Evaluating Measures of Collaborative GIS: Applications for Marine Spatial Planning on Multi-user Touch Tables

by

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BSc, Oklahoma State University, 2008
BSc, Oklahoma State University, 2006

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of

MASTER OF SCIENCE

in the Department of Geography

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Supervisory Committee

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Abstract

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Marine Spatial Planning (MSP) increasingly utilizes Geographic Information Systems (GIS) and technologies to support decision-making with stakeholders and policymakers. The study of the group use of GIS to support decision-making processes is called Collaborative GIS. Measuring the impact and influence the technology has on decision-making processes is an important aim of Collaborative GIS research. To date, Collaborative GIS research has relied on qualitative questionnaires to measure the impact of GIS on group decision-making and the GIS software and technology being used, lacking support of quantitative measures. A novel technology increasingly being used for group planning processes with maps is multi-user touch tables; this technology encourages equality of technology interactions and increases participant engagement by allowing all group members the opportunity to interact with the technology, transcending limitations of single-user mouse environments.

This research identifies and evaluates measures of collaboration for Collaborative GIS on multi-user touch tables for MSP activities. Group measures of participation are explored using coding systems to determine fluctuations in the groups' participation using technological interactions and verbal participation by Google Earth task performed and by decision phase. Results indicate variation in participation across role play simulations due largely to group dynamics and participant personality, evidenced by researcher observation. Coding systems require improvements in capturing participation levels.

Individual measures of participation are also collected to determine the equality of technological interactions and verbal participation by seat location around a multi-user touch table. Results indicate technological interactions and verbal participation are not equally distributed around a multi-user touch table using Google Earth. Seat locations

closest to the Google Earth menus tend to have higher participation rates, with seat locations farthest from the menus marginalized. Furthermore, technological interactions by interface-menus, dialogue boxes, and earth display –have variation in equality of interactions by seat location. Menus and dialogue boxes have higher rates of inequality of participation than the earth display has.

To date, study and collection of group and individual participation has been limited in Collaborative GIS research. With reliance on qualitative questionnaires to collect data, this study represents quantitative measures to describe Collaborative GIS group decision-making processes on touch tables. Whereas, previous literature represents coarse scale measures of the group's process and outcome constructs, this study focuses on fine scale measures of collaboration.

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Acknowledgments

“Education is not the filling of a pail, but the lighting of a fire.”-William Butler Yeats

Thank you to the supervisors, colleagues, and friends who have inspired me the last three years and took part in not only the shaping of my master’s program, but also those things which I find the most passion in.

Dr. Rosaline Canessa, Dr. Charles Burnett, Norma Serra-Sogas, Karla Poplakowski, Steeve Deschesnes, Basil Veerman, Eleanor Setton, Roz Cheasly, Aleja Orozco-Robinson, Noah Edwards, Bruce Downie, Rheannon Brooks, Jenny Lucas, Jordan Eamer, Blake Hodgin, James Foley, Julian Bakker, Kyle Plumb, Lindsey Orr, Courtney Edwards, Kylee Pawluk, Brian Tucker, Baker Masuruli, Katie Bills, Andrew Agyare, Emmanuel Acquah, Enock Makupa, Kinga Menu, Katie Tebutt, Maral Sotodehnia, Jolene Jackson, and Ayse Karanci.

Personal thank yous to : Becky Brandon, Annelle Norman, Teresa Cinco, Alison Leedham, Maya Christobel, Steve Gunn, Evey and Zuzu

Dedication

To Tara Lingle who, unknowingly and serendipitously, helped me discover UVic on a map during one cold, snowy Thanksgiving day in Colorado. And to her mother, Annelle Norman, who helped get me to this beautiful island-literally and figuratively.

Chapter 1. Introduction

1.1 Marine Spatial Planning

Marine Spatial Planning is "the public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process" (Ehler & Douvere, 2009, p. 18). Marine Spatial Planning (MSP) processes are moving towards greater stakeholder engagement and often use maps as a means of involving stakeholders in the planning process (St. Martin & Hall-Arber, 2008; Ehler & Douvere, 2009). Stakeholder involvement is an essential component of effective MSP because it reduces conflict around planning by allowing stakeholders' interests to be addressed, which may lead to greater acceptance of marine spatial plans and increased support to management and implementation of policies (Pomeroy & Douvere, 2008; Ehler & Douvere, 2009). Maps are used in the planning process with stakeholders to communicate information about physical, biological, human and economic processes; to incorporate stakeholders' knowledge of marine environments and human uses as spatial data added to maps; and to generate MSP alternatives by visually addressing where to place activities (spatial) and when (temporal) to place activities in consideration with other spatial and aspatial data (St. Martin & Hall-Arber, 2008; Ehler & Douvere, 2009).

1.2 Collaborative GIS Technologies and MSP

Geographic Information Systems (GIS), geovisualization tools, such as Google Earth, and technologies that support group work have played a strong role in MSP processes. Geographic information systems (GIS), which provide geovisual and spatial analysis capabilities, have proven to be a useful tool for MSP when integrated with decision support systems, particularly in engaging and generating input from stakeholders (St. Martin & Hall-Arber, 2008). "GIS is quickly becoming the forum where marine spatial data are aggregated, planning options are visualized, impact analyses are performed, and regulatory zones are established and mapped" (St. Martin & Hall-Arber, 2008, p. 780). Lewis et al. (2003) describe the use of GIS and spatial analysis as a key tool in the development of Australia’s Great Barrier Reef Marine Park reserve design process, emphasizing the use of spatial decision support tools for analysis and as a communication tool for presenting results to stakeholders. Gleason et al. (2010) discuss the use of participatory GIS techniques to elicit local knowledge and marine protected area proposals from stakeholders in the planning of a network of marine protected areas in Northern California.

Geovisualization technologies, such as Google Earth and coastal landscape visualizations have also been used in MSP as decision support tools with stakeholders. Coastal landscape visualizations were used in Delta, British Columbia to communicate a variety of scenarios illustrating impacts of climate change related to sea level rise (Sheppard et al., 2011). In California, MarineMap was a web-based collaborative planning platform which used a Google Earth API that allowed stakeholders to view over a hundred layers of spatial data (Merrifield et al. 2013). The authors comment that: “Anecdotally, stakeholders found the three dimensional capability [of Google Earth] fun and engaging, further increasing effective participation” (Merrifield et al., 2013, p. 71). MarineMap also had GIS design and analysis capabilities.

These case studies demonstrate the capacity of a GIS and geovisualization tools to be used as support tools in the MSP process involving a variety of stakeholders. Participatory involvement builds stakeholder trust in the planning process and its outcomes (Ehler & Douvere, 2009), and using GIS, geovisualization, and group work technologies collaboratively may elicit a high degree and quality of participation, building trust, consensus, and satisfaction with the planning process and outcome.

1.3 Collaborative GIS

The use of GIS for group decision making has been a research interest in the realms of GIScience and critical Geographies since the mid-1990s and more recently, has been termed Collaborative GIS (Balram & Dragicevic, 2006; Jankowski & Nyerges, 2001a). Collaborative GIS encompasses theories, tools, and technologies used to support decision-making with regard to place-based problems (Balram & Dragicevic, 2006). The term Collaborative GIS inherently implies the use of a GIS as the tool and technology of emphasis used to support a group’s decision-making process. Jankowski and Nyerges

(2001a, p. 4), argue that "reducing the complexity of a decision problem by reducing the cognitive workload of participants is one goal of developing collaborative decision support systems." Furthermore, the authors state that resulting decision-making is enhanced when technology is used to "reduce the group's cognitive workload" because the group's time may then be spent exploring dimensions of the place-based problem more critically. Balram and Dragicevic (2006) emphasize enhanced critical thinking and creativity when bringing groups together whose individual understandings can be bridged with collective exploration of spatial data. The concept of geovisualization as a communication bridge amongst stakeholders extends to literature on planning support systems (PSS) which support planning projects by allowing exploration and critique of multiple planning scenarios (Geertman, 2002; Schiffer, 1995). It is hoped that Collaborative GIS process will contribute to consensus-building regarding resolution of place-based problems (Boroushaki & Malczewski, 2010). The purpose of using GIS in groups then is to enhance place-based decision making by utilizing the geographic visualization and spatial analysis capabilities of a GIS to bridge stakeholder understandings of spatially oriented problems.

1.4 MSP on Touch Tables

A new technological environment to support co-located group processes are multi-user touch tables. To date, Collaborative GIS has traditionally been used in groups with a GIS technician chauffeuring the process while the proceedings are projected onto a large screen; individual participants or pairs each using a desktop computer while the group discusses collaboratively; or distributed online planning forums (Nyerges, Jankowski, Tuthill, & Ramsey, 2006; Merrifield et al., 2013). Traditional planning processes gathered stakeholders around paper maps; touch tables provide these same advantages but with digital capabilities of operating a GIS to facilitate spatial decision-making while providing a table space to facilitate dialogue and interaction (Arciniegas & Janssen, 2012; MacEachren, Brewer, Cai & Chen, 2003).

Multi-user touch tables may have the capability of bridging the strengths provided by traditional paper maps used in groups with the benefits of Collaborative GIS. There is recent support for this claim, with multi-user touch tables being innovatively used to support group work as demonstrated by Alexander et al. (2012) and Arciniegas and

Janssen (2012) who used multi-user touch tables as a platform for collaborative MSP GIS activities. Alexander, et al. (2012) use a spatial decision support system (SDSS) on multi user touch tables with stakeholders to identify sites appropriate for tidal energy development. Results of their workshops indicate high stakeholder satisfaction with the planning process due to the balance of scientific knowledge and elicitation of local knowledge. Feedback from the use of a land use planning SDSS on multi-user touch tables in the Netherlands showed that the technology increased group cooperation (Arciniegas & Janssen, 2012, p. 340). Furthermore, MSP processes generally involve a variety of stakeholders, policy makers, and technical/scientific experts; the use of GIS in collaborative settings has proven to be an effective means of bridging stakeholder understandings by promoting joint fact-finding, integration of local knowledge and scientific data, and participatory generation of planning scenarios (Alexander et al., 2012; Lewis et al., 2003; Gleason et al., 2010; Ehler & Douvere, 2009). Multi-user touch tables are a technology designed to support group work and have demonstrated use in MSP case studies.

Multi-user touch tables provide an environment in which stakeholders and policymakers now have the ability to directly interact with technology and data themselves, instead of solely relying on GIS technicians to chauffeur the process. This direct interaction may increase participation in the planning process, as well as facilitate greater understanding of the data being used in the decision-making process.

1.5 Evaluating Collaborative GIS: Research Gaps

A crucial aspect of Collaborative GIS research is evaluating the role technology, such as touch tables, plays in the decision-making process (Jankowski & Nyerges, 2001a; Balram & Dragicevic, 2006). How does the technology support the group's decision-making? How does the technology guide or restrict the group's process? What are the group's perceptions of the role the technology played in supporting their proceedings? For example, in Nyerges et al. (2006) the authors measure the impact on scenario generation, group consensus, and group conflict between two different groups: one group of nine that had the ability to operate a water resources decision support tool in pairs and another group that had access only through a technical facilitator who chauffeured the

GIS on their behalf. Results showed that the group with the ability to operate the decision support system in groups of two generated more options and alternatives, had less total group consensus, and had greater group conflict than the group that was guided by a technical facilitator-chauffeur (Nyerges et al., 2006).

To properly evaluate the role the technology plays in supporting group spatial decision-making, the collaboration must be measured. However, measuring the role the technology plays in decision making is not widely covered in the literature, let alone researched for multi-user touch table environments or MSP contexts. Research currently tends toward studying the development and applications of such systems with limited research done to empirically measure how these systems facilitate decision-making; furthermore, the research is dominated by online Collaborative GIS applications, with less emphasis on co-located Collaborative GIS activities provided by technologies such as multi-user touch tables (Balram & Dragicevic, 2006). With the exception of work by Nyerges and Jankowski (Nyerges et al., 2006; Nyerges, Moore, Montejano & Compton, 1998; Jankowski & Nyerges, 2001b), Collaborative GIS research tends to rely on one *qualitative* method, data collected from questionnaires, to answer research questions about the role technology plays in facilitating decision-making with GIS (Salter, Campbell, Journeay & Sheppard, 2009; Balram, Dragicevic & Meredith, 2004; Faber, Wallace & Cuthbertson, 1995). Gaps exist in Collaborative GIS methodology regarding how to conduct studies with a more diverse, quantitative set of measures and methods to demonstrate the effectiveness and impact the technology has on decision-making. Measuring interaction and participation with group GIS systems is particularly rare.

1.6 Research Objectives & Questions

The purpose of this research is to examine how to measure participation in small group MSP activities with GIS on multi-user touch tables. In particular, this research explores group and individual participation on multi-user touch tables. Inequitable participation can cause stakeholders' objectives to be inadequately considered (DiMicco, Pandolfo & Bender, 2004, p. 616). Therefore, a Collaborative GIS environment that is capable of supporting participatory stakeholder interaction and engagement is desired. Quantifying participation on touch tables may demonstrate its utility as a platform to support equal, engaged participation which may translate into stakeholders' objectives being adequately voiced and considered in Collaborative GIS MSP mapping activities. Contributions are needed in advancing Collaborative GIS methodology to measure decision-making and participation with GIS. The objectives of this research are: *1) Measure group level participation related to Google Earth activities and decision phases using coding systems (Chapter 5);and 2) Measure individual participation related to Google Earth interfaces to determine accessibility of interface features by seat location (Chapter 6).* The results of these objectives will be used to provide analysis and critique of measures of collaboration. Objectives 1 and 2 (Chapters 5 & 6) use measures informed by the literature review and seek to advance understanding of group and individual participation using a role play simulation experiment with Google Earth on multi-user touch tables. Google Earth is used as a geovisualization software that serves the capacity of a simple GIS and was appropriate for the education and technology experience of the participants used in the role play simulation; this is discussed in more depth in sections 2.1 and 3.2.2. Outlined below in Table 1 are research questions related to each of the research objectives described above.

Table 1: Objectives and Research Questions

Objective: 1) Measure group level participation related to Google Earth activities and decision phases using coding systems (Chapter 5): Describing participation at the level of the group demonstrates the activities and decision phases that are most collaborative in nature and comments on participation during the group's decision-making process. Coding systems are used and evaluated to comment on their use as a method.	
Context	**Research Questions**
Group Dialogue and Group Technology Participation Using a MSP role play simulation, group participation is measured as technology interactions and verbal participation. Differences in technological and dialogue participation are measured across simulations.	**Q1.1a:** What is the distribution of degree of group dialogue participation by role play simulation?
	Q1.1b: What is the distribution of degree of group technological participation by role play participation?
	Q1.1c: What is the distribution of degree of group dialogue participation compared to technological participation by role play simulation?
Participation by Google Earth Task Degree of technological and verbal group participation are measured related to Google Earth tasks to determine if there are patterns in the distribution of participation related to Google Earth tasks.	**Q1.2a:** What is the distribution of Google Earth tasks by role play simulation?
	Q1.2b. What degree of technological participation dominated Google Earth tasks?
	Q1.2c: What degree of dialogue participation dominated Google Earth tasks?

Participation by Decision Phase Degree of technological and verbal group participation are measured related to decision phases to determine if there are patterns in the distribution of group participation related to decision phases.	**Q1.3a:** What is the distribution of decision phases by role play simulation?
	Q1.3b: What degree of technological participation dominated decision phases?
	Q1.3c: What degree of dialogue participation dominated decision phases?
Decision Phase by Google Earth Task Distribution of Google Earth tasks performed by decision phase is analyzed to determine if certain GIS tasks support different decision phases.	**Q1.4:** What is the distribution of Google Earth tasks by decision phase?
Objective: 2) Measure individual participation related to Google Earth interfaces to determine accessibility of interface features by seat location (Chapter 6).	
Context	**Research Question**
Measuring individual participation by seat location gives an indication of the accessibility of Google Earth features for each participant. Menus in Google Earth (and most GIS) are located on the left side of the interface and across the top of the interface; therefore, participants seated left of the center of the table have easier access to reach this part of the interface, whereas, participants right of center may be restricted from accessing these parts of the interface due to limits of reach. Unequal accessibility to technology may bias participation and the group's collaborative process.	**Q2.1:** What is the degree of inequality for frequency of technology interactions, dialogue turn taking, and number of words spoken by stakeholder seat location? Is participation uniformly distributed by seat location?
	Q2.2: What is the degree of inequality by seat location Google Earth interfaces (menus, dialogue boxes, earth display)? Is participation uniformly distributed by seat location?
	Q2.3: How are technology participation errors distributed by seat location?

1.7 Thesis Organization

This thesis is divided into six chapters. A literature review (Chapter 2) is provided on Collaborative GIS case studies and measures of collaboration identified in touch table literature. Chapter 3 details the methods used in Chapters 5 and 6, describing the MSP role play simulation this thesis is based on. Chapter 4 presents general results regarding how the role play simulations proceeded and differed from one another, providing further context for results presented in Chapters 5 and 6. Chapter 5 presents an experiment using a MSP role play simulation to develop decision-making coding systems for GIS activities on multi-user touch table, as well as an analysis of technology and verbal participation. Chapter 6 presents a study using the MSP role play simulation to test degree of inequality of participation by seat location using Google Earth software on a multi-user touch table to demonstrate accessibility to Google Earth interface by seat location. A conclusion

(Chapter 7) follows, in which measures of collaboration are evaluated; potential of using multi-user touch tables for group planning exercises are examined; and future research objectives are discussed.

Chapter 2. Literature Review

2.1 History and Context of Collaborative GIS

Research in Geography and other disciplines have contributed to the emergence of a research area in Collaborative GIS and the need to study group use of GIS. Collaborative GIS has roots in group decision support systems (GDSS), human computer interaction (HCI), and planning support systems research (Balram & Dragicevic, 2006; Jankowski & Nyerges, 2006). Collaborative GIS research reflects a turn in GIScience in which socio-behavioural use of GIS systems are quantitatively and qualitatively examined because "research 'about GIS use' is different from 'research using GIS'" as a method or tool (Nyerges, Jankowski & Drew, 2002, p. 2). The emphasis on cognitive implications of GIS use, rather than the utilization of GIS to solve problems, merges GIScience and the sub discipline of Cognitive Geography; essentially a geographic approach to human-computer-interaction research.

Collaborative GIS research involves studying the use of GIS technology for group use and for decision-making, and the studying and designing of user-friendly technology that promotes its use by those who need it; in addition to people and technology, the context of the data related to stakeholders and the context of the decision-making problem may play a part in how the technology is implemented and used to support group decision-making. Balram & Dragicevic (2006) describe this as the participant-technology-data nexus. GDSS originated in organizational psychology research (DeSanctis & Gallupe, 1987). It refers to the "communication, computer and decision technologies" that are utilized by groups to both define and resolve "unstructured problems" (DeSanctis and Gallupe, 1987, p. 589). GIScience, the science behind the development of GIS (Balram & Dragicevic, 2006), sought to integrate GDSS concepts with GIS thereby creating Group Spatial Decision Support Systems (Nyerges et al., 2006). Group SDSS then utilize GIS as a group decision-making aid to solve place-based problems. A GIS by itself is not necessarily a group SDSS, rather what constitutes a group SDSS is a GIS designed with group use in mind for decision-making purposes (Densham, 1991; Jankowski & Nyerges, 2001b; Simao et al., 2009, p. 2028). "GIS look at data, whereas SDSS look at problem situations (Hendricks & Vriens, p. 86, 2000)." It is common for GIS to be used to support decision-making, however, there is a difference between a GIS created for a single-user desktop environment to analyze data and a GIS designed specifically for group-use and decision-making (Simao et al., 2009, p. 2028). These concepts can be placed into further context with Human Computer Interaction (HCI) research to examine how stakeholders and policymakers interface with Collaborative GIS technologies (Haklay in Balram & Dragicevic, 2006).

To further situate this research, collaboration and Collaborative GIS are defined. For the purpose of this research, collaboration will be generalized per Jankowski & Nyerges (2001b) as a collective understanding of an issue that results in collective group decision-making tasks to explore or resolve the issue. To merge the concepts of collaboration and GIS, this paper adopts the definition of Collaborative GIS by Balram and Dragicevic (2006, p. 3) as the "theories, tools, and technologies focusing on, but not limited to, structuring human participation in group spatial decision processes." Collaborative GIS theories regarding the structuring of participation in group-based spatial decision-making are not described or detailed in the literature reviewed. The lack of theories for structuring group participation represents a significant gap in Collaborative GIS research. Tools and technologies refer to group voting tools, customized GIS decision-support systems, geovisualization and cartographic decision aids, or hardware like interactive touch tables for small groups. Therefore, while, Nyerges and Jankowski's definition of collaboration provides the emphasis on collective decision-making tasks (process) and group resolution of the problem (outcome), Balram and Dragicevic's definition of Collaborative GIS provides a means for structuring the group's decision-making *process* (theories, tools, and technologies) with the *outcome* being further convergence in group understanding and resolution of the spatial problem at hand.

Research into Collaborative GIS gained momentum in the mid-1990s when an initiative (Initiative 17) was proposed by the National Center of Geographic Information and Analysis (NCGIA) to study collaborative spatial decision-making (Balram & Dragicevic, 2006; Jankowski & Nyerges, 2001a; Nyerges et al., 2006; NCGIA, 1995). Initiative 17 emphasized research on the ability of GIS to be used as a decision-making aid for spatial problems; how to create user-friendly GIS decision support systems; and provisioning evaluation tools to help decision-makers assess the quality of alternative options generated with SDSSs (NCGIA, 1995). The research specifically addressed the weaknesses in GIS technologies' abilities to address needs of group collaborations. Two seminal works in Collaborative GIS have been published: *Geographic Information Systems for Group Decision Making: towards a participatory, geographic information Science* (Jankowski & Nyerges, 2001a) and *Collaborative Geographic Information Systems* (Balram & Dragicevic, 2006). The former focused on developing a strong theoretical framework to situate Collaborative GIS research questions (EAST2) and the latter focused on current research directions in Collaborative GIS technology, HCI, and web-based GIS decision support systems. These current research directions include: Public Participatory GIS systems for decision-making; web-based, mobile, distributed and crowd sourced systems; and an emphasis on the technological design of systems (Balram & Dragicevic, 2006; Nyerges et al., 2006; Simao et al., 2009; Carver, Evans & Kingston, 2004; Sigala, 2010; Boroushaki & Malczewski, 2010). Significant gaps still exist in providing strong quantitative evaluations of the role GIS, geovisualization tools, and group work technologies play in group decision-making processes and group collaboration outcomes.

2.2 Collaborative GIS Environments

Collaborative GIS environments can be differentiated in terms of spatial and temporal dimensions. Jankowski & Nyerges (2001a) describe a conventional meeting as same place, same time; a story-board meeting as same place, different time; a conference call meeting as different place, same time; and a distributed meeting as different place, different time, as seen in Figure 1 (Jankowski & Nyerges, 2001a, p. 71; DeSanctis & Gallupe, 1987). For example, web-based Collaborative GIS may be used to broaden participation by allowing distributed feedback by stakeholders who may be constrained by conventional meetings that are same time, same place (Jankowski & Nyerges, 2001a). Touch tables on the other hand are designed for collaborative tasks with a conventional meeting style in mind (same time, same place); however, distributed use of multi-user touch tables may also be possible if two or more distributed groups are using the technology with video-conferencing and shared display technologies. Therefore, co-located technologies are not necessarily confined to the context of same-place when used in conjunction with conferencing technologies, as originally described by Jankowski & Nyerges. The following analysis of literature distinguishes between co-located and distributed Collaborative GIS environments.

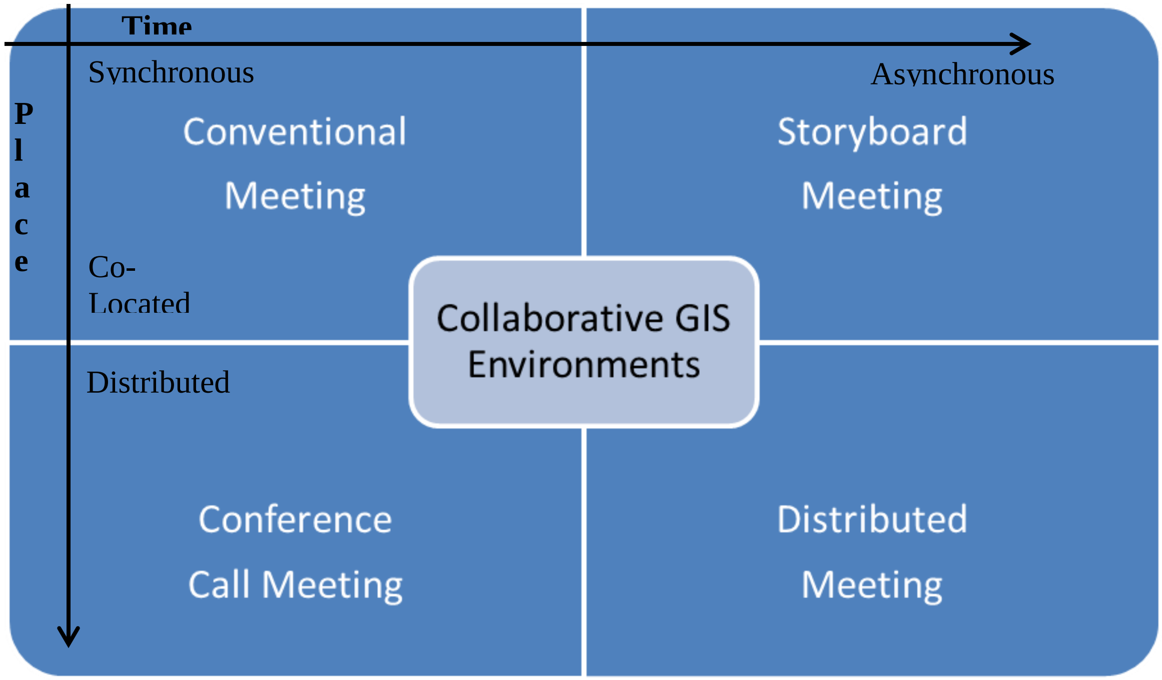


Figure 1. Collaborative GIS Environments

2.3 Measuring Collaboration with GIS and SDSS

As stated previously, Collaborative GIS aims to facilitate problem solving and decision-making of groups working collectively on spatial issues. A strong understanding and assessment of how and to what extent people collaborate with spatial technology and each other are at the core of advancing Collaborative GIS research. While this is a broad field that extends into group psychology, the literature review on measuring collaboration is explored within the context of spatial decision-making.

Themes of measures were identified during the literature review and measures were then divided into two groups: measures of participation and measures of collaborative decision-making. Measures of participation describe methods of quantifying and qualifying the amount of participation by individuals and groups. Measuring participation is important for determining components of the technology that are used most frequently by the group, accessibility of the components by group members, and group dynamics of participation as indicators of group collaboration. Identifying *measures of participation* was also motivated as a means to examine participation on touch table technology to determine the degree of equality of participation as a proxy for accessibility to technology features by seat location.

Measures of collaborative decision-making are used to describe group interactions during the decision-making process; quality and outcome of the groups' decision-making process; and phases of the decision-making process. These measures characterize the support the technology provides to decision-making by describing how the group used the technology. Jankowski and Nyerges (2001) describe three constructs for Collaborative GIS research: convening constructs which bring a group together, process constructs which guide the group's decision-making process, and outcome constructs which relate to the outcome of the group decision-making process. Measures of participation can describe the distribution of participation and interactions, but do not necessarily capture the quality, efficiency, and accuracy of the group decision-making process or its outcomes; therefore, measures of collaborative decision-making are emphasized to fill this gap.

The two groups of measures (measures of participation and measures of collaborative decision-making) are each subdivided into three sections: first, by co-located Collaborative GIS literature; second, by distributed Collaborative GIS literature; third, by computer science touch table literature. The measures divided by co-located and distributed are not necessarily environment-specific; the subdivision by environments is to emphasize measures with demonstrated use by environment in the literature. It is possible for measures identified in distributed GIS literature to be used for co-located environments and vice versa. A third division is touch table literature, which is included to examine differences in measures in comparison to Collaborative GIS literature; there is little to no overlap of Collaborative GIS literature and touch table literature. This body of literature from Computer Science research provides unique measures to touch tables, especially with regards to measuring participation on touch tables, filling a strong gap in measuring participation and collaborative decision-making with GIS on multi-user touch tables.

2.3.1 Measures of Participation

Co-located Collaborative GIS Research

Two articles reviewed provide inferred measures of participation; the measures are inferred as the intent of the measures is not necessarily to measure participation. Salter et al. (2009) measured how much time each participant spoke, facilitator time, as well as presentation components, and interactive components of a community planning workshop using landscape visualization. Although the specific intent was to measure the timing of the workshop structure, rather than participation, this still provides a measure for analyzing participant interaction by indicating overall amounts of participation. Nyerges et al. (2006) also measured participant time spent on different tasks; again this is not necessarily an overall individual measure of participant interaction but does provide information on participant time spent on different tasks and allows for inferences to be made regarding participation. These articles address participation at a very generalized level, limiting the ability to describe participation with greater richness and detail.

McCall and Minang (2005) use three qualitative coding systems to assess legitimacy of participation with participation intensities, purposes of participation, and degree of involvement in a participatory GIS project in Cameroon to evaluate Good Governance. Intensities include: manipulative participation, passive participation, participation by consultation, participation for material benefits, functional participation, interactive participation, and self-mobilization. Purpose of participation codes include: facilitation, mediation, and empowerment. Degree of involvement for various actors in the community participatory GIS process is coded as significant involvement, no involvement, and partial involvement. Criteria used to assign these codes were not discussed.

Two more articles written about the same project by Nyerges et al. (1998) and Jankowski and Nyerges (2001b) discuss measuring participation as *group attention* rather than focusing on the individual. Group attention is defined for their experimental simulation on habitat site selection as “4 out of 5 head directed awareness” determined from coding video footage of the role play simulations (Nyerges et al., 1998, p. 136). Coding systems were used only on video footage that showed group attention to ascertain information at the group level. A critique of this method of analyzing participation is that by focusing only on instances where nearly full group participation occurred with 4 out of 5 individuals showing attention, it limited the assessment of group participation. Group participation may naturally fluctuate during a group's decision-making process; by limiting analysis to only high group participation levels, important aspects of the group's decision-making process may be missed during lower levels of group participation. However, these articles both provide solid methods for measuring collaboration from a group perspective, rather than assessing group collaboration by making inferences from individual contributions. This was a unique approach; no other article looked at the group collective in this way. A summary of the co-located Collaborative GIS participation measures is provided in Table 2.

