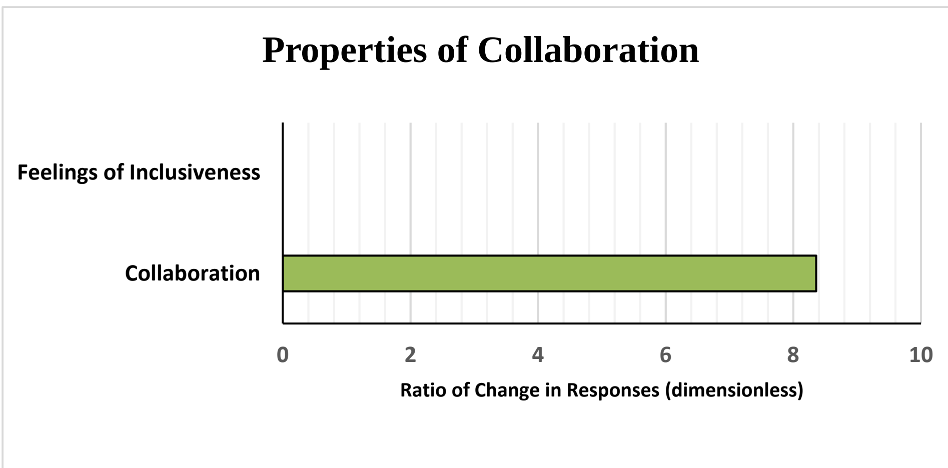

Figure 5.1 Changes in participant responses regarding properties of collaboration.

Properties of Relationships: this criterion represents the players' negotiation styles and collaboration preferences, which could remain the same even after playing the serious game. The players are responsible for deciding whether or not they want to make an internal change in their properties of collaboration.

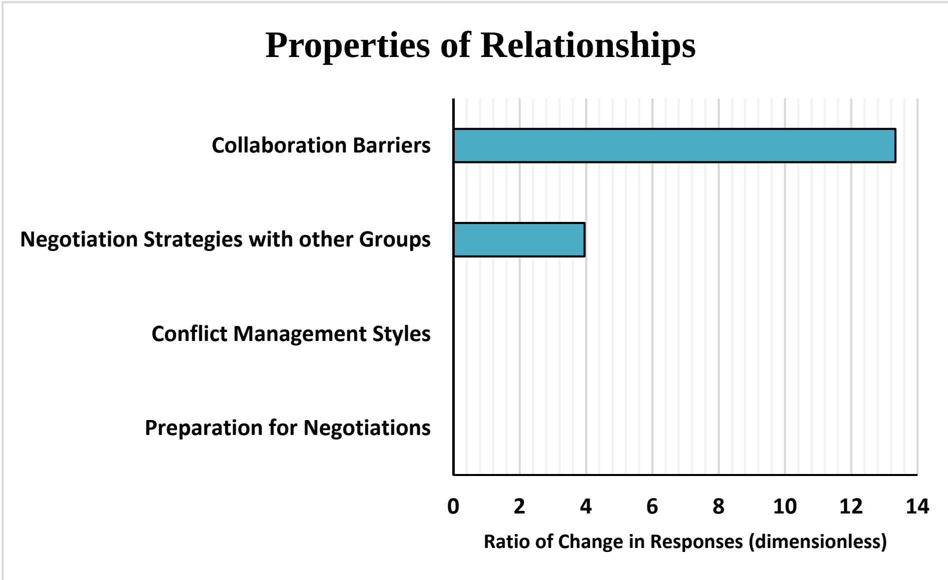

Figure 5.2 Changes in participant responses regarding properties of relationships.

(2) Given the initial survey setup, each social learning criterion was represented in a set of relevant questions. The largest amount of questions in the survey (eight questions) were related to the participants' properties of knowledge.

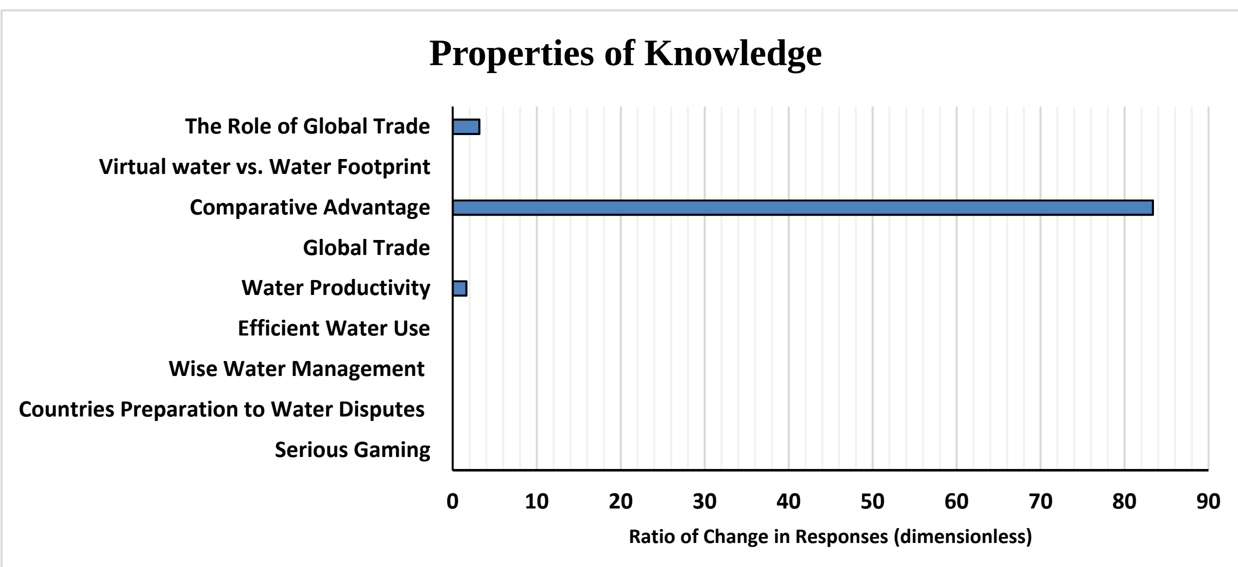

Figure 5.3 Changes in participant responses regarding properties of knowledge.

Given the results in the previous tables, by assigning a weight of 2 for both the properties of the collaboration and the properties of relationships. The properties of knowledge were assigned a weight of 3 from the overall goal; social learning. The reason behind the weighting system is because of the number of questions in the survey, questions on the properties of knowledge received much of the survey questions. Moreover, each question within the criterion was assigned different weight according to the level of contribution to the overall goal. The final score was calculated using the equation:

$$\text{Final score} = \text{ratio} * \text{contribution to the goal}$$

For the three categories, Table 5.6 summarized the final outcomes and the ratio of each criterion with respect to the other social learning criteria.

Table 5.6 Social learning framework Q-Test Summary

Goal		Criteria	Weight level 1	Contribution to Goal (%)	Questions	Weight Level 2	Contribution to Criteria	Ratio	Final score (%)	
Social Learning Framework	100%	Properties of Collaboration	2	28.571	Collaboration	2	19.05	8.357	159.18	
					Feelings of Inclusiveness	1	9.52	0.000	0.00	
		Sum of Properties of Collaboration Score							159.18	15%
		Properties of Relationships	2	28.571	Preparation for Negotiations	2	7.14	0.000	0.00	
					Conflict Management Styles	2	7.14	0.000	0.00	
					Negotiation Strategies with other Groups	3	10.71	3.956	42.39	
					Collaboration Barriers	1	3.57	13.333	47.62	
		Sum of Properties of Relationships Score							90.01	8%
		Properties of Knowledge	3	42.857	Serious Gaming	2	6.59	0.000	0.00	
					Countries Preparation to International Water Disputes	1	3.30	0.000	0.00	
					Wise Water Management	2	6.59	0.000	0.00	
					Efficient Water Use	1	3.30	0.000	0.00	
					Water Productivity	1	3.30	1.618	5.33	
					Global Trade	1	3.30	0.000	0.00	
					Comparative Advantage in International Trade	1	3.30	83.375	274.86	
					Difference between Virtual water and Water Footprint	3	9.89	0.000	0.00	
					The Role of Global Trade	1	3.30	3.158	10.41	
		Sum of Properties of Knowledge Score							290.61	27%
Sum of weights			**7**	**100**	**Sum of weights**	**24**	**100**		**1079.59**	**50%**

As can be seen in the results of the previous table, participants' perceptions in terms of their properties of knowledge changed significantly over the course of the game (27% overall change). Despite this change in perception, the results of the players' properties of relationships demonstrated the least changes over the game duration (only 8% overall change).

