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USER INTERFACES FOR SIMULTANEOUS GROUP COLLABORATION THROUGH MULTI-TOUCH DEVICES

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User Interfaces for Simultaneous Group Collaboration through Multi-touch Devices

In partial fulfillment of the requirements for the
Degree of Master of Science in Technology

A Directed Project Report

By

Frank Joseph Garofalo

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Prof. Terry L. Burton	*[signature]*	7/12/10
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USER INTERFACES FOR SIMULTANEOUS GROUP COLLABORATION
THROUGH MULTI-TOUCH DEVICES

A Directed Project Report

Submitted to the Faculty

of

Purdue University

by

Frank Joseph Garofalo

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science in Computer Graphics Technology

August 2010

DEDICATION

To my parents and brother: Russ, Ellen and Matthew. For their continuous love and support over the years, to push me to achieve whatever I set my mind to.

ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

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Through a qualitative investigation using the phenomenological approach, this research study will explored the lived experience of individuals using a multi-touch interface and device for a group collaboration activity in a shared workspace. The research question was "what is the experience of users interacting simultaneously to complete a common task, with the display output of a multi-touch device?" Two rounds of user testing of approximately three participants for each respective round, performed a Six Sigma Affinity Diagram exercise using a multi-touch device. The exercise was a brainstorming component to the Six Sigma process in which qualitative data is sorted into groupings to be categorized. A moderator certified as a Six Sigma Green-Belt facilitated during the Affinity Diagram exercises. Participants of each testing round were individually interviewed by the researcher. All participants attended a focus group session for their respective testing round. The moderator was interviewed after each round and attended both focus group sessions. The described experiences were compared to the context-awareness indicators of Hornecker et al. (2008) for team collaboration. The results of the study indicate that participants increased their level of awareness of each others' actions. The multi-touch provided visual benefits where all participants could observe both the data and the actions of the other participants. Some challenges were experienced by the participants such as touch sensitivity of the multi-touch device used in the study. This study offers recommendations for future multi-touch research and financial implications for both research and industry. A Provisional U.S. Patent #62/327,354 was filed in April 2010 for the hardware device developed

during this study. Also a technical article was published on the Adobe Developer Connection web site, in the Education Developer Center category, entitled "Adobe AIR and Multi-touch for Multi-user Collaboration" (http://www.adobe.com/devnet/edu/articles/frank_garofalo.html).

SECTION 1. INTRODUCTION

The introduction provides the details in order to establish a basis and foundation on which this study has been built. The details cover the topics of: scope, significance, definitions/glossary, assumptions, limitations, and delimitations.

1.1. <u>Scope</u>

With the emerging technology of multi-touch devices enabling users to interact simultaneously with the display output of the device, what is the experience of those users? Especially during the 2008 presidential election many news media channels explored emerging technologies to display different perspectives of the political campaign to their viewers. Several channels turned to multi-touch devices. However, it was noticed that in many situations it was one individual interacting with the multi-touch device. Often these individuals would take advantage of the device by having multiple simultaneous points of contact, such has using more than one finger to zoom into a map or image. The true capabilities of multi-touch were not being utilized with one user when the device can handle multiple users interacting all at once.

This led to the pursuit of capturing the user experience of multiple users interacting with a multi-touch device. A software application for the users to perform a task while interacting with the device was needed. The Six Sigma Affinity Diagram exercise was selected due to its characteristics of multiple individuals interacting simultaneously as well as having the individuals move note cards attached to a wall. These are conditions that can be replicated in a multi-touch device environment. There are several Affinity Diagram software programs currently available on the market. Each of the software programs were created for the desktop PC model of a single display with a keyboard and mouse input. This does not capture the true essence of having the

Affinity Diagram participants simultaneously move the elements with the ideas/concepts into categories. Multi-touch solves this limitation presented by the desktop PC.

A target audience of five or six participants were selected to perform the Affinity Diagram exercise as following the standard process for performing such a process. First the researchers conducted a brief interview of each participant to determine the participants' prior experience Affinity Diagram exercise. Also a moderator for the Affinity Diagram exercise was selected and was required to have had prior experience with an Affinity Diagram exercise process. Second the participants were given a verbal explanation by the researcher of how the logistics of the multi-touch device operates. This explanation was described to the participants the acts of using gestures with the multi-touch device. Next the participants began the Affinity Diagram exercise by having the participants begin grouping the ideas. The ideas displayed on the sticky notes were provided in advance and pre-populated on the sticky notes. The context of the ideas were related to the real world brainstorming needs of the participants and their respective departments. While the participants are performing the task, the researcher documented observations. The initial behaviors the researchers looked for included reaction time, interaction, errors, and user frustration. Following the Affinity Diagram process the researcher will interview each participant independently to record the participants' descriptions of their experience.

1.2. Significance

Multi-touch devices provide a new model for interactivity with group collaboration. While this provides new opportunities, it also incorporates challenges, especially because users will be sharing the same display output of the device. Users are provided a more intuitive experience by interacting directly with the digital elements on the display rather than using a mouse and cursor. As this technology becomes more readily available, the goal for this study was to determine what the advantages and disadvantages were concerning the user experience in the specific environment of using a Six Sigma Affinity Diagram.

1.3. <u>Definitions</u>

ActionScript – the object-oriented programming language for the Adobe Flash Platform (Adobe Systems, n.d.; Natural User Interface Group, n.d.).

Adobe AIR – a cross-platform runtime for software applications developed with the Adobe Flash Platform to run natively on a desktop computer or mobile device and utilize connectivity with the internet (Adobe Systems, n.d., "Adobe AIR").

Adobe Flash Platform – a set of technologies and tools for building interactive applications for the web, desktop, and mobile environments (Adobe Systems, n.d., "Adobe Flash Platform").

Affinity Diagram – a Six Sigma exercise tool, created by Jiro Kawakita, used as a means of organizing data and ideas (Hallowell, n.d.).

Blob Detection – the infrared camera of a multi-touch device will recognize the bright areas of the video input created by objects or fingers of users making contact with the device (Natural User Interface Group, n.d., "Blog Detection").

Blob Tracking – A method was developed to assign a unique identifier to each blob detected (Natural User Interface Group, n.d., "Blob Tracking").

Community Core Vision (CCV) – formerly called t-Beta, an open-source cross-platform software derived from Touchlib to detect and recognize objects in contact with a multi-touch device and send out data about the objects detected using the TUIO protocol to software applications (Natural User Interface Group, n.d., "Community Core Vision").

Computer-support cooperative work (CSCW) – providing users with information regarding interactions other users have with a single computer application especially in a group setting with multiple users (Gross, Stary, & Totter, 2005, p. 1).

Multi-model – The ability for multiple users to interact with a computer simultaneously (Natural User Interface Group, 2008).

Multi-touch – the ability for a computing device to recognize multiple points of contact simultaneously (Han, 2006, p. 1).

Natural User Interface Group (NUI Group) - an on-line community to promote the collaboration of research related to interactive media and multi-touch technologies founded in 2006 (Natural User Interface Group, n.d., "About NUI Group").

Rich interactive applications (RIA) – software utilizing interactive elements and multimedia to provide a graphical user interface, deployed through the web to run on desktops or mobile devices (Tretola, 2008).

Six Sigma – a business methodology focused on data-driven decision making processes to strive for a measure of quality that nears perfection by reviewing processes in an attempt to remove all defects or errors that make occur during a process (iSixSigma, n.d.).

Table-Top User Interfaces Objects (TUIO) – an open-source protocol developed by the NUI Group to serve as a communication standard between the software application and the device hardware device by detecting and recognizing objects making contact with the surface of the device (Kaltenbrunner, Bovermann, Bencina, & Costanza, n.d., p. 1; Natural User Interface Group, 2009a).

Touch – the ability for a computing device to recognize input from a user through a method other than a manually held object, including but not limited to, a stylus or a computer mouse (Buxton, Hill, & Rowley, 1985, p. 216).

Touchlib – a multi-touch development kit that was first to use the TUIO protocol which detected and recognized objects in contact with the hardware device and sent data about the objects (position, orientation, and size) to software applications, such as Adobe Flash (Natural User Interface Group, 2009a).

1.4. Assumptions

The assumptions for this study are:

- The research participants were truthful about having previous experience with Six Sigma Affinity Diagrams.
- The research participants were truthful when describing their experiences from the testing conducted in this study.
- The research participants were able to describe their experiences to the researchers.

- The multi-touch device used for this study performed equally well for all participants.

1.5. Limitations

The limitations for this study are:

- The research participants were not be required to have any prior experience partaking in a Six Sigma Affinity Diagram exercise.
- The research participants were asked to share their experiences using touch and gestures on a multi-touch device only.
- The research participants were asked to share their experiences performing a shared task with other participants on a multi-touch device only.
- The research participants were volunteers and were able to drop out of the research study at any time.
- This study focused on the human-computer interaction between the participants and the multi-touch device, in addition to the human-human interaction on the shared workspace of the multi-touch device.
- The study made every effort to have an experienced Six Sigma Affinity Diagram moderator to facilitate the Affinity Diagram sessions.

1.6. Delimitations

The delimitations for this study are:

- This study did not assess a comparison between a live, traditional process for conducting a Six Sigma Affinity Diagram and using a digital (software) process for conducting a Six Sigma Affinity Diagram.
- This study did not assess the physical performance of the multi-touch device hardware.
- No research participants with disabilities that would prevent hand-eye coordination using the multi-touch device were selected.

1.7. <u>Summary</u>

The purpose of this section was to establish the level of knowledge for which this study is focused. The next section will discuss the existing body of knowledge related to the topic of this study.

SECTION 2. BACKGROUND REVIEW

The interest surrounding multi-touch devices and computer applications for such devices increased in 2006 with a presentation at the TED Conference by Jeff Han, a consulting research scientist at New York University Courant Institute of Mathematical Sciences (TED 2006 Conference, 2006). Since then many have conducted research on the various techniques to construct a multi-touch device. Others have conducted studies of the gesture actions users make while interacting with multi-touch devices. The ability for multiple users to interact with a computer simultaneously, such as with a multi-touch device, is referred to as "multi-model" (Natural User Interface Group, 2008). Several applications have been developed to showcase the capabilities of this "multi-model" form of input to a computer. Research of utilizing a multi-touch device for a group/team collaboration task will also be reviewed.

2.1. <u>Multi-touch Screen Devices</u>

Jeff Han, a consulting research scientist at New York University Courant Institute of Mathematical Sciences, is recognized as one of the leading content experts in the industry regarding multi-touch computing. The multi-touch device created by Han in 2005 takes touch sensing technology, which can recognize one point of contact, to the next level to recognize multiple points of contact simultaneously. These points of contact can include more than one finger at a time or even an object placed on the device. Han (2006, p. 1) describes this new model of touch sensing technology as "a very natural and intuitive way for people to interact." This now presents a new means of interactivity between humans and computers, which Han (2006, p. 1) describes as "enabling the user to finally interact with both hands at once, as well as employ more complex chording gestures, promising great improvements in usability, intuitiveness, and efficiency."

Now not only can one user be able to use both hands simultaneously and have an application respond accordingly, but more than one user can interact with the same application at the same time. Developers can now create applications with richer experiences for users, which can create an "inviting environment for multiple attendees to be able to walk up to and interact with the display" (Han, 2006, p. 1). He stated that this new means of interactivity fits naturally with applications for music, games, and entertainment where such applications will be able to "seamlessly accommodate multiple users either collaboratively or competitively" (Han, 2006, p. 1).

In addition to Han's research, several others in both industry and academia have taken interest in multi-touch devices. An on-line community to promote the collaboration of research related to interactive media and multi-touch technologies was founded in 2006 as the Natural User Interface Group (NUI Group). Today the on-line community has several open-source projects currently being developed with an emphasis on "machine sensing techniques" (Natural User Interface Group, n.d., "About NUI Group"). The goal of the NUI Group is to discover methods to utilize multi-touch applications for the areas of business, education and the arts. By focusing on discovering the most effective, budget-friendly solutions, the NUI Group's community projects are open-source. Two of the NUI Group projects which are used in this study are: T-Beta and Touchlib (Natural User Interface Group, n.d., "About NUI Group"). These two projects will be further discussed.

2.2. Types of Multi-touch Screen Devices

From the inspiration of Jeff Han's success in addition to the available resources provided by the NUI Group, the number of individuals experimenting with multi-touch technologies continues to grow, through this influx of interest several configurations have been developed. There are five primary multi-touch technologies: Frustrated Total Internal Reflection (FTIR), Diffused Illumination (DI), Laser Light Plane (LLP), Diffused Surface Illumination (DSI), and Capacitance Testing.

Regardless of the technology used for a multi-touch device the robustness of the system is critical. Over time with use the surface of the device in which the user

interacts, either with their hands or with objects, can become "contaminated with oils and sweat left behind from users, along with nicks and scratches, creating an increase in background noise against which a true signal must be isolated" (Han, 2005, p. 115). The background noise created detracts from the sensors, especially for the FTIR and DI methods, used to detect objects making contact with the surface of the device.

2.2.1. Frustrated Total Internal Reflection Method

The Frustrated Total Internal Reflection (FTIR) uses light generated by infrared light emitting diodes (LEDs) through a medium, such as acrylic also referred to as Plexiglas (Han, 2005, p. 115; Saffer, 2008, p. 15). This causes the light to be trapped inside the acrylic by internal reflection. Han (2005, p. 116) recommends using "high-power infrared LEDs" along all the edges of the medium. Once a finger from a user touches the acrylic surface the light is "frustrated," which results in the light redirected downwards to be sensed by an infrared camera (as shown in Figure 1).

Figure 1: Screen capture of a hand from an infrared camera
using the FTIR method (Natural User Interface Group, 2008).