Table 2. Co-located Collaborative GIS Participation Measures

Study	Participation Measures	Methods
Salter, Campbell, Journeay, and Sheppard (2009)	Participant time, facilitator time, presentation components time, interactive components time	Video footage
Nyerges, Jankowski, Tuthill and Ramsey (2006),	Participant time related to tasks	Video footage
McCall and Minang (2005)	Participation intensities; purpose of participation; degree of participant involvement	Catley and McCall Ladders coding systems
Jankowski & Nyerges (2001b)	Amount of group attention time	4 out of 5 group members showing head directed awareness, derived from video footage
Nyerges, Moore, Montejano, and Compton (1998)	Amount of group attention time	4 out of 5 group members showing head directed awareness, derived from video footage

Distributed Collaborative GIS Research

Only one of the distributed web-based Collaborative GIS articles reviewed had any notable measures of participation that attempted to quantify amount of participation or technology interaction (MacEachren, 2004). MacEachren (2004) proposes a system for measuring participation with a computer graphic called Participant Watcher. The Participant Watcher graphic is based on similar work done by Erickson & Kellogg (2000, p. 73) who developed a social proxy graph. This graph shows which participants are currently involved in a conversation, and how active each has been in the conversation, as well as illustrating who is not involved in the conversation (Figure 2). Participants are visualized as dots within a circle. The closer the participant dot is to the center of the circle the more recently they have participated in the conversation. The less recent the participant has been in the conversation the farther away from the center their dot appears. If a participant is outside of the conversation circle it means they have not participated in the conversation. For example, in Figure 2, dots 1 and 2 are closest to the center of the circle and are currently engaged in discussion. Dot 3 is part of the conversation but has less recent activity demonstrated by the dot moving away from the center. Dot 4 is outside of the conversation circle, and therefore is not part of the conversation. The dots are animated (as depicted with Dot 3) and will slowly move away from the center of the circle with lack of participation in the conversation (depicted with dashed dots fading in colour from the center outwards).

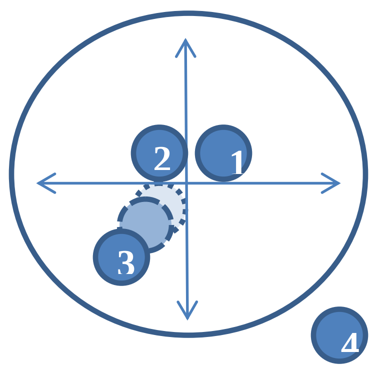


Figure 2. Social Proxy Graph by Erickson & Kellogg (2000)

The Participant Watcher graphic follows along a similar theme as the social proxy graph by demonstrating the current state of participation. MacEachren (2004) describes the participant watcher graphic: "it attempts to depict not only who is participating and how active they have been but also, how they have manipulated three different visual components of their display, the relative amount of time spent using each, who is in control of the shared displays, and which visual component they are currently manipulating" (MacEachren, 2004, p. 443; MacEachren et al., 2001) (Figure 3). Not only is it possible to see the current state of participation within the activity meters, but the cumulative state of the participation and manipulation of decision aids by the participants is characterized. In Figure 3, the activity meters on the left are for scatter plot (s), map (m) and plot (p) windows visually describing the time spent using each. The activity meters at the top represent participants a, b and c and visually demonstrate the amount of time each has been in control. The boxes below each participant show the layout of the scatter plot, map and plot components on that individual's computer screen, with the green representing the active component-in this case the map of participant b. The color coded activity meters at the bottom are to represent data variables that are being utilized; there is a bar for each window type-plot, map, and scatter to show which variables (represented by a color) are being viewed in each. MacEachren's measure is summarized in Table 3.

The strength of the Participant Watcher graphic is its ability to capture group participation in real-time with different decision aids. A weakness however, is that it does not capture detailed interactions by participants or verbal participation. Participants "a" and "c" may be contributing with verbal participation and dialogue, rather than technological interactions, which is not captured by the graphic.

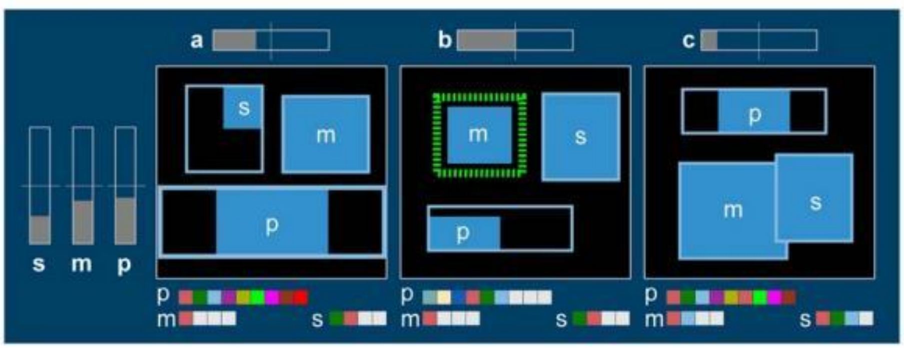


Figure 3. Participant Watcher Graphic (MacEachren, 2001, p. 443)

Table 3. Distributed Collaborative GIS Participation Measures

Study	**Participation Measures**	**Methods**
MacEachren (2004)	Amount of participation time for each participant, relative to each Amount of time spent using each decision aid	Represented visually with activity meters using a computer graphic

Touch Table Research

Primary measures of participation in touch table literature include technological interactions and verbal interactions and are summarized in **Table 4**. Technological interaction is measured by time or frequency of physical interactions with the display and software components; verbal interaction is measured as time, frequency of turn taking or frequency of utterances (Rogers, Lim, Hazlewood & Marshall, 2009; Scott, Carpendale & Inkpen, 2004; Potvin, Swindells, Tory & Storey, 2012; Ryall, Forlines, Shen & Morris, 2004; Morris, Cassanego, Paepcke & Winograd, 2006; Harris et al., 2009; Marshall, Hornecker, Morris, Dalton & Rogers, 2008; Morris & Winograd, 2004). Several studies use a measure called *inequality of participation* where inequality of participation is measured from 0 to 1 with 0 being a perfectly uniform distribution of participation by group members (no inequality), and 1 being the least equitable (total inequality); these statistics include the Gini coefficient and index of inequality (Roger, Lim, Hazlewood, Marshall, 2009; Potvin et al., 2012; Harris et al., 2009; Marshall et al., 2008). Another study also measures level or degree of participation by analyzing the average number of utterances per touch interaction per minute, which allows both physical and verbal interaction to be combined into one measure of participation (Harris et al., 2009). Furthermore, Marshall et al. (2008), not only include quantitative measures of verbal and physical participation, but combine these measures by qualitatively assessing participant perceptions of the equality of participation using questionnaires.

A unique approach taken to quantifying participation in touch table literature, specifically measured *spatial* participation on a physical table with groups completing puzzles (Scott et al., 2004). The table was divided into 16 directional zones measured from the center of the table and divided concentrically into four divisions. Percent interaction in each zone was then measured to gauge the amount of participant activity within each zone. The authors were then able to comment upon workspace territoriality by discerning areas most easily accessible to participants by seat location.

Table 4. Touch Table Participation Measures

Study	Participation Measures	Methods
Rogers, Lim, Hazlewood & Marshall (2009)	Physical and verbal participation	Task time, utterances/minute, Index of Inequality
Scott, Carpendale & Inkpen (2004)	Number and location of physical interactions	Activity diagrams show frequency of interaction and percent total from that area of interaction
Potvin, Swindells, Tory & Storey (2012)	Physical and verbal participation	Frequency and duration of activities using manual video coding; Index of inequality
Ryall, Forlines, Shen & Morris (2004)	Physical interactions	Frequency
Morris, Cassanego, Paepcke & Winograd (2006)	Physical and verbal participation	Amount of discussion (time); percent total physical interaction
Harris et al. (2009)	Physical and verbal participation; level of participation	Number of touch interactions and utterances using Gini coefficient; level of participation using mean utterances/touch per minute
Marshall et al. (2008)	Physical interaction and dialogue turn taking; participant perception of equality of participation	Index of Inequality, ANOVA, Likert questionnaire
Morris & Winograd (2004)	Amount of talking, distribution of interactions	Not applicable

2.3.2 Measures of Collaborative Decision-making

Co-located Collaborative GIS Research

Co-located, conventional Collaborative GIS studies include a more diverse set of collaborative decision-making measures in the literature than identified in the distributed web-based Collaborative GIS studies. Eleven studies were identified that measured group decision-making related to GIS technology.

McCall and Minang (2005) measure a participatory GIS project using six dimensions of good governance: participation, empowerment, ownership, respect for participants and indigenous/local knowledge, equity, and effectiveness. Methods for collecting data included recording sessions that employed participatory rural appraisal techniques that included focus group discussions, semi-structured interviews, and diagramming. Content analysis was applied to transcripts derived from recordings. Good governance dimensions were then measured by making inferences from the transcripts.

Studies frequently used participant perceptions from questionnaires to assess geo-technologies' impact on group collaborations. Salter et al. (2009) explore the use of landscape visualizations for community planning using a Likert scale and reporting results as means, medians and modes; their statistics were limited due to small sample size. The authors used the Likert questionnaire to assess the workshop technology on dimensions of landscape visualization realism and interactivity. Balram et al. (2004) use a 3-point Likert questionnaire (agree, neither agree nor disagree, disagree) to evaluate perceptions regarding the following: "role of the GIS in focusing deliberations, the adequacy of the explanations about using the GIS technology, role of the GIS in communicating ideas, the usefulness of the GIS map overlays in real-time, and the overall usefulness of the process in capturing the information of the experts (p. 1204)." The questionnaire results are assessed collectively using a satisfaction index to gauge the overall impact of GIS on the collaboration. Faber et al. (1995) analyze the utility of a Collaborative GIS system for forest resources planning using an open-ended questionnaire, asking participants how the system improved their process and how the system hindered their process. Questionnaires are efficient and cost-effective as a method but are often limited by small sample sizes and relying solely on participant perceptions may produce results with high subjectivity.

Group interaction coding systems have been demonstrated to be a useful measure of group decision-making for Collaborative GIS (Nyerges et al., 1998; Jankowski & Nyerges, 2001b; Nyerges et al., 2006). "Coding systems are translation devices that allow researchers to assign behaviors into functional categories (Trujillo, p.371, 1986)." Similarly, "coding requires the inference and assignment of meaning to utterances; it attempts to duplicate the outcomes of human interpretive processes, to identify the conventional meanings of utterances (Poole & Folger, 1981, p. 26)." Coding systems, therefore, allow quantities of dialogue to be labeled into categories as a way of analyzing the distribution of the types and meaning of communication in small groups to make inferences about patterns of communication. Limitations of coding systems revolve around the subjective nature of assigning codes (Poole & Folger, 1981; Trujillo, 1986).

Having multiple people code the data to determine the code reliability or having the same coder, code the data twice can give an indication of the reliability of the coding system (Nyerges et al., 1998; Poole & Folger, 1981; Trujillo, 1986).

Jankowski and Nyerges (2001b) describe a group role play experiment for habitat site selection in which three interaction coding systems are used to answer a variety of research questions. These three coding systems include: decision structures, decision phases, and group working relations. The decision structures coding system allowed group use of decision aids to be analyzed by assessing the frequency use of maps and multi-criteria decision-making aids using a test for correlation and general linear model. The decision phases coding system measured function structuring, problem exploration, criteria identification, criteria valuation, criteria prioritization, evaluating alternatives and selecting alternatives to assess variations in decision phases with decision structure use, as well as, group conflict by decision phase. The group working relations coding system measured opposition, accommodation, tabling, negotiation, compromise, and justification. These coding systems are also used in a more recent field experiment by Nyerges et al. (2006) for workshops on collaboration over water resource issues in Idaho.

Analyzing the use of technology by decision phases can demonstrate which components of the technology are most useful during each step of the decision-making process and inform how to increase or balance participation and collaboration at each phase. Consistency exists amongst identified typologies of decision phases for spatially oriented problems, which are depicted in Table 5. Decision-making phases should not be viewed entirely as a linear process but may be recursive and iterative in nature (Jankowski & Nyerges, 2001a). The problem exploration phase involves identifying the values, objectives, and criteria regarding the spatially oriented problem in question (Jankowski & Nyerges, 2001a). The next generalized phase is that of generating options-also described as designing, negotiating, and analyzing options (Jankowski & Nyerges, 2001a; MacEachren & Brewer, 2004). The option selection phase is characterized by choosing amongst the alternatives that were generated in the previous generating options phase (Jankowski & Nyerges, 2001a; MacEachren & Brewer, 2004). A fourth phase, evaluation can be described as a review or presentation phase of the final decisions that are made during the spatial decision-making process (Jankowski & Nyerges, 2001a;

MacEachren & Brewer, 2004). By examining GIS task types that occur within each phase-and micro phases-of the decision-making process, group activities and software may be refined to optimally structure group decision-making.

Table 5. Decision Phases

Decision-Making Phase	**Decision Strategy (**Jankowski & Nyerges, 2001a, p. 17**)**	**Decision Task (MacEachren & Brewer, 2004, p. 7)**	**Knowledge Construction Task (MacEachren & Brewer, 2004, p. 7)**
Problem Exploration	Intelligence: “Intelligence about values, objectives, and criteria”	Generate ideas and options	*Explore* as a stage of knowledge construction
Generating Options	Design: “Design of a set of feasible options”	Negotiate amongst ideas and options	*Analyze* as a stage of knowledge construction
Option Selection	Choice: “Choice about recommendations”	Choose amongst ideas and options	*Synthesize* as a stage of knowledge construction
Evaluation	Review “Review recommendations in line with original values, goals, and objectives”	Execute	*Present* as a stage of knowledge construction

Two articles in particular use measures of accuracy and efficiency of a spatial task as a measure of group decision-making processes in an experimental setting (Dennis & Carte, 1998; Mennecke, Crossland & Killingsworth, 2000; Fernquist, 2010). Dennis and Carte (1998) measured decision processes expressed as analytical versus perceptual; decision accuracy expressed as distance from the correct solution; and decision efficiency expressed by measuring total time it took to reach a solution. These measures were collected to assess differences in using map based visuals to reach a decision versus tabular data. Similarly, Mennecke et al. (2000) measure task accuracy and efficiency related to the factors of experience; spatial decision support used versus no spatial decision support used; and task complexity of high, medium, and low.

A master’s thesis by Fernquist (2010) also looks at similar measures of spatial task accuracy and efficiency for an experimental neighborhood planning task in a single-user touch table environment and a multi-user touch table environment of eight groups of two individuals, each. In addition to measuring task completion time and accuracy of group solutions, groups were asked to fill out questionnaires after completing each task that asked their perception of task efficiency, accuracy, complexity and amount of group collaboration. Fernquist's results are surprising and demonstrate the need to collect both data on participant perceptions, as well as quantitative measures to compare their consistency with each other. Fernquist found that although groups perceived the multi-touch table environment to be more collaborative and task accurate and efficient, the quantitative data collected on task accuracy, efficiency, and collaboration were not significantly different in either environment. This demonstrates the subjectivity that exists when basing results solely on questionnaire data. Fernquist attributes the discrepancy in participant perceptions to cognitive absorption theory which is a "state of deep involvement with software, exhibited through five dimensions: temporal dissociation, focused immersion, heightened enjoyment, control and curiosity (Fernquist, 2010, p. 50)."

Collaborative GIS exercises on multi-user touch tables have relied upon questionnaires to collect data about participant's experiences. Alexander et al. (2012) demonstrates a Collaborative GIS MSP activity on multi-user touch tables. Although collaboration and decision-making specifically were not measured, the authors did have participants fill out a post-workshop questionnaire regarding their perceptions of the planning process in identifying potential tidal energy sites using a group decision support system on a multi-user touch table. Arciniegas and Janssen (2012) describe a collaborative planning workshop on land use planning using multi-user touch tables. They used five point Likert scale questionnaires to measure participant preferences of touch tables versus paper maps and to rate their satisfaction with elements of the workshop on touch tables. Good governance dimensions, participant perceptions, group interaction coding systems, and task completion time and accuracy are described and summarized in Table 6.

Table 6. Co-located Collaborative GIS Measures of Collaborative Decision-making

Study	**Group Decision-Making Measures**	**Methods**
McCall and Minang (2005)	6 dimensions of good governance: participation, empowerment, ownership, respect for participants and indigenous/local knowledge, equity, and effectiveness	Recording sessions that employed participatory rural appraisal techniques including focus group discussions, semi-structured interviews, and diagramming. Content analysis applied to transcripts.
Salter, Campbell, Journeay & Sheppard (2009)	Visualization realism and interactivity	Questionnaires with Likert scale and open-ended questions; report results as means, medians and modes
Balram, Dragicevic & Meredith (2004)	"Role of the GIS in focusing deliberations, the adequacy of the explanations about using the GIS technology, role of the GIS in communicating ideas, the usefulness of the GIS map overlays in real-time, and the overall usefulness of the process in capturing the information of the experts, (p. 1204)."	3 point Likert questionnaire (agree, neither agree nor disagree, disagree). Use a satisfaction index to interpret questionnaire results
Faber, Wallace & Cuthbertson (1995)	How did the system improve participants' process; how did the system hinder participants' processes?	Open-ended questionnaire
Nyerges, Moore, Montejano & Compton (1998); Jankowski & Nyerges (2001b); Nyerges, Jankowski, Tuthill & Ramsey (2006)	Decision structures- frequency use of maps and multi-criteria decision-making aids using a test for correlation and general linear model; decision phases-function structuring, problem exploration, criteria identification, criteria valuation, criteria prioritization, evaluating alternatives and selecting alternatives to assess variations in decision phases with decision structure use, as well as, group conflict by decision phase; group working relations-opposition, accommodation, tabling, negotiation, compromise, and justification	Group interaction coding systems; frequency use of maps and decision aids; time for each code; test for correlation; general linear model
Dennis & Carte (1998)	Analytical versus perceptual decision processes; decision accuracy expressed as distance from the correct solution (p199), and decision efficiency expressed by measuring total time it took to reach a solution	Decision processes: numeric recorded data coded as analytic, while relative terms were coded as perceptual; Accuracy: expressed as distance from the correct solution(p199); Efficiency: expressed by measuring total time it took to reach a solution

Study	Group Decision-Making Measures	Methods
Mennecke, Crossland & Killingsworth (2000)	Task accuracy and efficiency related to experience, decision support, and task complexity	Efficiency as solution time, correlation test and ANOVA; Kendall Tau's test of accuracy
Fernquist (2010)	Efficiency and accuracy of group solutions; participant perception of task efficiency, accuracy, complexity and amount of group collaboration	Efficiency measured as solution time; experts scored quality of solutions and normalized results (correlation and ANOVA); participant perceptions measured using questionnaires after completion of each task
Alexander et al. (2012)	Usefulness of Collaborative GIS workshop	Questionnaire
Arciniegas & Janssen (2012)	Measured participants' experience, preference and satisfaction using touch tables	Five point Likert questionnaire

Distributed Collaborative GIS Research

Distributed Collaborative GIS measures of collaborative decision-making processes appear to be limited. Only one article (Boroushaki & Malczewski, 2010) identified a research-based measure of the collaborative decision-making process in the context of consensus measures. One more article measured collaborative decision-making using a participant questionnaire (Sigala, 2010). These are summarized in Table 7.

Boroushaki and Malczewski (2010) detail a method for calculating consensus based on a consensus measure and a proximity measure for multi-criteria decision-making tasks. The consensus measure quantifies the level of agreement between individual participant preferences and that of the overall group solution, whereas, the proximity measure describes the distance each participant preference is from the group solution. The authors implement the measure using a participatory web-based planning tool that elicits feedback from public participants to identify possible sites for a city parkade. Individuals interacted with the system independently to submit their own plans, while all solutions were collected to produce a group solution. Consensus was then measured by determining how far each individual contribution deviated from the final group solution. In this case, little collaboration is done at the group level.

Sigala (2010) measured satisfaction with 188 questionnaires for a collaborative trip planning experiment with undergraduate students. Sigala's study assesses satisfaction of the group's collaboration and decision-making components of the trip planning geoportal used in the experiment. Four factors were measured using exploratory factor analysis and principal component analysis to discover the impact upon the participant's satisfaction with the trip planning process. Effectiveness of the system, community building, task completion efficiency, and outcome of the trip planning process are measured in relation to participant satisfaction of distributed trip planning with the geoportal. This case study provides a detailed description of how a group's Collaborative GIS decision-making processes can be assessed with participant questionnaires.

Table 7. Distributed Collaborative GIS Measures of Collaborative Decision-making

Study	**Group Decision-Making Measures**	**Methods**
Boroushaki & Malczewski (2010)	Consensus	A calculation that uses ranked individual preferences compared to a group's final solution
Sigala (2010)	Satisfaction with trip planning using effectiveness, community building, task completion frequency, and outcome	Questionnaires, exploratory factor analysis and principal component analysis

Touch Table Research

Collaborative task measures are emphasized in HCI literature; however, collaboration is oriented towards task coordination and task cooperation, rather than analysis of group decision-making. Rogers et al. (2009) use a coding system to analyze dialogue, as well as, using researcher observations and qualitative analysis to assess group coordination and collaboration strategies. Ryall et al. (2004) also explore collaboration strategies like group members that work independently in parallel versus group work that is collective with members working on the same task altogether. Task completion time is also measured, as well as, diffusion of responsibility in which parts of the table are under the responsibility of certain individuals based on their proximity and adjacency to it. In addition, Harris et al. (2009) code dialogue by task related, turn taking, brief response, and other for a game-based experiment with children on multi-user touch tables.

Morris and Winograd (2004) discuss a variety of collaboration measures. These include: "amount of talking, types of talking, distribution of actions among group members, location of interactions, number of people that handle each object, reorientation of objects, task outcome, number of corrections, [task completion] time, learning, self-reports [i.e., questionnaires], strategy type (p1-3).” Some of these are participation measures; others assess the group’s collaboration. Three measures in particular can be extrapolated to measuring decision-making; these include: types of talking, learning, and strategy type. Methods for measuring learning or knowledge construction are not discussed and the article did not relate any research results. Studies are summarized in Table 8.

Table 8. Touch Table Measures of Collaborative Decision-Making

Study	**Group Decision-Making Measures**	**Methods**
Rogers, Lim, Hazelwood and Marshall (2009)	Coded dialogue to look for patterns between environments; collaboration & coordination strategies; participant’s perspectives of their collaboration	Dialogue coded for suggestions, confirmations, probing questions, queries, answers, other with data normalized by participant/minute; qualitative analysis of verbal and nonverbal communication; qualitative analysis of collaboration & coordination strategies; open-ended interview and post-workshop questionnaire
Harris et al. (2009)	Discussion coding system: task related, turn taking, brief response, and other	MANOVA statistic
Ryall, Forlines, Shen and Morris (2004)	Large versus small group task speed; interaction effect by table size or group size; diffusion of responsibility; work strategy	Direct observations of group interactions; computer logging, ANOVA using words per minute; seven point Likert scale questionnaire measuring level of agreement; work strategy: logged number and type of touches, parallel mode versus collective mode
Morris and Winograd (2004)	Types of talking, learning, group strategy, task completion time	Not applicable

2.3.3 Synthesis of collaboration measures and Research Gaps

Participation and group decision-making are aspects of collaboration. To measure collaboration with GIS on touch tables, we can analyze the components of collaboration, such as participation, cooperation, coordination, group interaction, and decision-making. Our emphasis in this chapter is identifying methods for measuring participation and decision-making on touch tables for collaboration with GIS or a SDSS. The literature reviewed demonstrates multiple ways of measuring Collaborative GIS in distributed environments and co-located ones; and the HCI literature offers further examples of measures for touch table environments Table 9 demonstrates the variety of ways in which participation and group decision-making have been measured in the literature. The measures identified within the literature were used to inform measures of collaboration for the role play simulation described in detail in the following methods section (Chapter 3).

Measures of participation are very limited in co-located and distributed Collaborative GIS literature; however, a diversity of participation measures exists in touch table literature. Touch table research fills a significant gap in how to measure participation for Collaborative GIS exercises. These measures are not confined to touch table environments by any means, but may prove useful for a variety of Collaborative GIS environments, both co-located and distributed. A greater richness of collaborative decision-making measures exists in Collaborative GIS literature compared to touch table literature. Touch table literature deals very little with spatial decision-making, therefore, its measures of decision-making are less useful than what presently exists in Collaborative GIS literature.

Overall, research gaps still exist in Collaborative GIS methodology and designing systems and processes with GIS that support group decision-making. Collaborative GIS research tends to evaluate the technical aspects of group spatial decision support systems with limited results presented on these systems' abilities to support group-based decision-making, the original goal outlined by the NCGIA's Initiative 17. Qualitative questionnaires dominate over quantitative measures, representing a significant gap in Collaborative GIS methodology.

Table 9. Synthesis of Collaboration Measures

Measures of Participation	
Description	**Environment**
-Participation time -Participation intensity, purpose, and degree of involvement -Group attention time	Co-located Collaborative GIS research

-Participant Activity Meter: measures relative participant *time* spent using different components of a system	Distributed Collaborative GIS research
-Frequency of physical interaction and verbal utterances and turn taking -Physical and verbal participation time -Participation level (average utterances per interaction per minute) -Participation Equity (Gini coefficient and Index of Inequality) -Participant perception of participation equity (questionnaire)	Touch table research
Measures of Collaborative Decision-making	
-Good governance: participation, empowerment, ownership, respect for participants and indigenous/local knowledge, equity, effectiveness (interviews, content analysis) -Questionnaires on perceptions of collaboration and decision-making -Group Interaction Coding Systems: decision structures, decision phases, and group working relations -Accuracy of decision solution (distance from the correct solution) -Efficiency of decision solution (task completion time)	Co-located Collaborative GIS research
-Consensus -Group satisfaction with collaboration and decision-making (questionnaire)	Distributed Collaborative GIS research
-Group coordination and collaboration strategies -Task completion time -Group interaction coding systems -Diffusion of responsibility -Task outcome -Learning -Number of corrections	Touch table research

Chapter 3. Methods

3.1 Introduction

This chapter presents details on a multi-stakeholder MSP role play simulation, which this thesis is based on; technology and data collection; and analysis methods. The role play simulation is described in section 3.2, including: context of the MSP activity on multi-user touch tables; description of stakeholder roles and characteristics of individuals that participated; and role play simulation instructions. Section 3.3 describes the hardware and software used for the role play simulation. Section 3.4 describes hardware and software used and data collected, such as technological and verbal interactions, and participant questionnaires. And, Section 3.5 describes data analysis, group interaction and decision phase coding systems, index of inequality and combined participation index.

3.2 Role Play Simulation

Due to challenges related to collecting information with audio and video footage in real world planning situations, such as participants' hesitancies at being videotaped, and possibly hindering a real world planning process for research, a multi-stakeholder MSP role play simulation was designed to test measures of collaboration (Nyerges et al., 2006). The role play simulation was designed to simulate a real world MSP activity with stakeholder roles designed to simulate objectives and concerns of actual stakeholders that have a stake in MSP. The simulation design was intended to produce results that would then have strong construct validity for MSP activities on multi-user touch tables with GIS. Previous research by Nyerges et al. (1998) and Jankowski & Nyerges (2001b) used a role play simulation to design decision-making coding systems to analyze participants' use of a decision support system designed for habitat site selection. The aim is to be able to apply these measures to real world MSP after they have been rigorously tested so that the research objectives do not overshadow or hinder the MSP process.

3.2.1 MSP Role Play Simulation: Identifying No-take Marine Reserves

The objectives of the role play simulation were to have four stakeholders work together to identify locations for two no-take marine reserves in the proposed Southern Strait of Georgia National Marine Conservation Area (NMCA) in the Gulf Islands of British Columbia. This context was chosen to simulate a real world MSP activity and was loosely designed around an actual workshop to identify potential representative marine areas (PRMAs) for the West Coast Vancouver Island Shelf Marine Ecoregion with experts from Parks Canada, Department of Fisheries and Oceans, Canadian Parks and Wilderness Society, and West Coast Aquatic. The role play simulation deviated from identifying PRMAs on the West Coast Vancouver Island Shelf to identifying no-take marine reserves for the Strait of Georgia NMCA. It should be noted that a Collaborative GIS MSP activity is only one small part of an overall marine spatial planning process

3.2.2 Stakeholder Roles and Participant Characteristics

The four stakeholder roles included First Nations, conservation NGO, transportation, and sport fishing. These roles were chosen to simulate types of stakeholders whose concerns might be considered during an actual MSP process. A diversity of roles was sought to represent economic, cultural, recreational and conservation interests in the area. The First Nations role was loosely based on the Tsawwassen First Nation whose territories extend to Galiano, Mayne and Saturna Islands. Several NGOs like Canadian Parks and Wilderness Society and Georgia Strait Alliance are involved in MSP processes in the Strait of Georgia, which justified the conservation role. Transportation interests were considered as heavy ferry and cruise ship traffic occurs in the area. Lastly, sport fishing was considered as it is a recreational activity in the Strait of Georgia. The role play simulation was designed to take place within one hour and needing only twenty minutes of preparation time by participants. As a result, some authenticity of the roles and the role play was sacrificed due to participant knowledge level and time constraints.

A primary objective of the research design was to determine the extent to which seat location impacted participation by examining equality of interactions amongst seat locations. This research also seeks to fill gaps in Collaborative GIS research to determine equality of participation and its impact on the ability of participants to effectively share their perspectives and protect their interests. It was desired to create roles that would be relatively even in terms of content to ensure that the role itself, rather than seat location, did not bias itself towards more participation than another role. Each stakeholder had relatively the same amount of data, three layers, except for the transportation representative who was given four layers of data because their interests were easier to protect. The transportation role was not tasked with finding an ideal location for a no-take reserve, only keeping the no-take reserve away from its shipping lanes which have high economic and social value. Stakeholder roles are described in greater detail in Table 10.

Table 10. Stakeholder Roles

Stakeholder Role	**Spatial Data**	**Concerns**
First Nations	-Important harbours -Crab harvesting areas -Clam harvesting areas (this did not exist as spatial data, but was indicated verbally by the First Nations representative and kinesthetically by pointing to the map).	-You are reluctant to concede any clam or crab harvesting areas that your Nation is allowed to use for subsistence harvesting. -Likewise, you would like to make sure the no-take marine reserve is not too close to an important harbor.
Transportation	-Vessel traffic lanes -Cruise ship routes -Ferry routes -Important harbours	-You are looking to protect transportation interests and would like to make sure the no-take marine reserves do not conflict with traffic routes, especially the ferry route from Tsawassen to Swartz Bay.
Conservation NGO	-Eelgrass -Kelp -Sponge reefs	-You are personally in favour of no-take marine reserves and would like to see the no-take marine reserve protect eelgrass, kelp and sponge reefs. -Sponge reefs are your number one priority
Sport Fishing	-Prawn & shrimp Sport fishing areas -Groundfish sport fishing areas -Anadromous sport fishing areas	-You are personally in favour of no-take marine reserves and don't mind conceding some of your sport fishing areas for that purpose, as a large portion of the study area is covered by your sport fishing areas, and 4 km^2 would be a small concession.

Participants were recruited from undergraduate and graduate Geography and Anthropology departments at the University of Victoria. Six groups of role play simulations were held with four students in each group. Participants were chosen first come, first serve basis and paid for their time. The first group of four was used to test the role play sheets and understanding of the questionnaires. Materials were updated following this role play simulation to reflect recommendations.

3.2.3 Role Play Simulation Instructions

Each stakeholder role was given a stakeholder role play sheet of three to four pages that described the participant's role, objective, important terms and definitions, workshop preparation tasks and workshop agenda. Each stakeholder role was also provided with paper maps displaying their stakeholder's spatial data, marine and terrestrial protected areas and delineation of the study area, depicted in Figure 5. The role play simulation used technology to support two decision phases, namely, problem exploration and option generations. Option selection and evaluation decision phases were not part of the simulations. A synopsis is provided in Appendix 1.

The participants were explained the objective of the role play simulation and criteria for identifying the no-take marine reserves. Participants were then assigned seat locations by stakeholder role to maintain consistency across role play simulations, shown in Figure 4. They were given a tutorial in how to perform touch table gestures, e.g. zooming in/out and right clicking; and also how to interact with Google Earth, especially adding and editing features. Ten minutes was allotted to participants to acquaint them with their spatial data in Google Earth and to practice adding points, lines, and polygons to the system. Participants were then instructed to first share their role's objective and spatial data with the group, one by one, before identifying no-take marine reserve locations as a group. The facilitator informed the participants that they could ask questions if needed at any time.