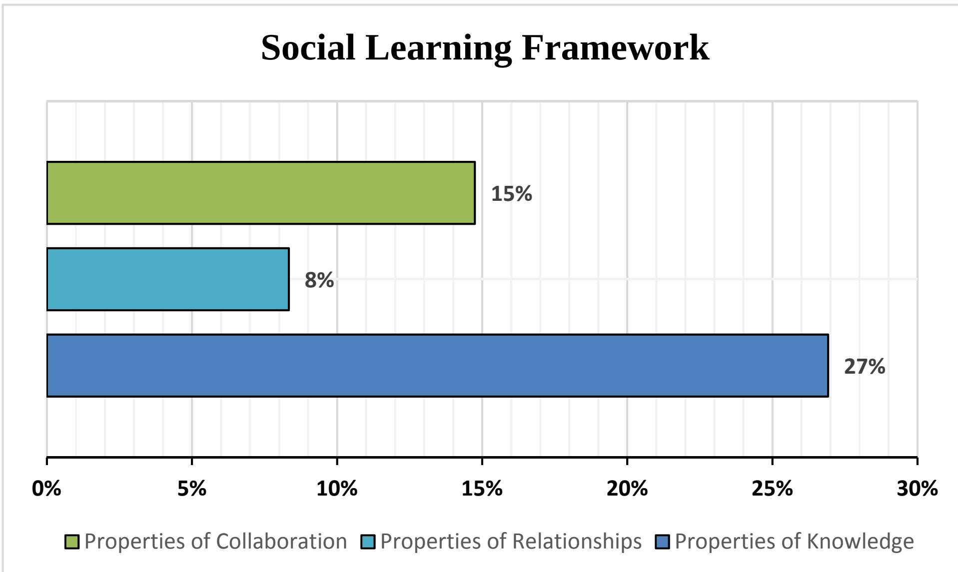

Figure 5.4 Changes in participant responses across components of the social learning framework.

Although there was a considerable change in participants' perception across the three categories (properties of collaboration, relationships, and knowledge). Since it is evident from these results that there was a considerable change. Therefore, the null hypothesis (H_1: *Hypothesize seeing no pattern*) can be rejected; the WFCABG proved to have a significant social learning impact.

RQ2: what is the relationship between the participants' background and social behaviors that derive the outcomes of the game?

<u>Demographic Characteristics</u>

This study aimed to determine the type of individuals engaged in serious games, similar to what has been done in other studies by scholars such as Williams et al. (2008); Yee (2006); and Bartle (1996).

Each player has five demographic characters namely: age, gender, educational background, highest degree, and country of origin. Some players (American students only), had a sixth character (U.S. state). Since this study focused on the characteristics of the players that were associated with the game outcomes, players were used as the unit of analysis.

<u>Measures</u>

Players, as the dependent variable, were measured as the sum of each player's statistics and upon successful completion of tasks, e.g. national development indicators. As players obtained more improved game outcomes, their game outcomes statistics showed progress; this made them more influential. All of the indicators were considered equally important for the player. The sum of all of the indicators provided an index that indicated the overall game level that applied to all the players. Each of the following attributes has been put forth as primary drivers of game outcomes.

Age and gender

In the survey, players were asked for basic demographic information such as their age and gender. The age range was coded from 1 to 6 with one indicating under 18 and 6 indicating 65 and above. Gender wise, the statistics from the whole sample including UPEACE and OSU showed that more females than males tended to participate in the game in greater numbers, making up 52.3 percent of the players. More females volunteered their time to participate in the game than male. However, male participants who played the games were not that far from these records (47.7%). In contrast, these gender statistics differ from Cassell's (1998) and Ivory's (2006) argument that games are mainly created with males in mind. Hypothetically, women would enjoy socialized games instead of games that aim to win or require competition (Wang, Huffaker, Treem, and Fullerton, 2011). This suggests the possibility that females are equally interested or more interested in competitive games than are males. More likely, the ratio in this study may be a subset of the population size in Costa Rica and the United States.

Educational Background and Highest Degree

This study anticipated that those who had high knowledge levels would perform better at tasks. Moreover, it was anticipated that those who would fail to make achievements would have little knowledge about water resources management. The game content requires a minimum of four players to work together to complete all three rounds. Having more people on one team means assigning tasks to each individual, e.g. instigator, job completer, mediator, group representative, and other roles. These positions or roles can be exchanged within the group from one round to another. Ackerman (1996) highlighted the importance of player knowledge as a competence factor to achieve their interests. However, to improve the outcomes, players need to advance their skills and knowledge by constantly learning from each other and exploring the game world (Wang et al., 2011). In the game environment, players gain more knowledge and practice many skills that can be either self-taught or absorbed from other players.

Country of Origin and States (USA)

In this study, another characteristic of the game players that may be associated with the outcomes is the water culture in their country of origin or at the state level, in the case of the participants from the United States. Thus, the results of the game – at any given point – can be characterized as a result of their choices on how to navigate the game world in a way that is of greater interest to them (Wang et al., 2011). The game is flexible regarding its ability to allow the players to escape from the real world by thinking outside the box.

Average scores for each development indicator variable, e.g. food supply, economic welfare, meeting environmental flow requirements, national water footprint, water saving, and dependency on foreign resources were calculated as was shown in Table 4.7.

In the following portion of the study, an in-depth analysis is conducted for two of the played games (game samples) to explore relationships between the game outcomes and the player-related data, such as, Who played? What is their age? What is their country of origin? These questions are inherent in the first social learning criterion, e.g. the properties of participants. The two samples are UP1 (first sample at UPEACE – dominated by participants from water-poor countries) and OSU1 (first sample at OSU – dominated by participants from water-rich countries). Eight participants played in each of these two games. It was difficult to do the same analysis for the remaining 10 games because many games-countries were represented either by a group (two or three players) or a single player.

This also explains why there was a wide distribution of the data shown in Table 4.7 (see Chapter 4). For example, in the two sample games, the average water-saving value for country D was -336.69 m^3/yr/capita (the negative value represents water loss), whereas in OSU2 (second sample at OSU), this value was 795.26 m^3/yr/capita. The positive value here represents water saving.

Type of Variables

- *Ordinal variable:* a possible value in between categorical and quantitative variables. Example: Educational level might be categorized.
- *Categorical variable:* a qualitative or attribute variable. The value is a countable number of categories or different groups. Example: State.
- *Quantitative variable:* a measured number. Examples: Age. Any variable that is not quantitative is categorical.

Table 5.7 shows the types of variables used in this study, participant's characteristics and game-model outcomes.

Table 5.7 Type of variables

Type	Variable(s)
Quantitative	Age
Ordinal	Educational background, and highest degree
Categorical	Gender, country of origin, States (USA), food supply, economic welfare, meeting environmental flow requirements, national water footprint, water saving, and dependency on foreign resources.

Chi-Square Test of Independence (X^2)

The relationship between 2 or more categorical variables can be analyzed using the Chi-Square Test of Independence to determine whether there is a significant correlation between the two categorical variables or not.

$H_{o,2}$: water-rich country variable and WFP_i variable are independent.

$H_{a,2}$: water-poor country variable and WFP_i variable are not independent.

Where,

$H_{o,i}$: Null hypothesis

$H_{a,i}$: Alternative hypothesis

WFP_i : the related water footprint development indicators (e.g. water footprint, and water saving)

$H_{o,3}$: water-poor country variable and DI_i variable are independent.

$H_{a,3}$: water-poor country variable and DI_i variable are not independent.

Where,

DI_i : the six development indicators (e.g. food supply, economic development, environment, water footprint, water saving, and dependency)

Chi-square can be determined using the following equation:

$$X^2 = \Sigma [(O_i - E_i)^2 / E_i]$$

Where,

O_i : the observed frequencies count

E_i : the expected frequencies count

Observed Frequencies (O)

The observed or measured counts are made from the experimental game data (see Tables 5.8 and 5.9).