This technique is currently the most popular, which can be attributed to the devices built by Jeff Han. The FTIR method, as described by Han (Han, 2005, p. 116), is "zero-force and true" meaning that it does not rely on pressure, although pressure can affect the accuracy of the contact area of the object. "True" refers to the ability to distinguish the difference between an object hovering over the surface versus an object

making contact with the surface (Han, 2005, p. 116; Natural User Interface Group, 2009b).
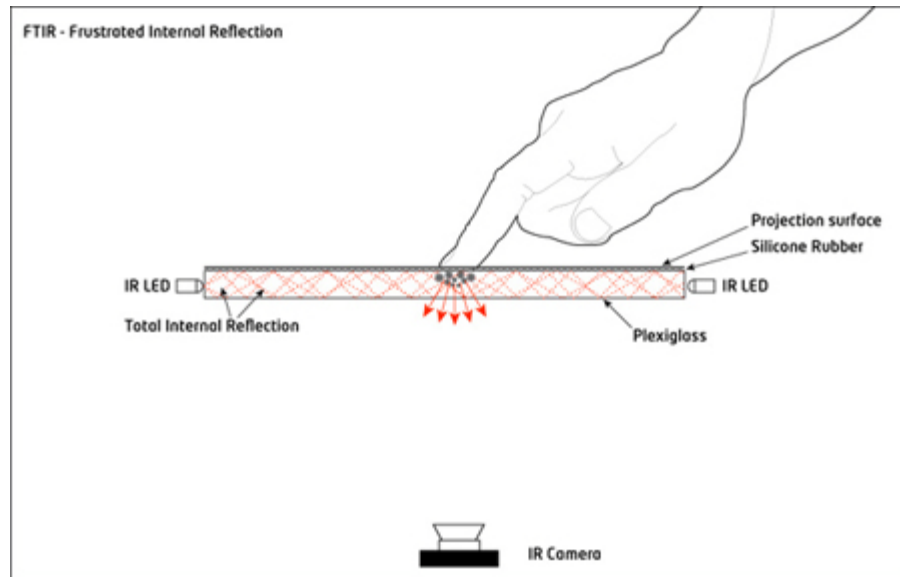
Figure 2: A diagram of the FTIR configuration
(Natural User Interface Group, 2008).

As shown in the Figure 2, there is a silicone rubber and a projection surface needed above the Plexiglas which is referred to as a "compliant surface." This serves the purpose of enabling the sensor to respond to force rather than just contact (Fantini, 2008; Han, 2005, p. 117).

2.2.2. Diffused Illumination Method

Diffused Illumination (DI) is a process in which infrared light is mounted either above or below the surface of the medium, in which either glass or acrylic can be used (as shown in Figure 3). The light is directed at the surface of the medium, when an object makes contact with the surface light is reflected, and detected by the camera (as shown in Figure 4). Variations of this method can also sense objects placed on the screen and objects hovering over the screen, depending on the diffuser used (Natural User Interface Group, 2009b, 2008; Saffer, 2008, p. 15). The ability to detect objects

making contact with the surface of the device provides several potential benefits over the FTIR configuration.
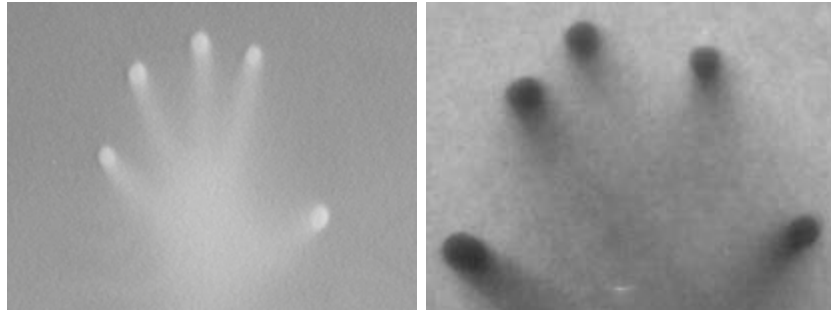
Figure 3: DI Rear Projection, left, and DI Front Projection, right (Natural User Interface Group, 2008).
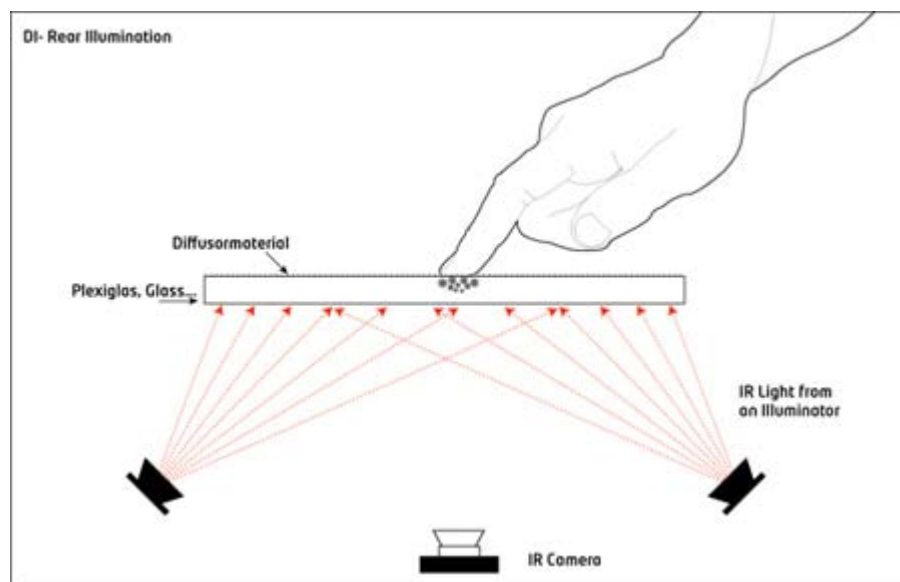
Figure 4: A diagram of the DI Rear Projection configuration (Natural User Interface Group, 2008).

The Microsoft (MS) Surface multi-touch device uses the DI Rear Projection method. As illustrated in a *Popular Mechanics* article by Glenn Derene (2007), the diagram in Figure 5 shows the top of the device with a diffuser which serves as a screen (highlighted as number 1 in Figure 5) with the multi-touch capabilities. Because the MS Surface is using DI Rear Projection, it can recognize objects placed on the screen of the

device based upon their shapes or by recognizing coded tags called "domino" (Derene, 2007). Also labeled in Figure 5, item number 2 is what Derene (2007) refers to as the Microsoft Surface's "machine vision," which is an infrared beam of 850 nanometer-wavelength LED lights that are directed at the screen. Number 3 is the device's computer central processing unit, commonly referred to as a CPU. Finally, number 4 is a projector with a maximum resolution of 1280 x 960 pixels. However, what is not labeled in the diagram are the four infrared cameras to capture the infrared light reflected off the screen by fingers of users and objects placed on the screen.
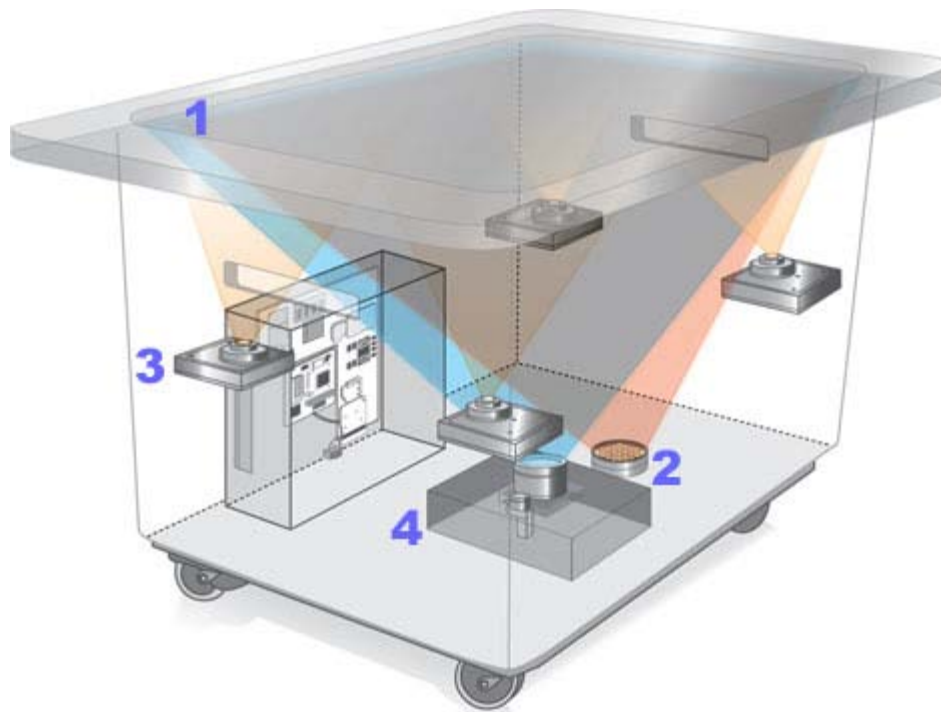
Figure 5: Diagram of a Microsoft Surface device.
Diagram created by Intoaroute (Derene, 2007).

2.2.3. Laser Light Plane Method

Laser Light Plane (LLP), also referred to as the Gap Method, uses a "wide baffle" located on around the outer edges of the medium, such as glass or acrylic, with space approximately 0.5mm between the baffle and the medium. This space, or gap, allows a small infrared beam to pass over the medium. When an object or user breaks the beam,

a camera mounted below the screen senses the infrared light. It is suggested that on all four sides of the medium LEDs should be mounted (Natural User Interface Group, 2008, 2009b).

2.2.4. Diffused Surface Illumination Method

Diffused Surface Illumination (DSI) is similar to the FTIR configuration with a series of infrared LEDs around the edges of the acrylic. However the primary difference is with the type of acrylic used called Enlightened Plexiglas. Within this type of Plexiglas are small particles serving as mirrors to bounce the infrared light across the acrylic (Natural User Interface Group, 2009a). The challenge with DSI is that Enlightened Plexiglas can be very costly to purchase.

2.2.5. Capacitance Testing Method

Capacitance Testing method senses an object or user touching the screen using a "complex electronical grid." This is the technology used for Apple's iPhone (Natural User Interface Group, 2008, 2009b). Due to the electronic grid in these devices, there is a high cost to producing these devices on a large scale.

2.3. Hardware / Software Protocols and Interfaces

Protocols have been developed enable multi-touch device hardware to communicate with software applications. One of the open-source protocols developed by the NUI Group is called Table-Top User Interfaces Objects (TUIO). The communication mechanism is defined by the NUI Group as "a simple yet versatile protocol designed specifically to meet the requirements of table-top tangible user interfaces" (Natural User Interface Group, 2009a). The project web site for TUIO describes the protocol and its application programming interface (API) as having the purpose of transmitting encoded data of objects on the surface of the device from a tracker device, such as an infrared camera, to a software application that is capable of decoding the protocols information packets and responding accordingly ("TUIO.org,"

n.d.). In other words, the TUIO protocol has two primary properties: first the detection, recognition, position, and orientation of objects placed on the surface of the screen; second the detection of the users' gestures on the surface of the screen and assigns unique identification numbers to each object (Kaltenbrunner et al., n.d., p. 1; Natural User Interface Group, 2009a). Originally developed by Martin Kaltenbrunner, Ross Bencina, Enrico Costanza, and Till Bovermann, it now has received adoption for a variety of multi-touch and tangible projects including Touchlib and T-Beta, both projects of the NUI Group. The TUIO protocol is based on the OpenSound Control framework which allows for several other programming languages to support the TUIO protocol. Included in the list of these programming languages is ActionScript, Java, C/C++, and C#, just to name a few (Natural User Interface Group, 2009a). OpenSound Control (OSC) was originally developed as "a protocol for the communication between controllers and sound synthesizers" (Natural User Interface Group, 2009b).

Currently there are two protocols extended from the TUIO protocol that helps to configure and calibrate the hardware of a multi-touch device. The first is called Touchlib, which is a multi-touch development kit including a library that uses the TUIO protocol. Touchlib communicates with software applications as it tracks blobs on the surface through an infrared camera. Then the information is sent to Touchlib compatible application, which responds to the multi-touch events detected. Applications built on the Adobe Flash platform can interact with Touchlib. At this time, Touchlib is only available on a Microsoft Windows operating system (Natural User Interface Group, n.d., "Touchlib").

The configuration application for the Touchlib development kit, as shown in Figure 6, is displayed in a series of windows. Going from left to right, top to bottom the windows are: Capture0, Mono1, Smooth2, BackgroundRemove3, BrightnessContrast4, Rectify5, myWindow, and Microsoft Command-Prompt, a window part of the Microsoft Windows operating system (Natural User Interface Group, 2008a). The "Capture0" display provides raw video received by the infrared camera of the multi-touch device. "Mono1" ensures the image is in the necessary format by using a filter to convert the raw video input into a grayscale image. Filtering out any background noise that may be captured in the video input is accomplished in the "BackgroundRemove3" window. The

threshold scale in the "BackgroundRemove3" window can amplify the filter's intensity on the video input. The "BrightnessContrast4" window, which is also referred to as *high-pass*, as the name implies provides controls for the brightness and contrast levels of the video input. "Rectify5" is the last filter applied to the video input which prepares the output as a black and white image for detection by the Touchlib library. The level scale controls the intensity of the filter from Rectify5 applied to the video input (Natural User Interface Group, 2008a).
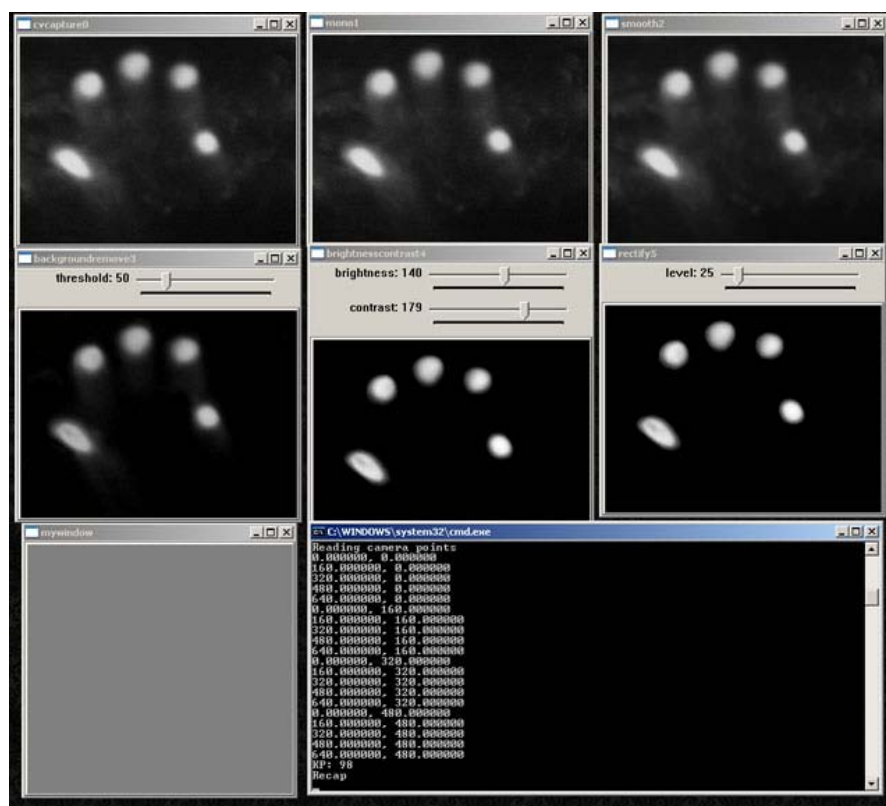
Figure 6: A diagram of the Touchlib interface
(Natural User Interface Group, n.d., "Touchlib Screenshots).