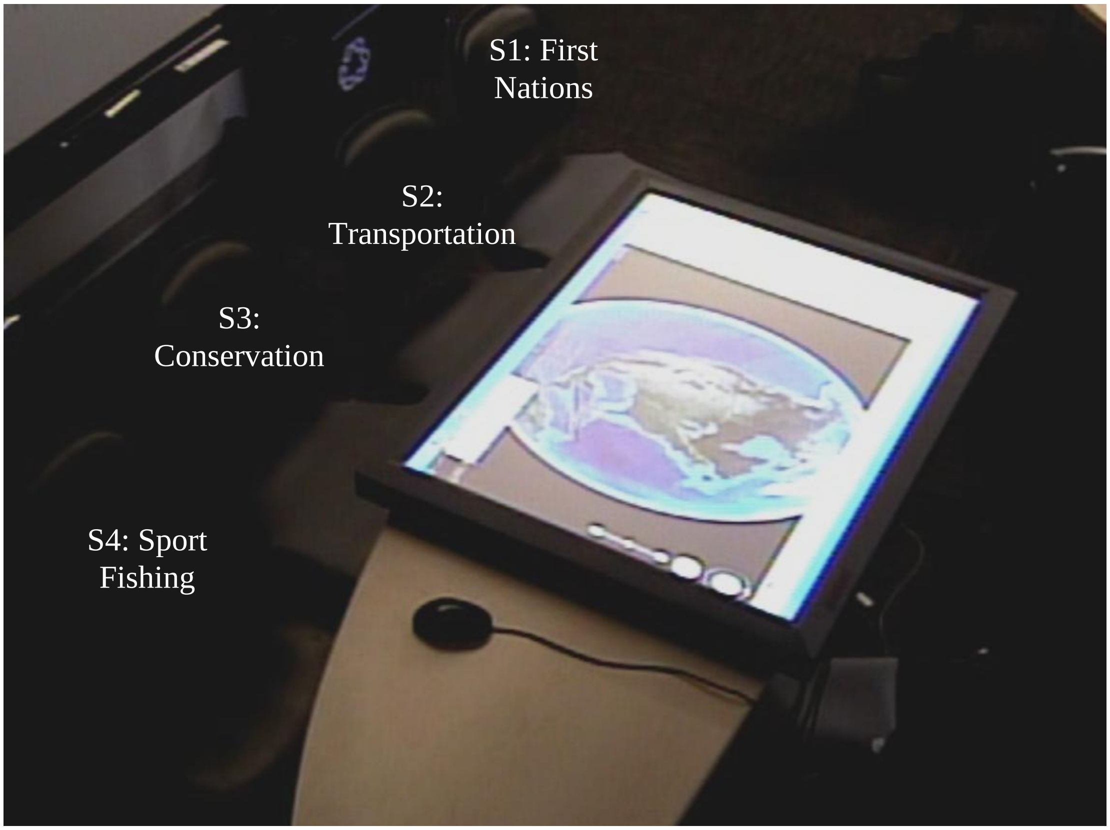


Figure 4: Expected Seating Arrangement

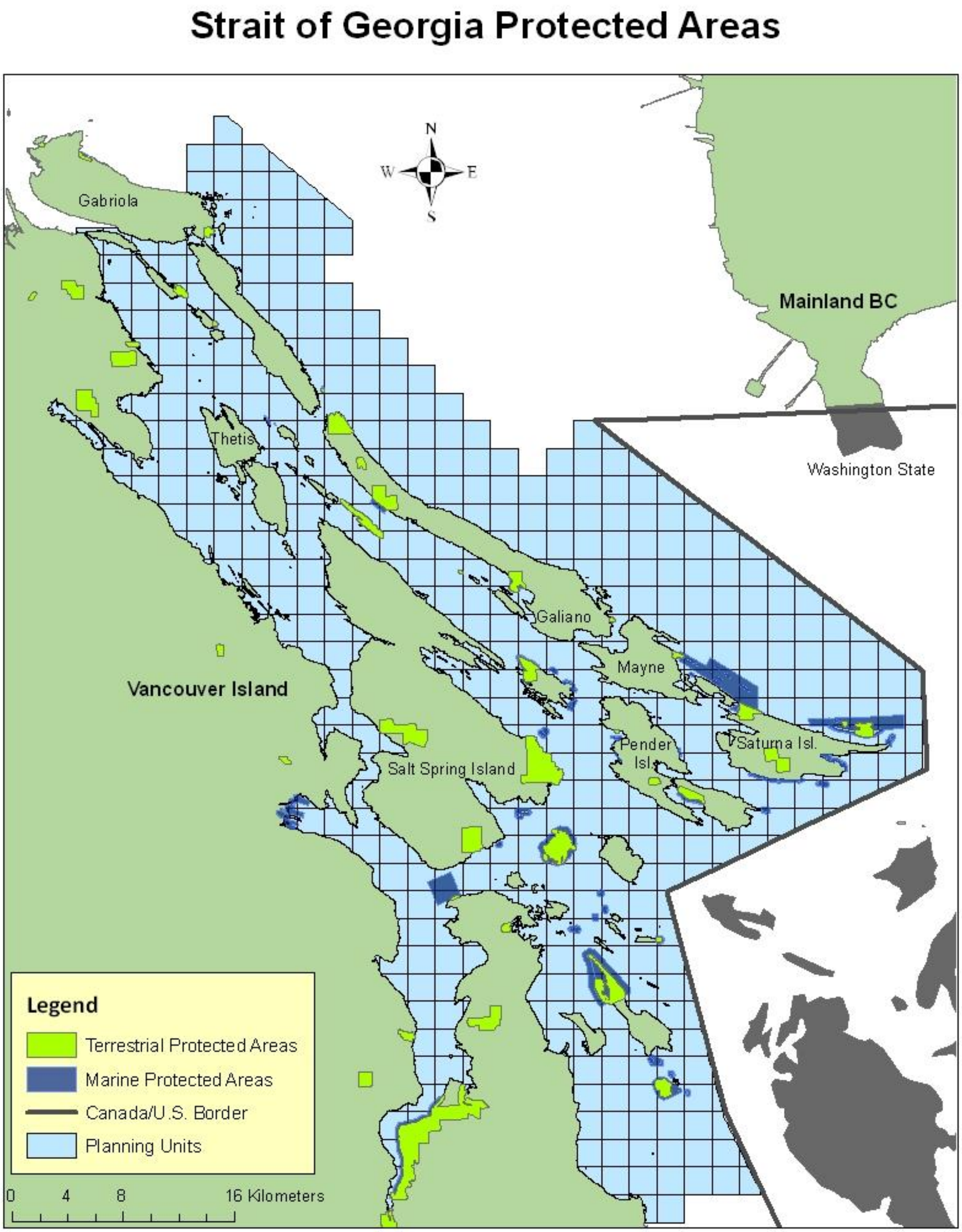


Figure 5. Role Play Simulation Study Area Map

3.3 Role Play Simulation Technology

3.3.1 Hardware

The role play simulation was structured around a multi-user, top-projected Diamond Touch touch table (Figure 6). The touch table was connected to a Dell desktop computer (Windows operating system) with a USB connector and placed on a table that was roughly 30 inches wide by 60 inches long and 30 inches tall. The touch table registers capacitive touch using touch pads, as seen in Figure 6. The touch pads are connected to the bottom of the touch table and connect to the pad via a connector cable. The touch pads were placed on the seat locations for participants to sit upon. Participants have to be in contact with the touch pad for the table to register their touch input. In other words, capacitive coupling occurs where the participant touches the touch table, the signal then moves through the user into a receiver (i.e., touch pad), which the participants are sitting upon (Dietz & Leigh, n.d.). The table communicates participants' interaction with the table through the touch pad. Participants were instructed to use either touch inputs for mouse and keyboard gestures, or a physical mouse and physical keyboard, depending on what they were most comfortable with. Neither method was encouraged over the other.

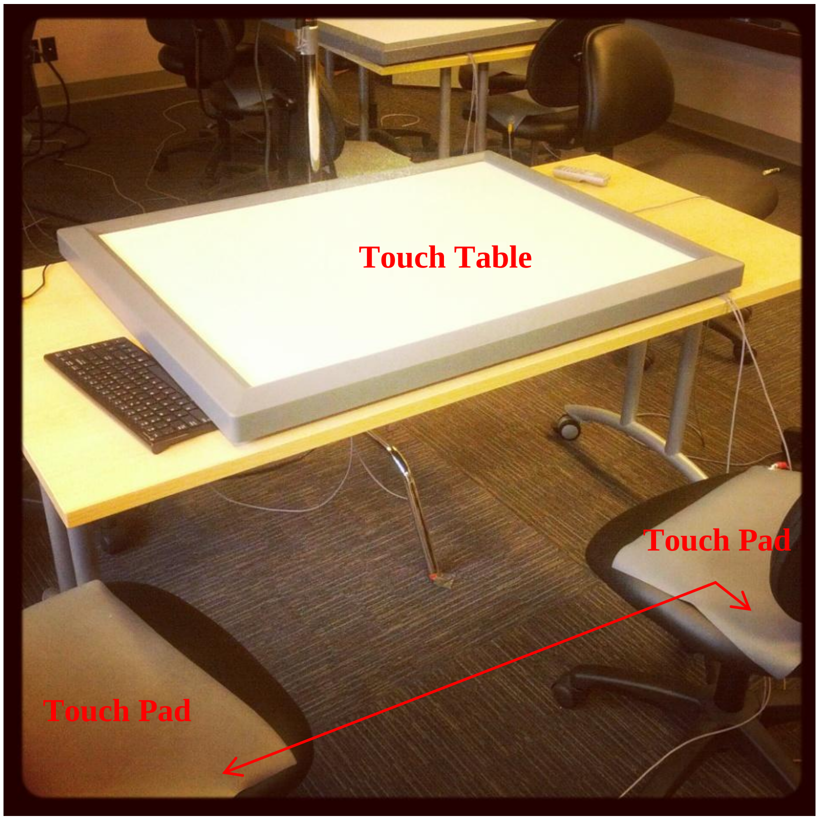


Figure 6. Role Play Simulation Hardware

3.3.2 Software

Google Earth was the software chosen for the role play simulation. Although Google Earth is not a true GIS, due to the limited GIS experience of the participants, it was determined the Google Earth interface would be more user friendly than a desktop GIS interface. Google Earth is a geovisualization software that allows points, lines, and polygons to be interactively added in real time to displayed spatial data. Points can be used to represent locations of interest to a stakeholder; lines can be used to represent routes or paths; and polygons can be used to represent areas, such as a no-take marine reserve. Participants were instructed on how to turn layers on and off, how to expand layers, how to edit layers-including symbology, as well as, how to add new features, such as, points, lines, polygons . Participants were also instructed on how to mouse, pan, zoom in and out, and right-click using touch gestures. A true GIS also has database and spatial analysis capabilities which Google Earth lacks. However, Google Earth is still suitable for Collaborative GIS because of its strong geovisualization capabilities and ability to add spatial data. In fact, Google Earth has previously been used in collaborative geovisualization workshops for community resilience planning to sea level rise (Sheppard et al., 2011).

3.4 Data Collection Methods

3.4.1 Hardware & Software

Data were collected using audio and video equipment. Four free-standing microphones were placed onto the table that the touch table was resting upon, in front of the participants. It was attempted to place them in locations that did not interfere with the participants' interaction with the touch table technology. The audio was synchronized to two video cameras, one that recorded screen-capture video within the computer system of what was taking place in Google Earth, and another wall camera to the right of (and several feet in front of) the touch table to capture the group's interactions (Figure 7A). A third projector mounted camera was placed directly above the touch table to capture the detailed physical interactions of the participants with the touch table (see Figure 7B.1 and a close-up in Figure 7B.2).

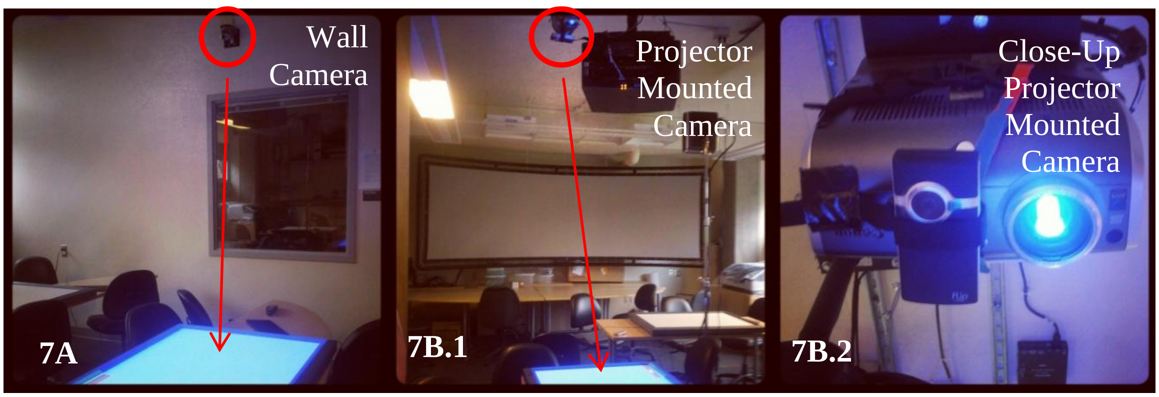


Figure 7. Data Collection Video Cameras

The video cameras captured different data. The screen-capture video generated a digital recording of the actions occurring within the computer display, capturing the cursor movements but not who has performed the movement, as the recording is within the computer display. The wall camera was able to capture the group discussion and their social interactions, but due to the angle of the camera, could not be zoomed in to capture the fine detail regarding who clicked what and the interface they were in. The projector mounted camera was able to capture physical interactions in incredible detail; however, the audio was poor due to the hum of the fan on the projector. The projector mounted video was used to collect frequency of interaction measures with the technology, while the other videos were used to create transcripts and code degree of group collaboration (technological and dialogue), Google Earth technology task, and decision phase. Therefore, the combination of all three videos was used to collect and verify data. Paper questionnaires were used to collect data on participants' perceptions of the role play simulation and their experience with touch tables (Appendix 2: Questionnaire).

3.4.2 Data Collected

Technological and Verbal Interactions

Technological and verbal frequency of interaction was recorded for all participants. Technological frequency of interaction (mouse and touch interface) was collected by manually coding video footage to examine the number of physical interactions that each stakeholder (by seat location) had with the software components (menus, dialogue boxes, earth display). Technological interactions between the participants and the technology were recorded from the projector mounted camera included:

- **Participant stakeholder role** -First Nations, Transportation, Conservation, Sport Fishing
- **Interaction type**-touch, mouse, manual keyboard, pointing, unknown, incomplete,
- **Action performed** -add/edit feature, canceled action, symbology, right click, tap, manual keyboard, onscreen keyboard, pointing, explore menus
- **Interface the action was performed in**-menus, dialogue box, earth display
- **Purpose of the interaction**-filled in when necessary to add context to the entry; for example, pointing at cruise ship routes to demonstrate an important area
- **Error**-filled in with *Error*
- **Error comment** -filled in with a description of the error, such as human error in gesture performed (e.g. using an iPhone gesture to zoom in) or gesture not registered (e.g. gesture was performed correctly but not registered by technology,

usually because the gesture is too coarse for the interface, like turning on/off layers).

Dialogue turn taking and number of words spoken by seat location were also collected as interaction measures and indicators of verbal participation. These data were collected from the wall-mounted camera. It was attempted to log every interaction with the technology by each participant for the length of the role play simulation. The majority of data on physical interactions are detailed in Chapter 6.

3.4.3 Participant Questionnaires

Pre- and post-workshop questionnaires were given to participants (Appendix 2: Questionnaire). The pre-workshop questionnaire asked about participant's experience with Google Earth, touch interfaces, and their understanding of their role's objective and spatial data. The pre-workshop questionnaire was given mainly to determine the degree to which participants understood their role prior to the commencement of the simulation to make inferences regarding impacts of role understanding on participation and to determine if new understanding or knowledge discovery occurred post role play simulation. The post-workshop questionnaire covered sections on knowledge discovery, options & alternatives generated, consensus, participation, and touch tables. For Chapter 6, the questionnaires were used to determine participants' perceptions of each individual's contribution of verbal and physical interactions compared to other group members. Question types included multiple choice, 5 point Likert scale, and open-ended questions.

3.5 Data Analysis Methods

3.5.1 Audio and Group Interaction Coding Systems

One of the key facets of my research is the development and testing of new coding systems to assess the following: degree of technological and dialogue collaboration (Table 11); Google Earth tasks (Table 13); decision phases (Table 14); and error (Table 15). In previous Collaborative GIS studies using group interaction coding systems, one minute segments were measured and it was recommended that finer segments be used to capture more variation in the group's process (Nyerges et al., 1998; Jankowski & Nyerges, 2001b). Alternatively, sections of dialogue could be coded, independent of length of time; for example, coding dialogue participation by length of task completion. To ensure variation was captured during the groups' processes, codes were assigned for each 15 second segment of video and compared to one another using frequency counts. Coding systems are used in Chapter 5. For technology and dialogue participation in Table 11, the code of *highly participatory* was chosen as three out of four participants to reflect previous research with group coding systems that used four out of five participants to measure group attention (Nyerges, et al., 1998; Jankowski & Nyerges, 2001b).

One coder, the researcher, coded all results. Multiple coders and iterations were desired to strengthen validity of coding systems, but unfeasible due to project constraints. Project time constraints prevented the researcher from re-coding the data to ensure inter-coder reliability. Therefore, Chapter 5 presents the first iteration of the coding system with the intention of identifying improvements and expansions needed for the coding system, which will be revised and tested for future research goals with multiple coders and inter-coder iterations to ensure reliability and validity.

Table 11. Degree of Technology and Dialogue Participation Coding System

Degree of Participation	**Technology**	**Dialogue**
Highly Participatory	3 or more group members interacting with technology during 15 second segment	3 or more group members engaged in dialogue during 15 second segment
Semi-Participatory	2 group members interacting with technology during 15 second segment	2 group members engaged in dialogue during 15 second segment
Individual	1 group member interacting with technology during 15 second segment	1 group member engaged in dialogue during 15 second segment
None	No group members interacting with technology during 15 second segment	No dialogue during 15 second segment

Table 12. Google Earth Tasks Coding System

Google Earth Task	**Description**
Adding/Editing Feature	15 second segment dominated by action involving creation of a feature such as a point, line or polygon (menus, dialogue boxes, and earth display) or editing of a feature (menus, dialogue boxes, earth display), EXCLUDING symbology.
Data/Map Exploration	15 second segment dominated by panning, zooming in or out, turning on or off layers, exploring menus
Symbology	15 second segment dominated by adding or editing symbology during

	an add/edit feature task
Pointing	15 second segment dominated pointing to help complete a task-like where to draw a node, or pointing to turn on a layer. Also, pointing associated with dialogue and discussion.
None	No Google Earth tasks performed during 15 second segment

Table 13. Decision Phases Coding System

Decision Phase	Definition	Description
Problem Exploration	-"Intelligence about values, objectives, and criteria" (Jankowski & Nyerges, 2001a, p. 17) -Generate ideas and options (MacEachren & Brewer, 2004, p. 7) -Explore as a stage of knowledge construction (MacEachren & Brewer, 2004, p. 7)	Majority of 15 second segment devoted to problem exploration (including stakeholders sharing their data and concerns), as well as, discussing the requirements of the no-take zones (discussion-based measure)
Generating Options	-"Design of a set of feasible options" (Jankowski & Nyerges, 2001a, p. 17) -Negotiate amongst ideas and options (MacEachren & Brewer, 2004, p. 7) -Analyze as a stage of knowledge construction (MacEachren & Brewer, 2004, p. 7)	Majority of 15 second segment devoted to analysis of potential no-take marine reserve sites (discussion-based measure)
Option Selection	-"Choice about recommendations" (Jankowski & Nyerges, 2001a, p. 17) -Choose amongst ideas and options (MacEachren & Brewer, 2004, p. 7) -Synthesize as a stage of knowledge construction (MacEachren & Brewer, 2004, p. 7)	Majority of 15 second segment devoted to choosing amongst 2 or more potential no-take marine sites (discussion-based measure)
Evaluation	-"Review recommendations in line with original values, goals, and objectives" (Jankowski & Nyerges, 2001a, p. 17) -Execute (MacEachren & Brewer, 2004, p. 7) -Present as a stage of knowledge construction (MacEachren & Brewer, 2004, p. 7)	Majority of 15 second segment devoted to evaluating final options with regards to "original, values, goals, and objectives"; concluding/finalizing statements and plans (discussion-based measure)
None		No decision-making tasks present

Table 14. Error Coding System

Error	Description
Error	Any 15 second segment dominated by a human or technological error present

3.5.2 Index of Inequality

Index of inequality, used in touch table research as an indicator of lack of equality of participation, is used to analyze data collected on physical and verbal interactions (Marshall et al., 2008; Hiltz, Turoff, & Johnson, 1989; Potvin et al., 2012). The strengths of this statistic are that it is not constrained by small group size and can be standardized for varying group sizes across simulations (Marshall et al., 2008). The role play simulation consisted of four participants in each simulation, so group size was consistent; however, because there are only four participants, it is difficult to use other statistics with a small group, such as a chi-square analysis.

The index of inequality computes a score between 0 and 1, with 0 being perfect equality of interactions (or a uniform distribution) and 1 being total inequality (i.e., only one person participates) (Marshall et al., 2008). The equation is as follows:

$$I = [\frac{1}{N}\sum_{i=1}^{N}(Ei - Oi) \quad]/[\frac{1}{2}\left(1 - \frac{1}{N}\right)]$$

where, N=group size; Ei=expected cumulative proportion starting with 0.25 for four group members (and working up to 0.50, 0.75, and 1.00); Oi=observed cumulative proportion starting with the smallest interaction contribution. This allows for a higher level score for situations when only one or two participants are interacting with technology (higher inequality and closer to 1), and a lower level score if three to four individuals are interacting with the technology (less inequality and closer to 0).

In addition to index of inequality, histograms are used to visualize interaction results and are standardized across role play simulations by using interactions per minute by seat location. These detail the distribution of interactions by seat location within a single role play and can be cross-compared with the other role plays to show the magnitude of difference in interactions per minute amongst them. While the index of inequality gives us an idea of the overall group inequality of participation in each role play simulation, the histograms allow us to see the actual distribution and comment on the magnitude of difference between the seat locations. This statistic is used in Chapter 6.

3.5.3 Combined Participation Index

Combined participation index is used in Chapter 6. This index is derived from using technology interactions per minute and number of words spoken per minute for each participant. The participant with the highest technology interaction per minute in each role play is taken and divided into itself to obtain 1. Each of the other three participants technology interactions per minute are then divided by the score of the participant with the highest technology interaction per minute to obtain a value less than one and standardized to the highest technology interaction. For example, in role play simulation 2, S1 (First Nations) had the highest technology interactions per minute; his technology interactions per minute was divided into itself to obtain 1, and then S2, S3, S4 were divided by his technology interactions per minute to obtain numbers less than 1. This was repeated uniquely for all role play simulations. This then gave S1, S2, S3 and S4 a number between 0 and 1 for technology interactions.

The same process was repeated for number of words spoken per minute. S3 (Conservation) had the highest number of words spoken per minute in role play simulation 2; her score was divided into itself to obtain 1, and S1, S3 and S4 were all divided by her number of words spoken per minute to obtain values less than 1. These standardized scores between 0 and 1 were added together for each participant's technology interactions and number of words spoken to obtain values between 0 and 2 to measure overall participation.

Chapter 4. General Results of Role Play Simulations

4.1 Introduction

This chapter presents general results of the proceedings of role play simulations 2, 4 and 6. Recruitment is discussed and effects of participants' characteristics and experience on the simulations, before presenting general results regarding the differences in the way groups 2, 4 and 6 completed the simulations.

4.2 Recruitment

Role play participants were recruited from various undergraduate courses held at the University of Victoria. In addition, two graduate students participated. Some of the students did not have a background in marine conservation issues, or even Geography, therefore the roles were simplified to allow participants to get acquainted with the context and the spatial data in a short amount of time. Twenty-four students participated in six experiment iterations or 'simulations" carried out over a two-week period from February-March 2012. The first iteration was used to test the simulation. Participant feedback was used to revise the simulation, the revision of which was used for the next five simulations. The second, fourth, and sixth groups of four students were used for this study, and are referred to as role play simulations 2, 4 and 6. Role play simulation 3 was not used due to project time constraints in processing data. Role play simulation 5 was not considered for use due to one participant not being properly prepared for their stakeholder role.

4.3 Participant Characteristics and Experience

Role play simulation groups varied in gender, student level, Google Earth experience, and experience with touch interfaces (Table 15). The majority of participants were undergraduate students with the exception of two participants who were graduate students. Participants were given a pre-workshop questionnaire asking about GIS experience and testing their understanding of their roles. Overall, participants had little experience with Google Earth, with seven of 12 participants reporting using it only a few times a year; while only two participants reported using it frequently or a few times a week. Participants in role play simulation 4 had the most experience with Google Earth while participants in role play simulation 6 had the least experience with Google Earth.

Overall participants had more experience with touch interfaces than Google Earth, with seven participants of 12 reporting they use touch interfaces frequently (a few times a week); while only two participants reported using is a few times a year. Role play simulation 2 had the most experience with touch interfaces while role play simulation 4 and 6 had similar group experience.

Table 15. Participant Characteristics and Experience

	Stakeholder Role	Role Play Simulation 2	Role Play Simulation 4	Role Play Simulation 6
Participant Characteristics	**First Nations**	Male, Undergraduate student	Female, Undergraduate student	Female, Undergraduate student
	Transportation	Male, Undergraduate student	Male, Undergraduate student	Female, Undergraduate student
	Conservation	Female, Graduate student	Female, Undergraduate student	Female, Undergraduate student
	Sport Fishing	Male, Undergraduate student	Male, Graduate student	Male, Undergraduate student
How often do you use Google Earth?	**First Nations**	A few times a year	A few times a week	A few times a year
	Transportation	A few times a year	A few times a year	A few times a year
	Conservation	A few times a month	A few times a month	A few times a year
	Sport Fishing	A few times a week	A few times a month	A few times a month
How often do you use touch interfaces?	**First Nations**	A few times a month	A few times a week	A few times a year
	Transportation	A few times a week	A few times a week	A few times a week
	Conservation	A few times a week	A few times a year	A few times a week
	Sport Fishing	A few times a month	A few times a week	A few times a month

4.4 Role Play Simulation Proceedings

4.4.1 Discussion of Proceedings

The role play simulations varied in duration, participation, and outcome (Table 16). Role play simulation 2 was approximately 44 minutes long; role play simulation 4 was 26 minutes long; and role play simulation 6 was 11 minutes long. The variation in duration can be attributed to personality of participants, understanding of role play simulation, and use of technology. Role play simulation 2 had the most thorough understanding of the role play simulation objectives evidenced by the quality of their solutions and discussed the most no-take reserve options (five) out of all the groups; this role play simulation also had the most use of Google Earth tasks (25), such as adding/editing features and symbology. Quality of solutions was examined by looking at the size of the reserves created, and how well they maximized conservation values (evidenced by the number of conservation features in each reserve) and minimized socio-cultural and economic costs (evidenced by blocking of transportation routes and harbours and placement with regards to First Nations interests). Role play simulation 4 took 40 percent less time than role play simulation 2, discussed three options, and had the next best quality solutions with some misunderstanding of the size of the reserve options. This simulation had twelve instances of adding/editing features and symbology.

Role play simulation 6 participants demonstrated the least understanding of the role play objectives. This observation is based on the quality of their group's solution, even though participants demonstrated they understood their roles in the pre-workshop questionnaire. This simulation only discussed two no-take reserves and only had five instances of adding/editing features and symbology. Two participants, conservation and sport fishing, did not argue their objectives and concerns. The conservation representative reported that her objectives conflicted with First Nations objectives and therefore could not place a no-take reserve in the location she wanted. The sport fishing representative demonstrated understanding of his role in the pre-workshop questionnaire, but in the post workshop questionnaire stated he was confused about where he was allowed to fish because of the transportation representative's cruise and fishing routes overlapping his interests. These results are presented Table 16 and discussed in more detail in Chapters 5 and 6.

Table 16. Role Play Simulation Proceedings

	Role Play Simulation 2	Role Play Simulation 4	Role Play Simulation 6
Total Duration	44 minutes 20 seconds	26 minutes 35 seconds	11 minutes
Problem Exploration	19% of simulation time	39% of simulation time	41% of simulation time
Generating Options	80% of simulation time	61% of simulation time	59% of simulation time
Option Selection	<1% of simulation time	<1% of simulation time	<1% of simulation time
Number of Reserve Locations Discussed	5	3	2
Number of Major GIS Tasks Performed (Add/Edit Features and Symbology tasks)	25	16	5
Number of Major Errors in GIS Tasks Performed	16	7	0
Comments on Quality of Solutions	-All conservation criteria met for 2 reserves -First reserve seemed to be under 4 grid cells in area; second reserve was over 9 grid cells in area - Second reserve caused an alteration in ferry route (economic cost) - Both reserves blocked some access to harbours (economic and socio-cultural cost) -First reserve bordered an existing marine protected area (park management advantage)	-The group created reserves under 4 grid cells in size; they seem to have thought the no-take reserves combined should total 4 cells rather than each no-take reserve had to be 4 grid cells in size. -Their first option met needs of all 4; had conservation value for 2 stakeholders and met economic and socio-cultural considerations; bordered an existing marine protected area (park management advantage) -The second option did not take into account the social and economic cost of blocking harbours (economic cost) and was relatively small although it met First Nations restrictions and had conservation value for sport fishing and conservation -The third option was the smallest and represented sponge reefs for conservation and conserved sport fishing species	-First no take solution is 4 grid cells but doesn't represent any conservation value; the solution supports the interests of the transportation and First Nations stakeholders, only. -Second no-take reserve also has no conservation value -Due to sport fishing and conservation not lobbying for conservation of their features, transportation and first nations placed reserves in locations w/ no conservation value that protected their harvesting areas and transportation interests. -Transportation and sport fishing both express that they think the group completed the role play simulation incorrectly because of how quickly they finished

Questionnaire results for all simulations demonstrate overall satisfaction with options generated and group's process of evaluating options. Participants were questioned about their overall satisfaction (Table 17) with the quality of no-take reserve options their group generated based on maximizing conservation and minimizing socio-cultural and economic costs, with only two participants reporting to be unsatisfied. Transportation's response as *Very Unsatisfied* from role play simulation 2 is inconsistent with his reported satisfaction with maximizing conservation and minimizing socio-cultural and economic costs; therefore, reporting *Very Unsatisfied* for the overall satisfaction represents an inconsistency in his questionnaire data.

Table 17. Participation Satisfaction with Generating Options

Generating Options	**Overall satisfaction with quality of no-take reserve options that your group generated?**					
Degree of Satisfaction		**Very Satisfied**	**Satisfied**	**Neutral**	**Unsatisfied**	**Very Unsatisfied**
Role Play Simulation 2	First Nations	X				
	Transportation					X
	Conservation	X				
	Sport Fishing	X				
Role Play Simulation 4	First Nations	X				
	Transportation	X				
	Conservation		X			
	Sport Fishing	X				
Role Play Simulation 6	First Nations	X				
	Transportation	X				
	Conservation				X	
	Sport Fishing	X				

All groups reported satisfaction with their group's process of evaluating options during the option selection decision phase (Table 18). A *Neutral* came from the Transportation representative in role play simulation 6 who expressed hesitancy at the end of the role play simulation that the group may have completed the simulation incorrectly because they finished so quickly. All participants also reported agreement with both no-take reserve options created by their groups, even the Conservation and Sport Fishing representatives from role play simulation 6 whose objectives were not met. Participants from role play simulation 2 had the highest level of agreement, followed by participants in role play simulation 4.