Table 5.8 Observed frequency counts for UP1 sample

Country of origin	Food supply	Economic development	Environment	Water footprint	Water saving	Dependency	Total
Lebanon	286.44	1.76	88.41	45.23	187.38	15.88	625.09
Vietnam	286.44	1.76	88.41	45.23	187.38	15.88	625.09
Myanmar	286.44	1.76	88.41	45.23	187.38	15.88	625.09
USA	122.11	0.84	91.67	0.00	330.98	13.46	559.06
Vietnam	86.40	0.60	84.06	37.26	1899.40	11.50	2119.22
Nigeria	86.40	0.60	84.06	37.26	1899.40	11.50	2119.22
Malawi	82.33	0.33	42.86	0.00	-336.69	7.42	-203.74
Japan	82.33	0.33	42.86	0.00	-336.69	7.42	-203.74
Total	1318.91	7.97	610.71	210.21	4018.55	98.94	6265.30

Table 5.9 Observed frequency counts for OSU1 sample

Country of origin	Water footprint	Water saving	Total
USA	49.53	453.92	503.45
USA	49.53	453.92	503.45
USA	46.09	66.81	112.90
USA	46.09	66.81	112.90
USA	23.10	3834.93	3858.03
Eritrea	23.10	3834.93	3858.03
USA	n/a	795.26	795.26
USA	n/a	795.26	795.26
Total	237.45	10301.84	10539.29

Expected Frequencies (E)

The probability count using probability theory for each cell in a contingency table (see Tables 5.10 and 5.11). The equation to calculate expected frequencies is:

$$E_{i,j} = (n_i \text{ x } n_j) / n$$

Where,

n : total sample size

$E_{i,j}$: the expected frequency count for the ith row/jth column

n_i : the total number of sample observations in the ith row

n_j: the total number of sample observations in the jth column

Table 5.10 Expected frequency counts for UP1 sample

Country of origin	Food supply	Economic development	Environment	Water footprint	Water saving	Dependency
Lebanon	131.59	0.80	60.93	20.97	400.93	9.87
Vietnam	131.59	0.80	60.93	20.97	400.93	9.87
Myanmar	131.59	0.80	60.93	20.97	400.93	9.87
USA	117.69	0.71	54.49	18.76	358.58	8.83
Vietnam	446.12	2.70	206.57	71.10	1359.27	33.47
Nigeria	446.12	2.70	206.57	71.10	1359.27	33.47
Malawi	-42.89	-0.26	-19.86	-6.84	-130.68	-3.22
Japan	-42.89	-0.26	-19.86	-6.84	-130.68	-3.22

Table 5.11 Expected frequency counts for OSU1 sample

Country of origin	Water footprint	Water saving
USA	48.75	48.75
USA	14.29	619.89
USA	5.93	257.33
USA	5.93	257.33
USA	79.73	3458.94
Eritrea	79.73	3458.94
USA	18.78	814.76
USA	18.78	814.76

Thus, the statistical value of chi-square for both samples are:

$X^2_{UP1} = 427.97$

$X^2_{OSU1} = 4525.19$

In order to determine if these figures represent significant chi-squares or not; the above chi statistical figures are compared with the critical figures in the chi-square distribution table by first determining the degrees of freedom.

Degrees of Freedom (DF)

The degrees of freedom can be calculated using the following equation:

$$DF = (r - 1) \times (c - 1)$$

Where,

r : total number of rows in the excepted frequency count table

c : total number of columns in the excepted frequency count table

Hence, for the two samples, the degrees of freedom equal:

$DF_{UP1} = (8-1) \times (6-1) = 35$

$DF_{OSU1} = (8-1) \times (2-1) = 7$

Significance level (α)

Often, significance levels equal to 0.01 (99 % confidence), 0.05 (95 % confidence), or 0.10 (90 % confidence) are used by many researchers. However, any value between 0 and 1 can be used. In this study, a value of 0.05 (95% confidence) is used.

Accordingly, from the chi-square distribution table, the value of chi critical $X^2_{0.05}$ for UP1 sample at DF equal 35 is 49.7655 and $X^2_{0.05}$ for OSU1 sample at DF equal 7 is 14.0671 (using interpolation).

Thus, for UP1 sample, since Chi stat (427.97) is greater than Chi critical (49.7655), thus the null hypothesis *water-poor country variable and DI_i variable are independent* is rejected (see Figure 5.5).

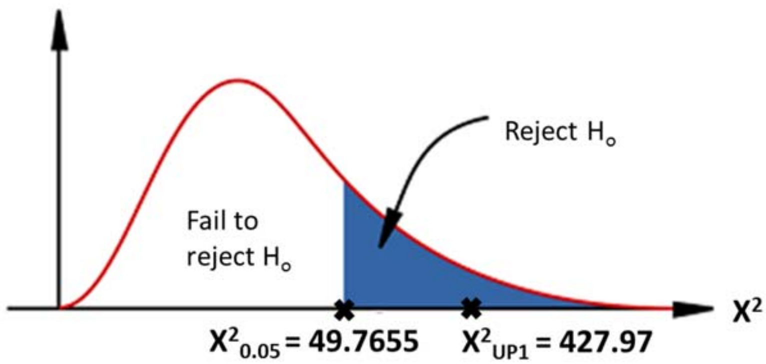

Figure 5.5 Chi-square distribution for UP1 sample

Similarly, for OSU1 sample, Chi stat (4525.19) is greater than Chi critical (14.0671), resulting in rejecting our null hypothesis and accepting the alternative hypothesis *water-rich country variable and WFP_i variable are not independent* (see Figure 5.6).

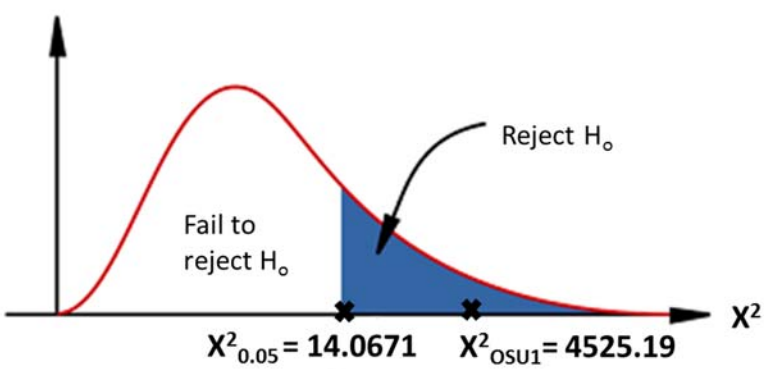

Figure 5.6 Chi-square distribution for OSU1 sample

The purpose of the research question was to examine the relationship between players' demographics and characteristic attributes, and the game outcomes. The results of the chi-square test were as expected. The game samples (UP1 and OSU1) showed that country of origin was related to the development indicator variable (including the WFP variable). This study hypothesized the following:

H_2: People from water-rich countries or people from countries with large water footprint would have a type of water culture that is profit driven, and would be unaware of the global water footprint because of the abundant nature of their waters.

H_3: People from water-poor countries would relate the water management in the game to their water cultures, and due to the level of water scarcity they would focus more on the negotiations.

According to the study prediction, the country of origin was a significant predictor of the game outcomes. Thus, players' performance was inextricably linked to the game results.

However, the data distribution was less than ideal.Thus, this study was useful in terms of showing significant results that can be further examined to explore additional means of analysis. Moreover, it would be interesting to conduct the same study and examine all 50 U.S. states or have a representative sample of the global population rather than the population of participants in the game. Also, examine ways that gender, age and other participant attributes (not just the country of origin) might influence the game approach and the expected outcomes with careful consideration taken of the different water cultures as they vary by urban vs. rural and west vs. east, or north vs. south or other factors, rather than state vs. state or country vs. country.

RQ3: which of the options, the game outcomes or the baseline situation, represents the best scenario?

In order to answer this RQ, the six development indicators of the WFCABG obtained from the twelve different groups were supposed to be compared to the global baseline scenario of the four areas of sustainability: economic, social, environmental, and political for each country (France, Spain, Indonesia, and Kenya). It was anticipated that the evaluation for the best game scenario might not necessarily result in being the best in terms of the water footprint; however, it might represent the best across the board. This evaluation can be assessed using the scorecards method. The main aim was to help anticipate the limitations in the water footprint theory through testing the design of the game and the reached outcomes. However, a great consideration to the difference between the game results and the real world as they are not the same.

Unfortunately, this research question was not addressed in this study for two reasons: (1) the above research question is beyond the scope of the study, and (2) another drawback is the issue of scale. The WFCABG was designed based on the national scale with no consideration to smaller water management systems within the country. Although RQ3 was not answered in this study, this study provided a body of knowledge and data that can be used in future research to try to answer the above RQ. Thus, this study recommends conducting more research to contribute to this work, given the existing game data outcomes.

5.2 Limitations and Future Research Directions

5.2.1 Elements Beyond the Scope of the Game Scope

The game was played to simplify and explore the water resources management issues inherent in the trade of commodities. The nuances of global water management cannot be portrayed in a single game. However, many scenarios could be added to the game. The aim was not to complicate the game and push the attention away from the main objective, learning about water resource management. Below are some scenarios outside the game scope:

- Other water consumption categories, such as commercial industries, ecosystems, household uses, and spiritual needs, among others.
- Various settings of each country regarding their resources, wealth, size, tradition, food diet, technology, labor, sovereignty, and so on.
- The scale of water conflict management: river basin, watershed, regional, or transboundary.
- Other water sources such as desalinated water and the reuse of water.
- Additional existing development indicators such as health, education, employment, gender equality, poverty, national security, and others.