T-Beta (also written as tBeta), an abbreviation for "The Beta," is another protocol that utilizes TUIO. It is described as an "open source / cross-platform solution for computer vision and multi-touch sensing" (Natural User Interface Group, n.d., "Community Core Vision"). Recently the name of the T-Beta project has been changed to Community Core Vision (CCV). The T-Beta protocol is cross-platform, making it

capable of running on the three major operating systems: Microsoft Windows, Apple/Macintosh, and Linux. When using the T-Beta protocol filers, such as "dynamic background subtraction, high-pass, amplify/scaler, [and] threshold," enable it to be compatible with the following optical multi-touch technologies: FTIR, DI, LLP, & DSI. T-Beta can also take advantage of the computing resources of the GPU on the graphics card of the computer to increase the tracking of contact points (Natural User Interface Group, n.d., "tBeta"). T-Beta can communicate with applications built with ActionScript if the application has been developed to recognize data sent from T-Beta. Compared to Touchlib, T-Beta at times has been found to not be stable. Touchlib is a predecessor of T-Beta, which expanded upon the foundation Touchlib set by adding new features such as an improved configuration interface.
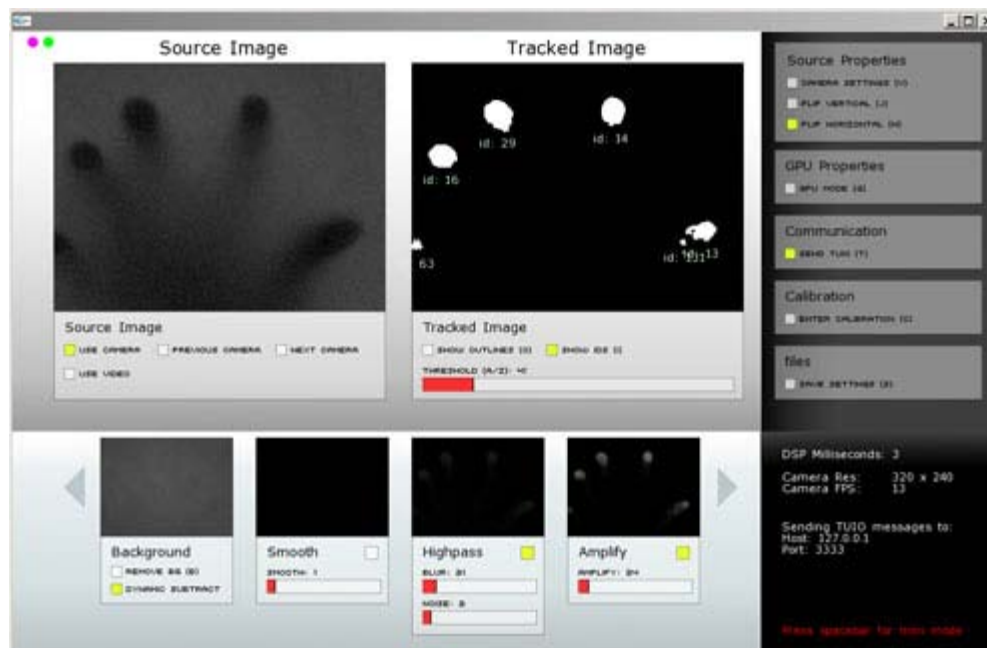
Figure 7: A diagram of the t-Beta interface
("Multitouch table: finger tracking," 2009).

In Figure 7 the "Source Image" on the left shows the raw video input captured by the infrared camera of the multi-touch device. On the right is the "Tracked Image" depicting the processed black and white image by tBeta to track the contact points on

the surface of the device. The four smaller images in the lower part of the diagram are similar to Touchlib. Going from left to right, the displays are: Background, Smooth, High-pass, and Amplify. Each of these serve the same control functionality as described for Touchlib. The menu of options on the right side of the diagram provides additional features for configuration. The top section, titled Source Properties, allows the user to control the infrared camera and flip the video input both horizontally and vertically. The next section titled GPU Properties will allow T-Beta to activate a GPU processing capability to use the graphical processor on the computer's video card. Activating the TUIO data sent by the T-Beta application is controlled in the next section, titled Communication. The Calibration section enables to user to enter into another mode of calibrating the resolution and number of detection points for the T-Beta application to sense contacts make with the surface of the multi-touch device. The last section gives the user the option to save the configuration and calibration settings (Natural User Interface Group, 2008b).

2.4. Current Use of Multi-touch Devices

As the popularity of multi-touch devices has increase, so have the uses that individuals, across several industries, have found for multi-touch devices. From entertainment to museums, uses for multi-touch devices are coming to the forefront. In movies such as the *Day the Earth Stood Still* a multi-touch device (the Microsoft Surface) is showcased when doctors are explaining medical diagrams (Havir, 2008). For television several entities have adopted the use of multi-touch devices, for example CNN using a multi-touch device during the U.S. Presidential election coverage in 2008. At the time, CNN referred to the device as the "Magic Wall" (Bradley, 2008; Farhi, 2008). Now CNN's meteorologists are using multi-touch device screens on a daily basis with their weather forecasts. Following the debut of the CNN "Magic Wall," NBC's *Saturday Night Live* included a multi-touch device during a skit to use a comedic-license regarding the use of a multi-touch device on CNN's election coverage. Also, ESPN's *Sports Center* has picked up multi-touch technologies to showcase draft picks and sports plays (Wilk, 2009).

Museums have embraced multi-touch devices to give their patrons a new medium to interact with exhibits. One such example is the Grammy Museum's musical multi-touch device allowing users to sort through pictures and songs from artists in a variety of genres ("The GRAMMY Museum - Exhibits," n.d.).

Looking forward into the future some movie magic gives hints at possible directions multi-touch technologies can go, such as Steven Spielberg's *Minority Report* which features multi-touch technology in combination with holographic displays (Torkington, 2008).

2.5. <u>Gestural Interfaces</u>

What distinguishes a touch device from other means of interacting with a computer, according to William Buxton at the Computer Systems Research Institute at the University of Toronto (Toronto, Ontario, Canada), is "that the user is not required [to] point with some manually held device such as a stylus or puck" (Buxton et al., 1985, p. 216). Buxton and his research team describe the difference from a one-touch device to a device capable of sensing "multiple points of contact" as unlike the one-touch device with a multi-touch device the location of items, such as fingers of users or items placed on the device, making contact with the device are recognized instantaneously. Some devices also have the capability to respond to the pressure the item exerts onto the device. Buxton (1985, p. 216) highlights the properties of touch-sensitive devices being ideal for "hostile environments" where input peripherals such as a computer mouse or stylus could become damaged, lost or stolen. He goes on to state that these devices "present no mechanical or kinesthetic restrictions on [a user's] ability to indicate more than one point at a time," thus enhancing the experience a user has with an application by allowing a user to have simultaneous points of contact with the device (Buxton et al., 1985, p. 216). As the device communicates with the application, the data sent back and forth can replicate the interaction that a one-button mouse provides to a user. However, Buxton (1985, p. 218) points out that the research does not signify that these devices are "equivalent or interchangeable," rather a touch device should be used where its

properties are beneficial for a user over a traditional means of input for a computer, such as a mouse, keyboard, or stylus.

To track the interactions of users with a multi-touch device, the infrared camera of the device will recognize the bright areas of the video input created by objects or fingers of users making contact with the device. This process is referred to as "Blob Detection" (Natural User Interface Group, n.d., "Blog Detection"). The different configurations of multi-touch devices are discussed in Section 2.2. Regardless of the configuration the process for each is the same.

Figure 8: Image showing blob detection from an infrared camera on a multi-touch device (Natural User Interface Group, 2009, "Multi-Touch Terminology").

Video captured by a camera is a series of frames of still images combined together immediately following each other in a chronological order. A method was developed to assign a unique identifier to each blob detected for each frame of a still image. Through the series of still images each blog is tracked with the unique identifier assigned. This method is called "blog tracking" (Natural User Interface Group, n.d., "Blob Tracking"). As each frame from the video source changes the blobs are compared to the previous frame to determine which blobs on the new frame belong to which unique identifier (Natural User Interface Group, n.d., "Blob Tracking").

Over the past few years the research and development of multi-touch sensing devices has increased in popularity. With these devices comes a new model regarding how a user interacts with computer applications, versus the traditional computer mouse and keyboard. The new model allows the user to use multiple fingers with a series of

movements, typically referred to as gestures. Multimedia applications need to be able to recognize this new form of input in order for the application to respond according to the user's interaction. One example of input techniques as used in an application called *RoomPlanner*, which was developed to aide people in planning the location of items in a room using a multi-touch device (Wu & Balakrishnan, 2003, p. 193).
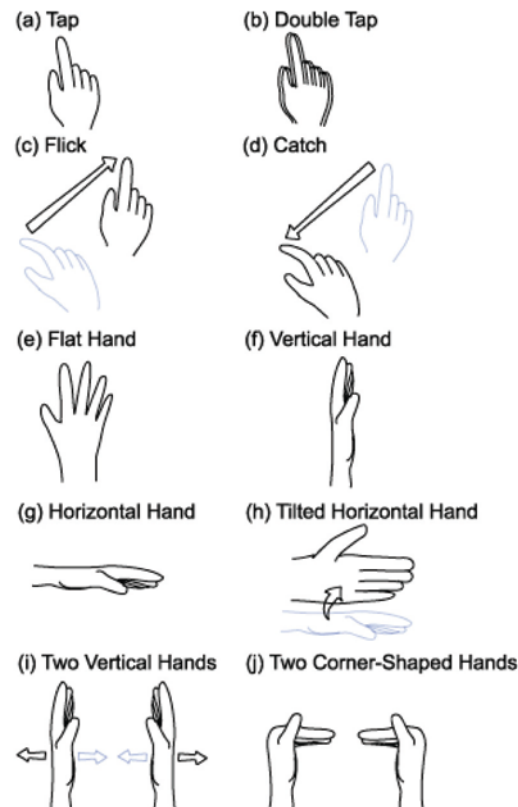
Figure 9: A set of gestures developed for the *RoomPlanner* application
(Wu & Balakrishnan, 2003, p. 195).

The gestures developed for this application are: tap, double tap, flick (tapping and dragging away from the user), catch (tapping and dragging towards the user), flat hand, vertical hand, horizontal hand, tilted hand, two vertical hands, and two corner-shaped hands, as shown in Figure 9. In this specific application, a double tap pops up a pie-shaped menu for the use relative to what the user is doing with options in the menu

to control the properties of a specific item. A single tap will select a menu option or select a specific item, depending on the context (Wu & Balakrishnan, 2003, p. 196).

In *Designing Gestural Interfaces* by Dan Saffer, he describes specific gestures for touch screen devices similar to those used in the *RoomPlanner* application. The first is called Tap which is the action of placing the "tip or pad of the finger" on the surface of the device for less than 100 milliseconds (Saffer, 2008, pp. 181-182). Similarly a Double Tap is as the name implies the act of performing a tap "twice rapidly with a [less than] 75-millisecond pause in between the two contacts" (Saffer, 2008, p. 181). Saffer recommends the use of these gestures for selecting items or buttons.
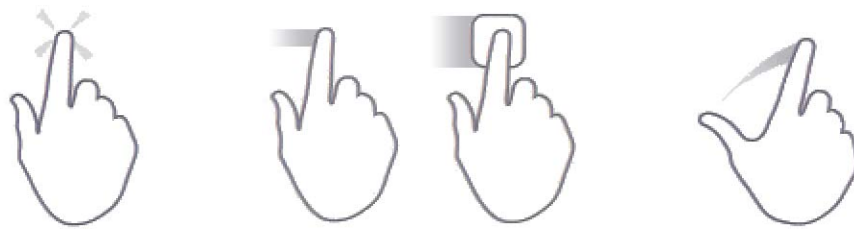
Figure 10: Common gestures used for touchscreen devices, part 1. From left to right: Tap, Drag/Slide, and Flick ("Fling") (Saffer, 2008, p. 181).