Table 18. Participant Satisfaction with Evaluating Options

Option Selection	**Satisfaction with evaluating options?**					
		Very Satisfied	**Satisfied**	**Neutral**	**Unsatisfied**	**Very Unsatisfied**
Role Play Simulation 2	First Nations	X				
	Transportation	X				
	Conservation	X				
	Sport Fishing		X			
Role Play Simulation 4	First Nations	X				
	Transportation		X			
	Conservation		X			
	Sport Fishing	X				
Role Play Simulation 6	First Nations	X				
	Transportation			X		
	Conservation		X			
	Sport Fishing	X				

4.4.2 Seating Orientation

Seating arrangements differed by role play simulation. It was expected that S1 would be seated far left of center; S2 would be seated left of center; S3 would be right of center; and S4 would be far right of center as seen in Figure 8A. Although it was intended to have each participant sitting parallel to the bottom of the table and therefore, each participant would be seated side by side, S4 deviated from the intended seating arrangement. For role play simulation 2, depicted in Figure 8B, the Sport Fishing representative moved his seat to the top of the table in alignment and opposite S1 and S2. In role play simulation 4 (Figure 8C) and role play simulation 6 (Figure 8D) the seating arrangement for S4 shows the participants sat at the side of the table. The impact of the deviation in seating arrangements is discussed in more detail in Chapter 6.

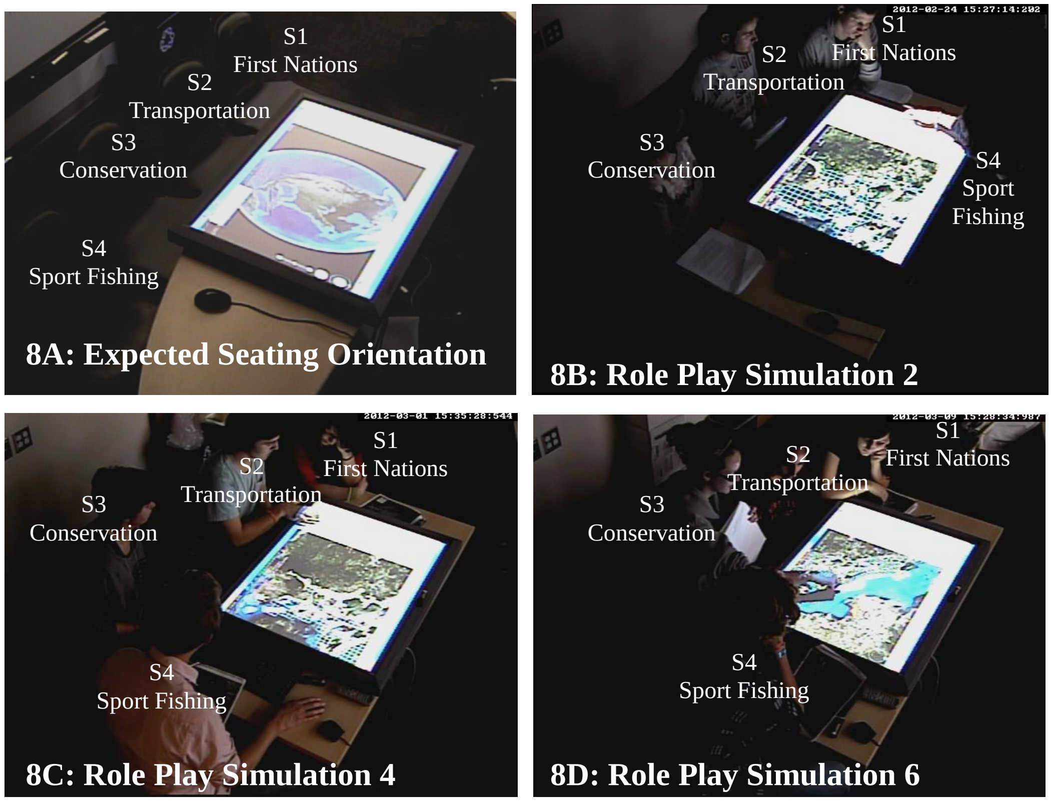


Figure 8. Role Play Simulation Seating Orientation

Chapter 5. Analysis and Discussion: Group Participation Coding Systems

5.1 Introduction

The objective of this chapter is to analyze new group participation coding systems for group work on a multi-user touch table. Specifically, how well do these group participation coding systems describe the degree of group collaboration? Related objectives and research questions outlined in section 1.5 are listed below in Table 19.

Table 19. Objective 1 Research Questions

<table>
<tr><td colspan="2">Objective: 1) Measure group level participation related to Google Earth activities and decision phases using coding systems (Chapter 5): Describing participation at the level of the group demonstrates the activities and decision phases that are most collaborative in nature and comments on participation during the group's decision-making process. Coding systems are used and evaluated to comment on their use as a method.</td></tr>
<tr><td>Context</td><td>Research Questions</td></tr>
<tr><td rowspan="3">Group Dialogue and Group Technology Participation

Using a MSP role play simulation, group participation is measured as technology interactions and verbal participation. Differences in technological and dialogue participation are measured across simulations.</td><td>Q1.1a: What is the distribution of degree of group dialogue participation by role play simulation?</td></tr>
<tr><td>Q1.1b: What is the distribution of degree of group technological participation by role play participation?</td></tr>
<tr><td>Q1.1c: What is the distribution of degree of group dialogue participation compared to technological participation by role play simulation?</td></tr>
<tr><td rowspan="3">Participation by Google Earth Task

Degree of technological and verbal group participation are measured related to Google Earth tasks to determine if there are patterns in the distribution of participation related to Google Earth tasks.</td><td>Q1.2a: What is the distribution of Google Earth tasks by role play simulation?</td></tr>
<tr><td>Q1.2b. What degree of technological participation dominated Google Earth tasks?</td></tr>
<tr><td>Q1.2c: What degree of dialogue participation dominated Google Earth tasks?</td></tr>
<tr><td rowspan="3">Participation by Decision Phase

Degree of technological and verbal group participation are measured related to decision phases to determine if there are patterns in the distribution of group participation related to decision phases.</td><td>Q1.3a: What is the distribution of decision phases by role play simulation?</td></tr>
<tr><td>Q1.3b: What degree of technological participation dominated decision phases?</td></tr>
<tr><td>Q1.3c: What degree of dialogue participation dominated decision phases?</td></tr>
<tr><td>Decision Phase by Google Earth Task

Distribution of Google Earth tasks performed by decision phase is analyzed to determine if certain GIS tasks support different decision phases.</td><td>Q1.4: What is the distribution of Google Earth tasks by decision phase?</td></tr>
</table>

5.2 Analysis

5.2.1 Degrees of Participation

Q1.1a: What is the distribution of degree of dialogue participation by role play simulation?

Results suggest high to medium levels of group dialogue dominated the role play simulations, as seen in Figure 9. High and medium group dialogue participation occurred 75 percent of simulation time or greater, with lesser amounts of individual dialogue, and almost no instances of no dialogue. Role play simulation 4 has the highest distribution of high group dialogue participation, comprising a little more than half of simulation time. Medium group dialogue participation is similar across all role play simulations. Individual dialogue participation is higher for role play simulations 2 and 6; in comparison, role play simulation 4 had half the amount of individual dialogue as role play simulations 2 and 6. No dialogue was less than one percent of simulation times. Results suggest role play simulation 4 had the greatest degree of group dialogue participation out of the three role play simulations.

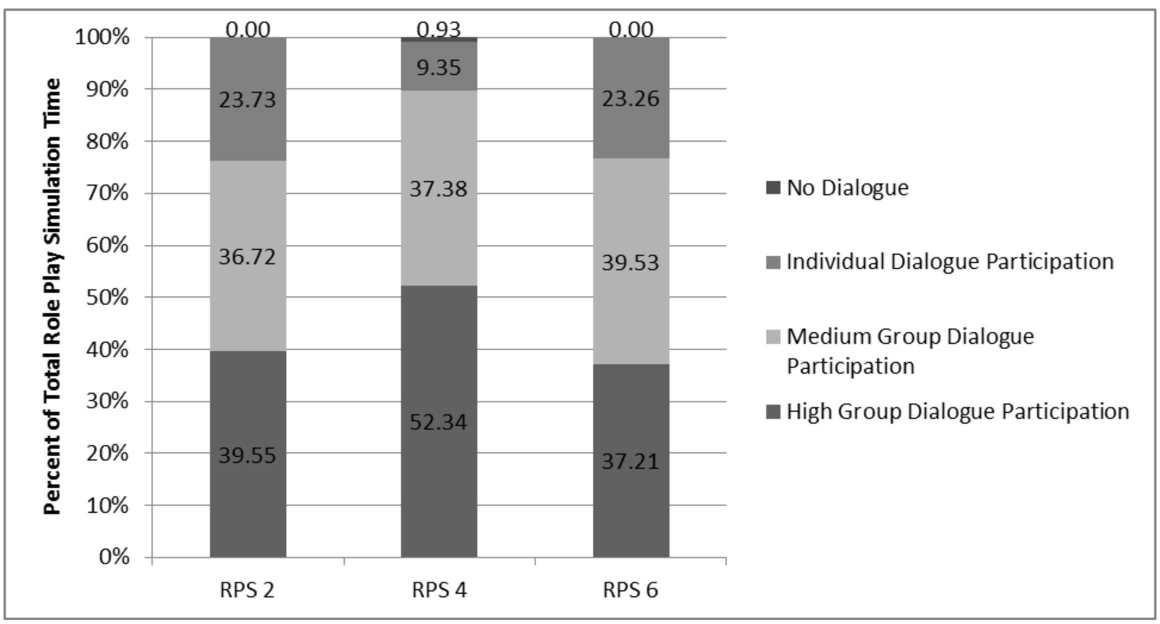


Figure 9. Degree of Dialogue Participation by Role Play Simulation

Q1.1b: What is the distribution of degree of technological participation by role play simulation?

Variation exists across role play simulations for degrees of group technology participation, with medium and individual group technology participation dominating the role play simulations, as seen in Figure 10. Medium and individual group technology participation combined occurred approximately 70-80 percent of simulation time, followed by high technology participation and *no technology use*. High group technology participation comprised less than twenty percent of simulation time for all role play simulations, with role play simulation 2 having the least amount. Medium group technology participation comprised over half of role play simulation 6. Individual technology participation had the greatest variation, dominating role play simulation 2 over 40 percent of the time; role play simulation 4 had one third of group technology participation at the individual level; and role play simulation 6 had the least amount of individual technology use. *No technology use* was less than ten percent of simulation times. Results suggest role play simulation 6 had the greatest degrees of group technology participation, followed by role play simulation 4.

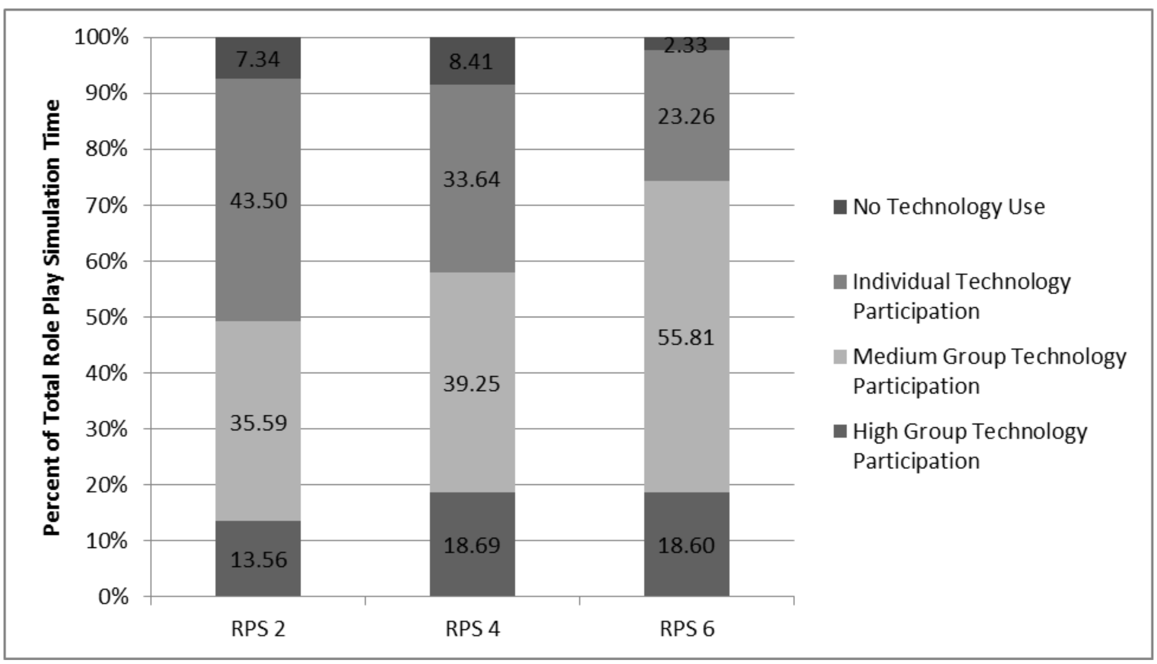


Figure 10. Degree of Technology Participation by Role Play Simulation

Q1.1c: What is the distribution of degree of technological collaboration related to degree of dialogue collaboration?

Various degrees of technology participation occur with each degree of dialogue participation. High group dialogue participation for role play simulation 2 (Figure 11A) and 4 (Figure 11B) is distributed between medium group technology and individual technology participation, and to a lesser extent high group technology participation. High group dialogue participation for role play simulation 6 (Figure 11C) is dominated by medium group technology participation followed by high group technology participation, with no individual technology participation. Medium group dialogue participation is dominated by medium group technology participation and individual technology participation with lesser amounts of high group technology participation for all role play simulations. Individual dialogue is most variable across the role play simulations but dominated by individual technology participation for all role plays, and to a lesser extent medium group technology participation, with the exception of role play simulation 6 which has a higher representation for medium group technology participation. Periods of no dialogue were infrequent across the role play simulations.

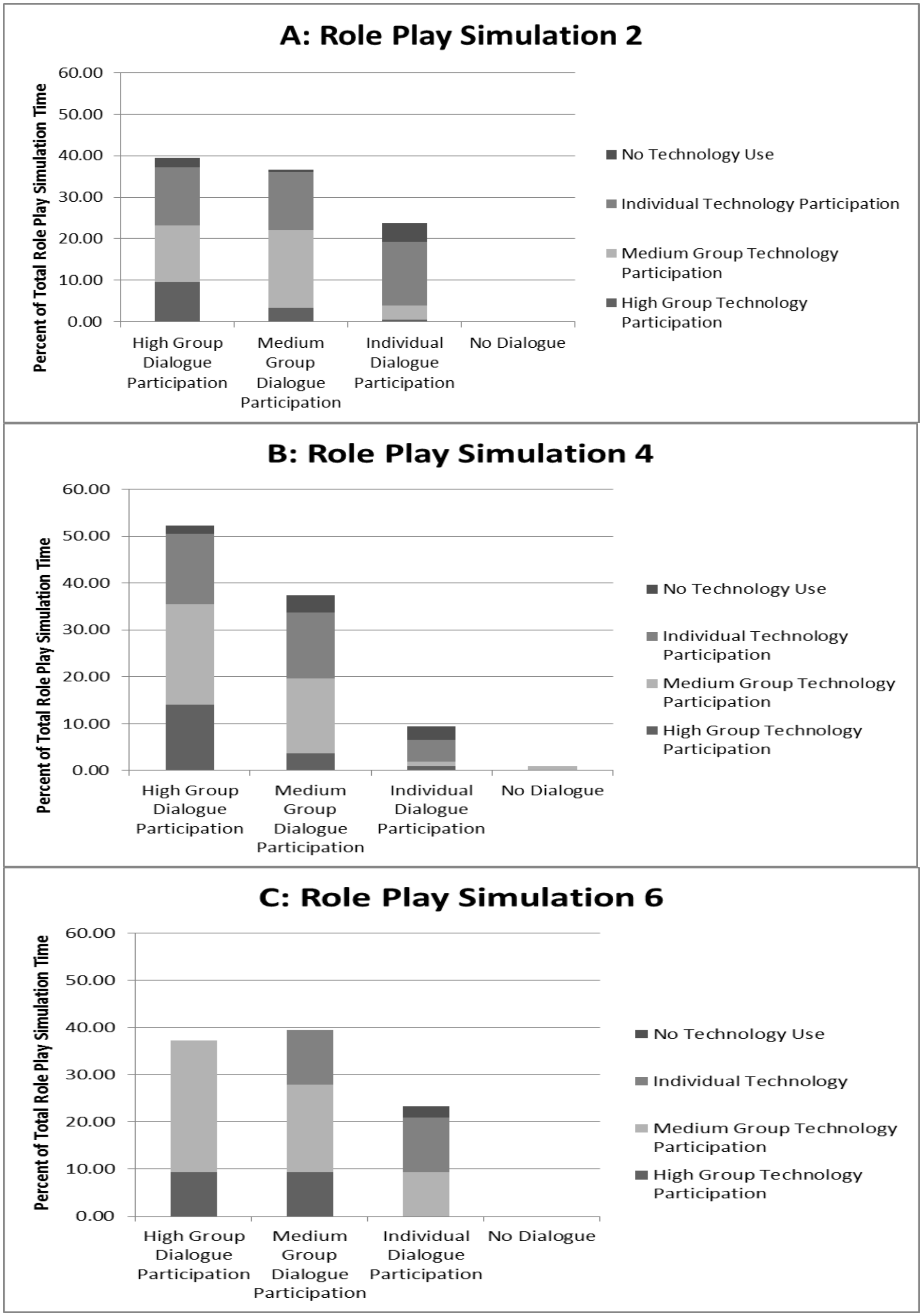


Figure 11. Degree of Dialogue Participation by Degree of Technology Participation

5.2.2 Google Earth Tasks

Q1.2a: What is the distribution of Google Earth tasks by role play simulation?

Distribution and dominance of Google Earth tasks varied by role play simulation, with role play simulations 2 and 4 being more similar than role play simulation 6, as seen in Figure 12. Role play simulations 2 and 4 spent the majority of their time adding/editing features and using data/map exploration. Role play simulation 6, however, spent half of their time pointing and a third of their time with data/map exploration. Symbology was performed infrequently for all role play simulations. Role play simulation 6 spent more of their time engaged with the technology than role play simulations 2 and 4.

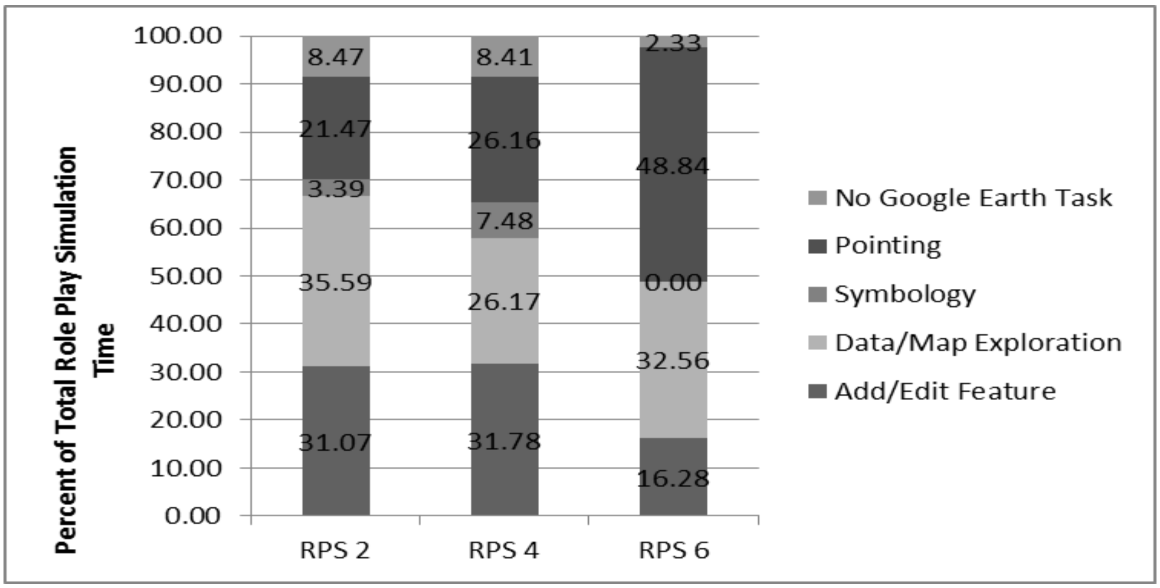


Figure 12. Distribution of Google Earth Tasks by Role Play Simulation

Q1.2b What degree of technological participation dominated Google Earth tasks?

Technological collaboration in the form of medium group technology participation was dominant for most tasks across the role play simulations (Figure 13). Adding/editing features, data/map exploration, and pointing were all dominated by medium group technology participation. The only deviation was in role play simulation 2 (Figure 13A) for data/map exploration which was dominated by individual technology use. Individual technology use also occurred in relatively proportional amounts as medium group technology participation for most tasks, with the exception of role play simulation 6 (Figure 13C) where individual technology use occurred in smaller proportions.

Q1.2c: What degree of dialogue participation dominated Google Earth tasks?

Google Earth tasks were mostly dominated by high group dialogue participation, with a few exceptions, as seen in Figure 14. Group dialogue participation varied across the simulations for adding/editing features. For role play simulations 2 and 6 (Figure 14A and Figure 14C), adding/editing features occurred most with medium dialogue participation; for role play simulation 4 (Figure 14B), adding/editing features was dominated by high group dialogue participation. Data/map exploration was dominated by high group dialogue participation for all simulations. Symbology, although an infrequent task, occurred with high and medium dialogue participation in the two simulations it was utilized. Pointing was dominated mostly by high dialogue participation for all simulations, with the exception of role play simulation 6 which has higher amount of medium dialogue participation.

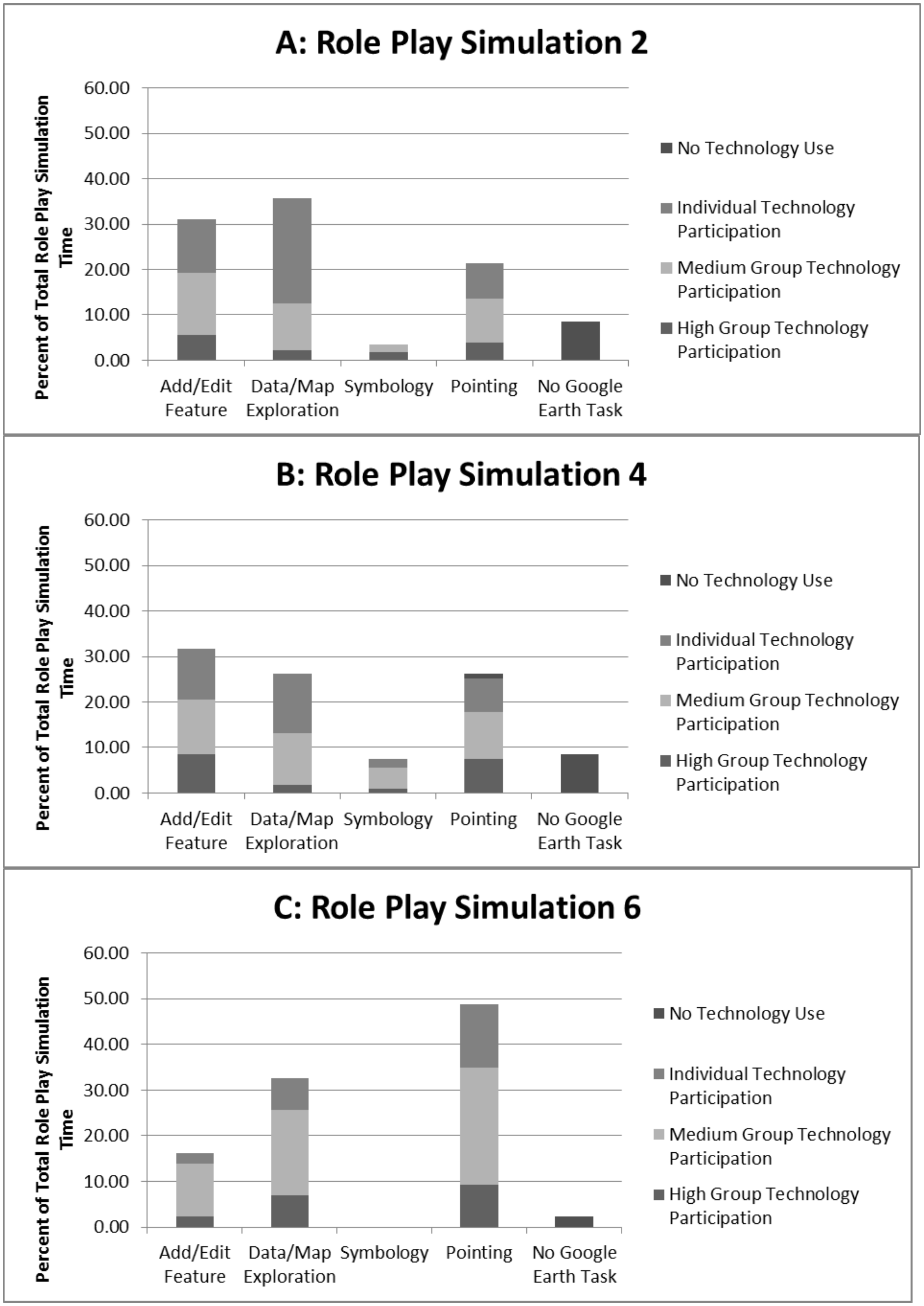


Figure 13. Degree of Technology Participation by Google Earth Task Type

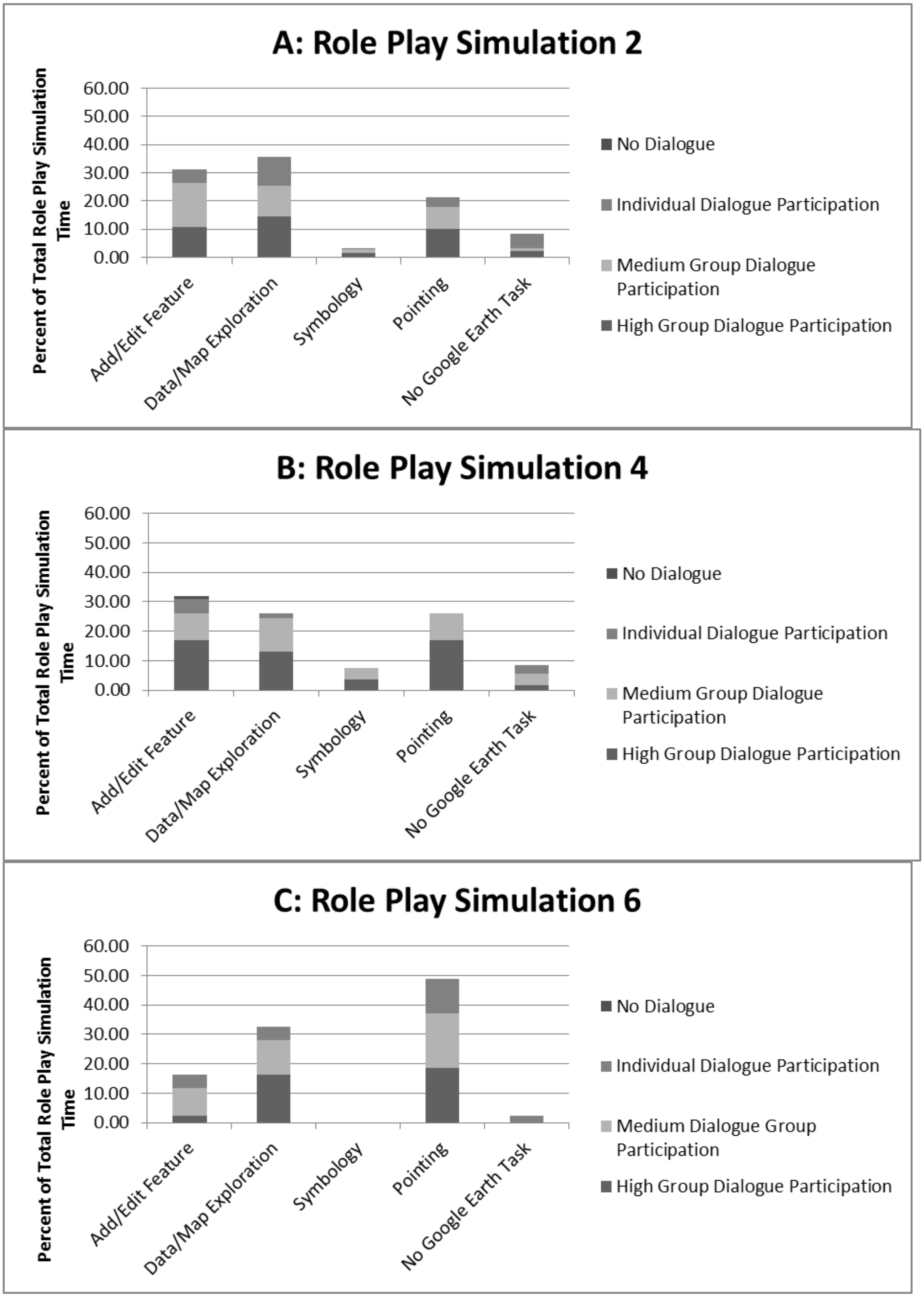


Figure 14. Degree of Dialogue Participation by Google Earth Task

5.2.3 Decision Phases

Q1.3a: What is the distribution of decision phases by role play simulation?

Overall, role play simulations were dominated by the generating options decision phase, followed by problem exploration with variation in distributions across role play simulations; very little simulation time was devoted to options selection and evaluation phases for all role play simulations (Figure 15). Problem exploration decision phase occupied one fourth of simulation time for role play simulation 2; over one third of simulation time in role play simulation 4; and nearly half of simulation time in role play simulation 6. Generating options decision phase occupied approximately three fourths of simulation time for role play simulation 2; approximately two thirds of simulation time in role play simulation 4; and approximately half of simulation time in role play simulation 6. Options selection and evaluation decision phases represented less than two percent of simulation time and occurred only for role play simulations 2 and 4 and absent from role play simulation 6.