The intent in conducting the game simulation was to allow the participants to gain exposure to the different kinds of problems that are inherent in their daily practices, as well as to demonstrate how collaboration "to take into account the interest of the others" can lead to mutual gains (Rumore, Schenk, & Susskind, 2016).

5.2.2 Methodological Limitations

Several limitations arose from this study. First, due to the small sample size, saturation was not reached. In this study, the population (n) was not very large, and it was biased because some of the people who were approached are the researcher's friends, who are also students and colleagues in the same two universities. Moreover, saturation was needed in order to have a full representation of the serious game. To illustrate, there was a need for participants (at least in one game simulation) from the same represented countries as in the serious game, with the aim of relating their water culture to the serious game outcomes. These countries are France, Spain, Indonesia, and Kenya. In this study, there was only one participant from Indonesia and no participants from the other three countries.

Second, the data collected does not represent nor comprehensively capture all perspectives. This may be true for several reasons. Because of the sampling, the perspectives of contacts recruited and questioned may represent their biases on the research concepts. Moreover, the recruitment procedure and sample population may have implications on the results. Thus, the grouping of participants into "water cultures" needs refinement to support the findings of this research.

Third, the surveys were unequally collected across the participants, limiting the degree to which reliable conclusions on each group tendency could be reached. As such, the results and analysis that follow should be considered as a preliminary evaluation of the potential for assessment of social learning on water resources management using WFCABG, and an opportunity for refinement of the methods used and for development and investigation of a more robust set of hypotheses that could be explored in future work.

Fourth, the survey answers varied from open-ended answers to categorical answers, to ordinal answers. Therefore, using the same technique to measure changes in response won't yield meaningful results. At best, this could stand as a pilot or observational study upon which further hypotheses may be developed.

Fifth, the WFCABG is a serious game developed by the proponents of the Water Footprint concept (Hoekstra & Chapagain, 2008). Therefore the game cannot be played without taking into consideration its mission; maybe to promote the use of the water footprint for the sustainable use of water. This aspect is very important specifically if this particular game is played and used in a different context or a larger scale (e.g. stakeholders) as it may have significant ramifications for the study findings.

As such, the results and analyses that follow this work can be considered as part of a preliminary evaluation of social learning on water resources management using WFCABG.

CHAPTER 6 – CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study aimed to examine the impact of serious games to enhance the social learning in different geographic settings. For this thesis research, a serious game concerning the Water Footprint concept (Hoekstra and Chapagain, 2008) was used and tested. The study analysis was based on the Mayer et al. (2016) social learning framework, which encompasses four categories: (1) properties of participants, (2) properties of collaboration, (3) properties of relationship, and (4) properties of knowledge. The aforementioned theory aims to assess the change in the participants' perception of the learning topic.

The experiment was conducted on students in two academic settings, OSU and UPEACE, through surveys, game models, follow-up sessions, and observations. It was predicted that (a) People from water-rich countries or people from countries with large water footprint would have a type of water culture that is profit driven, and would be unaware of the global water footprint because of the abundant nature of their waters, while (b) People from water-poor countries would relate the water management in the game to their water cultures, and due to the level of water scarcity, they would focus more on the negotiations. Other attributes investigated which might be expected to influence the outcomes of the game rounds included age, gender, educational background, highest degree attained.

One of the null hypotheses (H_1) is seeing no change or no distinct differences in outcomes based on social learning criteria.

In the WFCABG, players were put into similar situations to the one from which they learned and witnessed the results and the consequences of their actions as the representatives of their countries at the global meetings. The successful use of the game with students in UPEACE and OSU in examining the learning based on the social learning framework is due to the initial simple set-up of the game board version and the supporting spreadsheet used for showing the results.

From the beginning of each round, players attempted to manage their national water resources in a way that ensured increase (or at least not reduction) the six development indicators. Three simulated years were played. Some scenarios, such as drought, were introduced in the simulations. Despite the same initial setup of the game, the results differed dramatically. No changes were made to the game parameters (allowing only the commodity surplus to be carried over to the next round). This helped to anticipate the limitations and test the design of the game.

The presented game simulation had a potential pedagogical contribution and aimed at facilitating the discussion among participants. The game focused on showing how complicated are the negotiations over water on the international scale. It emphasized on trade-offs concerning water use for different commodities and the environment, a major factor in the decision making. The game could also be used for different purposes other than providing a safe learning environment and training, such as encouraging participation and for social behavior change. However, careful use of the game mission should be considered in different contexts.

The convenient use of board games was the basis for choosing this type of game rather than many other types of games such as role-plays, computer-assisted games, and online-computerized games. Thus, the WFCABG proved to be a useful and straightforward tool allowing participants to discuss and approach several aspects of the world of trade.

This study aimed to make a comparison of social experiences in a descriptive way based on the social learning assessment framework of Mayer et al. (2016) in order to examine the social learning. The pre- and post-game survey data showed that there was a 27% overall change in the participants' perceptions regarding their properties of knowledge, whereas the least change occurred on the properties of relationships, however, with only 8% overall change.

The game was useful in influencing the negotiation in later rounds (water years). Participants changed their strategies from one year to another to either improve or worsen one or more development indicators. However, the majority learned and improved their national developments indicators (at least one development indicator showed progress).

A major finding from the chi-square analysis demonstrates that individual characteristic (country of origin) is relevant variable that marked the players' outcomes in the WFCABG.

The WFCABG simulation proved to have great value and an impact both on learning and enhancing students' negotiation skills regarding water resources management issues. The pre- and post- game survey data represent some of the strongest evidence in which to infer that participant knowledge changed during the game, and thus that serious games can inform participants about water management concepts.

6.2 Lessons learned

This study was an attempt to examine ways in which the characteristics of the participants influenced both the outcomes of the game played and the participants' perceptions of global water management in the domain of serious gaming by studying the WFCABG. In this study, the associated components between the game outcomes and players' characteristics were investigated.

The findings suggest that the variable (player characteristic – country of origin) was indeed a significant influence on the game outcomes. This could help the understanding of the component of strategic choice during the negotiation of water-related issues in the real world. As different factors (income, experience, geography, etc.) may also play a role and affect the final decision. For future research, more measures can be added to the analysis to explore the results of the game (e.g. the time spent playing the game).

Scholars like Wang et al. (2011) proposed recording the game playing time as a control variable to assess whether the game outcomes were also a result of the game playing time (more time, more achievements) or not. On average, in this study, players spent two and a half hours to complete the three rounds. However, this study did not consider documenting the game playing time in each simulation. Therefore, in future studies, the author recommends detecting the game playing time in order to improve the negotiation process if the WFCABG will be used to facilitate the training process.

6.3 Recommendations

The following lists some useful techniques to enhance the learning, as proposed by many scholars:

- Improving communication and defining the terms used in discussions: mainstreaming the perceptions of water footprint through playing the game. For example, conducting a statistical comparison of pre- and post-game survey responses means to test whether the mean number of participants who knew the difference between virtual water and the water footprint is significantly different before and after playing the game.
- Observing trust change over time: during the negotiation stage — which is typically a competitive phase — measuring the changes in trust between players can help to assess the learning, especially if the players are highly dependent on each other (Zaag, Bos, Odendaal, & Savenije, 2003).
- Other learning measurements: scholars like Kaufman et al., (2015) stated that "knowing what's being measured and not measured may result in an overemphasis on particular aspects of negotiation that are not especially important." These measures can include the participant income, race, etc. and how it might influence the outcomes of the game.
- Making a video reflection: to help participants become aware of their negotiation behavior and to give insights into what went wrong/right during the game simulation and where (Kaufman et al., 2015).
- Asking questions: interrogating each group about what they were trying to achieve (e.g. achieving one, multiple, or all of the development indicators).
- Finding measurable ways to quantify the learning and possibly present it at the end of the simulation.

The study provided data and results from the game trials and feedback surveys that may allow making inferences about social learning within the framework that have been chosen. The study was helpful to examine the learning in an academic context with undergraduate and graduate students. The author believes the above recommended areas can be further investigated in the same context or in other contexts (with communities or stakeholders).

BIBLIOGRAPHY

Abt, C. C. (1970). Serious Games. *Report: ED039447. 176pp. 1970*.