The second gesture is referred to as either Drag or Slide which occurs once the tip or pad of the finger makes contact with the surface and moves without loosing contact. Scrolling and a drag/drop sequence is usually associated to the drag/slide gesture. The next gesture defined by Saffer can be called either Flick or Fling. This action can be performed in one of two ways. The finger starts in a crooked position, then part of the finger makes a brushing motion lasting approximately 75 milliseconds as the finger straightens out. Another method of performing a flick occurs when the finger starts straight and moves in a reversed manner motioning toward the thumb as it makes contact with the surface for the same duration. This action is commonly used for objects to be quickly moved as well as to scroll.
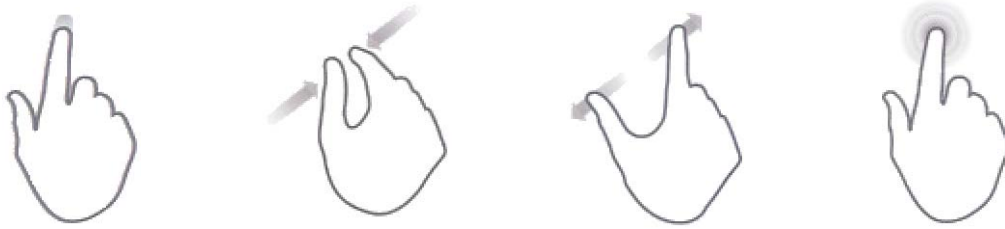
Figure 11: Common gestures used for touchscreen devices, part 2. From left to right: Nudge, Pinch, Spread, and Hold (Saffer, 2008, pp. 181-182).

The fourth gesture is named Nudge and is used to move objects a short distance. This gesture is simply to have the tip or pad of a straight finger make contact with the surface and briefly slides forward lasting no more than two seconds. Pinch is the next gesture described by Saffer, as two fingers, usually the index finger and thumb, move closer together. Scaling elements of an interface typically uses this gesture. The fifth gesture is called Spread which is similar to the Pinch gesture, however the two fingers move away from eachother. This gesture is also used for scaling. Finally, the last gesture defined by Saffer is referred to as Hold or Press. For this action the tip or pad of the finger makes contact with the surface of the device for a longer duration than Tap. Uses for this gesture include selection and scrolling for an extended period of time.

Saffer also describes in his book how direct manipulation of digital objects on a computer, without using the system's command lines, generates a more interactive experience for users through gestures of what is referred to as a natural user interface (Saffer, 2008, p. 15). He goes on to provide a list of best-practices for gestural interfaces referred to as affordances. Saffer defines affordances as "one or more properties of an object that give some indication of how to interact with that object or a feature on that object" (Saffer, 2008, p. 19). The characteristics Saffer defines are discoverable, trustworthy, responsive, appropriate, meaningful, smart, clever, playful, pleasurable, and good. "Discoverable" – indicating to the user that the device is touchable and interactive; "Trustworthy" – the user needs to feel a level of safety and security when using the device; "Responsive" – the device needs to provide on-going, preferrable in real-time, feedback to the user as an acknowledgement of the user's actions; "Appropriate" – the factors of culture, situation as well as context of the situation

where the user is engaging with the device should be taken into consideration; "Meaningful" – the actions and tasks the device asks a user to accomplish should aide the user in reaching the user's goal for engaging with the device; "Smart" – the device needs to be able to perform tasks for the user that are usually difficult or challenging for the user; "Clever" – the interface should be adaptive to the user's needs and be able to predict what the next needs of the user will be while interacting with the device; "Playful" – interfaces should be welcoming and promote the exploration of the user to try new features and use variations of gestures; "Pleasurable" – a positive experience needs to be provided to the user to increase the likelyhood of the user to engage with the device in the future; and "Good" – the interface should respect all possible users that will engage with the device as to not embarrass or offend any user (Saffer, 2008, pp. 19-22).

<h2 style="text-align:center">2.6. <u>Adobe Flash Platform</u></h2>

One of the interface technologies that both Touchlib and T-Beta can communicate with is Adobe Flash. Adobe describes their Flash Platform as "an integrated set of technologies surrounded by an established ecosystem of support programs, business partners, and enthusiastic user communities" (Adobe Systems, n.d., "Adobe Flash Platform"). At the core of the Flash Platform is the Adobe Flash Player, which is a free downloadable plug-in for users. According to Adobe, the Flash Player is "the de facto standard for rich applications, content and video in the browser… Flash Player is a high-performance, cross-platform client runtime that delivers powerful and consistent user experiences in the browser to more than 99% of Internet users" (Adobe Systems, n.d., "Adobe Flash Platform"). In addition to Flash's "visual programming interface," ActionScript is the object-oriented programming language for the Adobe Flash Platform (Adobe Systems, n.d.; Natural User Interface Group, n.d.). Another means of delivering content and interactive applications developed using the Adobe Flash Platform is through the Adobe Integrated Runtime (AIR). Adobe describes AIR as a "runtime" that allows developers familiar with web technologies to create applications that run on the desktop of a computer rather than in an Internet browser

(Adobe Systems, n.d., "Adobe AIR"). AIR provides a new channel for businesses to offer their customers engaging experiences across all major operating systems. Developers already familiar with Adobe Flash, Adobe Flex, or ActionScript 3.0 can be utilized to rapidly deploy applications using Adobe AIR.

Developing computer applications using technologies, such as the Adobe Flash Platform is referred to as "rich interactive applications" (Tretola, 2008). Tim O'Reilly of O'Reilly Publishing stated that Macromedia, now owned by Adobe Systems, originally coined the term "to highlight the capabilities of Flash to deliver not just multimedia content but also graphical-user-interface-style application experiences" (Tretola, 2008). Through an interview with Allen Lewis (2008) of eBay, Inc., who served as the project manager for eBay Desktop, Lewis shared his experience with the selection process his team used for choosing Adobe AIR. He described how his team wanted to offer eBay's customers a unique experience without reinventing the existing ebay.com web site. Lewis's experience using AIR improved the production pipeline process of his team by promoting new levels of collaboration between the traditionally silos of designers and developers.

Adobe posted a video in a digital publication, called *Inspire*, produced by the Adobe Experience Design team where Julie Meridian, Senior Experience Designer with Adobe, and Tim Kukulski, Senior Computer Scientist with Adobe, shares how Adobe sees the industry future for multi-touch devices (*Adobe and the future of multitouch*, 2009). Meridian (2009) describes multi-touch as "a way to help you get your idea in the form you wanted to faster." She goes on to state that some current touch technologies provide an indirect means of manipulating objects of an interface, however the best form of multi-touch - as discussed in Section 2.4 with Saffer's description of direct manipulation of interfaces. Meridian references the Steven Spielberg movie *Minority Report* with actor Tom Cruise and the computer system in which Cruise's character interacts as one of the movies that inspired research in the multi-touch field. She states that Adobe is hardware agnostic with the focus being on delivering tools and services that are cross-device and cross-platform. Kukulski highlights the challenge Adobe has had determining how multi-touch technologies will fit into the Adobe Flash Platform, as well as Adobe's other tools such as Photoshop and Illustrator. Meridian (2009) states

that "touch is encountered in our daily lives when we are doing simple things… multi-touch is just an extension of the touch technology, but it enables much richer interactions." Adobe foresees multi-touch technologies to enable users to work faster with computers, especially providing more accessibility to users with disabilities through gestural interfaces. Multi-touch is viewed by Adobe as an alliance between "hardware, industrial design, and software" (*Adobe and the future of multitouch*, 2009).

Richard Monson-Haefel, an award winning author as well as a multimedia designer and developer, sheds light on Adobe's commitment to exploring multi-touch technologies. In his professional opinion, once Adobe is able to release an ActionScript API for multi-touch devices, it will help Adobe to keep their market share based upon the vast number of developers currently using ActionScript through Adobe Flash (Monson-Haefel, 2009). At the 2009 Adobe MAX conference in Los Angeles, California Adobe announced a new multi-touch API for ActionScript to run a new the Flash Flayer version 10.1 and Adobe AIR 2.0 both set to be released in early 2010 ("Adobe Flash Platform Speeds Web Innovation Across Desktops and Devices," 2009).

2.7. Six Sigma Affinity Diagram

Six Sigma is a business methodology focused on data-driven decision making processes to strive for a measure of quality that approaches perfection. Through this model processes are reviewed to attempt to remove all defects or errors that may occur during a process. The Six Sigma methodology has saved companies hundreds of thousands of dollars by increasing productivity and efficiency (iSixSigma, n.d.). One of the many tools used with the Six Sigma methodology is called an Affinity Diagram, which serves as a means of organizing qualitative data and ideas. The Affinity Diagram, created by Jiro Kawakita, is achieved through a group exercise consisting of five or six people with one individual serving as a moderator (Hallowell, n.d.). To start the exercise an initial key phrase or topic needs to be defined by the participants that will serve as the overarching theme. Steven Bonacorsi (2008), a Senior Master Black Belt instructor and coach of Six Sigma, recommends that the results produced by the exercise will be

more effective if the key phrase is written loosely in broad terms (Arnheiter & Maleyeff, 2005, p. 7; Bonacorsi, 2008; Mind Tools, n.d.; Quinn, n.d.).

During the exercise there are typically three methods to generate issues, concepts, and/or ideas. The first is to silently have the participants record their ideas onto index cards or Post-it notes. The ideas recorded should include a few characteristics: concise with no more than seven words in length; direct and unambiguous; and limited to one concept per card. A second form of generating ideas is retrieving ideas collected by a qualitative survey with each idea on a separate card, following the same characteristics mentioned above. An additional form of generating ideas is to have the moderator record the ideas that each participant vocalize. While participants are performing one of these methods a few guidelines are recommended: everyone needs to be included; ideas should be recorded exactly as verbalized; criticism or discussion of concepts should not be allowed; and produce as many concepts as quickly as possible (Arnheiter & Maleyeff, 2005, p. 7; Bonacorsi, 2008; Mind Tools, n.d.; Quinn, n.d.).

Figure 12: Affinity diagramming process in the random ideas stage, using social media as an example. Diagram created by research team.

The next step in the exercise is to arrange all the cards randomly so that all the participants can view them as shown in Figure 12. Simultaneously each of the

participants will then silently arrange the cards that have a relation into groups. Forming the groups into vertical columns is the preferred method. As this occurs each card should remain visible and not be covered by other cards. Participants should freely exchange cards as they are clustering, which may involve participants silently disputing where some cards should belong. Some cards may need to belong in more than one group, which may create a connection between groups. If repetitive cards exist, the cards may be overlapped but in a fashion where it can still be read. Some cards may not fit into any group as the groups emerge and may need to remain independent. Cards should not be forced into groups. Once the groups and categories are formed as shown in Figure 13, discussion is now permitted with the participants.
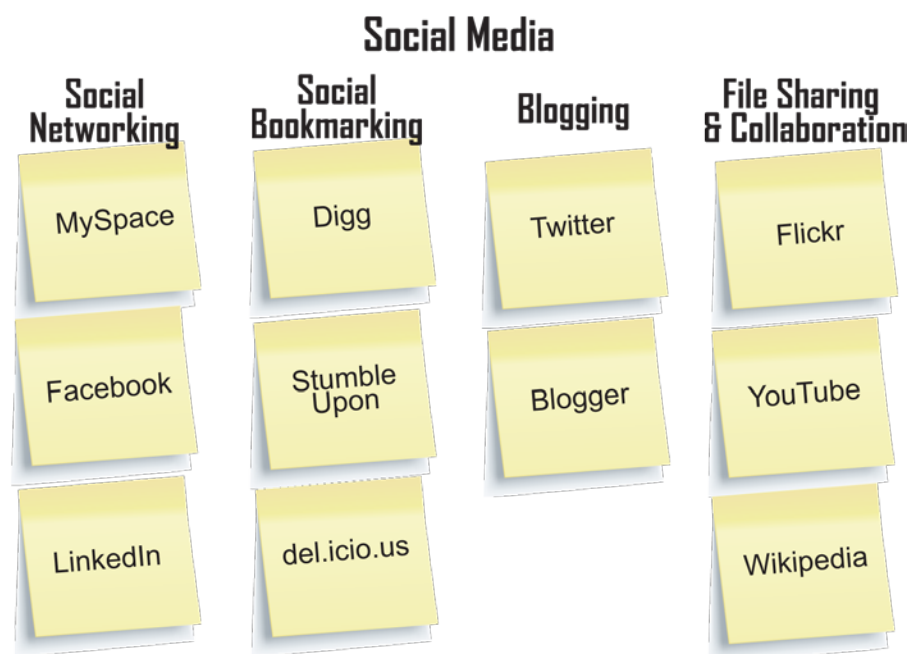
Figure 13: A completed Affinity Diagram, using social media as an example. Diagram created by research team.

Through this discussion a card that captures the central idea of a group should be used as the group header and moved to the top as a title. If a central idea does not exist on a card, a new card can be created (following the card characteristics already described) with a word or short phrase that highlights the intent of that category. If there

are large groups of cards that exist, these groups can be divided into smaller sub-groups each with their own headings. Over all there should not be more than ten groups created (Arnheiter & Maleyeff, 2005, p. 7; Bonacorsi, 2008; Mind Tools, n.d.; Quinn, n.d.).

By performing this exercise the categories of common themes may help to discover unseen relationships of the ideas. The focus of the exercise is to brainstorm solutions to the root cause of issues (Bonacorsi, 2008; Quinn, n.d.).

2.8. Six Sigma Affinity Diagram Software

There are currently a limited number of desktop-based software programs to perform Six Sigma Affinity Diagrams. One such program for creating Affinity Diagrams is a software package from Microsoft Office Labs called Sticky Sorter and is currently available to download for free. This program is especially useful when the data to be sorted is already a digital format. Compared to having to take the digital data and generate hard-copy in the past, tangible note cards / sticky notes for each item then to be placed onto a wall to conduct an Affinity Diagram. This can be quite a tedious process. Sticky Sorter allows for the data to remain in a digital format and generate an Affinity Diagram through the computer (Agarwal, 2008; "StickySorter," n.d.). The product features of Sticky Sorter include: importing and exporting data from CSV, Excel, and Access files; creating and labeling groups of items; displaying the information items in a structure format; creating customized views of the data; and the capability to work with large data sets ("StickySorter," n.d.). Some users of the software have found some issues with the program. A few did not like the aspect of the program automatically sending usage data back to Microsoft because the software was still in a "labs" / beta format. One comment mentions that Sticky Sorter needs to allow for more than one hierarchy when grouping notes. Also the same comment highlighted that the program currently requires each group to have a name, whereas with the Affinity Diagram process naming groups is not an initial requirement when forming the group. Another comment states that they could foresee using a program like Sticky Sorter on a multi-touch capable device (Agarwal, 2008). The program does not follow the true Affinity

Diagramming process because the software does not allow the participants to simultaneously arrange the notes into groups due to limitations with a desktop computer. However, a software program for an Affinity Diagramming process built to be used on a multi-touch device, as the researchers are proposing in this paper, would help to resolve the issue presented by Sticky Sorter.