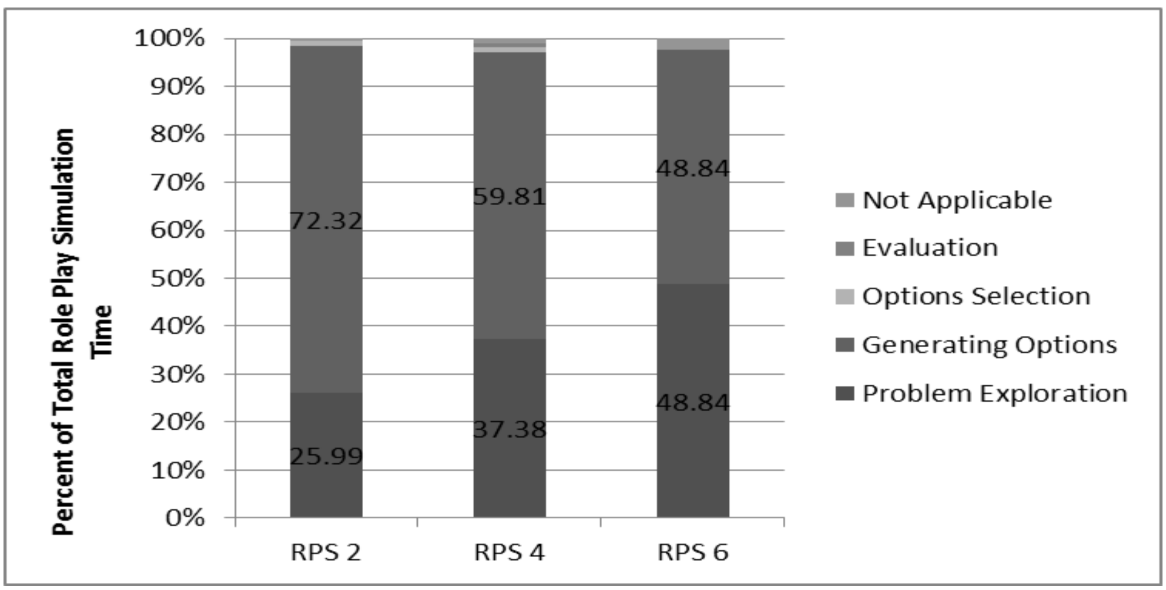


Figure 15. Distribution of Decision Phases by Role Play Simulation

Q1.3b: What degree of technological collaboration dominated decision phases?

Degree of group technological participation varied across the role play simulations for problem exploration and generating options phases, while options selection and evaluation occurred infrequently (Figure 16). The problem exploration decision phase was characterized by individual technology participation in role play simulation 2 (Figure 16A); and medium group technology participation in role play simulation 4 (Figure 16B); role play simulation 6 (Figure 16C) was dominated by both medium and individual technology participation. The generating options decision phase was characterized by medium technology participation for role play simulations 2 and 6; while the generating options phase for role play simulation 4 was dominated by both medium group technology participation and individual technology participation.

Q1.3c What degree of dialogue participation dominated decision phases?

Problem exploration and generating options decision phases were similarly dominated by high group dialogue participation and medium group dialogue participation for all role play simulations, with the exception of the problem exploration decision phase in role play simulation 2 and 6 (Figure 17). Problem exploration in role play simulation 2 (Figure 17A) was dominated by individual dialogue; and problem exploration in role play simulation 6 (Figure 17C) was dominated slightly by medium dialogue participation with even proportions of high and individual dialogue participation. The generating options decision phase had high distributions of high group dialogue participation, followed by medium group dialogue participation, and smaller proportions of individual dialogue, for all role play simulations. Options selection and evaluation decision phases were infrequent.

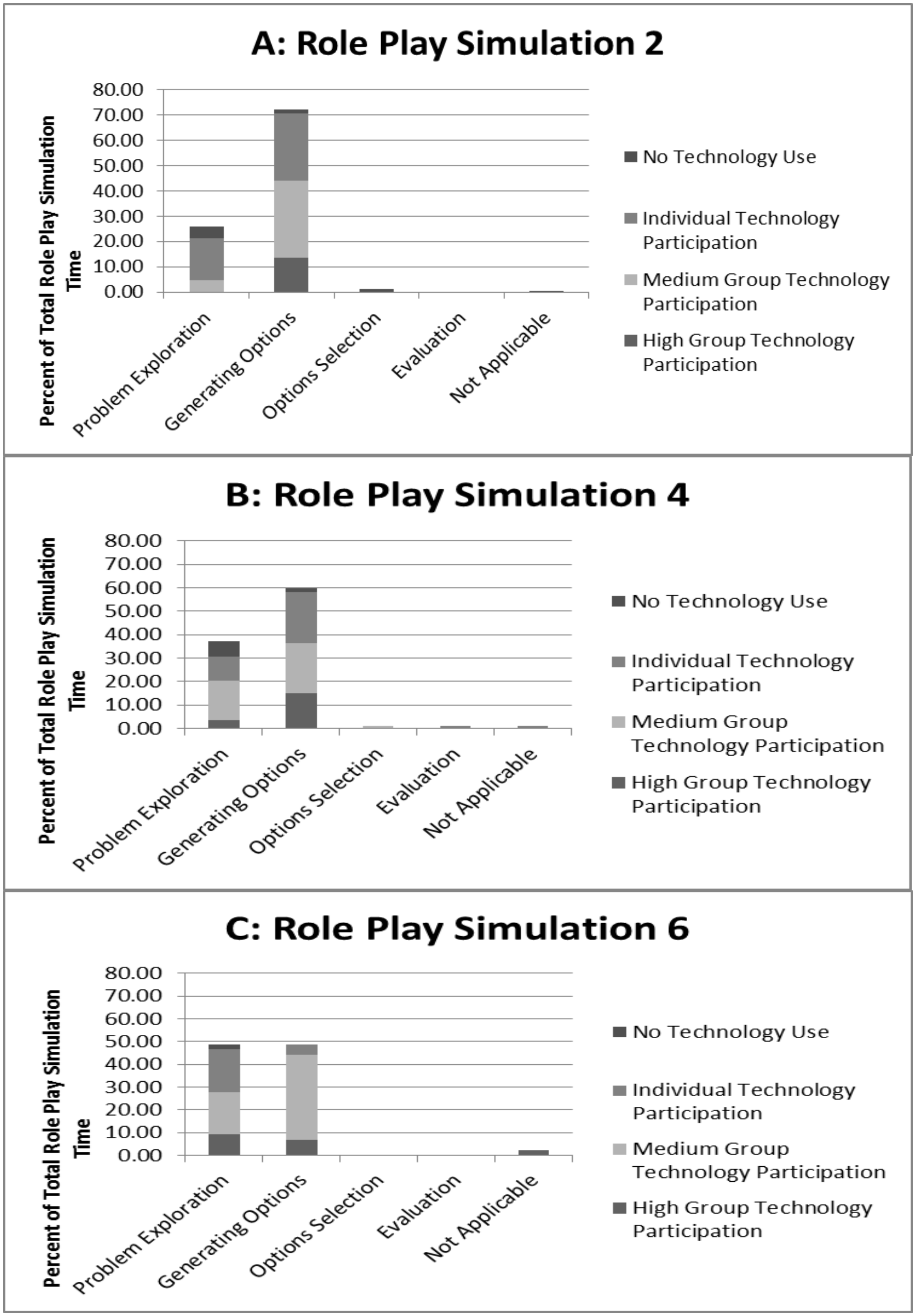


Figure 16. Degree of Technology Participation by Decision Phase

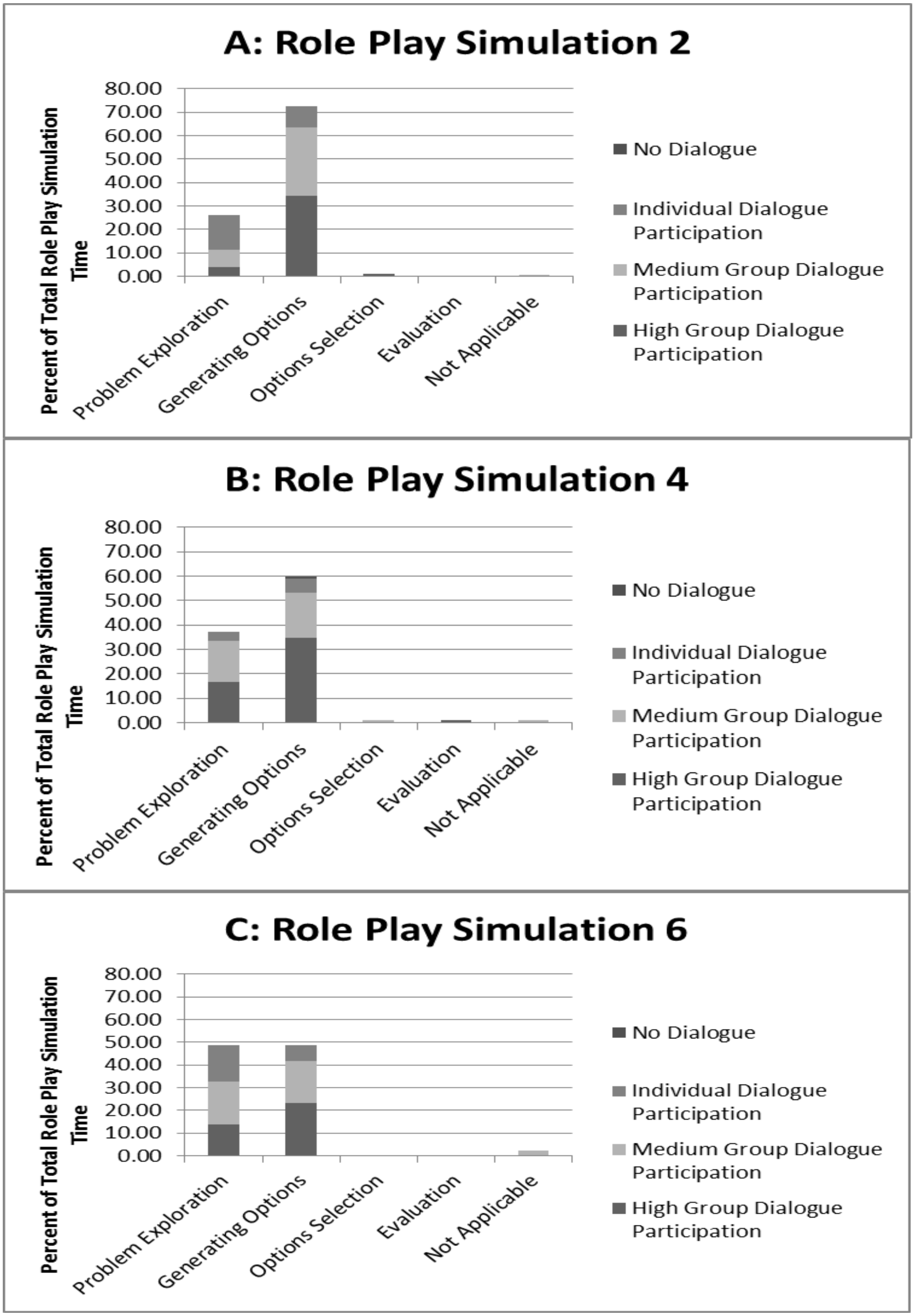


Figure 17. Degree of Dialogue Participation by Decision Phase

5.2.4 Google Earth Tasks by Decision Phases

Q1.4 What is the distribution of Google Earth tasks by decision phase for each simulation?

Variation exists in Google Earth tasks performed by decision phase across the simulations (Figure 18). The problem exploration phase is dominated by data/map exploration and pointing with differences in distributions across simulations. For role play simulation 2 (Figure 18A), data/map exploration dominated the problem exploration phase, whereas, role play simulation 4 (Figure 18B) had approximately equal distributions of data/map exploration and pointing; role play simulation 6 (Figure 18C) was dominated by pointing during problem exploration. Role play simulations 2 and 4 had similar distributions of Google Earth tasks performed during the generating options phase, while role play simulation 6 deviated in distribution and tasks present during this phase. For role play simulations 2 and 4, adding/editing features was performed most, followed by data/map exploration, and then pointing. For role play simulation 6, pointing ranked first, then adding/editing features, and data/map exploration; symbology was absent.

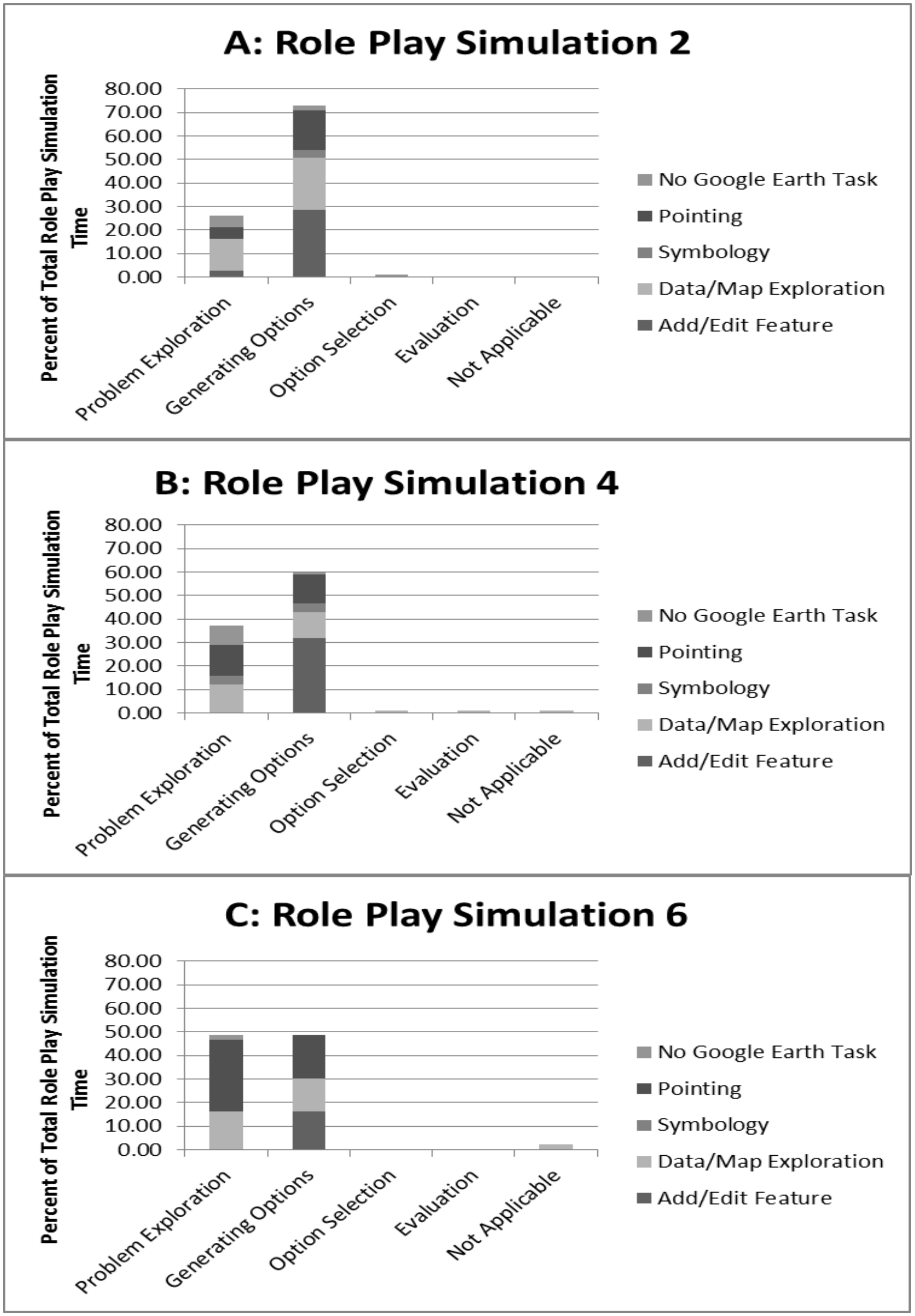


Figure 18. Decision Phase by Google Earth Task

5.3 Discussion

Using measures identified in Chapter 2, coding systems were designed to capture the level of group participation in technology interactions and verbal participation for Google Earth tasks and decision phases. Measuring the quantity and quality of group participation has not been addressed in Collaborative GIS literature, with this research in particular exploring group participation on multi-user touch tables. The three role play simulations demonstrate that, despite the same assignment of roles and simulation objectives, groups completed the simulation differently in decision-making processes, use of technology to support their process and produced varying quality of results. Variation existed in the use of Google Earth tasks and distribution of decision phases related to the degree of group technology and dialogue participation.

The variation witnessed in the role play simulation seems to be related to personality of individual participants, which impacts the group as a collective and experience with Google Earth. Strong personalities can dominate group processes and can weaken the group's ability to address all participants' objectives, as demonstrated by role play simulation 6; the First Nations and Transportation roles dominated participation and had their objectives met at the expense of Conservation and Sport Fishing. Role play simulations 2 and 4 had more group cooperation and produced higher quality no-take reserve options, representing objectives of all participants. In addition, the groups used the Google Earth technology in different ways to support their group's decision phases. The variation in the use of the technology resulted from how the technology was used to support the group's discussions. Role play simulation 6 had the least amount of experience with Google Earth and used the technology the least to support their group's decision-making process. This group also had the poorest quality solution.

Clearly it is difficult to draw conclusions across groups regarding best practices and implementation of Collaborative GIS processes due to the small number of groups represented in this research and the variation different groups will exhibit. Measuring the distribution of dialogue and technology participation by Google Earth task and decision phase provides insight into the use of the technology to support group discussions and decision-making. This research is the first step in measuring group participation on multi-user touch tables and provides a foundation to pursue more complex research questions regarding the role of technology in supporting group participation in decision-making processes. For example, this research examined the distribution of different levels of group participation, however, it cannot comment on whether high technology participation is preferable to medium or individual technology. More research may answer this question which would support implementation of Collaborative GIS processes for real world MSP activities.

Before implementing this research in real world MSP, further refinement of coding systems is needed. The coding systems for dialogue and technological participation overestimated degrees of group participation for role play simulation 6 when compared with researcher observations of the video footage and experience facilitating the role play simulations. This suggests coding systems need further refinement to objectively represent the degree of technology and dialogue participation occurring during Google Earth tasks and decision phases.

5.3.1 Technology and Dialogue Participation

The results of the coding systems for *technology* participation deviate from expected researcher observations of the video footage; this is supported in the results of Chapter 6 which detail individual participant technological and verbal participation rates. Role play simulation 6 has the highest degree of technology participation, as determined by the coding schemes, between high group participation and medium group participation comprising nearly three fourths of the simulation; followed by role play simulation 4 at 58 percent; and role play simulation 2 with half of its simulation time at high and medium degrees of technology participation. These results are surprising as researcher observations of video footage suggest that role play simulation 2 had a high amount of cooperation amongst group members when completing technological tasks, as did role play simulation 4. This is supported in Chapter 6 with individual technological and verbal participation being most equal in role play simulations 2 and 4, and exhibiting the least equality in role play simulation 6. Role play simulation 2 results may be more skewed, as this group took the longest to complete the simulation at 45 minutes and had more 15 second segments with individual technology use. Role play simulation 6 only lasted 10 minutes, and was dominated by two group members, hence medium technology participation of 56%, but based on researcher observation, is the least collaborative of all of the simulations. This is in part due to the coding scheme's inability to bridge group coordination and cooperation between verbal and technological participation.

Overall the role play simulation results demonstrated high to medium degrees for *dialogue* participation. Role play simulation 2 had a mix of group participation in dialogue and members tended to take turns and were more formal about the way they engaged in dialogue. Role play simulation 4 had a very active group discussion, sometimes with conversations overlapping and usually most group members would participate. Results for role play simulation 6 are surprising as the data indicates the simulation had high participation, but two members tended to dominate the conversation of the group, with one participant barely speaking. This may be skewed as there were many instances where one or two participants would give a one or two word reply during a 15 second segment-enough to be coded as participation, when in actuality there was little participation by two members of the group.

Degree of dialogue participation by degree of technology participation was captured to see if technology participation compensated for dialogue participation and vice versa. Because there seems to be high and medium amounts of group technology participation during high and medium group dialogue for all of the role play simulations, it appears that group technology participation does not compensate for lack of dialogue or vice versa at the group level, but occurs in concert with it.

5.3.2 Participation and Google Earth Tasks

The simulations exhibited variation in distribution of Google Earth tasks performed. Role play simulation 2 performed adding/editing features more during their generating options because they discussed at least five locations for no-take marine reserves and had frequent error when adding/editing features and therefore canceled and re-performed the task more often. Role play simulation 4 discussed at least three locations for no-take marine reserves and had a similar proportion of time devoted to adding/editing features as role play simulation 2 did. Role play simulation 6 only lasted 10 minutes and this group only aimed to meet the bare minimum number of proposed no-take marine reserves therefore had half as much time devoted to adding/editing features.

The most surprising find is that of pointing as a task. Pointing to the earth display serves to focus discussion, to indicate where to place nodes, as well as to direct other participants in performing menu and dialogue box interactions. Pointing for role play simulation 6 was the most common task at nearly 50 percent of their task time, with role play simulations 2 and 4 being half as much. Role play simulation 6 group frequently had more than one person pointing at the display during problem exploration phase of the simulation, as well as discussing locations for proposed no-take marine reserves during the generating options decision phase; for role play simulation 6 pointing appeared to serve the same function as adding/editing features did for role play simulations 2 and 4 by identifying the location for a no-take reserve, without adding the feature to the display.

Google Earth tasks tended towards medium to high group technology and dialogue participation across the simulations. Adding/editing features tends to be a cooperative group activity because the task spans the three main interfaces-menus, dialogue boxes, and earth display, and is therefore, more difficult to complete with just one individual participant. Data/Map Exploration for role play simulations 2 and 4 was the main activity during the problem exploration phase of the role play simulations-which tended to be dominated by 15 second segments of individual participation; panning, zooming in/out, and turning on and off layers is best accomplished by one participant rather than a cooperative group effort. Although data/map exploration was dominated by individual technology use, this task occurred the most with high group dialogue participation. No real barriers exist for pointing, therefore, we see it occurring in all three role play simulations for all levels of group technology participation-high, medium, and individual; it is collaborative in both technology and dialogue participation. The most obvious pattern is for role play simulation 6; participation-both dialogue and technology-was dominated by two participants; however, dialogue appears to be more collaborative than expectations based on researcher observations of the simulation.

5.3.3 Participation and Decision Phases

The role play simulation and technology were primarily designed to facilitate problem exploration and generating options decision phases. An initial problem exploration phase was represented by instructing participants to first share their individual data before generating options for the no-take marine reserve. Participants were then told they needed to identify two locations with given criteria for no-take marine reserves representing the generating options decision phase. The primary consideration given to participants for the options selection decision phase was that the no-take marine reserve should maximize conservation value while minimizing economic and socio-cultural costs. Participants were not given any indicators to evaluate these criteria to represent an evaluation decision phase, which may be why we see an absence of this decision phase for all role play simulations.

The technology in particular did not lend itself to facilitating the option selection phase or evaluation decision phases and we see these decision phases with negligible presence in the results. Two groups identified three or more locations for no-take reserves, and therefore, had a brief option selection phase. Role play simulation 6 did the bare minimum, and therefore did not require an option selection phase.

Varying degrees of group technology and dialogue participation were represented during the decision phases of problem exploration and generating options. Medium group technology and individual *technology* participation dominated, while high group *dialogue* and medium group dialogue participation dominated. Deviations existed for role play simulation 2 in the problem exploration phase which was dominated by individual dialogue and technology use only and for role play simulation 6 during the generating options phase which was dominated by medium group technology participation only. Role play simulation 2 had less group dialogue and technology participation during the problem exploration phase and tended to be more formal and respectful of each other's personal space which may account for more individual participation during this phase. Role play simulation 6 had two members that were less active during the role play simulation, and two members that were very active when interacting with the technology, therefore results show generating options phase dominated by medium group technology participation.

Google Earth Tasks by Decision Phase

Data/map exploration and pointing dominated problem exploration, and adding/editing features, data/map exploration, and pointing were all represented in the generating options decision phase. In general, Google Earth tasks by decision phase were dominated by medium and individual technology participation and high and medium dialogue participation. It is not surprising that the problem exploration phase is dominated by data/map exploration and pointing. Data/map exploration consists of panning, zooming in/out, and turning on and off layers, all of which are necessary in participants relating their data and concerns during the first part of the role play simulation. Participants were told that they could indicate areas of inclusion or exclusion that aligned with their concerns during the first part of the exercise, however, most participants across all three simulations usually chose to verbally share their preferences and by pointing.

Google Earth tasks by decision phase were dominated by medium and individual technology participation. Higher amounts of individual technology participation were expected during the problem exploration phase, as participants were told to share their concerns, one by one. Medium technology participation is somewhat expected as it is easier for the person sitting on the far left side of the table to turn on/off layers for other participants, as they share their data and concerns. The groups tended to use the add/edit features task during the generating options phase, and data/map exploration and pointing also served to focus group discussion, the same way it did for individual participants during the problem exploration phase. The generating options phase had a variation of technology participation which is expected as adding/editing features can be collaborative task, but data/map exploration and pointing are more medium or individual technology participation level tasks.

Google Earth tasks by decision phase were dominated by high and medium dialogue participation. The problem exploration phase was expected to be dominated by individual dialogue since participants were instructed to share their data one by one; however, members in role play simulations 4 and 6 asked a fair amount of questions about each other's data and concerns which led to greater levels of participation for these groups. Levels of dialogue participation were not surprising for the generating options phase, as this is the phase that lends itself to the greatest amount of group discussion regarding identifying locations for the no-take marine reserve.

5.4 Recommendations

5.4.1 Collaborative GIS

This research sought to characterize the degree of dialogue and technological participation at the group level for Google Earth tasks performed and by decision phases with multi-user touch tables. To date, Collaborative GIS literature lacks analysis of group participation levels during the group's decision-making process. Only one Collaborative GIS project identified attempts to measure group participation as *group attention* (defined as four out of five head directed awareness), analyzing video footage of the use of decision aids only for this level of group participation. A limitation of measuring the group participation in this way, however, is that it does not allow for fluctuations in the levels of group participation as a natural and dynamic part of the group's decision-making process. Characterizing the degree of dialogue and technological participation can describe which software tasks and decision phases generate the most group collaboration and inform how to structure group GIS activities on multi-user touch tables.

This research explored using coding systems for levels of group participation in contrast to literature using coding systems designed to answer questions about types of dialogue, decision phases and group interaction dynamics. Work by Nyerges and Jankowski emphasized decision phases and group interaction dynamics using coding systems designed for decision aids, decision phases, group conflict and group working relations (Nyerges et al., 1998; Jankowski & Nyerges, 2001b; Nyerges et al., 2006). Touch table literature used coding schemes to characterize types of dialogue, such as suggestions, confirmations, probing questions, queries, answers, and other to look for dialogue patterns (Rogers et al., 2009); and task related, turn taking, brief response, and other (Harris et al., 2009). Similarities exist between this research and work by Nyerges and Jankowski, as group participation levels were examined by decision phases and Google Earth tasks (comparable to decision aids) (Nyerges et al., 1998; Jankowski & Nyerges, 2001b; Nyerges et al., 2006).

Coding systems designed to measure the level of group participation can also be used to answer more complex research questions regarding group interaction with technology. Most literature examines the technology in two different environments: single touch versus multiple-touch (Fernquist, 2010); horizontal versus vertical display (Potvin et al., 2012); laptop versus touch table (Rogers et al., 2009). Similarly, group participation coding systems can be used to examine the fluctuations in group participation between environments. For example, the seat location of participants plays a large role in how individuals can participate with the technology and what Google Earth, or GIS, tasks they can perform (which is examined in Chapter 6). Participants seated left of center have a better opportunity to interact with menus, whereas, participants to the right of center have a better opportunity to interact with the earth display. This can lend itself to group cooperation by creating an environment for distributing task responsibility. However, it can also marginalize participants seated to the right, as the participants on the left have greater ability to control data and tasks.

How might group participation dynamics change with more individual control and access to software features? Software designed with multiple movable menus might allow participants to have the same level of control as each other. However, this might decrease cooperation in the group, and make tasks less collaborative because each individual would have the ability to complete tasks on their own without the aid of fellow group members. By using methods to characterize and describe group participation levels, such as presented in this research, more complex questions like this can be answered. Applying coding systems to measure group participation levels with multiple movable menus versus distributed group tasks can demonstrate the differences in degrees of group participation by tasks and how that impacts the participation dynamics by decision phases. Whereas previous literature assessed types of dialogue and group interaction, participation coding schemes can answer Collaborative GIS questions about variations in levels of group participation during the group's decision-making process on touch tables.

5.4.2 Coding Systems

Coding systems are a useful method for characterizing group interactions. As a best practice when developing coding systems, several iterations are usually done testing the system with multiple coders, as well as, the same coder to ensure the objectivity and reliability of the coding system (Nyerges et al., 1998; Poole & Folger, 1981; Trujillo, 1986). This research represents the first step in developing a coding system for characterizing group participation with GIS on multi-user touch tables. By comparing the results of the coding systems with researcher observation of the video footage and experience facilitating the role play simulations, as well as results presented in Chapter 6, several recommendations are given to improve the current design of the coding systems for future research. Future research will strengthen coding system validity by testing it with multiple coders and performing inter-coder reliability testing.

A more precise measure of participation would be to measure intensity as opposed to degree of participation. Intensity could be measured as words per interaction per 15 second segment (Harris et al., 2009). This would give an indication of which role play simulation was most participatory. A constraint in the coding system is that participation for technology and dialogue were recorded as any participant speech or interaction, regardless of quantity. Therefore, if four participants said one word each (i.e., 4 words total) in a 15 second segment this was coded as high participation, the same as if four participants each exchanged 20 words each (i.e., 80 words total) during the 15 second segment. Likewise for technology interaction; one interaction by each of the four participants (i.e., 4 interactions total) was considered high technology participation, whereas as three interactions for each participant (i.e., 12 interactions total) would also be *high participation,* despite it being three times as many interactions as the former. By standardizing the role play simulations by words per interaction per 15 second segment, the intensity of participation can be identified.

Another refinement would be to characterize the number of participants interacting between group technology and dialogue participation. In the current system, if medium group dialogue participation co-occurs with medium technology participation, this could be the same two participants engaged in dialogue and technology use, or it could be two participants engaged in dialogue while the remaining two participants in the group use the technology. The latter represents more group collaboration than the former and suggests dialogue and technology use may be compensating for one another. For example, role play simulation 2 had more individual technology participation than did role play simulations 4 and 6; however, frequently group members directed an individual to perform a task, which is not captured by the coding system. Using an intensity measure of participation, combined with a group level indicator might give a more robust quantitative look at participation at the group level.

The Google Earth tasks coding system requires the most refinement. The percent of total role play simulation time is quite misleading as the 15 second segment was often dominated by two tasks, such as pointing and data/map exploration with usually only one task having a slight majority. In this case, the task that appeared to be performed the most or the task that supported the main intent of the discussion was assigned the code for that 15 second segment; the limitations of this are in part due to the subjectivity of assigning the code. For example, using frequency of task interaction per 15 second segment would be a more precise and objective way of assigning the task code because it would allow tasks to be quantitatively compared to one another before assigning a code, as opposed to a subjective assignation. Further refinement is needed to resolve how to handle situations where one task does not constitute the majority. For example, No Google Earth task was also a code, however, if any Google Earth task was performed during a 15 second segment, the entire 15 second segment was coded as such, when in reality, assigning No Google Earth Task might have been more appropriate. Developing a threshold for the number of interactions that need to occur in a 15 second segment to constitute the assigning of a code could resolve this situation.

The coding system can also be strengthened with sensitivity testing. Sensitivity testing is a statistical method of determining the extent to which variables, such as length of time of coding segment or number of participants within each code, statistically and quantitatively impacts the results (Ardron, Possingham & Klein, 2010). Sensitivity testing of 15 second segments compared to 30 second segments or one minute segments would demonstrate differences in the distribution of participation levels and the impact on sensitivity of degrees of participation due to the length of the coding segments. A sensitivity analysis could also be performed on high group participation to determine if it is advisable to code participation of four out of four partcipants as high participation rather than three out of four participants used as high participation in the current design of the coding system.