Ackerman, P. (1996). A theory of adult intellectual development: Process, personality, interests, and knowledge. *Intelligence*. Retrieved from http://www.sciencedirect.com/science/article/pii/S0160289696900161

Alfred Twu. (2014). California Water Crisis. Retrieved January 1, 2017, from https://boardgamegeek.com/boardgame/169872/california-water-crisis

Allan, J. a. (1997). "Virtual water": a long term solution for water short Middle Eastern economies? *1997 British Association Festival of Science, Water and Development Session - TUE.51, 14.45, 9 September 1997*, (September), 1–21. https://doi.org/http://dx.doi.org/10.1016/S0921-8009(02)00031-9

Arndt, T., & Klentzin, J. C. (2010). Pecha Kucha: using "lightning talk" in university instruction. *Reference Services*. Retrieved from http://www.emeraldinsight.com/doi/full/10.1108/00907321011020798

Baldaro, B., Tuozzi, G., & Codispoti, M. (2004). Aggressive and non□violent videogames: short□term psychological and cardiovascular effects on habitual players. *Stress and*. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/smi.1015/full

Barreteau, O., Bousquet, F., & Attonaty, J.-M. (2000). Role-playing games for opening the black box of multi-agent systems: method and lessons of its application to Senegal River. *Journal of Artificial Societies and Social Simulation*, *4*(2), 5. https://doi.org/10.1016/j.foreco.2011.01.001

Barreteau, O., & Page, C. Le. (2003). Role-playing games, models and negotiation processes. *Of Artificial Societies and …*. Retrieved from http://jasss.soc.surrey.ac.uk/6/2/10.html

Bartle, R. (1996). Hearts, clubs, diamonds, spades: Players who suit MUDs. *Journal of MUD Research*. Retrieved from http://www.arcadetheory.org/wp-content/uploads/2014/03/1996bartle.pdf

Boissau, S., Anh, H. L., & Castella, J. C. (2004). The SAMBA role play game in northern Vietnam: An innovative approach to participatory natural resource management. *Mountain Research and Development*, *24*(2), 101–105. https://doi.org/10.1659/0276-4741(2004)024{[}0101:TSRPGI]2.0.CO;2

Bots, P., & Daalen, E. Van. (2007). Functional design of games to support natural resource management policy development. *Simulation & Gaming*. Retrieved from http://journals.sagepub.com/doi/abs/10.1177/1046878107300674

Buhaug, H., Gleditsch, N. P., & Theisen, O. M. (2008). Implications of Climate Change for Armed Conflict. *Group*, *1*, 48. https://doi.org/http://siteresources.worldbank.org/INTRANETSOCIALDEVELOPMENT/Resources/SDCCWorkingPaper_Conflict.pdf

Cassell, J. (1998). Chess for girls?: Feminism and computer games. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.50.6849

Castella, J. C., Trung, T. N., & Boissau, S. (2005). Participatory simulation of land-use changes in the northern mountains of Vietnam: The combined use of an agent-based model, a role-playing game, and a geographic information system. *Ecology and Society*, *10*(1). https://doi.org/27

Chapagain, A. K., & Hoekstra, A. Y. (2003). *The water needed to have the Dutch drink coffee*. Retrieved from http://waterfootprint.org/media/downloads/Report14.pdf

Chenoweth, J., Hadjikakou, M., & Zoumides, C. (2013). Quantifying the human impact on water resources: A critical review of the water footprint concept. *Hydrology and Earth System Sciences*, *10*, 9389–9433. https://doi.org/10.5194/hess-18-2325-2014

Chew, C., Lloyd, G., & Knudsen, E. (2015). Capacity building in water with serious games. *Learning via Games and Social Media*. Retrieved from http://link.springer.com/chapter/10.1007/978-981-287-408-5_3

Connolly, T., Boyle, E., MacArthur, E., & Hainey, T. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers &*. Retrieved from http://www.sciencedirect.com/science/article/pii/S0360131512000619

Craven, J., Angarita, H., Corzo Perez, G. A., & Vasquez, D. (2017). Development and testing of a river basin management simulation game for integrated management of the Magdalena-Cauca river basin. *Environmental Modelling & Software*, *90*, 78–88. https://doi.org/10.1016/j.envsoft.2017.01.002

Curry, J. E. (1999). *A short course in international negotiating : planning and conducting international commercial negotiations*. World Trade Press. Retrieved from https://books.google.com/books?id=wV8lAgGZK4EC&dq=A+short+course+in+international+negotiating+:+planning+and+conducting+international+commercial+negotiations+/%09&lr=&source=gbs_navlinks_s

Daniels, S., & Walker, G. (2012). Lessons from the trenches: Twenty years of using systems thinking in natural resource conflict situations. *Systems Research and Behavioral*. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/sres.2100/full

Delli Priscoli, J., & Wolf, A. T. (2009). Water conflict management: Theory and practice. In *Managing and Transforming Water Conflicts* (pp. 33–49). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511551536.006

Dent, W. (2016). The Value of Using Scorable Simulations in Negotiation Training. Retrieved January 1, 2017, from https://www.pon.harvard.edu/daily/teaching-negotiation-daily/scorable-negotiation-simulations/

Douven, W., Mul, M., Son, L., & Bakker, N. (2014). Games to create awareness and design policies for transboundary cooperation in river basins: Lessons from the shariva game of the Mekong river commission. *Water Resources*. Retrieved from http://link.springer.com/article/10.1007/s11269-014-0562-x

Durkin, K., & Barber, B. (2002). Not so doomed: Computer game play and positive adolescent development. *Journal of Applied Developmental Psychology*. Retrieved from http://www.sciencedirect.com/science/article/pii/S0193397302001247

Evers, J. (2017). Playing Ravilla. When the game gets serious. Retrieved January 6, 2017, from https://flows.hypotheses.org/215

Fader, M., Gerten, D., Thammer, M., Heinke, J., Lotze-Campen, H., Lucht, W., & Cramer, W. (2011). Hydrology and Earth System Sciences Internal and external green-blue agricultural water footprints of nations, and related water and land savings through trade. *Hydrol. Earth Syst. Sci*, *15*, 1641–1660. https://doi.org/10.5194/hess-15-1641-2011

Fantini, E. (2017). Playing Ravilla: When the game gets serious. Retrieved January 1, 2017, from https://flows.hypotheses.org/215.

Farolfi, S., Abrami, G., Ferrand, N., & Aquae-Gaudi, W. (2013). Learning about river basin complexity and governance through a role-playing game. The use of Wat-A-Game for pedagogical purposes in Southern Africa: Retrieved from http://agritrop.cirad.fr/567550/1/document_567550.pdf

Fulton, J., Cooley, H., Gleick, P. H., Ross, N., & Luu, P. (2012). California's Water Footprint About the Pacific Institute About the Authors. Retrieved from http://pacinst.org/app/uploads/2013/02/ca_ftprint_full_report3.pdf

Gintis, H. (2000). Game Theory Evolving. *Ecological Economics*, *39*(3), 479–480. https://doi.org/10.1016/S0921-8009(01)00247-6

Gleick, P. (1996). Basic water requirements for human activities: Meeting basic needs. *Water International*. Retrieved from http://www.tandfonline.com/doi/pdf/10.1080/02508069608686494

Green, K. C. (2002). Forecasting decisions in conflict situations: A comparison of game theory, role-playing, and unaided judgement. *International Journal of Forecasting*, *18*(3), 321–344. https://doi.org/10.1016/S0169-2070(02)00025-0

Hamdaoui, N., Idrissi, M. K., & Bennani, S. (2015). Resorting to IMS-LD to standardize the learning process of Serious Game design in education. *International Journal of Education and Information Technologies*, *9*, 36–45.

Hanjra, M. A., & Qureshi, M. E. (2010). Global water crisis and future food security in an era of climate change. *Food Policy*, *35*(5), 365–377. https://doi.org/10.1016/j.foodpol.2010.05.006

Hockaday, S., Jarvis, T., & Taha, F. (2017). Serious Gaming in Water.

Hoekstra, A. (2012). Computer-supported games and role plays in teaching water management. *Hydrology and Earth System Sciences Discussions*. Retrieved from http://doc.utwente.nl/81596/

Hoekstra, A., & Chapagain, A. K. (2007). Water footprints of nations.Water use by people as a function of their consumption pattern. *Water Resource Management*, *21*(1), 35–48.