Three other software programs for Affinity Diagrams were found; however, less detailed information was provided about each program from the respective developers. SmartDraw, which is a reputable company known for visual diagramming tools, also has a software program for creating Affinity Diagrams. SmartDraw's Affinity Diagram Software is available to download for free. According to the product description page, both Amazon.com (based on customer reviews) and CNET's Editor have rated the program with five out of five stars ("Affinity Diagram," n.d.). No information is provided about product features, such as importing and exporting data.

The third software system found for Affinity Diagrams is from QI Macros called Excel Statistical Process Control (SPC) Software for Six Sigma. QI Macros software package is a plug-in for Microsoft Excel using macros to enable a user to generate Affinity Diagrams from data already in an Excel spreadsheet. This is a time saving solution. There is a cost factor involved in acquiring the software of 139.00 USD. From the screen captures showcased, there seems to be a limitation of the software to producing visually appealing diagrams and charts (QI Macros, n.d.).

The final product found is the Brainstorm and Affinity Diagram Tool from PathMaker Software. This software package has its own means of data collection and the product description does not specify if data can be imported from outside sources. Grouping the separate ideas into categories is done through a spreadsheet-like interface, which is not graphically appealing. The diagram creation process uses another product feature from PathMaker called the Cause and Effect Diagram tool. This is what is actually used to create a flow chart display. The purchase price for a single license of the software is $179.00 USD (PathMaker Software, n.d.). .

2.9. <u>Group-based Behavior While Interacting with Computing Devices</u>

As a group of multiple users interact with a single computing device, several issues need to be addressed, for example awareness of information being displayed as well as simultaneous input into the device. The concept of computer-support cooperative work (CSCW) describes how computer applications can be designed to "provide users with awareness information" especially for a group setting of multiple users (Gross et al., 2005, p. 1). Stewart defines single display groupware as an extension of computer-supported cooperative work (CSCW) focusing on "computer programs that enable co-present users to collaborate via a shared computer with a single shared display and simultaneous use of multiple input devices" (Stewart, Bederson, & Druin, 1999, p. 286). Certainly multi-touch devices fall into the Stewart's description for single display groupware.

Morris (2004, p. 262) describes when multiple users are interacting with a single display system traditional "social protocols," as they define as standards of polite behavior, are not always enough. Morris goes on to suggest incorporating "coordination policies" for a group of individuals using, for example, a multi-touch device with a shared single display (2004, pp. 262-263). To highlight a few of the coordination policies that are examples of these polices applied in a scenario to that being proposed for a Six Sigma Affinity Diagram session. The first would be implementing the "rank" policy to determine who the moderator of the Affinity Diagram session is versus who the participants are. The second example can be using the "tear" policy when a conflict between two individuals over a digital object (with an idea or concept on it). The moderator can then split or "tear" the single object into two duplicate objects to be placed into two different groupings / categories (Morris et al., 2004, p. 264). As participants in the Affinity Diagram session interact with the shared digital objects on a multi-touch device these polices can aid in developing the software interface for the multi-touch device. Conflicts may occur between participants as "they attempt simultaneous incompatible actions" with the digital objects within a single display groupware (Morris et al., 2004, p. 262; Stewart et al., 1999, p. 290).

When working in a collaborative environment with a shared computing device, individuals need to have an awareness of the activities of the other individuals in the

group. Providing a group shared feedback based upon one individual's actions keeps the entire group informed of each other's actions. This method prevents having to restrict actions of certain individuals while others are permitted to perform actions. It is also less strong of a means for notifications since individuals are enabled to quickly glance at the shared feedback and focus on only those with the most relevance to them (Dourish & Bellotti, 1992, pp. 109-110). Developers of groupware systems need to perform a review of the tasks the system will require users to complete and determine throughout each step of the task what awareness information should be made available. This needs to take into consideration strategies users may employ to complete the task (Gutwin & Greenberg, 1998, p. 515). Tasks that may appear obvious to the groupware developer may prove to be a challenge to users. This is especially true with the new interaction levels of multi-touch devices. By conducting user testing, these unforeseen interaction challenges can be revealed (Everitt, Forlines, Ryall, & Shen, 2004, p. 2). Through this process usability of the groupware can be increased, which can positively influence the completion time on tasks, the perceived effort for users to complete the tasks and the efficiency of communication between users (Gutwin & Greenberg, 1998, p. 514). Through Gutwin's study, providing awareness information and feedback of each user's actions in a visual format rather than an audio format can also improve usability.

2.10. Testing Methodologies

Considered one of the most widely accepted and used techniques to collect subjective qualitative data from users, the National Aeronautics and Space Administration (NASA) Task Load Index (NASA-TLX) is a tool for workload assessment ("NASA TLX: Task Load Index," n.d.; Proctor & Van Zandt, 2008, p. 255). To determine the workload placed upon a user, six scales have been developed: mental demand, physical demand, temporal demand, performance, effort, and frustration level. Each of these scales has proven through research to "make a relatively unique contribution to the subjective impression of workload" (Proctor & Van Zandt, 2008, p. 255). The NASA-TLX was created by NASA in 1988 to have a multi-dimensional rating scale to assess how "information about the magnitude and sources of size workload-related factors are

combined to derive a sensitive and reliable estimate of workload" (Hart & Staveland, 1988, p. 1). The NASA-TLX can be used in a variety of human-machine settings to evaluate workload ("NASA TLX: Task Load Index," n.d.).

Another testing methodology that was reviewed during this study was conducted by Hornecker et al. to collect qualitative data from participants interacting with multi-touch devices by testing the informational awareness of participants and their interactions with their fellow participants. Through the research conducted by Hornecker, positive and negative awareness indicators were used to measure the effect individuals behaviors and actions had on the entire group of participants. The negative indicators specifically measured: Interference (more than one participant reaching for the same digital object) and Verbal monitoring (user's verbally questioning each other for clarification of actions). Through the Affinity Diagram process, verbal monitoring would not be allowed since participants must conduct the idea grouping activity silently. The positive indicators measured: participants' reaction without direct request; conducting parallel activities without verbal communication; performing complimentary actions to other participants without verbal communication; and sharing objects between participants without verbal communication. Finally, Hornecker also captured awareness information regarding verbal shadowing (a participant verbally acknowledging their own actions to the group); "exaggerated manual actions;" and "visible postural changes for monitoring" (2008, pp. 170 - 171). Hornecker was able to established connections with known research for context-awareness for group/team settings. Through their testing they were able to show utilizing touch surfaces can be beneficial by providing users with a "higher level of awareness" as well as promote "fluidity of interaction and switching of roles between co-located users." The researchers noticed from the qualitative analysis that users adapted "their behaviors to different affordances, risking more interference when they are easier to manage and resolve" (2008, p. 175).

2.11. Summary

Currently the two leading expert sources of information regarding multi-touch devices are Jeff Han and the Natural User Interface Group. There are five primary

configurations for building a multi-touch device. The two configurations receiving the most attention are Frustrated Total Internal Reflection and Diffused Illumination. The Table-Top User Interfaces Objects (TUIO) is a protocol that allows software applications to communication with an infrared camera sensing objects making contact with the surface of a multi-touch device. Two primary interfaces that aide in calibrating a multi-touch device to work with TUIO are Touchlib and T-Beta. Gestures are the standard method of interacting with applications on a multi-touch device, which include: tap, double tap, drag/slide, flick, nudge, pinch, spread, and hold. The Adobe Flash Platform enables developers to build rich internet applications using the ActionScript programming language. Utilizing either Touchlib or T-Beta applications developed for multi-touch devices with the Adobe Flash Platform can respond to multi-touch gestures. The Six Sigma Affinity Diagram exercise is a group exercise that involves multiple people interacting simulataneously, which can take advantage of the multi-user capabilities of a multi-touch device. The Affinity Diagram software currently available on the market is still restricted to the input mechanisms of a desktop or laptop computer. This doesn't follow the true methodology of the Affinity Diagram exercise of allowing the participants of the session to simultaneously group the ideas/concepts into common categories. Utilizing the capabilities of a multi-touch device should address these issues. Information sharing can be increased among teams to increase performance through the use of a computer-supported cooperative work-system.

SECTION 3. METHODOLOGY

This section will cover the testing methodology used during this study including the process of selecting testing participants, procedures participants will follow and how data will be collected.

3.1. Framework / Unit

The goal of this study was to capture the experience in first-person view of the participants in a specific environment. This follows the phenomenological methodology for qualitative research. The experience to be determined was a combination of two items: the participants interacting with a multi-touch device and the participants interacting collaboratively within a shared workspace.

3.2. Researcher Bias

To protect the credibility of the data collection for a phenomenological study, the views of the researcher are presented. Throughout this study the researcher acknowledged and attempted to set aside preconceived notions related to the research of this study in an attempt to capture and understand the true experiences of the study's participants. This process occurred before, during and after the testing procedures by having the researcher keep a journal.

3.2.1. Researcher's Initial Viewpoints

I believe there is a significant potential for multi-touch technology to enter into the industry and be available to the masses through devices with this technology. We have already seen the fast adoption of touch screen smart-phones after the release of

Apple's iPhone in 2007. I think the existing touch technology is just the beginning of what we will see in the near future. The current touch devices are the precursor to more sophisticated multi-touch devices that will become more readily available in the industry. As these new devices become readily available developers as well as end-users will determine new mediums of creating interactive experiences. At the current moment, end-users, such as the participants in this study, may have had limited exposure with touch and multi-touch devices. This current limitation of exposure may have an effect on how the participants of this study experience interacting with the multi-touch device and the related software presented in this study as part of the testing procedures.

3.3. Sampling

The study was conducted at Purdue University, West Lafayette, Indiana. There were two rounds of participants from separate academic/business units on the Purdue University campus. The two rounds used different data sets; however they each followed the same process. The location of Round 1 was in a conference room in Knoy Hall of Technology. Round 2 was in a conference room located at Cary Quadrangle residence hall. Locations for both rounds were selected due to the similarity of the type of meeting space that would be used for the traditional method for an Affinity Diagram exercise. Interviews were held in each participant's office on the Purdue University campus. Focus groups were held in the same room as each respective round's location for the Affinity Diagram exercise. Purdue University was selected due to the location of my current enrollment in the graduate program at Purdue. The population of participants was selected from members of the Purdue University community. The participants were not necessarily required to have prior experience in the Six Sigma Affinity Diagram exercise. As following with the recommended number of participants for an Affinity Diagram exercise (as discussed in Section 2.6), there were two group of participants comprised of a minimum of three and no more than five participants. A moderator was selected to lead the process who was a Six Sigma certified Green-Belt with past experience moderating the Six Sigma Affinity Diagram exercise process.

3.4. <u>Study Design</u>

Initial brief interviews were conducted with each participant to determine their prior experience and to what extent their experience has been with sorting a large collection of qualitative data in a team-based setting, such as an Affinity Diagram exercise (Appendix A). For each of the user testing rounds, the participants were in a conference room (such a room typically used during a traditional Affinity Diagram process). The respective organizations for each group of participants provided qualitative data sets, consisting of raw ideas/concepts, relevant to that group of participants. The researcher than populated the data sets as sticky notes onto the multi-touch device user interface. Each raw data item was no longer than 140 characters. The intent of limiting the characters to 140 or less was to adhere to the proper procedure for an Affinity Diagram session of having the ideas/concepts be one or two sentences for each card (usually either a Post-it Note or an index card).

Participants gathered around the multi-touch device. The raw data items were displayed as digital sticky notes on the multi-touch device display. The moderator of the Affinity Diagram exercise had the participants simultaneously group the sticky notes by moving those with common ideas/concepts into categories without any form of verbal communication. Once each participant felt pleased with the result, the exercise advanced to categorizing the categories. This step created a hierarchy of the organized data set. At the higher level, the participants could each vote on what they believed to be the categories with the highest priorities. Votes were cast by the participants pressing either a plus sign ("+") or a minus sign ("-"). The minus sign option was provided within the system interface to decrement a vote count in the event a participant decided to change their vote. After all participants had indicated their votes, the exercise was over. Following the guidelines of an Affinity Diagram exercise, if conflicts or other abnormalities had occurred during the process the moderator would have interjected to resolve the situation.

Following completion of the Affinity Diagram exercise for each round of user testing, participants of that round had a one-on-one interview with the researcher (Appendix B). The interview session was voice recorded, with the permission of the participant. Upon the completion of the interviews, there was focus group comprised of

the participants of that specific user testing round (Appendix C). The goal of the focus group was to collect more anecdotal comments regarding the participant experiences.

The metrics used to collect data for this study, originated from the study conducted by Hornecker et al. (2008), which was focused on collaboration and interference with multiple participants working on a single display output. Their metrics were "1) Negative Awareness indicators: Interference, Verbal monitoring; 2) Positive Awareness indicators: Reaction without explicit request, Parallel work on same activity without verbal coordination, Complementary actions without verbal coordination, Object handovers without verbal coordination; 3) Awareness Work: Verbal shadowing, Exaggerated manual actions, Visible postural changes for monitoring" (p. 170). Not all these metrics directly applied especially those involving verbal communication because the Affinity Diagram exercise calls for no verbal communication of the participants during the process.