Several recommendations exist to improve the coding systems’ ability to quantitatively assess group dialogue and technology participation. Measuring intensity of dialogue and technology participation as interactions over time, using a group indicator to characterize the number of participants interacting between technology and dialogue participation, and developing a Google Earth task interaction threshold to constitute the assigning of a code would create more precise coding systems to quantify group participation on multi-user touch tables.

Chapter 6. Analysis and Discussion: Seat Accessibility

6.1 Introduction

In this chapter I analyze and discuss the accessibility of Google Earth interfaces by seat location and its impact on participation levels. Google Earth is not designed for multi-user touch table use, but for a single-user desktop environment. There exists a lack of software designed for use on multi-user touch tables, and until this software gap is filled, existing desktop software will be used for MSP activities on touch tables. Although the touch table may allow for greater equality in participation, desktop software design may hinder this aim. Desktop software is often designed with menu options along the top and/or the left side of the frame with small button sizes appropriate for a mouse input; therefore, participants sitting to the left of center have easier access to menus and more control of the GIS system, which may marginalize participants sitting to the right of center who have better access to the earth display. This is depicted in Figure 19 where S1(seat far left of center) and S2 (seat left of center) have the best access to the menus and dialogue boxes, while S3 (seat right of center) and S4 (seat far right of center) have the best access to the earth display. S2 has the best access to all components of the software while S4 has no access to the menus. Dialogue boxes open up in a similar location as the menus, also seen in Figure 19. They can be moved to different areas of the interface. S1 and S2 have the best access to the dialogue boxes in the locations they default to when opened; S3 has limited access and S4 has no access. Also, to avoid looking at the image/software upside down, everybody needs to sit next to each other, as opposed to sitting opposite each other, which might put them in closer proximity to the menus, albeit upside down.

The objective of this research is to test whether or not technology participation and dialogue participation were equitable based on seat location. Multi-user touch tables are promoted as a platform for equitable technology participation (Marshall et al., 2008). The technology encourages equal and distributed participation with its ability to register the touch of multiple users (Marshall et al., 2008). The Oxford online dictionary defines equitable as fair and impartial (http://oxforddictionaries.com). While equality is defined as the state of being equal, or the fact that two quantities are equal. Equality is one means of measuring equitability. Inequitable participation in collaborative decision-making may translate to an "imbalance in a group's consideration of the different opinions and viewpoints relevant to the decision at hand (DiMicco et al., 2004, p. 616)" reducing the effectiveness and fairness of decision-making. Multi-user touch tables are argued to promote equitable *technology interactions* in Computer Science literature because users have an equal and fair opportunity to interact with the technology. It remains to be seen whether or not equitable technology interaction supported by multi-user touch tables would also translate into greater equitability in spatial decision-making activities.

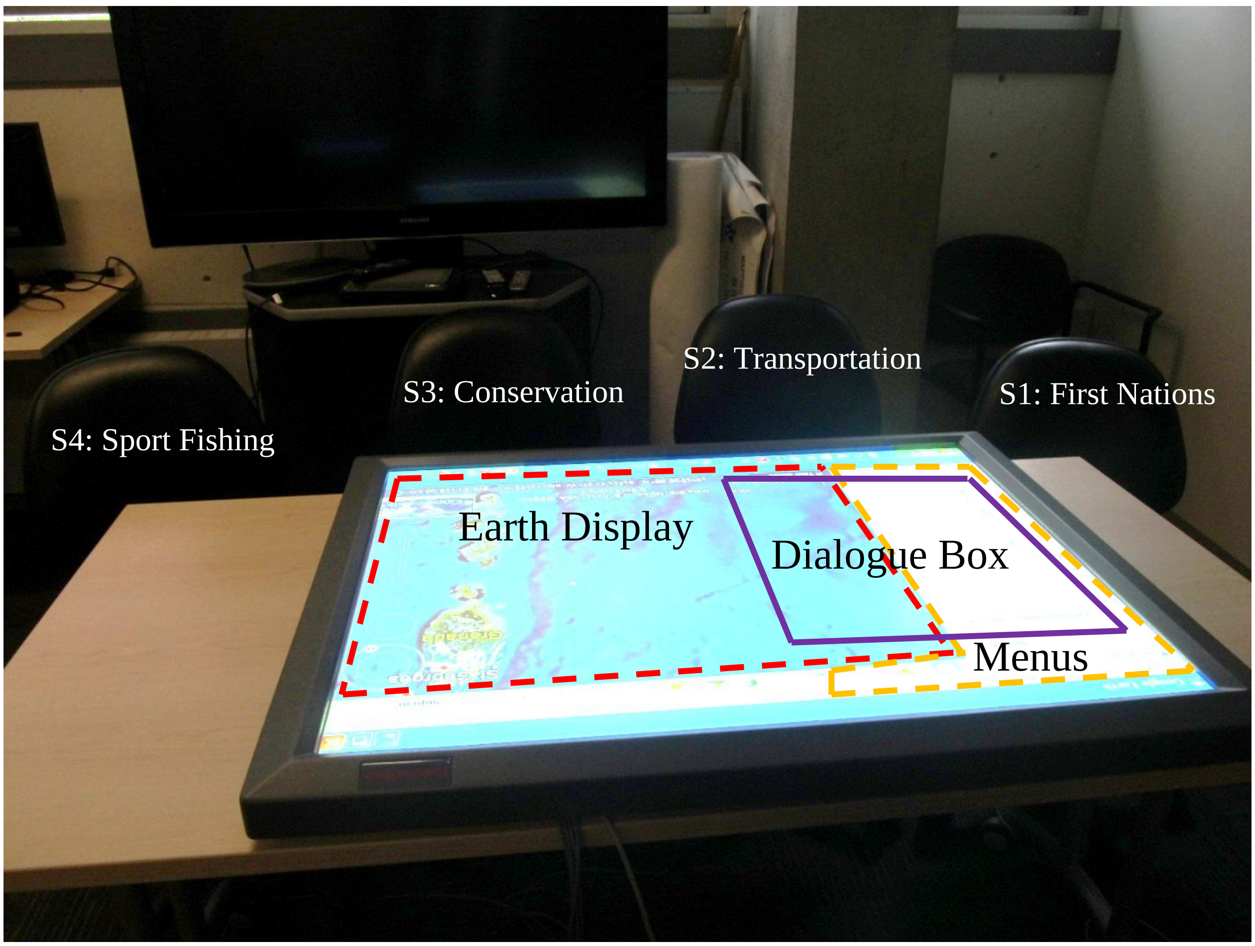


Figure 19. Seat Locations and Interfaces

By examining interactions with each component of the interface by seat location, inferences can be made regarding equality of participation for GIS tasks performed by seat location. Google Earth tasks are listed in

Table 20 with their associated Interface and seat locations with the best proximity.

Table 20. Google Earth Task and Interface

GIS Task	Google Earth Interface
Panning	Earth Display
Zooming In/Out	Earth Display
Turning On/Off Layers	Menus
Adding/Editing Features	Menus, Dialogue Boxes, Earth Display
Symbology	Dialogue Boxes
Pointing	Menus, Dialogue Boxes, Earth Display

By examining all interactions that took place in each interface by seat location, we can draw more solid conclusions about equitable participation than merely looking at the task alone. This research seeks to address research objective 2 with the following research questions listed in Table 21:

Table 21: Objective 2 Research Questions

Objective: 2) Measure individual participation related to Google Earth interfaces to determine accessibility of interface features by seat location (Chapter 6).	
Context	**Research Question**
Measuring individual participation by seat location gives an indication of the accessibility of Google Earth features for each participant. Menus in Google Earth (and most GIS) are located on the left side of the interface and across the top of the interface; therefore, participants seated left of the center of the table have easier access to reach this part of the interface, whereas, participants right of center may be restricted from accessing these parts of the interface due to limits of reach. Unequal accessibility to technology may bias participation and the group's collaborative process.	**Q2.1:** What is the degree of inequality for frequency of technology interactions, dialogue turn taking, and number of words spoken by stakeholder seat location? Is participation uniformly distributed by seat location?
	Q2.2: What is the degree of inequality by seat location Google Earth interfaces (menus, dialogue boxes, earth display)? Is participation uniformly distributed by seat location?
	Q2.3: How are technology participation errors distributed by seat location?

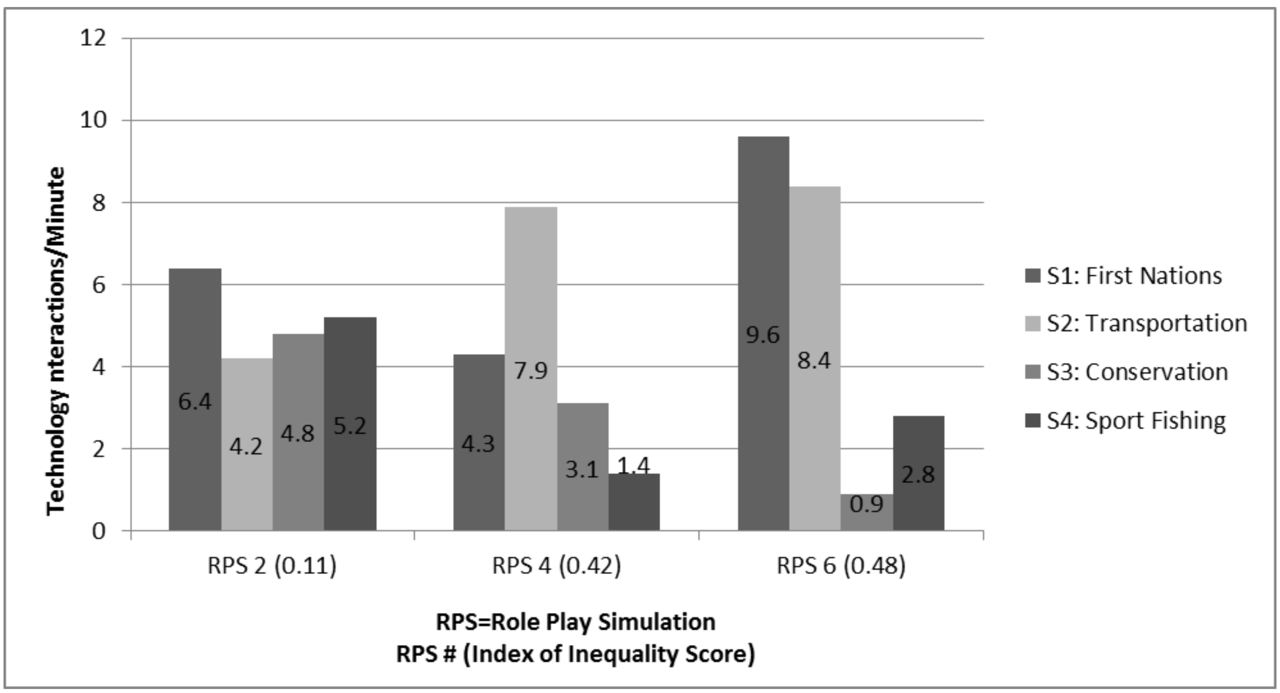
6.2 Analysis

6.2.1 Measures of Participation

Distribution and index of inequality for frequency of interaction

*Q3.1: Is **frequency of technology interaction**, dialogue turn taking and number of words spoken by stakeholder seat location uniformly distributed across role play simulations?*

Distribution of physical interactions varied across role play simulations from very low inequality to medium inequality suggesting participation is not uniformly distributed by seat location for frequency of technology interactions. The histogram results in Figure 20 for frequency of technology interaction for role play simulation 2 has the most even distribution amongst seat locations. This is confirmed by a low index of inequality score indicating interactions with the technology were more uniformly distributed by seat location. Role play simulation 4 has less participation by seat location S3 & S4, with the most contributions by S2; this variation is supported by a moderate index of inequality score of 0.42. Role play simulation 6 has the greatest variation in interaction distributions by seat location, with S1 & S2 contributing the majority of interactions, with low contributions by S3 and S4. Role play simulation 6 also has the highest index of inequality score at 0.48, demonstrating more inequality of participation than either role play simulations 2 or 4.



*It should be noted that S4: Sport Fishing in role play simulation 2 moved his seat opposite S2: Transportation effectively interacting with the table while viewing the display upside down.

Figure 20. Frequency of Technology Interactions per Minute by Seat Location

Comparison of Perceived versus Actual Amount of Participation

Role play simulation 2 participants thought technology interactions were relatively equal by seat location and were similar to actual percentages (Table 22). For role play simulation 2, group members thought everyone contributed fairly equally. Although S1 commented that proximity to the touch table and proficiency using it contributed to the levels of participation for each stakeholder, he distributed his percentages equally amongst the participants seemingly contradicting his comment. S2 stated that the participants interacted as a group and considered everyone's interests making the process go smoothly in terms of participation. This contributed to an equal distribution of technology interactions. S3 agreed with S1 that technology interactions were a function of seat location and previous knowledge of Google Earth/GIS. This participant had significant GIS experience and had the most variation in the distribution of percent interactions. S4 thought the group members all had the ability to share their information equally. Actual percentages indicate S1 contributed about five to ten percent more than expected and S2 contributed about five percent less than expected. S3 and S4 were both fairly close to the estimated 25 percent.

Table 22. Perceived and Actual Participant Interaction with Technology

Perceived Participant Interaction with Technology	Role Play Simulation 2				Role Play Simulation 4				Role Play Simulation 6			
	S1	S2	S3	S4*	S1	S2	S3	S4	S1	S2	S3	S4
S1: First Nations	25%	25%	25%	25%	30%	30%	30%	10%	40%	40%	10%	10%
S2: Transportation	25%	25%	25%	25%	30%	30%	30%	10%	75%	8%	6%	11%
S3: Conservation	20%	25%	25%	30%	30%	40%	20%	10%	30%	30%	20%	20%
S4: Sport Fishing	25%	25%	25%	25%	22.5%	40%	22.5%	15%	30%	30%	20%	20%
Actual Percentages	31%	20%	23%	25%	26%	47%	18%	8%	44%	39%	4%	13%

*It should be noted that S4: Sport Fishing in role play simulation 2 moved his seat opposite S2: Transportation effectively interacting with the table while viewing the display upside down.

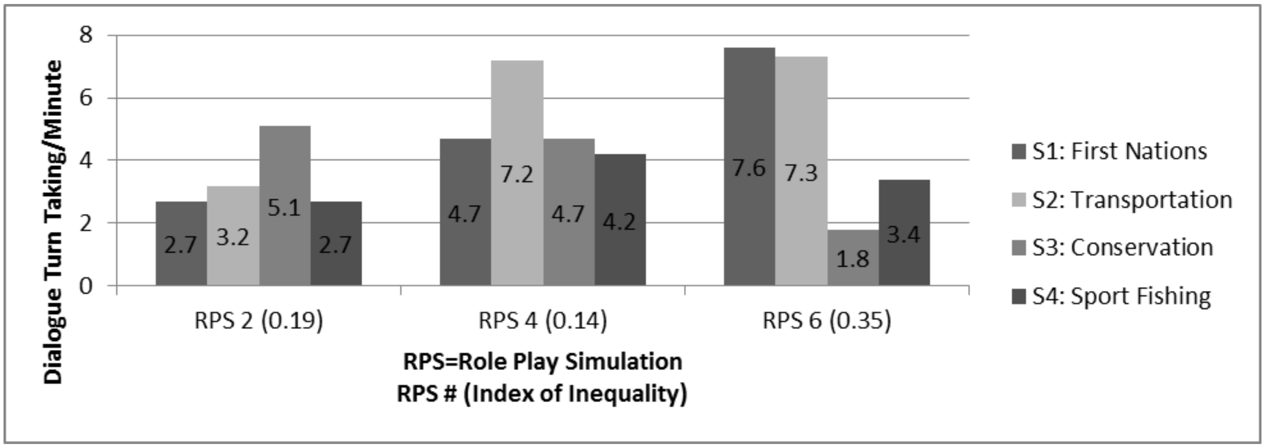
Participant perceptions of technology interaction by seat location varied amongst participants and deviated from actual percentages for role play simulation 4 (Table 22). Participants awarded the greatest contributions to S2 followed by S1 and S3; S4 was awarded the lowest percentages for technology participation. S1 commented that S4 interacted with the mouse and that S1, S2 and S3 could all reach the table better. S2 commented that the placement of the Sport Fishing representative made it difficult for him to interact with the table. S3 commented that people near the far left of the table had significantly more interaction, while "people sitting farther away were more prone to using the keyboard and mouse to contribute." S4 commented that because he was "on the edge" using touch interaction was "awkward" and the viewing angle made it difficult to use the mouse, therefore he contributed verbally and with the keyboard. Actual percentages indicate S2 contributed the most and more than participants perceived. S4 contributed the least and was close to perceived results for three of the participants. Interestingly, three participants perceived S1 and S3 to have contributed the same as each other when actual percentages show approximately a ten percent deviation in technology interactions.

The greatest variation in perceptions came from role play simulation 6, whose perceptions demonstrated little consistency amongst participants and varied dramatically from actual percentages (Table 22). S1 thought S1 and S2 contributed the most and S3 and S4 contributed significantly less in comparison. S2 thought S1 contributed overwhelmingly, with S2, S3 and S4 contributing approximately the same with low percentages. S3 and S4 had the same perception that S1 and S2 contributed the most with their seat locations of S3 and S4 contributing a bit less with a ten percent deviation. S1 stated that S1 and S2 are closer to the menu options and acted on behalf of participants S3 and S4 from verbal cues to make group decisions. S2 stated that S1 took over the map controls and would not let her or the other participants contribute to technology interactions. S3 commented that S1 and S2 were "seated closer to the objects on the screen." S4 stated that the people closest to the "side bar" [left] had more opportunity to use the table and more control. Actual percentages indicate S1 had the most accurate perception while strong deviations existed in the perceptions of S2, S3 and S4. S1 contributed the most with S3 having slightly less contribution than S1; S3 contributed three times less than S1 and S2; and S4 was significantly less than the other participants at only 4%.

Distribution and index of inequality for dialogue turn taking and number of words spoken

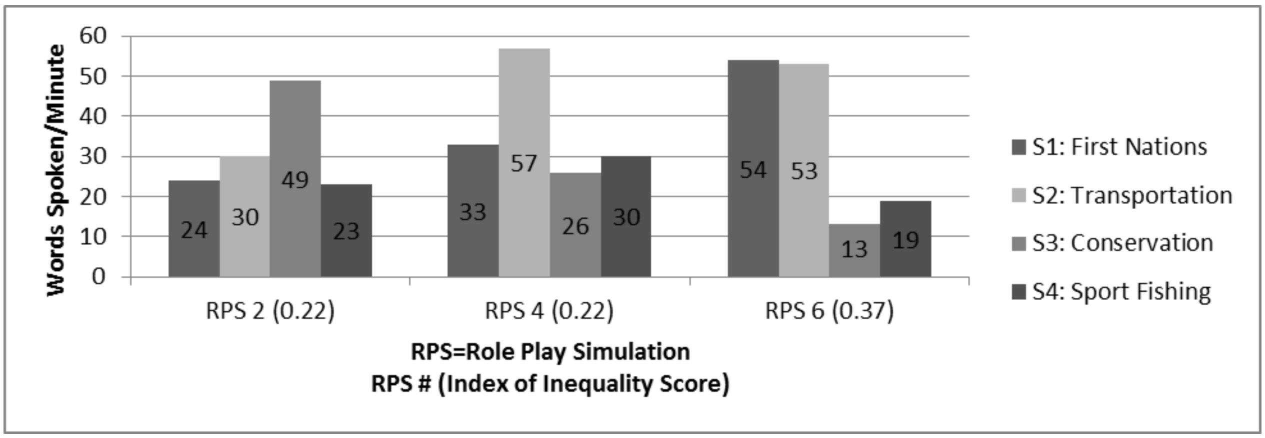
Q3.1: Is frequency of interaction, ***dialogue turn taking and number of words spoken*** *by stakeholder seat location uniformly distributed across role play simulations?*

Dialogue turn taking and words spoken per minute are not uniformly distributed by seat location but do have low inequality. Variation exists across role play simulation for the seat location with the most verbal interactions using dialogue turn taking per minute (Figure 21) and words spoken per minute (Figure 22). Role play simulations 2 and 4 have the least inequality in distributions demonstrated by both histogram distributions and index of inequality scores. In role play simulation 2, S3 dominated verbal interactions; for role play simulation 4, S2 dominated verbal interactions. Role play simulation 6 demonstrates greater inequality when looking at the histogram distribution, with S1 and S2 seat locations having a much higher distribution than S3 and S4. The index of inequality score is less equitable than role play simulations 2 and 4, but still is a low to moderate index score. The results for frequency of words spoken are nearly identical to both dialogue turn taking histograms for all role play simulations, as well as, index of inequality scores for all role play simulations, with a slight deviation for role play simulation 4 from 0.14 dialogue turn taking index to 0.22 for words spoken per minute index.



*It should be noted that S4: Sport Fishing in role play simulation 2 moved his seat opposite S2: Transportation effectively interacting with the table while viewing the display upside down.

Figure 21. Frequency of Dialogue Turn Taking per Minute by Seat Location



*It should be noted that S4: Sport Fishing in role play simulation 2 moved his seat opposite S2: Transportation effectively interacting with the table while viewing the display upside down.

Figure 22. Frequency of Words Spoken per Minute by Seat Location

Comparison of Perceived versus Actual Amount of Participation

Role play simulation 2 exhibits the greatest consistency across participant perceptions with deviations from actual percentages being greatest for S3 and S4 (Table 23). Perception of participation distributions indicate that S1 and S2 thought all participants spoke the same amount of time. S3 and S4 thought there was more variation in amount of time spoken, particularly that S1 spoke the least and S3 and S4 spoke the same amount; differences existed for S2 . S1 did not provide comments on the distributions he assigned. S2 reiterated his comments from technology participation stating that the group worked together to consider each other's interests equally. S3 stated verbal participation was a function of comfort with the role play, material and scenario. S4 stated the verbal participation was due to the vested interests of the different roles. Actual percentages of dialogue turn taking and words spoken demonstrate S1 and S4 contributed the least and had the same distribution while S3 contributed the most to verbal participation followed by S2.

Table 23. Perceived and Actual Participant Dialogue Interaction

Perceived Participant Time Spent Talking	**RPS 2**				**RPS 4**				**RPS 6**			
	S1	**S2**	**S3**	**S4***	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**
S1: First Nations	25%	25%	25%	25%	25%	25%	25%	25%	30%	30%	20%	20%
S2: Transportation	25%	25%	25%	25%	20%	40%	20%	20%	25%	25%	25%	25%
S3: Conservation	20%	20%	30%	30%	30%	40%	15%	15%	30%	30%	20%	20%
S4: Sport Fishing	20%	30%	25%	25%	20%	30%	20%	30%	30%	30%	10%	30%
Actual Percentages Dialogue Turn Taking	20%	24%	37%	20%	23%	35%	22%	20%	38%	36%	9%	17%
Actual Percentages Words Spoken	19%	24%	39%	19%	23%	39%	18%	20%	39%	38%	9%	14%

*It should be noted that S4: Sport Fishing in role play simulation 2 moved his seat opposite S2: Transportation effectively interacting with the table while viewing the display upside down.

Role play simulation 4 participants had mixed perceptions of verbal participation with some perceptions close to actual percentages (Table 23). S2, S3 and S4 perceived variation in verbal participation while S1 thought verbal participation was uniformly distributed. S2 thought he contributed the most to verbal participation and the other stakeholders contributed equally but spoke half the amount that he did. S3 thought S2 contributed the most followed by S1, with S3 and S4 contributing much less. S4 thought S2 and S4 contributed the most while S1 and S3 contributed less. S1 stated he thought everyone shared equally. S2, whose distribution stated he contributed the most to verbal participation, stated that he took on a leadership position in the group and guided the discussion while establishing a connection amongst the other stakeholders. S3 commented that verbal participation was a function of seat location because those able to interact most with the table had more technology-related dialogue than those participants, reflected in the higher distributions she awarded to S1 and S2. S4 in particular states that Transportation (S2) had an easy mandate, but was outgoing, implying that personality can drive verbal participation. Actual percentages indicate that S2 had approximately 10-15 percent greater participation than S1, S3 and S4 whose percentages were similar to one another.

Role play simulation 6 had the most variation in responses with nearly all participants overestimating verbal participation for S3 and S4 and underestimating participation for S1 and S2 (Table 23). For this simulation, S2 perceived equal dialogue participation; S4 perceiving equal participation by 3 members with S3 having significantly less participation; and with S2and S3 participants perceiving more participation by S1 and S2 with ten percent less participation by S3 and S4. S1 commented that “it is more natural to explain our actions while using the map, so we would suggest things and others would respond,” indicating the S1 and S2 had more verbal participation because of their ability to interact more with the technology. S2 stated her distribution for verbal participation was uniform because everyone went around the table and equally discussed. S3 and S4 both commented that verbal participation was a function of personality and how outgoing the other participants were; S3 also indicates that more technology interaction by S1 and S2 contributed to more dialogue on their part. Actual results favour greater participation by S1 & S2, with substantially less participation by S3 & S4.

Participant Perception of Seat Locations Impact on Interacting with Technology and Participating in Discussion

Participants were asked their agreement with a statement pertaining to seat location making it difficult to interact with the technology as much as they wanted to (Table 24). For technology interaction, there was a greater variation in responses. For S1 and S2 participants generally disagreed that seat location made it difficult for them to interact with technology, with the exception being role play simulation 6, S1: First Nations and S2: Transportation agreeing with the statement. S3 and S4 participants generally agreed with the statement. Exceptions came from S3: Conservation for role play simulation 6 and S4: Sport Fishing for role play simulation 2 responding with neutrals.

Table 24. Perceptions of Seat Location and Technology and Dialogue Interaction

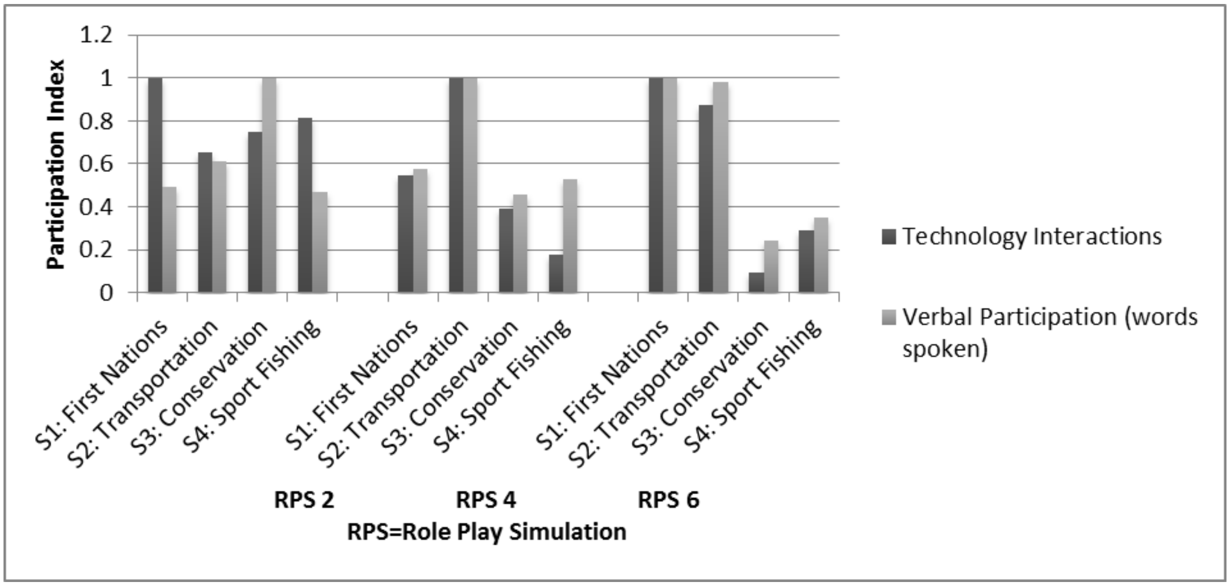
"My seating location around the touch table made it difficult for me to interact with Google Earth as much as I wanted to."				
	S1: First Nations	S2: Transportation	S3: Conservation	S4: Sport Fishing
RPS 2	Disagree	Strongly Disagree	Agree	Neutral*
RPS 4	Strongly Disagree	Strongly Disagree	Agree	Strongly Agree
RPS 6	Agree	Agree**	Neutral	Strongly Disagree
"My seating location around the touch table made it difficult for me to contribute to the discussion as much as I wanted to."				
	S1: First Nations	S2: Transportation	S3: Conservation	S4: Sport Fishing
RPS 2	Disagree	Strongly Disagree	Disagree	Strongly Disagree*
RPS 4	Strongly Disagree	Strongly Disagree	Agree	Disagree
RPS 6	Strongly Disagree	Strongly Disagree	Disagree	Strongly Disagree

*It should be noted that S4: Sport Fishing in role play simulation 2 moved his seat opposite S2: Transportation effectively interacting with the table while viewing the display upside down.
**S2: Transportation states she agrees mainly because S1: First Nations controlled the technology

Participants were asked their agreement with a statement pertaining to seat location making it difficult to contribute to discussion as much as they wanted to (Table 24). Related to discussion, results demonstrate that dialogue is not constrained by seat location as perceived by participants. Only S3: Conservation in role play simulation 4 thought their seat location constrained their ability to contribute to the discussion.

Combined Technology Interaction and Verbal Participation

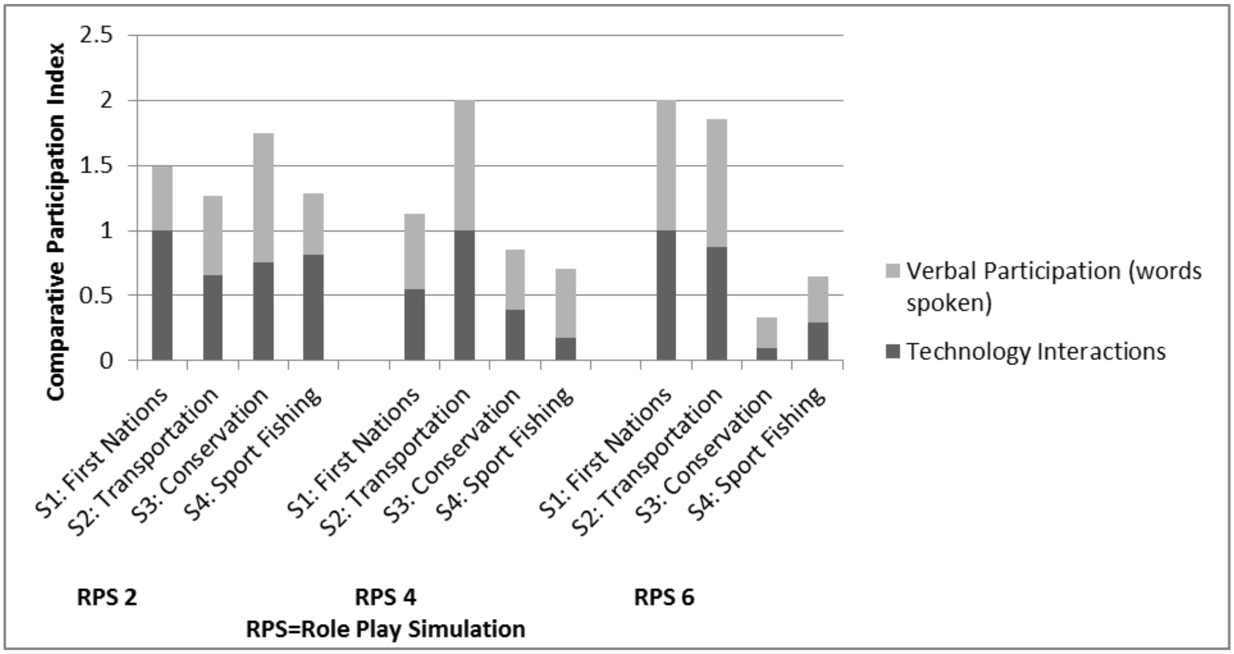
Overall, technology participation does not appear to compensate for low dialogue participation or vice versa. A relationship appears to exist between technology interaction and verbal participation where higher amounts of technology interaction occur with higher rates of verbal participation for role play simulations 4 and 6 (Figure 23). In two of the role play simulations, the two participants with greatest technology interaction, S1 and S2, also had the most verbal participation; likewise, the two participants, S3 and S4, with the least technology participation had the least verbal participation. Role play simulation 2 deviates from the trends seen in role play simulations 4 and 6 because the two participants, S1 and S4, with the most technology interactions had lesser rates of dialogue, whereas the two participants, S2 and S3, with the least amount of technology interactions had the highest rates of dialogue.