Hoekstra, A., Mekonnen, M., & Gerbens-Leenes, P. (2009). Role play on globalization of water management: Interactive learning about water footprint and virtual water trade. *Enschede, the Netherlands/World Bank …*. Retrieved from http://temp.waterfootprint.org/?page=files/RolePlay

Hoekstra, A. Y. (2008). Water neutral. *Water*, *117*(28), 22–25. Retrieved from http://linkinghub.elsevier.com/retrieve/pii/s0378775303003100

Hoekstra, A. Y., & Chapagain, A. K. (2008). *Globalization of Water: Sharing the Planet's Freshwater Resources*. *Globalization of Water: Sharing the Planet's Freshwater Resources*. https://doi.org/10.1002/9780470696224

Hoekstra, A. Y., Chapagain, A. K., Aldaya, M. M., & Mekonnen, M. M. (2011). *The Water Footprint Assessment Manual - Setting the Global Standard*. *Febrero 2011*. https://doi.org/10.1080/0969160X.2011.593864

Innes, J., & Booher, D. (1999). Consensus building and complex adaptive systems: A framework for evaluating collaborative planning. *Journal of the American Planning*. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/01944369908976071

Institute for Water Resources US Army Corps of Engineers. (2016). Playing for Keeps: Using Games to Address Flooding and Drought in the Cedar River Basin. Retrieved January 1, 2017, from http://www.iwr.usace.army.mil/Media/News-Stories/Article/1009509/playing-for-keeps-using-games-to-address-flooding-and-drought-in-the-cedar-rive/

IPCC. (2008). Climate Change and water Intergovernmental Panel on Climate Change. *Technical Paper VI*. Retrieved from http://www.ipcc.ch/pdf/technical-papers/climate-change-water-en.pdf

Isaak, M. T. (2012). Tragedy of the Commons Game | wrrc.arizona.edu. Retrieved June 2, 2017, from https://wrrc.arizona.edu/awr/w12/commonsgame

Islam, S., & Susskind, L. (2012). *Water diplomacy: a negotiated approach to managing complex water networks*. Retrieved from https://books.google.com/books?hl=en&lr=&id=mwVQiWdChAsC&oi=fnd&pg=PP2&dq=Islam,+S.,+and+L.E.+Susskind.+2012.+Water+Diplomacy:+A+Negotiated+Approach+to+Managing+Complex+Water+Networks.+RFF+Press,+Abingdon,+Oxon,+UK.&ots=Kv6GEBYaeP&sig=aYYC7KlTkgM8DC5FKwtQ

Ivory, J. (2006). Still a man's game: Gender representation in online reviews of video games. *Mass Communication & Society*. Retrieved from http://www.tandfonline.com/doi/abs/10.1207/s15327825mcs0901_6

Jarvis, W. (2014). *Contesting hidden waters: Conflict resolution for groundwater and aquifers*. Retrieved from https://books.google.com/books?hl=en&lr=&id=pS2iAwAAQBAJ&oi=fnd&pg=PP1&dq=Jarvis,+W.T.+2014.+Contesting+Hidden+Waters:+Conflict+Resolution+for+Groundwater+and+Aquifers.+Earthscan,+Abingdon,+Oxon,+UK.&ots=T3IN9TMRS5&sig=LEoE3zguPf74Kpi1sGzg8YaxgHE

Jia, S., Long, Q., & Liu, W. (2017). The fallacious strategy of virtual water trade. *International Journal of Water*. Retrieved from http://iahr.tandfonline.com/doi/abs/10.1080/07900627.2016.1180591

Katie Salen and Eric Zimmerman. (2004). *Rules of play: Game design fundamentals*. Retrieved from https://books.google.com/books?hl=en&lr=&id=UM-xyczrZuQC&oi=fnd&pg=PP13&dq=Salen+K,+Zimmerman+E+(2004)+Rules+of+play:+Game+design+fundamentals.+MIT+Press,+Cambridge,+688+pages&ots=2ALEuW8AZx&sig=xLS647DsYNZR0qCPSCeUfYJlnwA

Kaufman, Gordon; Sebenius, James; Hong, Kessely; Patton, Bruce; Bordone, Robert; Baker, R, Lisle; Susskind, L. (2015). *Tracking Student Learning Trajectories: Designing Experiments in Integrative Bargaining.*

Kevin Werbach and Dan Hunter. (2012). *For the win: How game thinking can revolutionize your business*. Philadelphia: Wharton Digital Press. Retrieved from https://books.google.com/books?hl=en&lr=&id=abg0SnK3XdMC&oi=fnd&pg=PA7&dq=Werbach,+K.,+%26+Hunter,+D.+(2012).+For+the+win:+How+game+thinking+can+revolutionize+your+business.+Wharton+Digital+Press.&ots=aQtr2i8GDm&sig=IgL44snZMzPOcRuAdeiJELao8T8#v=onepage&q

Lankford, B., Sokile, C., Yawson, D., & Lévite, L. (2004). The River Basin Game: A role-playing board game for initiating discussions on visions and strategies of water allocation. *Management For Local* …. Retrieved from ftp://193.43.36.92/agl/emailconf/wfe2005/Lankford_river_basin_game.pdf

Launiainen, S., Futter, M. N., Ellison, D., Clarke, N., Fin??r, L., H??gbom, L., … Ring, E. (2014). Is the water footprint an appropriate tool for forestry and forest products: The fennoscandian case. *Ambio*. https://doi.org/10.1007/s13280-013-0380-z

Mayer, I., Daalen, C. van, & Bots, P. (2013). Perspectives on policy analysis: A framework for understanding and design. *Public Policy Analysis*. Retrieved from http://link.springer.com/chapter/10.1007/978-1-4614-4602-6_3

Mayer, Z. I., & Medema W. Adamowski J., Zhou Q., Mayer I., F. A. (2016). Exploring the potential impact of serious games on social learning and stakeholder collaborations for transboundary watershed management of the St. Lawrence river basin. *Water {(Switzerland)}*, *8*(5), 175. https://doi.org/10.3390/w8050175

Mcmanus, P., & Haughton, G. (2006). Planning with Ecological Footprints: a sympathetic critique of theory and practice. *Environment and Urbanization*, *18*(1), 113–127. https://doi.org/10.1177/0956247806063963

Medema, W., Furber, A., Adamowski, J., Zhou, Q., & Mayer, I. (2016). Exploring the Potential Impact of Serious Games on Social Learning and Stakeholder Collaborations for Transboundary Watershed Management of the St. Lawrence River Basin. *Water*, *8*(5), 175. https://doi.org/10.3390/w8050175

Perry, C. (2014). Water footprints: Path to enlightenment, or false trail? *Agricultural Water Management*, *134*, 119–125. https://doi.org/10.1016/j.agwat.2013.12.004

Princen, T. (1999). Consumption and environment: some conceptual issues. *Ecological Economics*, *31*(3), 347–363. https://doi.org/10.1016/S0921-8009(99)00039-7

Raiffa, H. (1982). The art and science of negotiation. *Vasa*, 7–19. https://doi.org/10.2307/1340912

Ritterfeld, U., Cody, M., & Vorderer, P. (2009). Serious Games: Mechanisms and Effects. *Defence Management Journal*, *12*, 530. https://doi.org/10.4324/9780203891650

Roman Pelek and Claudia Hely. (2003). Santiago. Retrieved January 1, 2017, from https://boardgamegeek.com/boardgame/8125/santiago

Rosegrant, M., Cai, X., & Cline, S. (2002). *World water and food to 2025: dealing with scarcity*. Retrieved from https://books.google.com/books?hl=en&lr=&id=jxANzj_5CksC&oi=fnd&pg=PR5&dq=food+security+was+founded+in+order+to+bring+together+the+global+water+distribution+through+trade&ots=2sNiWnrxYX&sig=M2pWwEtakldfC0z5o0CKBbMcD6s

Rumore, D. (2015). ENHANCING READINESS TO ADAPT THROUGH ROLE-PLAY SIMULATIONS. *JSTOR*. Retrieved from http://www.jstor.org/stable/pdf/j.ctt1gxp7qz.10.pdf

Rumore, D. (2015). Role-Play Simulations: A Tool for Transformative Civic Education and Engagement Around Science-Intensive Environmental Issues. Retrieved from https://publicdisputes.mit.edu/sites/default/files/documents/Rumore_2015_dissertation_Role-play simulations- A tool for transformative civic education and engagement_FINAL.pdf

Rumore, D., Schenk, T., & Susskind, L. (2016). Role-play simulations for climate change adaptation education and engagement. *Nature Climate Change Change*, *6*, 745–750. https://doi.org/10.1038/NCLIMATE3084

Rusca, M., Heun, J., & Schwartz, K. (2012). Water management simulation games and the construction of knowledge. *Hydrology and Earth System*. Retrieved from http://search.proquest.com/openview/1b34a7f53e951a37254c2bbffe8608e8/1?pq-origsite=gscholar&cbl=105724

Salen, K., and Zimmerman, E. (2003). Rules of Play: Game Design Fundamentals. *MIT Press*, *2004*, 688. https://doi.org/10.1093/intimm/dxs150

Savic, D., Morley, M., & Khoury, M. (2016). Serious Gaming for Water Systems Planning and Management. *Water*, *8*(10), 456. https://doi.org/10.3390/w8100456

Serrano-Laguna, Á., Martínez-Ortiz, I., & Haag, J. (2017). Applying standards to systematize learning analytics in serious games. *Computer Standards &*. Retrieved from http://www.sciencedirect.com/science/article/pii/S0920548916301040

Shubik, M. (1975). Games for society, business and war. *Elsevier, Amsterdam*.