3.5. Data Collection & Triangulation

There were three points of collecting data throughout this study. The media of data collection were the researcher's journal, testing observations, and participant interviews. Through the researcher's journal portion of data collection, there were three phenomenological reductions, also known as "epoché," of the researcher's judgments about the study. The first occurred prior to conducting the testing; the researcher answered each of the questions the study's participants were asked. The second collection of the researcher's judgments occurred before the analysis of data collected from the study. The third and final collection of the researcher's judgments was performed immediately following the data analysis. The triangulation of data collection from the researcher's journal, testing observations and participant interviews provided the ability to capture the experience of the participants from different perspectives to attempt to understand the true phenomena that the participants experienced.

3.6. <u>Summary</u>

This section discussed the details regarding how the experimentation aspect of the study will be accomplished. The study attempted to understand the experience of the participants while completing a common task in the shared work environment of a multi-touch device. The common task was completing a Six Sigma Affinity Diagram. This process follows the phenomenological methodology for qualitative research.

SECTION 4. DATA COLLECTION AND ANALYSIS

As detailed in the prior sections, the objective of this study was to investigate the lived experience of individuals working within a shared environment of a multi-touch interface, to specifically answer the question "what is the experience of users interacting simultaneously to complete a common task, with the display output of a multi-touch device?"

The methods to collect data regarding the users' experiences were interviews, observations, and focus groups. The Six Sigma-certified Moderator for the Affinity Diagram exercises was interviewed after each round of testing in addition to participating in both focus groups.

This study was approved for Exemption status by the Institutional Review Board of Purdue University on 5 March 2010 (Ref. #1002008983) and received an additional approval for revision on 14 May 2010.

4.1. Presentation of Data

This section will present each of the participants from the study and the data collected from each participant at the various stages of the methodology. An analysis of the data collection from this section can be found in section 4.2.

4.1.1. Data from the Initial Interview Participant Descriptions

As stated in the methodology, all of the participants for this study were a convenience sample from the Purdue University campus in West Lafayette, Indiana. Participants 1 through 5 were all faculty members of the College of Technology at Purdue University as well as members of the College of Technology Core Curriculum Committee. Participants 6 through 8 were all professional staff members for Purdue

University Residences as well as members of the Resident Assistant Selection Committee. Round 1 consisted of Participants 1 through 5, whereas Round 2 consisted of Participants 6 through 8.

4.1.1.1. Participant 1

Participant 1 was an Associate Professor within the Department of Organizational Leadership and Supervision. He had previously heard of Six Sigma but had no prior experience with Six Sigma Affinity Diagrams. However he had participated in a team-based process to analyze collections of qualitative data.

4.1.1.2. Participant 2

Participant 2 was an Associate Professor within the Department of Computer Graphics Technology. While not having participated in a Six Sigma Affinity Diagram exercise previously, he had heard of Six Sigma. He had participated in other processes to analyze qualitative data in a group setting.

4.1.1.3. Participant 3

As an Associate Professor within the Department of Industrial Technology, Participant 3 had heard of Six Sigma but did not have previous experience with the Affinity Diagram exercise. He described his experience of participating in a session to process qualitative data in a team environment, as "not lately."

4.1.1.4. Participant 4

Participant 4 was a Professor in the Department of Electrical and Computer Engineering Technology. He had heard of Six Sigma but not performed in an Affinity Diagram exercise. He has past experience analyzing qualitative data in a team-based setting.

4.1.1.5. Participant 5

As an Assistant Professor within the Department of Mechanical Engineering Technology, Participant 5 had knowledge of Six Sigma and Affinity Diagrams, but had not participated in an Affinity Diagram exercise.

4.1.1.6. Participant 6

Participant 6 was a Residential Life Manager and she had not heard of Six Sigma or Affinity Diagrams before. However, she had participated in a group setting for analyzing a collection of qualitative data.

4.1.1.7. Participant 7

Participant 7 was a Residential Life Manager. He had heard of Six Sigma and had some experience with Affinity Diagrams during his graduate school studies. He acknowledged working in groups to process qualitative data.

4.1.1.8. Participant 8

Participant 8 was a Residential Life Manager who had prior knowledge of Six Sigma. She also indicated that she had attended two trainings and activities using Affinity Diagrams. She had participated in other processes to analyze qualitative data in a group setting.

4.1.1.9. Six Sigma Affinity Diagram Moderator

The Affinity Diagram Moderator for both rounds was a Visiting Professor within the Department of Computer and Information Technology. She was a Six Sigma certified Green-Belt and had experience facilitating Affinity Diagrams for companies in industry as well as for several groups within Purdue University. During her employment at Cummins corporation she had completed the full Six Sigma training and three projects. On a side note, within Cummins if an employee becomes Black-Belt certified

they do only Six Sigma projects for a period of two years, whereas she executed projects while continuing her existing role within the corporation.

4.1.2. Data from Affinity Diagram Exercise Observations

Both rounds of user testing were independent groups, each in need of sorting through collections of qualitative data. Through the voluntary arrangements with both groups, each group was able to utilize the results of the Affinity Diagram exercise performed during this study for their own institutional departments. During round one of the user testing with the College of Technology faculty, not all the participants were able to stay to complete the entire Affinity Diagram exercise. Due to Participant 3 and Participant 5 not completing the full exercise they were not interviewed, however Participant 5 did attend the focus group for his respective round of user testing.

4.1.2.1. Researcher Observation Notes from the R1 Exercise

The exercise for R1 of user testing presented several challenges for the Researcher, primarily due to the interface software failing and crashing twice. The Moderator started the exercise by having the participants determine what the prompt question would be, which would serve as the guide for the grouping / categorizing. The participants decided that the prompt question would be: "What are the technology CORE outcomes expected for COT students?" Next the Researcher explained the logistics of touching the multi-touch device's surface and compared the pressure needed versus a handheld mobile device, such as an Apple iPhone or a Motorola DROID.

Only after a few moments of the five participants interacting with the device, the software crashed. The Researcher restarted the software which caused the participants to have to start over grouping the sticky notes. Participant 1 talked the most during the activity; however the Moderator later acknowledged that she allowed this behavior since it was not discussing placement or reasons of placement of the sticky notes. Several participants had difficulty determining the needed amount of pressure to apply with their finger for the device to respond to their actions when touching the screen. Participant 5

needed to leave the session to attend another obligation. There was at least one occurrence of arms crossing each other causing line of sight issues for the participants. At this point the software crashed a second time. The Researcher quickly debugged the code and made some adjustments to the software's code. Unfortunately, this caused the participants to have to resume from the beginning of sorting the sticky notes again. Once the participants began sorting the sticky notes, a few participants would wait and watch while other participants moved the sticky notes. Some used non-verbal methods of communication, and what seemed to be, offering their confirmation of placement. Participant 3 had to leave the exercise. The remaining three participants were able to finish grouping the sticky notes. The Moderator verified with each of them that they were comfortable with the results and she then initiated moving on to the higher level of categorizing the newly formed groups. There was a flaw with the software, although minor and not causing a system failure, of the text on the higher level groupings to disappear on the sticky notes if the grouping was modified. Once the higher level groupings were completed, the participants were able to vote. Another software flaw was identified with receiving the touch input for the voting. The software interface required that the plus ("+") and minus ("-") icons be exactly pressed which proved to be very difficult for the participants. The voting tally was not accurately recorded from round one of user testing.

4.1.2.2. <u>Researcher Observation Notes from the R2 Exercise</u>

Round two of user testing began following the same procedure as round one, with the Moderator leading the participants through the initial process of solidifying a prompt question as the overarching guideline for the Affinity Diagram exercise. The prompt question was "How do we create a RA candidate pool in the most effective and efficient manner?" Once the prompt question was established, the Researcher provided details to the user participants about the logistics of touching the device. As with round one, he compared the needed pressure of touch was greater than that of a handheld mobile device.

From the start the participants appeared to have a significant difficulty applying the needed amount of pressure with their fingers. As Participant 6 and 8 were having difficulty, Participant 7 verbally suggested that they try to use their thumbs instead of their index fingers to press and touch the digital sticky notes on the multi-touch device's display. He also suggested that they point their fingernail in the opposite direction from their movement. The Moderator allowed this verbal communication since it was referring to the logistics of the multi-touch device and not of the Affinity Diagram activity. There were numerous occasions where the participants tapped a sticky note on the device's display before moving it. If another participant was interacting with the software at the same moment, the software appeared to have difficulty determining the exact placement of the sticky note that was tapped and would relocate that specific sticky note to the location of the other participant's touch point on the device. This caused the participants to make comments such as "I tapped one – where did it go?" or "I lost it – it disappeared."

The participants appeared to use hand gestures to indicate to other participants that clusters of sticky notes belonged in groupings by moving their hand in a circular motion above a cluster of sticky notes. Participants also used non-verbal means of communication such as nodding their heads in what seemed to be agreement of the actions of their fellow participants. Once the sticky notes were grouped into categories, the Moderator had them move on to the higher level of grouping the groups followed by voting for the higher level groups. A minor system issue occurred when the votes were being cast, however the issue was a user-interface design flaw regarding to the size of the voting buttons being too small and difficult to press with a finger.

4.1.3. Data from One-on-One Interviews

As defined in the methodology for this study, following the completion of the exercise for each round of user testing the participants of the respective round were each interviewed individually. The interviews were recorded with the permission of the participant and the audio recordings are later transcribed.

4.1.3.1. <u>Data Collection Round 1 (R1)</u>

Interviews from round one included the three participants who were able to participate for the entirety of the Affinity Diagram exercise. Participant 3 and Participant 5 were unable to stay for the duration of the exercise, therefore they were not interviewed. The epoché of the Researcher, interviews with the participants, as well as the interview with the Moderator.

4.1.3.1.1. Researcher Epoché from the R1 Interviews

The participants seemed to enjoy the process of performing the Affinity Diagram. A few commented on the interface for performing the Affinity Diagram, that they liked the interface. During the user testing the software application unfortunately crashed twice. Each time the users had to restart the Affinity Diagram from the beginning. After the second crash, I went into the code and quickly made some alterations. The problem was occurring with an open-source class written in ActionScript 3.0 which processes data received from Community Core Vision (the open-source software which interprets the images received from the camera component of the device's hardware). I added some "try / catch" statements. This seemed to resolve the issue since the software application did not crash after the modifications.

Some of the participants quickly caught onto moving the sticky notes into categories and had little difficulty moving them across the screen. While others struggled to maintain a consistent pressure when moving items. They were able to easily click on an item to bring it to the surface. However, moving items seemed to cause a degree of frustration for some participants.

It seemed like some of the participants were frustrated with two elements: First, the amount of necessary pressure to apply with their finger when moving items on the device's screen. Currently this is a limitation of the hardware of the system being optically based. Through further experimentation an optimal setting requiring less pressure could possibly be achieved. Second, some of the digital elements would "disappear" as they would click on them or try to move them. This seems to be an issue with the open-source software, Community Core Vision (CCV). When CCV, which interprets the image captured by the infrared camera and sends the data points to

Adobe Flash, is not sure of where a digital element within the user interface should be located it will place it at the 0,0 coordinate (of an x, y coordinate grid) by default. This appeared to cause confusion and disorientation for the participants during the testing activity. From preliminary testing, the same phenomena occurred but a programmatic solution has yet to be determined. A suggested solution would be to have the digital element remain at the last known x, y coordinate position of the element rather than placing it at the 0,0 coordinate.

The participants have previously worked together and there was a pre-existing established rapport. They appeared to work well with each other on the common task. Despite breaking the rules of no verbal communication during the Affinity Diagram activity, some of the participants gave verbal support to each other and commented on each other's movement/placement of the digital items. No frustration seemed to occur between each of the participants.

I did not observe any level of frustration regarding the participants interacting with each other. There were only a few, minor occasions when interference occurred. Some of this was line-of-sight issues with participant arms blocking each other's view of the digital item they were moving. Others were more intentional, and appeared to be friendly batter, where the participants purposefully tried to move a digital item with which another participant was interacting.

I noticed some participants would move a digital item as far as they could reach then another participant would take over and finish moving the item. Non-verbal communication, such has head nods from the participants would then confirm the item's final placement. During another instance, one participant who appeared to have difficulty through most of the activity moving items, tried to move a digital item. It was close to an existing cluster / group of other items, so another participant (who had experienced little difficulty) moved the item to the group.

4.1.3.1.2. Participant 1 – Textural Description

The experience for Participant 1 when performing the Affinity Diagram exercise was described as:

My experience was a little difficult to move the little guys. It was not on the level of frustrating, [but] it was more on the level of experimenting trying to get them to work. I had a strategy, again I was trying to not to talk - I know these other guys - I was doing a little cheating, non-verbal. [I] was trying to get them to do what I want. In that sense it went along ok. I have used these things, this affinity exercise with post-its in the past. To be honest, I think your method is terrific and I think it will work better than with Post-It Notes. I think it is a little more difficult to do than [with] Post-It Notes; to get these things organized [and] it is a little bit more complex than the post-it notes. In that sense, I think it might work well.

In terms of interacting with the multi-touch device and its interface he offered the following thoughts:

I found it a little difficult. I know it is a beta [and] we crashed it three or four times... that is part of the process. This is the beta and I am pretty impressed by the technology that is there and you explained what you had done [it] and how you conceptualized it. [That] was beyond my technical recognition. I was pretty impressed by that, I think it is a cool application. Conceptually I say wow that was pretty creative to use to do this. In that sense I think there is a wow factor there that is pretty cool. I see some application there. I have never seen anything like that [and] I would encourage the development.

