1. INTRODUCTION

Computer-mediated collaboration has rapidly become a common human interaction method, and the proliferation of Personal Data Assistants (PDA) devices that use wireless technologies places the collaborators in an environment were dramatic differences in devices' computing capabilities exist. Besides the difference in computer power in the last years, a breach between the PDAs and workstations is expected to be present due to their mobility limitations. Some of these problems include battery constraints, network bandwidth, number of display pixels and speed. This breach creates heterogeneity between the different computer platforms possibly affecting the collaboration between these platforms.

We are envisioning a scenario where a person in the field has some form of a Personal Data Assistant (PDA) that contains a shared environment with another individual. This second individual in the dyadic communication is either located in the field, and thus, is equipped with the same form of display platform, a PDA, or in the office with a high-end workstation (we are calling this a PC). If the two individuals are communicating on the same type of platform, the platforms are *homogenous*. If they are using different platforms, the platforms are *heterogeneous*.

With the spread of wireless communication and the desire to travel light, a PC to PDA collaboration is a likely scenario for future work practices. For example, office workers might send reduced versions of spreadsheets or drawings to workers who are off site and work on a budget collaboratively. Although computer power is continuing to increase dramatically, there is likely to always be a significant difference between the PDA and the PC because of portability constraints placed on the PDA. This raises both technical and human communication issues given the limitations in computing power, bandwidth, display size and input capabilities of the PDAs. It is not a well understood problem how to build groupware that can accommodate such platform disparities while effectively supporting collaboration. In this thesis we examine one small part of the differences that are likely to exist between a PDA and a PC, differences in problem representations brought upon by display and computing power differences, and differences in work roles.

Display disparities can take different forms. They can result from the physical characteristics of display devices, such as size, color resolution, aspect ratio, and spatial distribution. They can also result from the way information is visualized, such as: dimensionality of visualization (2D vs. 3D), degree of compression, abstraction or summarization, and level-of-detail differences. Most display differences are a combination of the above factors.

Work roles can also be very different. They can be peer-to-peer where two people are of equal status, mentor-to-disciple, manager-to-employee, expert-to-novice, etc. Each of these roles embodies different protocol requirements for communication exchange as the collaborators follow standard cultural practices. For example, Wynn [35] found that an employee of lesser status in an office that needed to request a favor of an individual of higher status, repeated the request three times when following normal office protocol.

In this work we focus on two types of display disparities combined: display size and dimensionality of visualization (2D vs. 3D). Since these differences are inherent in the two platforms selected, we also have two variations in user input: the traditional mouse of the PC interface and the stylus of the PDA interface. Possible application scenarios where 3D support is likely to occur include training, equipment maintenance, and medical emergency support. We have chosen to compare the 3D-to-2D visualizations because the number of pixels and screen size of a PDA prevent it from adequately rendering a useful 3D display for many tasks. Nevertheless, this difference between the two visualizations is likely to have a profound effect on problem solving. In as simple a task as finding and selecting an icon on a screen display, Ark et al. [1] found that users with a 3D representation of the icons performed faster than an equivalent task with a 2D representation. This performance advantage was maintained over two days of trials. Because input device differences are also likely to have an impact, the input interaction was designed for both mouse and stylus actions to be point-and-click menu selections. In an earlier study [25], it was found that significant performance differences arose because of the differences in input devices. Although individuals in the 3D environment had a better view of the task, they were hampered in moving about the 3D environment because, even after training, they had difficulty controlling the 3D mouse.

1.1. Objectives

The main objectives of this thesis are:

- Examine the impact of collaboration platform differences on performance time.
- Determine if collaboration platform differences affects roles of participants.
- Determine if common grounding increases with platforms differences.
- Examine the effect of platform differences on communication around level of politeness and degree of collaboration.
- Investigate the effect of platform differences on partners perception of each other and of the collaboration task

1.2. Organization of the thesis

The remainder of this thesis is organized as follows:

- **Chapter 2** presents prior work that has been done on collaboration associated with unequal platforms. We show some of the most relevant research conducted on the Collaborative Virtual Environments field, and how this kind of environments support and impair collaboration. We explain the concepts of common grounding and politeness, and their relevance in an effective collaboration. Finally, we explain a methodology called Conversation Analysis and describe how this was used to analyze the conversational exchanges in this study.
- **Chapter 3** provides a description of the task we developed to capture the characteristics of a real world task but also allowed us to run our studies on the typical undergraduate subject pool available at a university. We called this application the Slow Tetris game. This chapter also describes the game domain layer and the network architecture beneath 2D and 3D applications.
- **Chapter 4** states the expected outcomes, and a detailed description of the study. This description presents an outline of the technical and experimental setup, and a detailed description of the experimental procedures followed in the different stages of the study.
- **Chapter 5** presents the analysis of the performance information gathered in the three different phases of the experiment.
- **Chapter 6** describes the coding scheme developed to describe in detail the communication exchanges gathered in the experiment. It also presents the statistical analysis of the coded data.

- **Chapter 7** presents the data obtained through the questionnaires administrated to the subjects at the end of the experiment. In addition, it presents graphs of the aggregated data from the questionnaire and a statistical analysis of those pictures that addressed performance differences.
- **Chapter 8** synthesizes and discusses the statistical results shown in chapters 5, 6 and 7.
- **Chapter 9** concludes by presenting the implications, limitations, contributions and suggested future work derived from this study.