Smakhtin, V., Revenga, C., and Döll, P. (2004). *Taking Into Account Environmental Water Requirements in Global-scale Water Resources Assessments. Comprehensive Assessment Research Report 2.* Columbia, Sri Lanka. Retrieved from https://books.google.com/books?id=8yPeEgrCWDcC&printsec=frontcover#v=onepage&q

&f=false

Squire, K., Giovanetto, L., Devane, B., & Durga, S. (2005). From users to designers: Building a self-organizing game-based learning environment. *TechTrends*. Retrieved from http://link.springer.com/content/pdf/10.1007/BF02763688.pdf

Squire, K., & Jenkins, H. (2003). Harnessing the power of games in education. *Insight*. Retrieved from http://www.academia.edu/download/8132613/insight_3-1_vision.pdf

Stefano Farolfi , Geraldine Abrami, N. F. W., & Aquae-Gaudi. (2013). *Learning about river basin complexity and governance through a role-playing game*. Retrieved from http://www.iwega.org/files/iwega_policy_brief_n4_final.pdf

Susi, T., Johannesson, M., & Backlund, P. (2007). Serious Games – An Overview. *Elearning*, *73*(10), 28. https://doi.org/10.1.1.105.7828

The Omaha District US of Army Corps of Engineers. (2017). River Basin Balancer Game. Retrieved January 1, 2017, from http://www.nwo.usace.army.mil/Missions/Dam-and-Lake-Projects/Missouri-River-Dams/Basin-Balancer/

Thomas, K. L., & Kilman, R. H. (1974). Thomas Kilman conflict mode instrument. *Cmpresolutions.co.uk*, 1–16. https://doi.org/8006241765

Ulicsak, M. (2010). Games in Education: Serious Games. *A FutureLab Literature Review*, 139. Retrieved from http://www.futurelab.org.uk/projects/games-in-education

USAID. (2014). *Water and Conflict: A Toolkit for Programming*.

Velázquez, E., Madrid, C., & Beltrán, M. J. (2011). Rethinking the Concepts of Virtual Water and Water Footprint in Relation to the Production–Consumption Binomial and the Water–Energy Nexus. *Water Resources Management*, *25*(2), 743–761. https://doi.org/10.1007/s11269-010-9724-7

Wal, M. Van der, Kraker, J. De, & Kroeze, C. (2016). Can computer models be used for social learning? A serious game in water management. *Modelling & Software*. Retrieved from http://www.sciencedirect.com/science/article/pii/S1364815215300669

Wang, J., Huffaker, D., Treem, J., & Fullerton, L. (2011). Focused on the prize: Characteristics of experts in massive multiplayer online games. *First Monday*. Retrieved from http://journals.uic.edu/ojs/index.php/fm/article/view/3672

Water Footprint Network. (2016a). Glossary. Retrieved October 13, 2016, from http://waterfootprint.org/media/downloads/Glossary.pdf

Water Footprint Network. (2016b). What is a water footprint? Retrieved October 13, 2016, from http://waterfootprint.org/en/water-footprint/what-is-water-footprint/

Water Footprint Network. (2017). Role play on the globalization of water management. Retrieved January 1, 2017, from http://temp.waterfootprint.org/?page=files/RolePlay

Watson, J. (2015). Beyond Cooperation: Environmental Justice in Transboundary Water Management. Retrieved from http://ir.library.oregonstate.edu/xmlui/handle/1957/56693

Wattanasoontorn, V., Boada, I., García, R., & Sbert, M. (2013). Serious games for health. *Entertainment Computing*, *4*(4), 231–247. https://doi.org/10.1016/j.entcom.2013.09.002

Westera, W. (2017). How people learn while playing serious games: A computational modelling approach. *Journal of Computational Science*. Retrieved from http://www.sciencedirect.com/science/article/pii/S1877750316304483

Wichelns, D. (2015). Virtual water and water footprints do not provide helpful insight regarding international trade or water scarcity. *Ecological Indicators*, *52*, 277–283. https://doi.org/10.1016/j.ecolind.2014.12.013

Williams, D., Yee, N., & Caplan, S. E. (2008). Who plays, how much, and why? Debunking the stereotypical gamer profile. *Journal of Computer-Mediated Communication*, *13*(4), 993–1018. https://doi.org/10.1111/j.1083-6101.2008.00428.x

Wolf, A. (2010). *Sharing water, sharing benefits: working towards effective transboundary water resources management*. Retrieved from https://books.google.com/books?hl=en&lr=&id=wJGMAgAAQBAJ&oi=fnd&pg=PR7&dq=Wolf,+A.T.+2010.+Sharing+Water,+Sharing+Benefits:+Working+Towards+Effective+Transboundary+Water+Resources+Management+-+A+Graduate/Professional+Skills-Building+Workbook.+United+Natio

Work Group for Community Health and Development. (2016). Chapter 26. Changing the Physical and Social Environment | Section 9. Protecting Environmental Quality | Main Section | Community Tool Box. Retrieved June 1, 2017, from http://ctb.ku.edu/en/table-of-contents/implement/physical-social-environment/environmental-quality/main

Yee, N. (2006). The demographics, motivations, and derived experiences of users of massively multi-user online graphical environments. *Presence: Teleoperators and Virtual Environments*. Retrieved from http://www.mitpressjournals.org/doi/abs/10.1162/pres.15.3.309

Zaag, P. Van der, Bos, J., Odendaal, A., & Savenije, H. (2003). Educating Water for Peace: the new water managers as first-line conflict preventors. Retrieved from https://scholar.google.com/scholar?q=Educating+Water+for+Peace%3A+the+new+water+managers+as+first-line+conflict+preventors+Pieter+van&btnG=&hl=en&as_sdt=0%2C38

Zielke, M. A., Evans, M. J., Dufour, F., Christopher, T. V, Donahue, J. K., Johnson, P., … Flores, R. (2009). Serious Games for Immersive Cultural Training: Creating a Living World. Retrieved from https://www.utdallas.edu/~maz031000/res/IEEE_Article.pdf

APPENDICES

Appendix A: Social Behaviors and Learning - Pre game Survey

Q1: This survey is about your social behaviors and learning. We will be using the information you provide to assess the social learning impact through serious games. Do you agree to take the survey?

- ❍ Yes
- ❍ No

Condition: If No is selected. Skip to: End of Survey.

Q2: What is your age? (Please note that less than 18 years old are not allowed to take this survey)

- ❍ Under 18
- ❍ 18-34
- ❍ 35-44
- ❍ 45-54
- ❍ 55-64
- ❍ 65+

Condition: If under 18 is selected. Skip to: End of Survey.

Q3: Demography

First Name ____________________

Last Name ____________________

Q4: What is your gender?

- ❍ Female
- ❍ Male
- ❍ Other

Q5: What is your educational background?

- ❍ Arts
- ❍ Humanities
- ❍ Social and Political Sciences
- ❍ Biological and Physical Sciences
- ❍ Applied Sciences
- ❍ Management and Administration
- ❍ Other (please specify) ____________________

Q6: What is the highest degree you have completed?
❍ Bachelor's degree in college (4-year)
❍ Master's degree
❍ Doctoral degree
❍ Professional degree (JD, MD)

Q7: Which country you are originally from?
❍ List of countries

Condition: If United States of America is selected. Skip to: Q8. Condition: If United States of America is not selected. Skip to: Q9.

Q8: Which state are you from?
❍ List of states

Q9: Soon you will be participating in a collaborative serious game. Do you prefer to work within a team or alone?
❍ I prefer working alone
❍ I prefer teamwork
❍ I enjoy both

Q10: Before coming to the game session, what do you think are the most important things in the negotiations? (Choose up to three options)
❑ Preparedness to participate
❑ Leadership and capacity building
❑ Respecting diverse perspectives, interests, and goals
❑ Developing joint solutions
❑ Team building, involvement, and communications
❑ Knowledge exchange
❑ Trust building
❑ Other (please specify) ____________________

Q11: Imagine the following scenario during the game, you are part of a team of three people representing one country. In global negotiations, your country will have only one voice. You need to talk to your team members and decide on What to do, who will represent the country, etc. How are you planning to deal with conflict and disagreements within your team?

- ❍ Fight back and enforce your opinion
- ❍ Avoid conflict and accept any suggestions
- ❍ Argue until we all reach consensus
- ❍ Other (please specify) ____________________

Q12: What can be done to improve feelings of inclusiveness within your team members?

____

____

Q13: When negotiating with other teams, what strategy(s) will you adopt?