When he was asked to elaborate on the frustration he mentioned he had experienced, he stated that there was a level of frustration of becoming acquainted to the amount of finger pressure needed, which he added that he was not as familiar with. He went on to elaborate that he was more familiar with the mouse and using the cursor to drag and drop items on a computer screen. He expressed challenging with the sticky notes disappearing as he was trying to move them as well as trying to read sticky notes on the opposite side of the screen than where he was standing. He continued to comment:

You get used to it. We were more dependent on the finger pressure. Again, I am kind of new to that kind of interface. I am not real familiar, [and] the interface I typically use is the old mouse. I probably would have been a bit more comfortable with a drag and drop with the mouse for instance because I am familiar with that interface. But with a little practice then you are good to go. Some of the things would also disappear behind other ones, you would know where they were, but I did not know, and someone would say 'oh it is just beyond the other one' and it would be there. I lost a few of the little sticky notes just in process, not a big deal, but I would not know where they were. Here was the screen and I was about right here, I never moved and stayed pretty much right here and to be honest, I could not really see some of them. I could not read them up in that corner (referring to the opposite corner). Most of the ones I was looking at probably would have been about here. My vision is not that bad, and it is not that good for an old guy.

Participant 1 expressed his experiences of working with the other participants on the common task of the exercise as:

I said something like torch the other guys' affinities, [which] I did not particularly agree. I move[d] some of them out of some people's affinities, I did not notice they tried to move them back. I think there were some differences here; the differences would have been with perception piece. Up front we never really talked about definition of what these things had meant. I guess these had developed from a past Core [Curriculum] meeting. I knew the guys that were in there, actually to give an impression of the relationship, one of them I do not know that well and so I would probably be tepid and feel them out. I am a believer… let us build these relationships and move forward. One of the people there probably would not know me well enough to say that or if they did say that to me I would probably think they were a little pretentious, so something like that. I am on committees with some of them, so I see them all the time [and] you get

used to what you say to each other. I was good with all of them. Actually, I think it is a good thing.

When he was asked about some of the comments he verbally said to the other participants of the exercise, specifically asking another participant "Is that where you are going with that?" His description of the event was:

I did not do great at staying silent, but I did not influence. I was not trying to influence, but yes that was pretty hard for me to do. At one point, I did elaborate a strategy as I was trying to clear out a side so we could start. People seemed to agree with that so that we could open up a space… so that we could do some 'affinitizing.' When they were all over the board it was kind of hard to find a building spot, a foundational spot, were you could move something and start. Let us do that [and] the other participants were in on that, at least on the non-verbal.

There was at least one time when Participant 1 grabbed a sticky note as another participant was trying to move it. He explained the situation as:

I did not want them to move it. In some ways these affinity exercises, people move your sticky note and then you move it back and they move it and you move it back. My strategy, from my experience, was if I think that goes there then I put it there, [so] that is essentially I stole it. And I do not remember, maybe they might have moved it again when I was not looking; I do not remember where it ended up [from] where I moved it. Really that is my way of non-verbal of really [saying] 'I do not think you should move it.' I did not really see in our section people get really aggressive. Probably that move I made was the most aggressive I saw anyone make - I would suggest. I know I have used these affinity exercises to get the outcome I see - you do that. I am not a really assertive individual but in an exercise like that, my familiarity with the affinity exercise lends to that.

Participant 1 added some additional comments regarding the voting portion of the exercise:

It actually works. We always voted as hard copy never virtual like your instrument we would vote with dots [in the past]. To be quite honest it is lot better if you can somehow vote anonymously. If the boss is there as soon as the boss would vote everyone else would kiss ass and going to vote for whatever the boss votes, and I was 'oh no'. Your way was better - prioritize and vote for the ones you wanted with the touch and we could not see the votes and I liked that. Not so much how many they had but which one was getting more votes. In process when people cannot see then there is no influence, it is not go along with the crowd. Again, I saw too many times when you let the boss, you want the boss to put his dots on there last and get him out of the room. Even when people could see where all the dots were, 'oh yes I agree.' I like your way better. I like the anonymous tabulation and people are going to want to see at the end.

As a follow up he was asked if in the traditional process seeing the votes being cast and tallied with visuals, such as stickers, he offer his thoughts on not following the traditional process by providing a sense of anonymity:

Replicate, then it would be a running score board tally, on the virtual dots thing. You can see where the people put the dots. Everyone goes up there – we have three dots [and] you can vote for three things, and try to put them up there at the same time. It has limitations, if the boss goes up there first [then] he we go again.

Participant 1 offered some final thoughts on his awareness of the actions of his fellow participants during the exercise:

That is a piece I never really gave much consideration as we were going along. In the hard copy everyone is moving sticky notes around. I was not paying too much attention to where they were moving things, oh I paid attention to the guy right next to me, but I could not pay attention to everyone. That was too much

data. I could not see the ones up at the top. That is interesting. That is a lot to process at once. I was trying to make my own little affinities. I was paying attention to what the guy next to me was doing. I think it is a cool project.

4.1.3.1.3. Participant 1 – Structural Description

At the beginning of the exercise Participant 1 found moving the sticky notes on the display of the device to be a little difficult but not frustrating. He described his actions as a level of experimenting to get it to work. He acknowledged that even though he knew he was not supposed to talk during the activity, he said it was hard not to. He attempted to employ some strategies to get the other participants to do what he wanted when grouping the sticky notes. He was impressed with the technology and its concept, further detailing that there was a wow-factor. He stated that there was some frustration with determining the amount of finger pressure necessary, and emphasized that he is more familiar with the computer mouse click and drag model. Since he knew the other participants from prior work engagements, he explained that there easily were relationships with levels of trust established. During the sorting activity, he tried to clear out an open space on the display to begin creating groups of sticky notes. He liked the ability to vote and keep the vote tally kept anonymous compared to the traditional Affinity Diagram exercise. Participant 1 recognized than an action he made of stealing a sticky note from another participant as the most aggressive during his round of user testing. He explained that he made such an action because he did not want other participants to move sticky notes that he had already groups, as following with the rules of the Affinity Diagram exercise. During the exercise he noticed that he was able to pay attention to the actions of the participant next to him but not all of the participants.

4.1.3.1.4. Participant 2 – Textural Description

The initial thoughts Participant 2 had to share regarding the Affinity Diagram exercise were:

Very interesting; I actually found it to be an excellent organizational tool because using that was much like what I would be doing in my mind, [and] being able to physically pull the representations of the sticky notes to the different areas. It was good organizational tool for me.

He described his experience from interacting with the multi-touch interface and device while performing the exercise as:

It was good. I did not do very well at maintaining consistent pressure with the device, but visibility was outstanding. It was a good way to help me organize. There was obviously some user ramp-up, kind of familiarity things that would have made it even better for me getting the sticky notes to stack appropriately for me. All and all, I found it to be quite user friendly [and] usability was excellent. It was easy for multiple people to be working at the same time. I did not notice any burn or anything like that, but I did notice that I would push and then as I started to slide I would let up. Maybe if I had maintained a more constant pressure I would have felt a little more frictional discomfort [and] that would have probably been a negative for me to have to push that hard.

When asked about working with the other participants on the common task of the exercise, he commented:

No problem, a couple of reasons why, I know the other individuals quite well and we work very well together. We have worked together on this core curriculum. Personality wise, nobody was trying to dominate I do not think. One of the times where [another participant] was moving one of the things and it had stopped, but he kept moving his hand. And it stopped near a group, but it did not look like a group he was trying to get it to. It did not seem to fit from my perspective. Once or twice we got tangled up and one person would switch under or take their hands off for just a second. I could see if it was more than 3 or 4 people that it could get messy. I do not know if there is a possibility in the future for the device

if you are going with a large group with 6 or more people, maybe have a larger area for the screen.

Participant 1 elaborated on his thought of having a larger display size if there were more participants by stating:

I am not talking about a mega type of screen, but if you take the size of that screen and maybe make it double so it is twice as big the length and twice as big the width so four times the area, I think that would be optimum for a larger group. That size was ok for three but I think it was tight for 4 and would be pretty bad for six.

His experience helping other participants when he realized they were having difficulty, he described it as:

Maybe that is instinctive. We were probably cheating because [one of the other participants] was talking, but you could tell if the others were having an issue with something. Once or twice it was pretty natural for me to just reach over and take the post-it and put it in the pile that I thought; which made it two to one or help make that decision.

Participant 1 shared his overall thoughts on the experience as well as with the results from the exercise:

I thought that the process went very quickly and very smoothly. In fact it was very eye opening to me that if you do your homework on the first part that when you start grouping it goes very smoothly. I do not know if that is a direct result of working with that tool and working together at it and visualizing it so well, or if it is because we went through that exercise on a white board prior. It seems to me that using that tool so that everyone can visualize the organization of the data, it removes a lot of the ambiguity of trying to do it with someone as a scribe writing it down on a board. I think people's perspectives are lost with that kind of manual

method, which is why I like the touch screen and seeing the post-its fly around right before your eyes because things do not get lost. The only time people totally stopped was when they were dragging the post-it and it popped away. That to me was revelatory of the fact that the real advantage of this is that the data stays in front of you and everyone sees it being organized and it does not move around on anybody you can always go back and look at it. You can actually see them slide and see them moving. There is something very organizational, almost scaffolding, that visual translation of the post-it. I do not think we would have the same result at all, if you could double click on the post-it and double click where you wanted it and it would pop over there, I do not think that would be as good. I think it is much better to see it moving. I think that is important. It would be interesting to compare that type of device to a drag device, to see, but I think it helps.

He went on to provide suggestions of other applications where he thought this technology could be beneficial, these suggestions included:

I was trying to think of other applications besides doing this type of organizational exercise and I have not picked them out yet, they are right on the tip of my consciousness with one or two or three things. I wonder if there has been research with this type of technology and developmental mathematics grouping, sets, set type of teaching, or similarity/differences for primary age children. [I am] just trying to think of other applications. Visually it would be an interesting tool, for example, some companies with products that are very similar, if they make different types of springs, and use it as a categorization tool for families of products – is this how we want to arrange the catalog with product families.

4.1.3.1.5. Participant 2 – Structural Description

"Very Interesting" was the initial response from Participant 2 as he was describing his experience performing the Affinity Diagram activity with the multi-touch device. He found the process to be an excellent organizational tool, going on to state

the visual benefit of being able to pull the representations of the sticky notes and organize them. Participant 2 expressed his realization of needing to maintain a consistent pressure when touching the device. The times that he would press and let up with his finger as he was moving it were the times he had difficulty, since the sticky note would stop following his finger. However, he emphasized that the interface and its visuals to be outstanding. It took some "user ramp-up" to figure out how to operate the device. He highlighted that the experience was very "user friendly" and that he believed it was easy for multiple people to interact with. The times when the sticky notes would stack and overlap each other, it was difficult to read the text on the sticky notes. Working with the other participants on the common task was a positive experience, but he also knew the others well going into the activity. He could have seen if there were more people using the device, due to its size, that arms would have become tangled more often. He described helping other participants move the sticky notes when they were having difficulty as "instinctive," that it "felt natural" to reach out and help them. Participant 2 shared that he believed the experience would be better if the device's display screen was larger; at least four times the surface area. Overall, he felt that they were able to achieve the final result quickly and smoothly, despite the software failing twice. He valued the ability to visualize the sticky notes physically moving and that all the data stayed in front of them. Finally, he provided suggestions of other applications of the technology within education and industry.

4.1.3.1.6. Participant 4 – Textural Description

Participant 4 briefly touched on his thoughts of the Affinity Diagram exercise, sharing his experience as "The sorting, that was a good activity. We did some more of that today actually in a meeting. That seemed like a reasonable way to attack the problem we had."

Expressing his thoughts about the interaction with the multi-touch device, he commented:

I found it frustrating at first, because the little sticky notes would not track my finger. Some of it was learning to go slow. I was going way too fast at first and

did not realize it. I would get so far and it would be tracking me, and then all of a sudden it would just disappear and I did not know where it went. Then I started going a lot slower and holding a steady pressure. I think there is some room for improvement and to make it public ready, so that it does not take as much skill. I had to develop a little amount of skill to make it work.

He went into more detail to describe the frustration he experienced with the pressure applied by his finger touching the display:

A pressure and speed thing at which I tried to move too; I thought it was slow, once I realized that I had to adjust. Maybe a lighter amount of pressure, maybe a faster clock rate to make it move faster without losing it, I think my finger must have been getting away from the sticky. We were 'jockeying over,' to move that note were we wanted it to go. Several of them were having trouble losing them; sometimes when it would quit following my finger it would stay put and sometimes it would go somewhere else. The response time I would say... the pressure thing maybe at first I thought that was the issue and I was trying to hold even firmer pressure. By the time at the end it was pretty much the speed that I was moving where I had the most success, I slowed down and the pressure was not as critical.

When asked about his experience handing over sticky notes to other participants or them handing sticky notes over to him, he stated:

That was just us deciding where to put those things. I do not think we were having a hard time getting them there at that point. We were having a hard time deciding where they should go.

During the first round of user testing the software failed and crashed twice, Participant 4 offered his perspective:

All the early development things, you have a good structure there. It is refining it so it does not lock up – I do not need to tell you that. Getting the dynamics to where it works at the level people want to operate it at. The repeatability is from that, since sometimes it worked and sometimes it did not. Another thing I think that would really be good, I think I mentioned this there, is having more open space to start sorting because there is nowhere to go with the stuff; and then there were some challenges with notes covering up other notes, then finally we came up with a system of how to stack them so you could see what you wanted to see and yet have not completely independent and overlap a little bit. I would not care where they were at, whether to the start in the center and bring them to the edges or visa-versa. But to me, it would be a lot easier to start sorting if you had somewhere to go with it that you could start making these little rows of sticky notes overlapping with each other and keep them together and still read what they say. So I was going to say sometimes people would drag a new sticky note over and it would cover up some of the old ones and then we were trying to get in our mind which ones go together. Once you get so many together and you want to look at them to see if all these things seem to be same but half of this stuff is covered up because someone else had dragged a note and stuck it on top. I could see where grouping things together and the color thing was useful stuff.

4.1.3.1.7. Participant 4 – Structural Description

The sorting activity, Participant 4, thought was good and a reasonable method to organize the data. At first, he found moving the sticky notes on the display to be frustrating due to the amount of pressure that was required. He recognized that he learned to go slow and keep a steady pressure when touching the screen. He suggested that this would be the primary room for improvement of the device. He also felt that the speed of the responsiveness of the device could be improved to react faster to the touch points as well as moving the sticky notes. Participant 4 expressed difficulty when the sticky notes would overlap each other and being able to read the text on the notes.