*It should be noted that S4: Sport Fishing in role play simulation 2 moved his seat opposite S2: Transportation effectively interacting with the table while viewing the display upside down.

Figure 23. Comparison of Technology Interaction and Verbal Participation Indices

Role play simulation results are presented using a combined participation index of technology interaction and verbal participation with no distinct patterns existing across role play simulations (Figure 24). In role play simulation 2, S3 had the greatest participation, followed by S1; S2 and S4 had lesser participation but approximately the same amount of participation as each other. For role play simulation 4, S2 had a significantly more participation that S1, S3, and S4; S1 had the second most participation, followed by S3 and S4. In role play simulation 6, S1 had the greatest participation with S2 being similarly high; S3 and S4 had significantly less participation with S3 having the least.



*It should be noted that S4: Sport Fishing in role play simulation 2 moved his seat opposite S2: Transportation effectively interacting with the table while viewing the display upside down.

Figure 24. Combined Participation Index by Seat Location and Role Play Simulation

Comparison of Actual Percentages of Technology Interaction, Verbal Participation and Combined Participation Index

The combined participation index when ranked reflects the individual ranks for technology interaction and verbal participation when higher technology rates occur with higher verbal participation. The combined participation index does not demonstrate the same pattern in ranks as technology interaction and verbal participation when higher rates of technology interaction occurs with lower rates of verbal participation. There is a distinct pattern for role play simulations 4 and 6 whose technology interaction percentages and verbal participation percentages, when ranked, match the ranks of the combined participation index. Role play simulation 2 deviates from this pattern with less consistency in the combined participation index rank matching deviations in rankings between technology interaction and verbal participation. Results are summarized in Table 25.

Table 25. Combined Participation Index compared with Actual Technology and Verbal Participation

	RPS 2				RPS 4				RPS 6			
	S1	**S2**	**S3**	**S4***	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**
Actual Percentages Technology Interaction (Rank)	31% (1)	20% (4)	23% (3)	25% (2)	26% (2)	47% (1)	18% (3)	8% (4)	44% (1)	39% (2)	4% (4)	13% (3)
Actual Percentages Words Spoken (Rank)	19% (3)	24% (2)	39% (1)	19% (3)	23% (2)	39% (1)	18% (4)	20% (3)	39% (1)	38% (2)	9% (4)	14% (3)
Combined Participation Index (Rank)	1.49 (2)	1.27 (4)	1.75 (1)	1.28 (3)	1.12 (2)	2.00 (1)	0.85 (3)	0.70 (4)	2.00 (1)	1.86 (2)	0.33 (4)	0.64 (3)

*It should be noted that S4: Sport Fishing in role play simulation 2 moved his seat opposite S2: Transportation effectively interacting with the table while viewing the display upside down.

6.2.2 Technology Interactions by Google Earth Interface

Q3.2: Is frequency of interaction by seat location uniformly distributed for Google Earth interfaces (menus, dialogue boxes, earth display)?

Menus

Menu interactions are not uniformly distributed. Role play simulation 2 has the least inequality of menu interactions with role play simulations 4 and 6 being more similar with a high inequality of menu interactions (Figure 25). Role play simulation 2 has the least interaction by S3 which was the farthest seat from the menus in that role play simulation; S1 and S2 had moderate interaction rates with menus; and S4 (due to moving seat location) had the highest interaction rate with menus. Role play simulation 4 had the highest menu interactions by S2, followed by S1; S3 and S4 had little to no menu interactions and were located the farthest from the menus. This is represented by a high index of inequality score of 0.68. Role play simulation 6 had a similar distribution to Role play simulation 4, albeit with S1 having the most interactions followed by S2; S3 had few interactions and S4 had none. This is also represented by a similarly high index of inequality score as role play simulation 4, at 0.73.

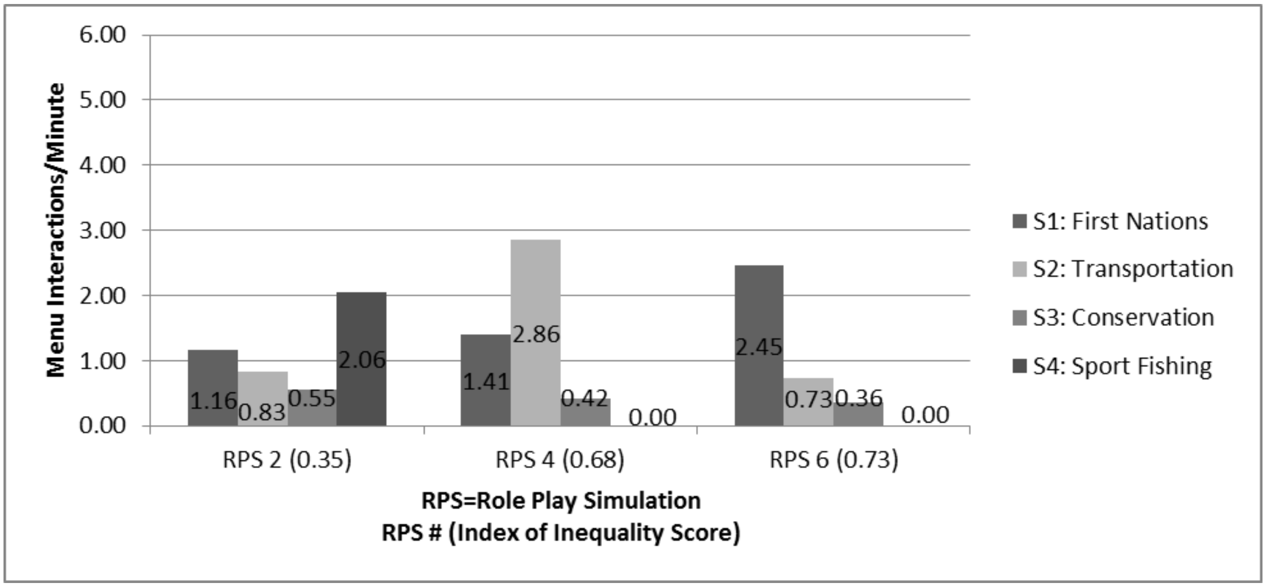


Figure 25. Menu Interactions per Minute by Role Play Simulation

Dialogue Boxes

Dialogue box interactions are not uniformly distributed, as seen in Figure 26. Role play simulation 4 has the least inequality of dialogue box interactions with role play simulations 2 and 6 having high inequality of dialogue box interactions. A lot of variation exists in dialogue box interactions across the role play simulations. Keeping in mind that S4 in role play simulation 2 had a similar seat location as S1 and S2 which would reduce their dialogue box interactions by redistributing interactions amongst three participants, we can see a clearer trend in higher rates of dialogue box interactions by S1 and S2 for all three role plays. Role play simulations 2 and 4 had some interactions by S3. Role play simulations 4 and 6 had almost no dialogue box interactions by S4 which was located to the far right of the table. RPS 6 had no dialogue box interactions by S3 and S4.

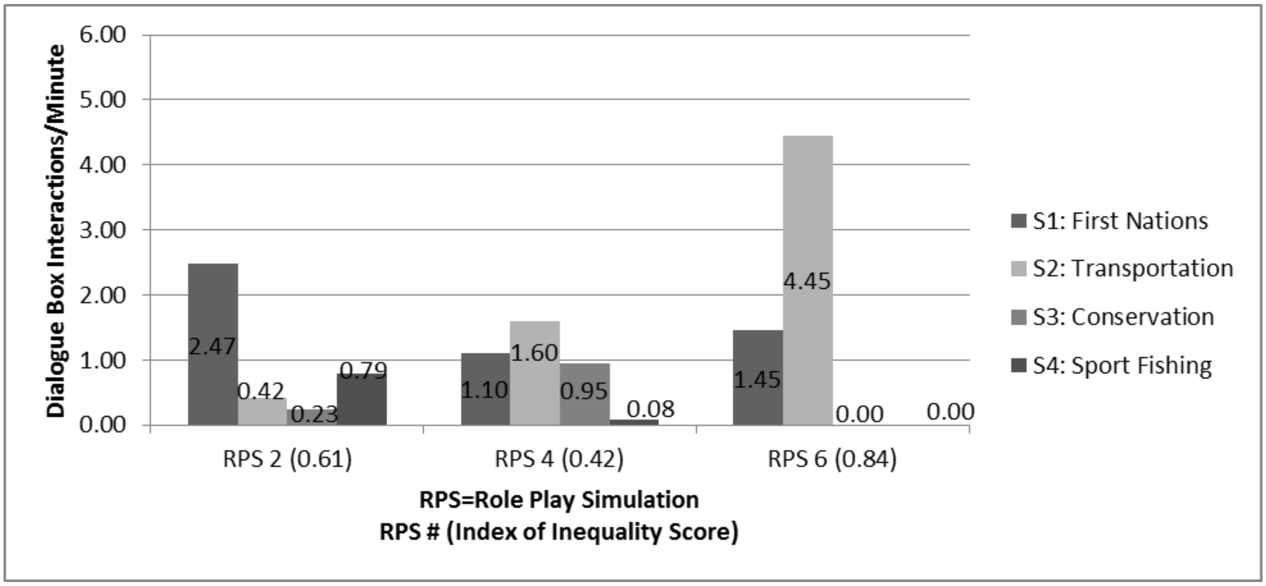


Figure 26. Dialogue Box Interactions per Minute by Role Play Simulation

Earth Display

Earth display interactions are not uniformly distributed but have less inequality of interaction than either menus or dialogue box interfaces as seen in Figure 27. Role play simulation 2 has the least inequality of Earth display interactions followed by role play simulation 4; role play simulation 6 has moderate inequality. In role play simulation 2, the distribution is fairly even with the exception of S3 having a higher rate. Role play simulation 4 is also fairly evenly distributed amongst S1, S3, and S4, while S2 has almost twice the interaction of the other seat locations. Greater variation exists in Earth display interactions for role play simulation 6, with S3 having little interactions, and S1 having the most; S2 and S4 have similar rates. Earth display interactions are well represented by all seat locations across role plays, with relatively higher interaction rates than menus and dialogue boxes.

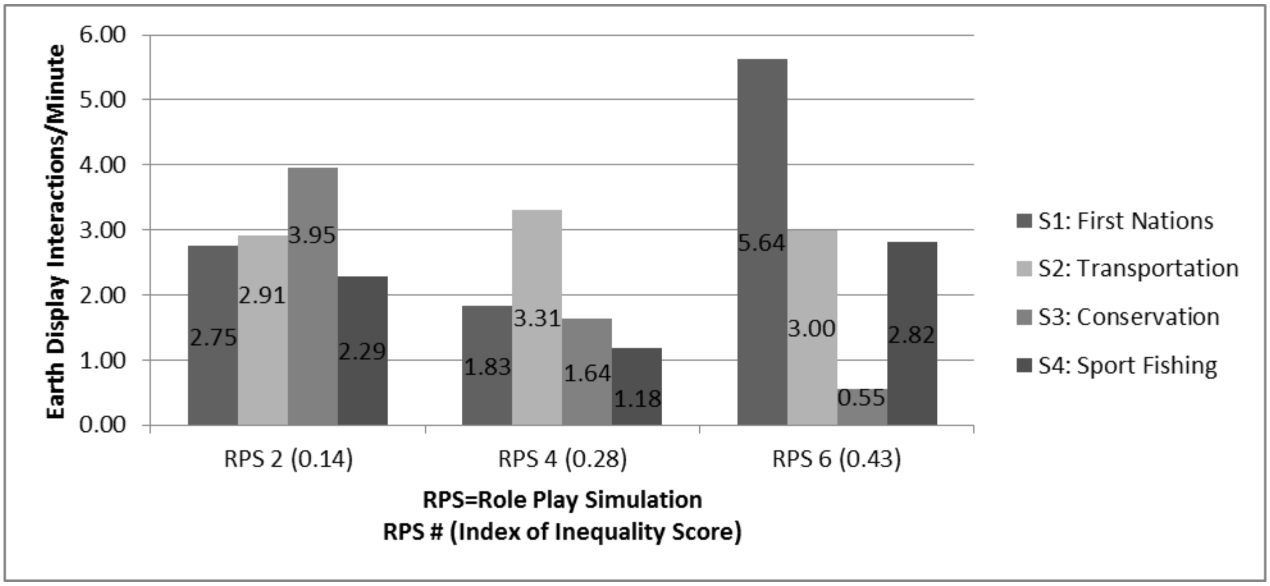


Figure 27. Earth Display Interactions per Minute by Role Play Simulation

6.2.3 Technology Errors by Seat Location

Q3.3: How are technology participation errors distributed by seat location?

Variation exists in distribution of errors across role play as seen in Figure 28. Role play simulation 2 has relatively similar percentage in touch table interaction errors across seat locations, represented respectively as a proportion of each participant's total interaction, with S4 having a slightly higher error rate. Role play simulation 4 has similar proportions of error for S2 and S3 with S1 being slightly higher and S4 being significantly lower. In role play simulation 6, S1 and S2 had similar rates of error slightly under ten percent. S3 has the highest proportion of error in role play simulation 6, despite having contributed little to overall frequency of interaction with the technology; this is because she had only 10 interactions total with the technology, 2 of which resulted in error, thus strongly inflating her distribution of error. S4 in role play simulations 4 and 6 have the same proportion of error and lowest error rates for the role play simulations; both of these participants had very little interaction with the touch table. In researcher observation notes, the majority of errors were due to turning on/off layers (menus), adding/editing features (dialogue boxes), and zooming in/out (Earth display).

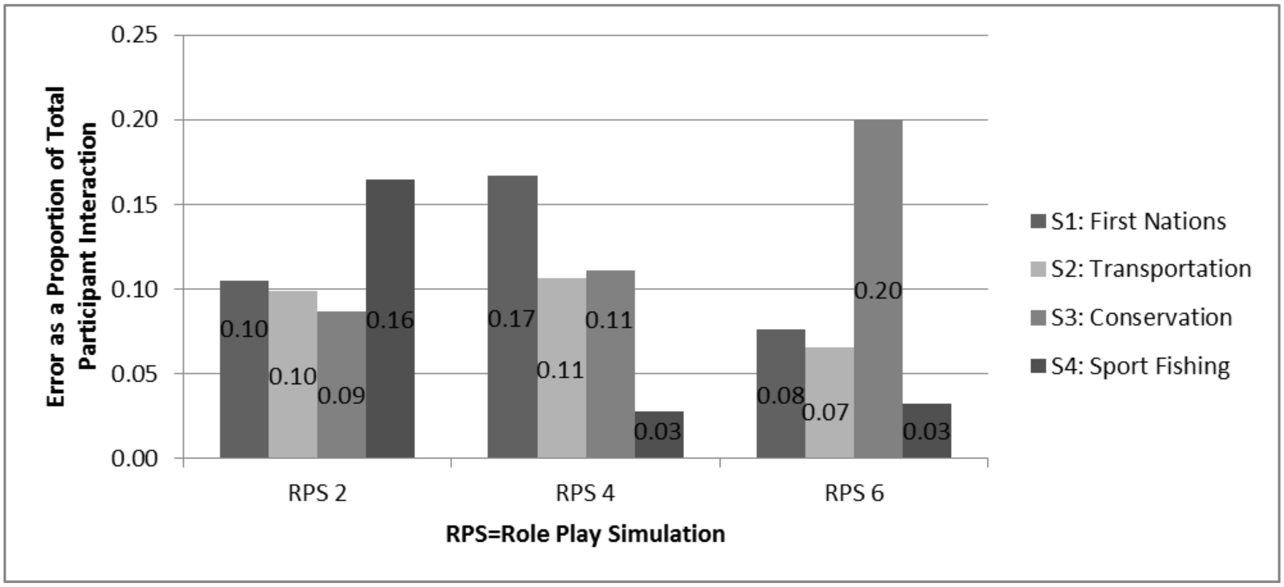


Figure 28. Error by Role Play Simulation

6.3 Discussion

Multi-user touch table technology is touted as an environment that supports equitable technology participation by transcending the constraints of single-user technology environments by allowing technology interactions to be distributed amongst multiple users (Rogers et al., 2009; Marshall et al., 2008). This research however, demonstrates that Google Earth software design may hinder the technology's ability to support equitable multi-user interactions across its interfaces, although caution should be taken with the results due to untested factors, such as participant personality, stakeholder role design, and participant familiarity with marine spatial planning context. Technology interactions had moderate to high inequality in menu and dialogue box interactions with less inequality in Earth display interactions. Unequal accessibility to technology did not appear to bias participation or group's collaborative process for role play simulations 2 and 4, but may have affected the group decision-making process for role play simulation 6. Software design for single-user desktops with a mouse led to frustrating errors and technology interactions during the group's activities suggesting Google Earth use on touch tables would benefit by redesigning interface to support touch interactions.

This research parallels some of the participation measures used in Collaborative GIS and touch table literature. Collaborative GIS literature used amount of participant time spent interacting with decision aids (Nyerges et al., 2006; Jankowski & Nyerges, 2001b; Nyerges, et al., 1998; MacEachren, 2004) which is comparable to examining types of software interfaces. Whereas Collaborative GIS literature uses time spent interacting or participating, more detailed information on frequency of technology interactions was collected for this study. Index of inequality was adopted from use in touch table literature (Rogers et al., 2009; Potvin et al., 2012; Harris et al., 2009).

This research is unique compared to touch table literature in looking at interactions with interface components by seat locations. The touch table literature reviewed generally compared variations across environments, such as vertical displays versus horizontal displays (Potvin et al., 2012); or laptop, touch table, and physical-digital table (Rogers et al., 2009); comparing impacts of group size and table size on touch table activities (Ryall et al., 2004). The most comparable research was a study done on group game and puzzle solving on a physical tabletop rather than a digital touch table (Scott et al., 2004). This study examined territoriality of workspace by seat location after dividing the table into 16 zones. Three types of workspace identified included personal, group and storage (for puzzle pieces). Similarly, Google Earth interfaces can be thought of as zones where we examine accessibility rather than territoriality. Outcomes of research are discussed in more detail below.

6.3.1 Participation Distribution and Inequality

Seating Configuration

Overall, the multi-user touch tables supported group work space above personal work space. Scott et al. (2004) state that personal territories are generally in front of participants and therefore controlled by seat location; whereas, group territories consist of all other table space not belonging within a personal territory. This is significant for the role play simulations with Google Earth on touch tables due to participants having overlapping personal territories because of the distribution of the menu, dialogue box, and Earth display interfaces. Personal territory was not confined to the space in front of participants because participants' interaction space was defined by the tasks being performed. It was anticipated that participants might perform the tasks suited to their seat location, but in actuality some participants tried to interact with interfaces not directly in front of their seat location, thereby reaching into the space of other participants, such as S3 (Conservation) in role play simulation 2. S1 (First Nations) and S2 (Transportation) had greater access to all interfaces and reached into each other's spaces. The most marginalized seat location was S4 (Sport Fishing) whose results indicate mostly Earth display interactions; role play simulations 4 and 6 both had nearly zero menu and dialogue box interactions suggesting their interactions were confined to their personal spaces dictated by their seat location. S3 (Conservation) also exhibits a similar trend with low interaction rates with menus and dialogue boxes and greater accessibility of interactions with the Earth display as defined by seat location. S1 (First Nations) and S2 (Transportation) have the greatest accessibility to all interfaces and therefore we see their interactions are not merely confined to their personal space but reaches out into the personal space of S1, S2 and S3 seat locations.

Overlapping personal territories is significant because it suggests the touch table is too small to accommodate personal work spaces for participants, which may lead to individual frustrations and social conflict if personal space is not respected. There is some evidence from role play simulation 6 to support this. S2 (Transportation) expressed frustration and thought S1 (First Nations) dominated the technology. However, this may lead to higher cooperation amongst participants in task completion by prioritizing group work space over personal work space thereby influencing social interactions in the group decision-making process. The participant configuration was designed to have each participant sitting parallel to the bottom of the table and therefore, each participant would be sitting side by side, an arrangement that supports coordinated group actions (Scott, Grant & Mandryck, 2002). However, participants rearranged the seats to suit their participation. Participants in S4 seat location tended to move to the side of the table and in role play simulation 2, S4 (Sport Fishing) moved to the top of the table so that he was in fact viewing the touch table upside down but was closer to the menus. S1 (First Nations) also tended to sit off to the side of the table. This suggests that although the table supports four users, it may not provide enough personal space for users to feel comfortable and that perhaps participants preferred face-to-face arrangements. Scott, Mandryck and Grant (2002) state that when participants are engaged in group conversation, face-to-face arrangments are preferred. Hofstra et al. (2012) discuss the impact that table size has on group work space dynamics, stating that individuals need to have their own space while at the same time being close enough to work together. The touch table is a large display (18 inches by 39 inches) with advantages over a small desktop monitor. Allowing groups to gather around the table increases informal group awareness, social awareness, group structural awareness, and workspace awareness (Hofstra et al., 2012). However, working in close proximity needs to be balanced with personal sense of space (Hofstra et al., 2012). This finding is also supported by Ryall et al. (2006, p. 5) who note that "users appreciate their elbow room." Given the dimensions of the touch table it may be best not to have more than three users at a table.

Google Earth software is currently designed to support distributed menu, dialogue box and Earth display interfaces that support coordinated group tasks on multi-user touch tables. This means that due to the size of the table and the design of the software, it takes distributed participation by multiple participants to complete some tasks, such as adding/editing features; or participants seated to the right of the center of the table may need to instruct participants seated left of center to turn on/off layers. Adapting the software to allow participants to have their own control of task functions (such as turning on/off layers or adding/editing features) regardless of seat location would change the group decision-making process by reducing group task completion to individual task completion, thereby altering group interactions with the technology. Further research could demonstrate the values and differences of distributed group task completion versus individual task completion on multi-user touch tables, the influence on personal versus group work spaces, and redistributions of interactions on touch tables by seat location with individual controlled task interfaces.

Technology Interaction

Examining dialogue and technology interactions, role play simulation 2 has the most equality of technology participation, possibly as a result of the S4 (Sport Fishing) representative moving his seat location to the top of the table. This in and of itself demonstrates the limited access that the S4 seat location provides the participant to the different components of the technology. This is demonstrated in the results of role play simulations 4 and 6 where S4 had very low interaction rates. In role play simulations 4 and 6, S1 and S2 had the highest technology interaction rates as these seats are closest to the menus and dialogue box functions and participants have access to the earth display, as well; S3 only has limited access to menus and dialogue boxes, whereas S4 has none. We can see a different situation in role play simulation 2, with S2 surprisingly having the lowest interaction rate. However, this is likely because S4 was seated opposite S2 and shared in the task responsibilities for the S2 seat location.

Verbal Participation: Dialogue Turn Taking and Number of Words Spoken

Dialogue turn taking and number of words spoken gave similar results. Both measures were taken as turn taking did not give an indication of quantity of dialogue, therefore, the similarities in the results were surprising. Although an effort was made to control for role influence on participation by giving participants the same amount of data to discuss and similar amounts of concerns and objectives, the participants' perceptions were that some roles did lend themselves to more dialogue than others did. For role play simulation 2, we see Conservation (S3) dominating dialogue, with First Nations (S1) and Sport Fishing (S4) on par with one another. For role play simulation 4, Transportation (S2) dominates, and First Nations (S1) and Conservation (S3) are on par, with Sport Fishing (S4) not far behind. A different situation exists for role play simulation 6 where First Nations (S1) and Transportation (S2) overwhelmingly dominated dialogue. Rather than the role lending itself to more dialogue participation the results suggest, as did one of the role play simulation participants in their questionnaire, that personality is a big factor in participation.

Participant Perceptions of Technology Interaction and Verbal Participation

Participant perceptions of technology interaction and verbal participation deviate from observed percentages for two of the role play simulations. It should be noted that participants were asked their perception of how much time they thought each participant spoke whereas, dialogue participation was not measured in time but in dialogue turn taking and number of words spoken. This was considered to be an appropriate proxy for dialogue time by participants. We can see for role play simulation 2 that participant perceptions of technology interaction and verbal participation were actually quite similar to observed. However, in role play simulation 4 it was acknowledged by several participants that S4 was marginalized from participating, while S1 & S2 were seated advantageously to participate greater with technology. Significant variations occurred for role play simulation 6 in which S2 (Transportation) was clearly irritated by the S1 (First Nations) dominating participation, despite S2 having a similar participation rate S1. The other two participants in role play simulation 6 over-inflated their own participation. The variation in perceptions suggests participants do not always perceive participation by other group members accurately. This is supported by the work of Fernquist (2010) whose subjects also misperceived the amount of time taken to complete tasks on a touch table; and also Marshall et al. (2008) who found that participants' perceptions of equity of interaction was dependent on participant perceptions of verbal participation rather than technology interactions. This demonstrates the strong value of collecting objective measures of participation such as participant interactions with the technology to understand the distribution of participation amongst participants and the components of the technology the participants are interacting with the most. Relying solely on a subjective measure, such as participant questionnaires, which again is the most common method used to measure the collaborative process with GIS, may offer a distorted view of group participation with the technology. Comparing actual quantitative measures of participation with perceptions by the participants provides a holistic representation of participation levels.

Combined Participation Index

The combined participation index is used to visualize technological and verbal participation together. Harris et al. (2009) use a quantitative measure of utterances per touch per minute to give a ratio number of total interaction. The combined participation index similarly attempts to depict a combined technological interaction and verbal participation scores to give a sense of overall participation. Higher rates of technology participation appear to be related to higher rates of verbal participation. In only one case does it appear that verbal participation compensated for lack of technology participation; S4 (Sport Fishing) had more verbal participation than technological interactions in role play simulation 4. Two participants in that role play simulation and the Sport Fishing participant himself, commented on how difficult it was for the Sport Fishing representative to interact with the technology because of his seat location. These findings are significant because it suggests that participants are not using one type of participation to compensate for another.

6.3.2 Interface Interactions Distribution and Inequality

Menus and Dialogue Boxes

From the results it is clear that S1 and S2 have a distinct advantage to interacting with menus and dialogue boxes. This trend is also supported by role play simulation 2 where S4 moved their seat location in a similar position to S2. The index of inequality scores are quite high for menus and dialogue boxes (with the exception of menus for role play simulation 2, where the score is deflated due to more equal participation by S4). The main GIS tasks associated with menus and dialogue boxes are turning on/off layers, adding/editing features, and symbology functions. Symbology is technically a part of adding/editing features, but is considered its own task as it supports the decision-making process and group dialogue in a different way than just adding/editing a feature. Turning on/off layers provides direct control over the stakeholder's marine spatial data that is being presented. Adding/editing features is the most important GIS task in the generating options decision phase as it allows participants to create options and add it as a spatial data layer to the map. Adding/editing features also spans the earth display interface and allows S3 and S4 to also have control over drawing the feature in the earth display. Symbology allows the participants to re-represent features using colour, line size, and transparency. We can see that menu and dialogue box interactions provide differing amounts of control and cooperation over the group's decision-making process, arguably lending more control of technology to those individuals in S1 and S2 seat locations.

The enhanced accessibility with the technology and spatial data for seat locations S1 and S2 is significant as it may bias the group's decision-making process in favour of the stakeholders in these seat locations by allowing them greater control over the group's activities on the touch table. Although most participants expressed satisfaction with the group's decision-making processes and outcomes, in role play simulation 6, S3 (Conservation) had little technology interaction and expressed dissatisfaction. Role play simulations 2 and 4 were cooperative and worked as a group to meet each other's objectives, so it is difficult to comment if accessibility contributed to greater consideration of these participant's objectives with the three groups in this study.

Earth Display

The earth display interface has a much lower index of inequality scores than menus and dialogue boxes. Even role play simulation 6 has much higher interaction rates than what is seen for menus and dialogue boxes. It was expected that S3 might have the highest interaction rates with the earth display since their seat location is directly in front of it, followed by S2 and S4 who would also be in good locations to interact with the earth display. The high rates for S1 however are not necessarily completely surprising as the Earth display takes up almost two thirds of the touch table screen and therefore is easily accessible by all participants.

The main GIS tasks performed on the earth display are panning and zooming in/out, which support data/map exploration, adding nodes as part of the adding/editing features. Lastly pointing serves to focus group discussion during problem exploration and generating options decision phases; and supports GIS tasks by allowing participants to discuss locations of drawing nodes during the adding/editing features task. Pointing was considered a direct technology interaction, as it is a kinesthetic gesture using the touch table technology and was important for focusing discussion. The earth display is the interface that supports geovisualization and is the main discussion focus of the MSP. The low inequality scores suggest accessibility to the earth display is not hindered by seat location.

Participation by Seat Location

Results demonstrate participation with touch table technology is biased by seat location when not controlling for personality, role, and domain expertise; however more importantly, is this an actual disadvantage to the group's decision-making process? This study was not designed to answer this question; however, observations are offered to further this discussion. The idea is that less inequality of technology interactions and verbal participation allows for more equitable participation in the planning process because all participants' views can be addressed if participation is distributed equally and fairly (DiMicco, et al., 2004). However, what is observed in small groups and which participants have commented on as a strength of the technology is the way in which the technology distributes tasks amongst group members. One participant who participated in a simulation (whose results are not presented in this study) commented she intended to be uncooperative and inflexible while playing her role as the Transportation representative. However, within a few minutes into the simulation she changed her mind as the technology required her to cooperate with the other group members to complete tasks and her resolve for being uncooperative dissolved. She commented after the role play simulation that the technology forces a sense of cooperation onto the group's proceedings by creating a situation in which group members share responsibilities in completing tasks.

The alternative to having distributed task responsibility amongst participants by seat locations would be to have multiple movable and rotatable menus and dialogue boxes for each participant, so that each participant has control of data (e.g., turning on/off layers), adding/editing features, and symbology. This study demonstrates that earth display functions are already fairly equitable, so developing an application that allows for multiple distributed menus would allow group members to each have control over the important GIS tasks, and might contribute to more equitable GIS task/interface interactions and greater satisfaction with technology use. Designing a study to test the value of individual participant control versus distributed participation would help determine whether the current limitations of the software are indeed an advantage or disadvantage to the group's decision-making process. Future research will control for personality, role, technology experience, and domain expertise to ensure more conclusive results.