- ❑ Be prepared for the worst and best scenario outcomes
- ❑ Give and Take
- ❑ Build relations and good reputation
- ❑ The team strategy will keep changing using a combination of the above strategies

Q14: What could be the barrier(s) for collaborative working with your counterparts?

- ❑ No trust
- ❑ Language barriers
- ❑ No respect
- ❑ Lack of coordination and communication
- ❑ Other (please specify) ____________________

Q15: Have you ever played a serious game before?

- ❍ Yes
- ❍ No

Condition: If Yes is selected. Skip to: Q16. Condition: If No is selected. Skip to: Q17.

Q16: On a scale of one to ten, how likely would you recommend playing one to a friend or colleague?

❍ 0
❍ 1
❍ 2
❍ 3
❍ 4
❍ 5
❍ 6
❍ 7
❍ 8
❍ 9
❍ 10

Q17: In real life scenario, whom do you think is more prepared in the negotiations over international water disputes?

❍ A water-rich country
❍ A water-poor country
❍ Both water-rich/poor countries
❍ The private sector
❍ Other (please specify) ____________________

Q18: Countries vary in terms of the quality, quantity, and use of their national water resources. According to your country's water culture, what is considered a wise water management? (Choose up to three options)

❑ The use of efficient agricultural technologies and practices
❑ Water_Food_Energy Nexus Strategy
❑ Meeting the environmental flows
❑ Access to safe drinking water
❑ Increase national economic status
❑ Implement resilience and disaster risk reduction plan
❑ Improving the water quality index
❑ Integrated Water Resources Management Plan
❑ I do not know
❑ Other (please specify) ____________________

Q19: Given the uncertainties associated with climate change, countries are encouraged to reduce their water use consumption by adopting effective management strategies in order to mitigate the negative impacts of climate change. How do you think we can achieve efficient water use? (Choose up to two options)

- ❑ Using water-saving techniques
- ❑ Reduce pollution and adopt waste management plan
- ❑ Cap environmental requirements then trade water-embedded products
- ❑ Reduce the global water footprint
- ❑ Is there a climate change? I don't think so!
- ❑ Other (please specify) ____________________

Q20: Water-scarce countries have low water productivity while water-abundant countries have high water productivity?

- ❍ True
- ❍ Maybe
- ❍ False

Q21: How much do you support global trade?

- ❍ Strongly support
- ❍ Somewhat support
- ❍ Somewhat oppose
- ❍ Strongly oppose

Q22: Globally, trade is a mechanism to exchange water-embedded goods, capital and services across borders to obtain national needs (food, energy, industrial products, etc.). How much do you know about the theory of “Comparative Advantage” in international trade?

- ❍ A lot
- ❍ A moderate amount
- ❍ A little
- ❍ None at all

Q23: In the field of water resources management, there are many conceptual frameworks such as virtual water and water footprint to name a few. Do you know the difference between the two concepts?

- ❍ Yes
- ❍ No
- ❍ Two names for the same concept
- ❍ I do not know

Q24: There is an ongoing debate about the conflict between ‘water for economy’ versus ‘water for nature’. What do you think of the role of global trade in this issue? (Choose up to three options)

- ❑ Efficient as it reduces the pressure on the production from the domestic waters
- ❑ It is an economic instrument to increase the country GDP
- ❑ A strategy that does not work for self-sufficient countries
- ❑ Trade is damaging the environment
- ❑ Provides job opportunities
- ❑ Other (please specify) ____________________

Appendix B title: Social Behaviors and Learning - Post Game Survey

Q1: Thank you for participating in the Globalization of Water Management game. You did great! This post-game survey is designed to assess the learning. You might see some similar questions in the previous survey, however, the main aim is to assess the internal change in your perspective (if any).

Q2: Demography (remind me your name)
First Name ____________________
Last Name ____________________

Q3: In the game, where you part of a team representing a country?
❍ Yes
❍ No

Condition: If Yes is selected. Skip to: Q4. Condition: If No is selected. Skip to: Q7.

Q4: If you play the game again, do you prefer to play with a team or alone?
❍ I prefer to play alone
❍ I prefer teamwork
❍ I enjoy both

Q5: How did you deal with conflict and disagreements within your team?
❍ Fought back and enforced my opinion
❍ Avoid conflict and accepted any suggestions
❍ Argued until we all reach consensus
❍ Other (please specify) ____________________

Condition: If Avoid conflict and accepted... is selected. Skip to: Q6. Condition: Avoid conflict and accepted... Is not selected. Skip to: Q7.

Q6: What can be done to improve feelings of inclusiveness within your team members?

____

____

Q7: When negotiating with other teams, what strategy(s) did you adopt?

- ❑ Be prepared for the worst and best scenario outcomes
- ❑ Give and Take
- ❑ Build relations and good reputation
- ❑ The team strategy will keep changing using a combination of the above strategies

Q8: What could be the barrier(s) for collaborative working with your counterparts?

- ❑ No trust
- ❑ Language barriers
- ❑ No respect
- ❑ Lack of coordination and communication
- ❑ Other (please specify) ____________________

Q9: What do you think are the most important things in the negotiations? (Choose up to three options)

- ❑ Preparedness to participate
- ❑ Leadership and capacity building
- ❑ Respecting diverse perspectives, interests, and goals
- ❑ Developing joint solutions
- ❑ Team building, involvement, and communications
- ❑ Knowledge exchange
- ❑ Trust building
- ❑ Other (please specify) ____________________

Q10: On a scale of one to ten, how likely would you recommend playing a serious game (e.g. the Globalization of Water Management game) to a friend or colleague?

- ❍ 0
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5
- ❍ 6
- ❍ 7
- ❍ 8
- ❍ 9
- ❍ 10

Q11: Whom do you think is more prepared in the negotiations over international water disputes?

- ❍ A water-rich country
- ❍ A water-poor country
- ❍ Both water-rich/poor countries
- ❍ The private sector
- ❍ Other (please specify) ____________________

Q12: What is considered a wise water management? (Choose up to three options)

- ❑ The use of efficient agricultural technologies and practices
- ❑ Water_Food_Energy Nexus Strategy
- ❑ Meeting the environmental flows
- ❑ Access to safe drinking water
- ❑ Increase national economic status
- ❑ Implement resilience and disaster risk reduction plan
- ❑ Improving the water quality index
- ❑ Integrated Water Resources Management Plan
- ❑ I do not know
- ❑ Other (please specify) ____________________

Q13: How do you think we can achieve efficient water use? (Choose up to two options)

- ❑ Using water-saving techniques
- ❑ Reduce pollution and adopt waste management plan
- ❑ Cap environmental requirements then trade water-embedded products
- ❑ Reduce the global water footprint
- ❑ Is there a climate change? I don't think so!
- ❑ Other (please specify) ____________________

Q14: Water-scarce countries have low water productivity while water-abundant countries have high water productivity?

- ❍ True
- ❍ Maybe
- ❍ False

Q15: How much do you support global trade?

- ❍ Strongly support
- ❍ Somewhat support
- ❍ Somewhat oppose
- ❍ Strongly oppose

Q16: With respect to the ongoing debate about the conflict between 'water for economy' versus 'water for nature'. What do you think is the role of global trade in this issue? (Choose up to three options)

- ❑ Efficient as it reduces the pressure on the production from the domestic waters
- ❑ It is an economic instrument to increase the country GDP
- ❑ A strategy that does not work for self-sufficient countries
- ❑ Trade is damaging the environment
- ❑ Provides job opportunities
- ❑ Other (please specify) ____________________

Q17: After playing the game, how much is your knowledge about the theory of "Comparative Advantage" in international trade?

- ❍ A lot
- ❍ A moderate amount
- ❍ A little
- ❍ I still do not understand

Q18: Do you know the difference between virtual water and water footprints concepts?

- ❍ Yes
- ❍ No
- ❍ Two names for the same concept
- ❍ I still do not know

Q19: What role play did you play?

- ❍ The Head of State
- ❍ Minister of the Environment
- ❍ Minister of Trade and Foreign Affair
- ❍ Both ministers
- ❍ None

Q20: To which extent does the role play represent reality and where does it contain simplifications?

____

____

Q21: Each country was represented by The Head of State, Minister of the Environment, and Minister of Trade and Foreign Affairs. Whom do you think should also be in the room?

- ❑ Minister of Finance and National Economy
- ❑ Minister of Water Resources and Agriculture
- ❑ Private sector
- ❑ Farmers
- ❑ Water users
- ❑ Media
- ❑ Other (please specify) ____________________

Appendix C: List of the Feedback Questions

- What did you learn? Do you think the game is effective?
- How did you do in each round? What changed?
- What would you do better the next time?
- What did we learn about wise water management?
- In each round, do you think you country’s decision was rational?
- How do you describe the working relations?

Appendix D: Playing the Globalization of Water Role Play

132