Does equitable technology interaction translate to equitable decision-making? This study offers some insight to this question, although it is difficult to draw solid conclusions since the results show that the software design hinders equality of interaction across the interfaces. In this study, two groups had a cooperative effort in addressing each other's objectives suggesting that overall, equality or low inequality of technology participation across interfaces is not needed for participants' objectives to be met (based on the context of this role play simulation). However, these two groups did exhibit the lowest degrees of inequality and therefore had more equitable technology interactions, even if it wasn't perfectly equal or a very low inequality score. However, role play simulation 6 only met the objectives for the two participants with the highest technology interactions and easiest accessibility to all of the interfaces. Overall, the findings suggest that instances where participants have greater equality of technology interactions, more equitable decision-making took place.

6.3.3 Errors

Errors are relatively evenly distributed amongst participants across role play simulations, with the exception of S4, presumably a result of low overall interaction. On average error represents 10% of frequency per participant. Errors occur for three main reasons: human error with software, human error in touch table gesture, and gesture interactions not being registered by the table-despite being performed correctly.

Human error with software occurs when the participant has limited familiarity with software tasks. The main task that resulted in this error was drawing nodes for polygon features during an add/edit feature task. The software is not designed for fine touch gestures, therefore, moving nodes that were incorrectly placed was very difficult for participants. Furthermore the software did not allow for nodes to be deleted or added afterwards, which participants expressed frustration about.

Human error in touch gesture results from limited experience with gestures, as well as, attempting to apply touch gestures for other interface gestures, such as an iPhone, to the touch table. For example, one participant tried to use the iPhone zoom gesture. Similarly, one participant had several errors because they chose to stand up and lost contact with the touch pad, which participants need to be in contact with for the technology to register the gesture.

The third type of error witnessed was when the gesture was performed correctly but the software did not register the gesture. For example, turning on/off layers and increasing transparency in the symbology dialogue box resulted in errors because the touch gesture is too coarse to interact with the size of the check boxes and transparency arrows for symbology.

Desktop Environments on Multi-User Touch Tables

Software and touch gestures require more refinement for group use on the multi-user touch table to minimize errors. The software is designed for individual desktop environments with a mouse (Ryall et al., 2006). To adequately interact with Google Earth the size of the buttons, check boxes and arrows should be increased so that the table registers the touch gesture. Gestures can also be finicky. Although participants performed the zoom in/out gesture correctly, which requires one to move their fist up and down across the surface of the table and perpendicular to the bottom of the table, many times the table did not register the gesture as a zoom, but as a panning gesture instead. Refining the gesture itself in some way, similar to the iPhone gesture for zooming in perhaps, would allow for a more positive interaction experience. Ryall et al. (2006, p. 4) supportingly note that “accidental input is common” and “GUI [graphical user interface] elements designed for a mouse need modification for finger-based input.”

It is important that the technology does not hinder the group’s decision-making process and work flow, but supports it. Errors were particularly frustrating in role play simulation 2 in which 16 add/edit features out of 25 were canceled; most of these cancels were due to error in drawing nodes. Likewise, in role play simulation 6, the group had the least experience with Google Earth and used the technology less to support their decision-making process. This group also had the lowest quality solution. Frustration and intimidation due to inexperience can deter the group from using the technology to support their decision-making. The significant error rate suggests the technology needs further refinement before being used for real world MSP activities.

6.3.4 Measures of Participation

One of the main objectives of this thesis is to advance methodology on measures of collaboration. Earlier, measures of participation and measures of collaborative decision-making were identified in the literature review (Chapter 2). The research presented in this thesis (chapters 5 and 6) focuses strongly on examining measures of participation. This chapter, used frequencies of technological and verbal participation by individual participants to examine participation and accessibility by seat location using a statistic called index of inequality. The implications of personality, types of touch interaction, verbal participation and index of inequality upon measuring participation is discussed.

Personality/Role

Participation as a result of personality cannot be controlled in experimental lab settings, or the real world. However, an examination of a larger number of role play simulations would limit the effect personality plays in skewing participation results by seat location. In a similar role play simulation Collaborative GIS study, Jankowski & Nyerges (2001b) had 22 groups with 109 participants in their study. This number of participants and groups allows stronger conclusions to be drawn regarding roles. Although it was endeavoured to create equal roles that would not lend themselves to more participation than another role, there was a perception by some participants that role might have had some impact on the amount of participation; however, data collected from the three simulations suggests roles did not lend themselves to greater participation than another.

The role play simulations offer competing evidence for seat location versus personality affecting participation levels. In role play simulation 2, S3 (Conservation) overwhelmingly had the highest rates of dialogue and fair amounts of technology participation; her seat location was in a marginalized position compared to S1 and S2, and also S4 who moved his seat to the top of the table. She was a grad student and had extensive familiarity with GIS and frequently directed other participants. Therefore, her personality contributed to the participation levels more than her seat location. In contrast, an outgoing grad student known to the researcher played the sport fishing role in role play simulation 4. Out of his group members, he would have had the greatest familiarity, expertise, and comfortableness with the simulation materials, technology and the researcher; this in addition to his outgoing personality would suggest his participation based on personality should be higher than other group members. However, it was acknowledged by the sport fishing rep and the members of his group that his participation rates were lower than his group mates, and limited due to his seat location. This suggests seat location played a stronger role in his participation levels than did personality. In role play simulation 6 though, two very quiet group members seated in locations S3 and S4 had little participation. Although these individuals were not known to the researcher, it appeared that both seat location and personality impacted their participation levels.

The use of students in place of experienced professionals and stakeholders also impacts findings. Students tend to be more comfortable with technology and have generalized understanding of the domain tasks. Students may interact with technology more than stakeholders with less technological literacy; likewise, students may feel less familiar with the domain of MSP and therefore participate differently than an experience professional or stakeholder.

This study examined accessibility and participation by seat location. However, participation levels will be influenced by personality not just the accessibility of the seat location to the interface components of the software. A simulation designed without roles, would control for stakeholder role effects; personality tests could control for personality effects by placing similar personality types within the same group; and using participants who have all taken a course in coastal management and resources could control for participant familiarity/domain expertise.

Technology Participation Measures

Next, frequency of interaction was measured for touch interaction, pointing, and mouse interactions. The touch interactions were not distinguished from the mouse interactions. However, there was very little use of the mouse in any of the role play simulations and it was almost entirely done by S4 (Sport Fishing). Future studies should distinguish between mouse interactions versus touch interaction to comment on the difference in technology participation. Manual keyboard interactions were coded as one interaction rather than coding each key stroke, as typing on a manual keyboard only takes a few seconds. However, when the touch keyboard was used, each letter typed was captured as its own interaction as it required one touch at a time. It was more difficult to count key strokes for participants using the manual keyboard as the camera was not positioned on the keyboard; it also represents a more fluid interaction requiring only a few seconds to type rather than the more prolonged interaction required using the touch keyboard. This represents an inconsistency that was not resolved or examined in detail but should be considered for future studies as to whether it represents an important deviation in coding. This is important for capturing information on frequency of technology interaction by participants because inconsistent coding of manual keyboard interactions may underestimate amounts of participation.

Verbal Participation Measures

Emphasis of verbal participation was on capturing quantity of dialogue by participant. Both dialogue turn taking and number of words spoken were used to measure dialogue quantitatively. Dialogue turn taking demonstrates how often participants are contributing to dialogue, while number of words spoken demonstrates the amount of dialogue being contributed. Interestingly, dialogue turn taking and number of words spoken yielded similar results; however, the measures really capture two different things and therefore, one should not be used as a substitute for the other. Quantity of dialogue does not imply quality, however. Coding schemes can be developed to measure types of dialogue, infer quality, and to comment on group interactions. Rogers et al. (2009) captured quality of dialogue using codes of suggestions, confirmations, probing questions, queries, answers and other to dialogue. Nyerges et al. (1998, 2006) and Jankowski and Nyerges (2001b) assess quality of dialogue for decision support aids, decision phases, and group conflict. This study mainly assessed quantity of participation; future research aims to assess both quantity and quality of dialogue.

Index of Inequality

Lastly, the index of inequality is a useful statistic for capturing degree of inequality, however it is limited in giving information on the characterization and distribution of participation. A moderate score of 0.45 could represent a variety of situations occurring, such as all four seat locations participating with unequal distributions, two participants participating with high rates of interaction while two more participants have insignificant amounts of interaction, or three participants with equitable interaction and the fourth participant with none. The index can give you some indication of inequality but not the character of it, therefore supporting the statistic with histograms or averages provides a richer examination of participation.

6.4 Future Research: Applications for Desktop GIS and SDSS

Collaborative GIS endeavours to utilize mapping technology designed to support decision-making in group processes. Although Google Earth is not a SDSS it can support collaborative geovisualization and allows spatial data such as points, lines, and polygons to be added to the system to support group decision-making. Real-world MSP activity with stakeholders would most likely utilize a group SDSS with spatial analysis capabilities like the customized ArcGIS water resources decision support system used by Nyerges et al. (2006); or a collaborative planning forum like MarineMap or SeaSketch which allows for participants to submit their own planning scenarios and participate in online discussion forums (Merrifield et al., 2013; http://www.seasketch.org/). Future research aims to examine participation with these softwares and the distribution of participation by seat location on touch tables with the decision aids that are available within these softwares. Limitations of the software for touch table environments could then lead to possible software refinements being made for touch table use or identifying MSP software most suitable for use on a touch table. This research provides a starting template or methodology to carry out future research with SDSSs and collaborative geovisualization tools on touch tables.

Future research also aims to explore questions regarding the impact of touch tables on equitable decision-making. Does equality and equitability of technology interactions translate to a more equitable decision-making process? Furthermore, what advantages and disadvantages exist for individual task completion with multiple movable menus versus distributed task completion. Measuring impacts on group coordination and cooperation multiple with movable menus versus distributed interfaces may answer these questions.

Chapter 7. Conclusion and Research Directions

7.1 Summary of Results

A summary of results and major findings by research objective is given in Table 26. Fine scale measures using coding systems (Objective 1, Chapter 5) are useful for characterizing variations in group participation; however, the current coding system needs improvement. Fine scale measures of individual participation can indicate equality of participation which is useful for identifying the use of technology to support decision-making, limitations of the software interface design for supporting group work, and commenting on the equitability of participation. A detailed discussion on scales of measures follows in section 7.2. The results of the research from Chapters 5 and 6 demonstrate the strength of using fine scale measures of participation identified in Computer Science literature for Collaborative GIS research. Multi-user touch tables for MSP is also discussed in section 7.3, followed by future research goals and current practical applications of multi-user touch tables for MSP.

Table 26. Summary of Research Findings

Objective	Findings	Limitations	Future Considerations
Objective 1: Measure group level participation commenting on and evaluating coding systems as a method (Chapter 5).	-Technological participation is dominated by medium and individual technology use -Dialogue participation is dominated by high and medium group participation -Problem exploration is dominated by data/map exploration; generating options is dominated by add/edit feature Google Earth task.	-Coding system overestimated participation levels from role play simulation 6	-Multiple coders and inter-coder reliability testing -Coding systems need a quantitative intensity measure for dialogue, technology interactions and Google Earth tasks to improve objectivity -Group level indicator to assess number of participants when comparing technology and dialogue -Sensitivity testing of coding time segments and participation levels
Objective 2: Measure individual participation related to Google Earth interfaces to determine accessibility of interface features by seat location (Chapter 6).	-Technology interaction by seat location exhibits low to moderate inequality; dialogue by seat location exhibits low inequality -Participant perceptions	-Seat locations constrain personal space -Caution should be exercised with results by seat location, as participant personality, role, experience with	-Use personality test to control for personality -Design a decision-making task independent of roles to eliminate effect role may play

Objective	Findings	Limitations	Future Considerations
	of participation deviate from quantitative measures of interaction -Menus and dialogue boxes exhibit high index of inequality results by seat location; earth display has low index of inequality by seat location -Error by seat location is similar	technology and domain expertise were not controlled in this experiment	-Choose participants that have similar technology experience level and domain expertise -Assess distributed task completion across the interfaces versus individual participant menu control

7.2 Scales of Collaborative GIS Measures

Collaborative GIS has focused on coarse-scale *process* and *outcome* measures of group use of GIS, rather than fine-scale *process* oriented measures (Figure 29). Three constructs are developed by Jankowski & Nyerges (2001a) to describe research objectives in Collaborative GIS, which are convening constructs, process constructs, and outcome constructs. These constructs can be measured as a process and/or the outcome of the construct can be measured. The theoretical framework of East2 proposed by Jankowski & Nyerges (2001a) to situate Collaborative GIS research consists of three constructs: *convening* constructs that frame how groups are brought together, such as the people and organizations participating, technology that is available for the process and any political and social constraints that dictate the proceedings; *process* constructs frame the group's Collaborative GIS proceedings and include how the group uses the technology, the structure of the decision process that develops and any products that are created by the group's process such as maps or tables; and *outcome* constructs frame results of the decision tasks and the nature of the social relationships that developed from the Collaborative GIS process (Jankowski & Nyerges, 2001b). For example, one can measure the process of choosing participants and Collaborative GIS technologies for a Collaborative GIS workshop in the convening construct; or one can measure the outcome of the convening construct by merely naming the participants selected and software chosen without any context as to *how* they were chosen. For process constructs, which this research focuses on, the process of the process construct of the Collaborative GIS workshop and the outcome of the Collaborative GIS workshop can be measured. Most

Collaborative GIS research with questionnaires has captured coarse-scale measures of big-picture results of the *process* or *outcome* constructs (Salter et al., 2009; Balram et al., 2004; Faber et al., 1995). Nyerges and Jankowski themselves (Jankowski & Nyerges, 2001b; Nyerges et al. 2006) have focused on both fine scale measures using one minute video segments to code group use of decision aids, decision phases and group conflict of the Collaborative GIS process; as well as, coarse-scale measures of *process* constructs related to number of options groups generate. This research measured process at an even finer level than Nyerges et al. (1998, 2006; Jankowski & Nyerges, 2001b) did, by looking at frequency of interactions for each individual participant and using 15 second segments of the process rather than one minute. Fine scale measures (the sinusoidal dashed lines in Figure 29) can capture detailed nuances in group and individual interaction with technology that may not be captured by coarse-scale measures of group process and outcomes (depicted as a single solid line in Figure 29).

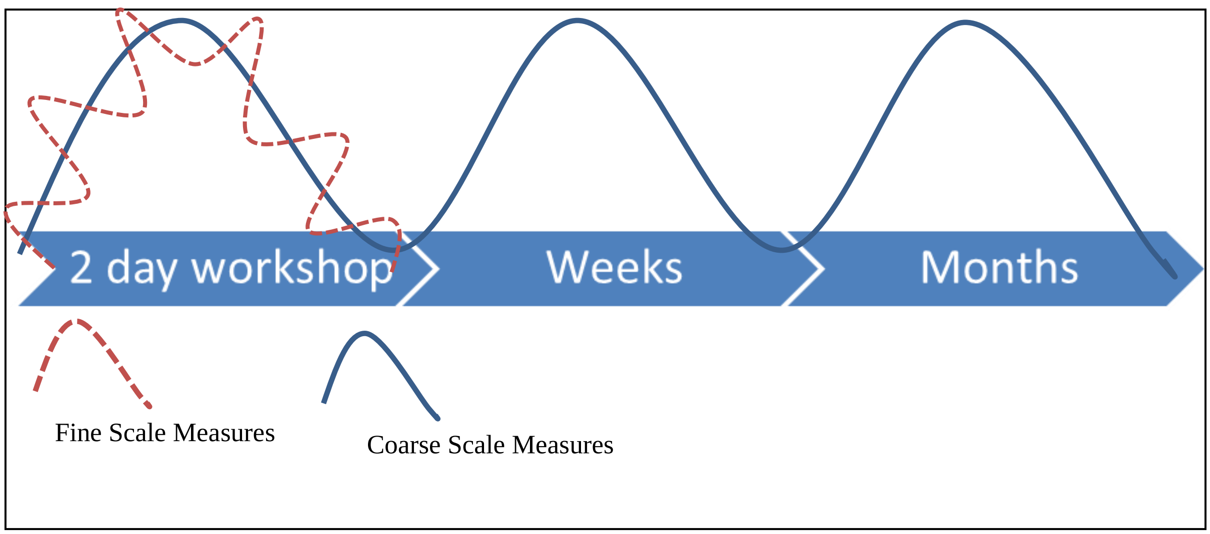


Figure 29. Scale of Collaboration Measures

Another scale of measures explored was group versus individual participation. When coarse-scale measures are used to explore group process and outcomes, the results are usually generalized at the group level. Nyerges et al. (1998; Jankowski & Nyerges, 2001b) study on habitat site selection only coded fine scale measures of the group process when there were four out of five participants with head directed awareness at technology or other participants, which diminishes the importance of natural fluctuations in participation for a group's decision-making process, missing finer nuances in participation. Likewise, Nyerges et al. (2006) water resources decision-support study used paired groups versus one large group to measure fine-scale and coarse-scale process and outcome constructs, missing the role that individuals play in contributing to the group. By measuring levels in group participation and individual contributions to the group a more detailed view of group participation with technology can emerge

7.3 Multi-User Touch Tables for Marine Spatial Planning

MSP is inherently map-based. Stakeholders can be actively engaged with maps by using maps to communicate biological, physical and social data. Having stakeholders generate their own spatial data on human uses of seascapes, and by having stakeholders submit their own spatial plans (Ehler & Douvere, 2009; Pomeroy & Douvere, 2009; Merrifield et al., 2013). Multi-user touch tables can be used as an interactive MSP tool. The multi-user aspect of the table promotes equality in technology interactions that may influence equality of participation verbally and in the overall MSP process. In most of the role play simulations, more technology interaction translated to more verbal participation by individuals. Technology and processes that actively engage participants ensure that stakeholders concerns can be heard and addressed.

Previous literature using multi-user touch tables demonstrates participants have positive experiences with touch tables in planning exercises (Alexander et al., 2012; Arciniegas & Janssen, 2012). Alexander et. al (2012) reported that 70 percent of participants found the touch table easy to use in their workshop siting tidal energy arrays; all participants agreed the workshop method was a good way to address local MSP. Arciniegas and Janssen's (2012) results are even more supportive of the use of touch tables as a planning tool. Seventy percent of their participants preferred the touch table over paper maps that were used with 80 percent of participants agreeing that the touch tables were more beneficial than paper maps because of the ability to turn on and off data and merge that data at different scales and levels of detail (Arciniegas & Janssen, 2012). Furthermore, 80 percent of participants thought "the touch table helped increase their awareness of new aspects of the region's problems and different standpoints, as well as scopes of other stakeholders," (p. 337). These findings demonstrate multi-user touch tables are an effective tool to promote stakeholder interaction and engagement in MSP.

This research demonstrates that multi-user touch tables may have limitations in its ability to accommodate equality of technology interactions due to the design of desktop geovisualization software, like Google Earth. It is unknown whether the inequality of interactions by seat location promotes group cooperation at the expense of individual participant control of spatial data and tasks. It appears that more technology interactions co-occurred with higher rates of verbal participation, which suggests that participants placed in marginalized seat locations may have less participation in the planning process on touch tables. However, high group cooperation existed in two role play simulations because participants had to work together to complete tasks, suggesting distributed tasks on touch tables may promote a sense of cooperation amongst stakeholders in the planning process. Future research endeavours to explore the differences in distributed tasks on touch tables versus group interactions with individuals controlling their own interfaces.

A Collaborative GIS MSP activity is only a small part of the overall MSP process. Other aspects of the MSP process involve the overarching political and environmental management constraints, such as the involvement of city, provincial and federal politics and actors. This may consist of private and public hearings, stakeholder identification, networking and outreach activities to inform and consult stakeholders, etc (Ehler & Douvere, 2009; Pomeroy & Douvere, 2008). Embedding the process of measuring Collaborative GIS MSP activities into an evaluation of the overall MSP process may contribute to advancement in assessing equitability of stakeholder involvement in MSP processes, by contributing measurements of stakeholder collaboration. This would fill gaps in Collaborative GIS research deficient in developing theories around structuring collaboration around GIS; and address gaps in MSP stakeholder engagement.

7.4 Future Research and Current Practical Applications

Future research endeavours to: improve and expand coding schemes; explore the use of other GIS and geovisualization software on touch tables, such as SeaSketch; extend fine-scale, process-oriented quantitative measures to web-based MSP forums; and explore interface design in relation to measuring distributed, collective group tasks versus individual participant control of tasks. Current practical considerations for MSP on touch tables is also discussed.

7.4.1 Future Research

Improvements and Expansion of Coding Systems

Improvements to current group participation coding systems include:

- Multi-coder and inter-coder reliability testing
- Developing an intensity measure to more objectively assign Google Earth task codes
- Developing a code based on quantity of participation (intensity measure) rather than degree of participation
- Attaching a group level indicator to bridge technology participation and dialogue participation. For example, if two people engaged in dialogue (medium participation) and two people interacted with technology in the same 15 second segment, was it the same two individuals? or all 4 participants? The latter indicates a higher degree of group collaboration.
- Performing a sensitivity analysis on the high participation code and the time segments

Whereas, expansions to the coding systems include:

- Developing coding systems that also analyze quality of dialogue and decision-making activities
- Developing a GIS coding system with high external validity across softwares, such as Google Earth, ArcGIS, and SeaSketch. For example, the tasks in the Google Earth coding system can be used in ArcGIS. However, ArcGIS would need new codes to accommodate the technologies abilities to spatially analyze phenomenon. Potential codes could include: Spatial query, attribute data, buffer analysis, etc.

GIS and Geovisualization Software

In the absence of GIS and geovisualization software designed for touch tables, identification of user-friendly softwares and potentially creating multi-user touch table add-ons or extensions to current software may be pursued. Current identified software includes: Google Earth; ArcGIS; and SeaSketch.

- Google Earth may require a multi-user touch table extension to accommodate individual task completion by seat location; such as a palette that allows each participant the ability to turn on/off menus and add/edit features without the user needing to reach into the personal workspace of others.
- A multi-user touch table extension has been developed for ArcGIS but requires testing. The extension allows each seat location to have its own palette to add features and change symbology allowing for individual task completion and participants working in parallel with one another. However, turning on/off layers and running spatial queries and spatial analyses are still limited by desktop design.
- SeaSketch appears to be user-friendly on touch tables with larger button sizes and may accommodate co-located and online collaboration on a multi-user touch table. It also has task/menu options on the right side of the display instead of the left, which is unique in design and may facilitate collaboration differently.

Collaborative GIS in Online MSP Applications

Current measures that were designed to collect data on collaboration on multi-user touch tables can be adapted to measure collaboration in web-based MSP applications, such as SeaSketch. Technology interactions can be captured with computer logging of participants interaction with software, and possibly aggregated by stakeholder type or concern, such as conservation, recreation, fishing, etc. Dialogue can be captured by counting number of words typed in the online web forum. Coding systems can be used to analyze typed dialogue into categories to assess group conflict and quality of decision-making.

Distributed Task Completion Versus Individual Task Completion

Determining the benefits of software design that promotes cooperation and coordination of participants working together to complete tasks versus software designed that allows each participant to work independently and possibly in parallel may inform software design for MSP activities on touch tables. Collaboration may be improved with software that promotes coordination and cooperation by reducing group conflict and increasing consensus (Nyerges, et al., 2006). However, individual task completion with software that allows each user to have their own menu palette might increase fairness and equitability of the group's process by ensuring each participant has the ability to control data, add data, and perform analyses. A comparative study of group work strategies would demonstrate advantages and disadvantages to these different software designs.

7.4.2 Current Practical Applications

Currently it is possible to perform Collaborative GIS MSP activities on multi-user touch tables, evidenced by a real world MSP activity that occurred in April of 2011, as well as case studies by Alexander, et al. (2012) and Arciniegas and Jannsen (2012). Based on anecdotal evidence from that workshop, the following should be addressed and considered when holding real world MSP activities on multi-user touch tables:

- Ensure participants have adequate time to get acquainted with the technology and software to increase participants' sense of comfort.
- Ensure participants have the ability to use both mouse and touch input, as well as a manual keyboard.

- Use a facilitator to guide participants use of the touch table to ensure tasks get performed smoothly and without frustration
- Have documents accessible electronically so participants can easily toggle back and forth between the GIS or geovisualization application and the text document

Challenges exist in capturing fine scale measures for real world MSP activities on multi-user touch tables. The main consideration is that participants may hesitate to be video taped due to sensitive work or political issues. A computer logging application could eliminate the use of video for capturing fine scale measures, however, participants may still be adverse to having audio taken. A wealth of future research opportunities exist to examine Collaborative GIS for real world MSP activities.

7.5 Conclusion

The strength of this research is in advancing methods for measuring collaboration with GIS and exploring applications of multi-user touch tables for MSP. Previous Collaborative GIS research has relied upon qualitative questionnaires and has lacked quantitative measures such as frequency of interactions. Studies have demonstrated that deviations exist in the way participants perceive their interactions versus what actually occurred (Fernquist, 2010; Marshall et al., 2008); furthermore, Collaborative GIS studies have emphasized outcome measures rather than process measures. Capturing fine-scale quantitative process measures with coarse-scale outcome measures and participants perceptions of the group's decision-making process with GIS can give a truer representation of the technology's impact on decision-making. By measuring the quantity and quality of collaborative spatial decision-making, the true support capacity of GIS software and hardware-like multi-user touch tables-can be identified and used to structure more engaging and effective participatory MSP processes.

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Appendix 1: Role Play Simulation Instructions

Role Play Simulation: No-take reserve areas proposal in the Strait of Georgia National Marine Conservation Area	
Context	You have been invited to a stakeholder workshop to discuss the locations of No-take marine reserves within a proposed National Marine Conservation Area in the Strait of Georgia.
Objectives	Identify 2 no-take marine reserves that meet the following guidelines: • Must not overlap with any other existing marine or terrestrial protected areas, but may border them. • As spatially aggregated as possible (as opposed to units that are dispersed individually across the study area). • Maximize conservation features while minimizing socio-cultural and economic costs. • Minimum size of each no-take reserve should be the area of at least 4 whole grid cells of 2 km by 2km, although partial planning units can be used to comprise the 4 square kilometers. Protect your interests while at the same time working collaboratively with other stakeholders (who may have competing interests).
Workshop Preparation	Participants were instructed to review their stakeholder role play sheets and using their paper maps of their data, identify areas of inclusion or exclusion that supported their stakeholder objectives.
Workshop Agenda	Workshop Introduction • Facilitator presentation • Fill out a pre-simulation questionnaire • Introduction to Google Earth and touch table technology Problem Exploration • One by one, each stakeholder shared their role's objectives and spatial data in Google Earth on the touch table • Participants were told to verbally share their identified areas of inclusion or exclusion, or to visually share these areas by drawing points, lines or polygons in Google Earth. Generating Options • After each stakeholder has shared their information, the group will discuss areas that fulfill the no-take reserve areas guidelines, identifying two potential no-take marine reserves within the study area. Evaluation • Upon completion of the role play simulation, participants filled out a post-workshop questionnaire regarding their experience.

Appendix 2: Questionnaire

Participant Questionnaire

Spatial Decision-Making with Touch Tables

Caty Brandon, MSc
CORAL Group

Participant Role:____

Date & Time of Study:____

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A. Experience Using Map Environments

1. How often do you use Google Earth?

☐ Never ☐ A few times a year ☐ A few times a month ☐ A few times a week

2. How often do you use Touch Interfaces (cell phones, ipads, etc.)?

☐ Never ☐ A few times a year ☐ A few times a month ☐ A few times a week

3. How often do you use Paper Maps?

☐ Never ☐ A few times a year ☐ A few times a month ☐ A few times a week

4. How often do you use online digital atlases and maps (Google Maps, Yahoo Maps, etc.)?

☐ Never ☐ A few times a year ☐ A few times a month ☐ A few times a week

B. Knowledge Discovery

5. After viewing your role's materials and watching the introductory video, share what you understand about *your* role's spatial data and areas of interest and/or conflict.

6. Having participated in today's role play simulation, share anything new that you understand about *your* role's spatial data and areas of interest and/or conflict that you didn't know before.

- **What factors contributed to this new understanding?**

C. Options & Alternatives Generated

7. From your role's perspective, how would you describe your <u>overall satisfaction</u> with the quality of the No-take reserve options that your group generated?

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

8. How would you describe your satisfaction with the No-take reserve options that your group generated in terms of your group's ability to <u>maximize conservation values</u>?

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

9. How would you describe your satisfaction with the No-take reserve options that your group generated in terms of your group's ability to <u>minimize socio-cultural costs</u>?

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

10. How would you describe your satisfaction with the No-take reserve options that your group generated in terms of your group's ability to <u>minimize economic costs</u>?

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

D. Consensus

11. How would you describe your satisfaction with the <u>group's process</u> of evaluating options and alternatives for No-take reserves?

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

12. What was your level of agreement with your group's <u>first no-take reserve solution</u>?

☐ Completely Agree ☐ Somewhat Agree ☐ Neutral ☐ Somewhat Disagree ☐ Completely Disagree

13. What was your level of agreement with your group's <u>second no-take reserve solution</u>?

☐ Completely Agree	☐ Somewhat Agree	☐ Neutral	☐ Somewhat Disagree	☐ Completely Disagree

E. Participation

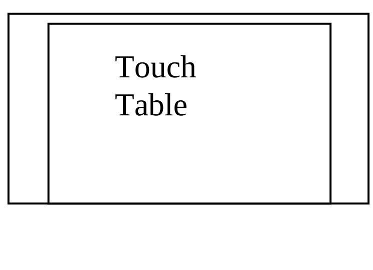
14. I had an equal opportunity compared with other participants to <u>interact with the Touch Table</u>. Please check the appropriate box.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

15. I had an equal opportunity compared with other participants <u>to share my perspective and address my interests verbally</u> during the "No-take reserve areas discussion"? Please check the appropriate box.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

16. Please indicate your seating location below with an "x".



17. In relation to your seating location around the touch table indicated above, how easy was it to interact with Google Earth using the following inputs?

Touch Input	Mouse Input	Preferred Input
☐Very Easy ☐Easy ☐Neutral ☐Difficult ☐Very Difficult ☐ N/A	☐Very Easy ☐Easy ☐Neutral ☐Difficult ☐Very Difficult ☐ N/A	☐Mouse ☐Touch Input ☐I only used: ☐Mouse ☐Touch Input ☐Equal Preference ☐ N/A

18. In relation to your seating location around the touch table, indicate your agreement level with the following statements:

a. My seating location around the touch table made it difficult for me to interact with Google Earth as much as I wanted to.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

b. My seating location around the touch table made it difficult for me to contribute to the discussion as much as I wanted to.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

19. Thinking about <u>your interaction with the touch table</u> and the interaction of the other participants, what percentage of total interaction with the touch table do you feel each participant contributed. (For example, if you feel all participants interacted with the touch table equally, award 25% to each participant). Write your percentage in the box below each participant.

Sport Fishing Rep	First Nations Rep	Conservation NGO Rep	Transportation Rep

20. Comment on what you think contributed to the levels of participation for each participant.

21. Thinking about the group's discussions and decision-making process, what percentage of the time do you feel each participant spent talking compared to other group members. (For ex, if you feel all participants talked an equal amount of time, award 25% to each participant). Write your percentage in the box below each participant.

Sport Fishing Rep	First Nations Rep	Conservation NGO Rep	Transportation Rep

22. Comment on what you think contributed to the levels of participation for each participant.

F. Touch Table

23. What do you think are the advantages of using touch tables in group collaborations for marine spatial planning?

24. What do you think are the disadvantages of using touch tables in group collaborations for marine spatial planning?

25. Please provide any other comments about your Experience.