4.1.3.1.8. Affinity Diagram Moderator – Textural Description

From round one of user testing the Moderator had numerous observations to share. First, she offered her perspective on how the participants performed the Affinity Diagram exercise:

I thought they jumped into it pretty quickly, so I thought that was good. They were not afraid of the technology. Right at first they were frustrated with, even though you said you had to hold a constant pressure, which is hard to learn how to do. But it seemed after they had done it for a while they got more confident and they learned how they had to move them and it seemed to go smoother after that initial few minutes. So one of the questions might be how do you think about it, do you want to just throw them in, it is probably the right thing just throw them in and have them start moving them around, or do you give them some sort of exercise as practice? It is probably just fine to let them start moving them around, because it did not seem to negatively impact how they did the rest of the session. That would probably be something to watch for if they were getting frustrated and checking out, but I did not think that was a problem.

Some participants were talking during the exercise regardless of the rule for no verbal communication. The Moderators thoughts on this were:

Yes, and it always happens. Some people always talk. So I try as I am watching that it is not excessive. It is 'no talking' but it is mostly 'do not talk about how you want to organize them.' I try to watch it. There are probably people who are purists who say 'no talking at all,' but I find that sometimes irritates people so I let it go a little bit but cut it off if it seems it is effecting how they are doing. If I remember some of the talking was about the logistics of how to do the exercise which to my mind is not a problem, what you do not want them doing is saying 'I think this one goes with that one because of this reason…' that is the piece you do not want them talking about because you do not want them influenced by other people. They can be influenced by what they see them doing, but you do

not necessarily want them to [know] why they are moving things the way they are.

At one point during the exercise the Moderator had the participants regroup and talk about the logistics before the exercise was complete. She explained this as:

In the room you tend to have them step back and look at the big picture. So there it was, just take a step back and look, do these seem right? Because there are times you do the exercise and you look at it, and you say "oh that does not seem right," so it is ok to talk at the end, that is kind of how the exercise works; you get it down to what you think is your final product, you take a step back and ask some questions.

From her observations of the participants interacting with the multi-touch device, she described:

If I look at that and compare it to doing it broadly, one thing that tends to happen at first, even if you are doing it paper wise, people tend to focus on a particular area, so because of moving around. One thing that occurs, even though they can stand on all four sides unless you are really good at reading upside down you are going to move yourself so you can see it even if it is on the side. What tended to happen is somebody would start working on the ones on this end and somebody else on this other end. Because of that the question was, it felt like it took them a little while because then they moved around what ended up happening, the person on one side probably did organize most of them on that side. Then the others looked and said, 'yes that is ok.' When you do it on the wall that happens to some extent, but it is a little easier to walk from one place to the other. From really looking at it you can do it with four people, any more than four is a pretty tough, when we ended up with three that was actually a pretty good number, in terms of facilitating moving around they probably interacted more with the whole screen when there was just three of them. I felt when there was four or five, they were definitely 'jockeying' and it was really clear that someone stepped

backwards. If you are at that corner, I do not remember who it was at first who took a stepped back, but I remember there just was not enough room for five of them, and so one of them stepped back. When the fourth person left, then they were able to move more freely around the device.

She noticed that the participants made some actions that are typical during the traditional method for the exercise, such as:

They did something pretty typical when you start and do not have a lot of white space you start clearing things out of the way. I think that was a little bit of a challenge. I do not know if you could do anything about it, because of the way they go over or under each other, remembering that there were ones underneath, this is almost more of a software question, do you almost want a snap to grid? If you put it over, like at the end we put them in one right under the other one so you could see the title. I almost wonder if when you get one and it is going to obliterate another one do you automatically cascade it so you could see the other one under neither it, just so that you know there is another one under there. There were a couple of times that people lost [and] they could not find them because they were buried under something else. That was a little difficult, not a huge issue, because eventually they found it. But it might help not loosing… I almost wonder that at the beginning rather than having them randomly scattered do you have them still random but have them in two, three or four tile lists, because then with some tiles listed and some blank space in the middle, you could start at the bottom or anywhere, grab one and move it.

If the participants had been provided more blank space on the display at the beginning of the exercise to provide an area to begin grouping the sticky notes in the blank space, she commented:

I do not know, I am thinking about it and I just do not know. Normally what we do, you kind of put them all over but they tend to go in a row just because you put them up there you are trying to maximize space. You tend to just put them in

rows, not on top of one of another, each individual one, but you do not have enough space for each individually. I am not sure if that makes much of a difference. I would probably take a look at it if you are going to do some tiling if it is easy enough to do - tile them at the beginning, [and] then test it with the folks. But it is probably not work, it is not a big deal, if it is a lot of work.

If the sticky notes were not only randomly placed on the screen, but also randomly rotated versus all oriented the same direction, the Moderator's thoughts were:

The only question is how much trouble would it be to turn them? Because at some point you need them all going the same direction so you can look at them in groups. The turning of them does that make if it makes them big or small does that make it more difficult? In the end you really are going to look at them in one orientation. I do not know. It does seem like you miss the walking around the circle opportunity, by having it face all one direction, but the question is if you are looking at it from one direction you are going to focus on the ones facing you and going to miss the ones that are not. I have always done it facing one direction on a table. Think of a conference room table and put the flip charts on the table, we were in a room and for some reason we could not put stuff on the wall I do not remember why, we just put them on the table and stood; some people did stand a look at them upside down, but generally we stood in a semi circle around. It was the same issue.

During the exercise she noted the level of frustration the participants were having with the device, to have it respond to their fingers touching the screen. She described this as:

The amount of pressure, getting used to how much pressure was needed. I think it is because everyone is used to their touch devices, where you do not have to touch them much at all, they are hyper-sensitive. I think that fear that I do not want to press too hard, because you are worried – do I need to press hard, because everything else tells you do not press hard? And when you press on

that, if you press too hard it does wrinkle a little bit and you can catch, and you are worried, a couple of times I pressed it and felt like I was getting a little ridge in front of me and you do not want to tear it. It is that sense of how much. But I think after the first five minutes, people got pretty comfortable. If you think after the second time it crashed, if it crashed one more time they would have given up, but after that second time think about how quickly they put everything back to where it was, it was really fast, so that had meant they sort of remember where they had put things but they were also much more comfortable with moving things around. So that in some ways was a fortunate accident, so you could see they figured out the logistics piece of how to move my fingers around.

Regarding the participants working together in the shared workspace of the multi-touch device on the common task of the Affinity Diagram exercise, her thoughts were:

I thought it caused them to have to pay attention to what the other people were doing because it was a smaller space then we would normally have. I do not think there was as much of… one thing you see when you do it on paper, people will take something off and then they will stand back and look for where it is going to go. And they obviously had to do that but they had to have their eye on something that someone else could pick up and move while they were doing it. So I think they were sensitive to where each of the other ones where gazing, but somebody was looking over here and somebody else would be looking over here, and I think part of that was partly from where they were physically located, they tended to be pulling from the part of the screen they were closest to. Which I think did help make the logistics smoother and it also, without talking; they kind of found a balance of working together and make it effective across the screen. And because of the crashing, they got comfortable that they needed to watch when they were moving something they had to see where someone else was, and that was probably helpful.

On the few occasions when a participant caused some form of interference for another participant, she described observing this as:

I think it was paying attention to what they were doing. I think it was more physically so they did not crash… so they would not bump into each other. But as a result I think it made them more aware of where people were putting things which I think made the process go a little faster. On the paper one you are kind of looking at yours and moving it, and until you have put something on a list that is already there and you are looking at that list, you are not really noticing what everyone else is doing. I think this caused them to be a little more spatially aware of what was going on other than just the place they were moving from and to. They would be noticing that other people would be moving to a particular place probably, a little more so, since your field of vision could take in the whole screen at once. Even though you were focused on moving from Point A to Point B, you would maybe notice that someone else was over here either coming to the same place which cause you to look what was on their tile or notice that there was a lot of activity over here on this other one. Even if it would cause you to glance over and look at it, and remember in your brain of I saw something over here that might go there.

She went on to describe how the participants appearing to be more aware of the actions of their fellow participants and how that impacted the overall exercise. Also, on a related topic, she provided a suggestion of future research:

I think it probably facilitated getting things moving quicker. This was a pretty fast process; I have not done one on paper that quickly. It would be very interesting, and I do not know how you would do it because you could not do it with the same people, it would be really interesting to see if you took a set of data and you put it on a sheet and did a set of data on there, and time it to see how long it took them to do it, to organize it. I do not know how you would know… if you had different people they are not going to come up with the exactly same categories but they would be fairly close. That might be an interesting thing, you would have to do it with data that the people would not be familiar with… here is some data we have collected about ideas of how to improve the dorms. For research purposes you

would have to have two or three groups on the screen and two or three groups doing it on paper, but it might be kind of interesting because it seemed to go really quickly for me.

In observing the participants who had difficulty with the pressure issue, they would be able to move the sticky note to a point but then it would stop following their finger. Then another participant would pick up the note for them and continuing moving it to what seemed to be the apparent destination. Her thoughts regarding this type of occurrence included:

I think that is okay. That goes back to my thought, even thought they were consciously thinking about… they see this person wants to move it from A to B, and when they reach down to do it there is not enough time to make a value judgment of where that is correct or not. But in the process of doing it, they are registering that this one is going here, so when they start thinking of other ones they kind of already have in their heads that there is a group over here that is related to it. I think probably facilitates making the process a little faster, even though it may be subconscious - that could be wrong. Maybe it seems like that because it was a smaller number that I had ever done before and if you had the same number of tiles it would go just as fast if you had done it on paper. I am thinking out loud... on paper there is a really low cost for putting it in the wrong place - you move it here, you move it back, you move it here, you move it back …it takes milliseconds. On here there is a little bit of lag in trying to get it moved, if you put it in the wrong place it is kind of a pain to have to move it somewhere else, so I think they were a little bit more thoughtful about where you put it. Now that there might be people who are purists that say that is an issue, I do not know. They want you to be able to do it on the spur of the moment, is that better than thinking about it before you do it because there is a little bit higher cost if you get it wrong, I do not know. You might be able to argue that either way as a plus or minus. If being a little bit more thoughtful about where you put it is an advantage than this would provide an advantage over the other. But if the

research would say that first instinct without giving it too much thought is better, than the paper one is better because you probably are more comfortable flipping it around and changing six times it does not matter.

The Moderator shared some additional comments regarding the exercise itself and how that has compared to past exercises she has moderated:

It was interesting that we did not use the second layer of groupings, but I think it is really just a numbers game. You might want to look, there has probably been some research out there or guidelines around how many groups and how many items per group. How the levels traditionally work out if you start with this number than you should expect to come up with roughly this many of groups and this many higher level. Maybe it is a condition that we had a smaller number to start with, because if the machine is going to restrain you to a certain number of tiles do you even need the second level of tiles? That might be something to think about. Another thing, if you had twice as many tiles as that, one possibility is to put half of them on the screen and have people sort them into groupings and then put the across the top. Then populate the other half and have people either put them into those groupings or set-up new ones. That might be a way to think about what if you had too many that would fit to find the optimum number for people to be able to do it easily on one go through. I have done exercises, and it is not the purist way to do it but it works. I did an exercise were we gathered data from the industrial advisory board and we went through and took the curriculum committee through organizing it and doing the affinity exercise and coming up with all the groupings. After I did that I collected data from the faculty, without sharing with them other than the three people from the committee, nobody else had seen the data from the advisory board; rather than have them go through and do another affinity exercise, I just went through and assigned them to groups that were already there because they basically all fit into the same groups. Then any that did not fit, I put them as outliers, and grabbed a few people and said 'what do you guys think?' It was not like, you get twenty pieces that say

'communication,' I can pretty much figure out that goes in the communication bucket. So the stuff we were dealing with makes it easy to do that, it is not the purist form, but it is a way and it does work – it worked fine for what we were doing. So that might be another way to think about it, if you need to do two or even three groups of tiles to be able to get a larger volume – maybe figuring out the optimum number of tiles on the device.

The software had an issue when identifying the higher level groupings by color coding them during the exercise, her remarks on this were:

Yes, that was a challenge. You need a way to see where you voted. Otherwise there is no good way to know who cast a vote. It is completely up to the person to know they have x number of votes. Unless you give them something where everybody – a number or a color – they could put their shape. You could do that right, you could put at the bottom – populate different shapes and they move their shape and they get three. That would be another way to do it – the normal way, the way that would be most similar, is with stickers and appropriate and you give everyone three so they cannot put any more down. But if you give them a marker, there absolutely is not any different from the way we did it because they could mark five things but nobody would count if they only mark three so you have to trust them to keep track of it. I think if they could see it as they did it and they would know – 'ok, I just saw it go up one I know I did it' and they could keep track that way.

She acknowledged that there were challenges presented when trying to have the interface do object placement recognition within the timeline available for the development of the software used in the research study. She provided a suggestion of:

And I think that is fine. It seems like commercializing it would be a feature you would want – I do not think it was that big of a deal. I think it is more important that they can see. The challenge, I think, was that they could not tell if it took their vote or not, that was the bigger challenge – to be able to know that it took it.

4.1.3.1.9. Affinity Diagram Moderator – Structural Description

From the Moderator's perspective, the participants jumped into the exercise very quickly; furthermore she felt that they were not afraid of the technology. She recognized that they had difficulty with maintaining a consistent pressure when touching the display with their finger and moving the sticky notes, but they learned how to move them. A more elaborate practice exercise was suggested. Despite the difficulty, the Moderator did not believe it negatively impacted the exercise. She addressed that some participants talked during the exercise, which is normal, but she tries to make sure that it is not excessive. In this case, she stated that most of the talking was about the logistics of how to do the exercise. In her opinion, the participants were influenced more from what they saw during the exercise. She compared the traditional exercise method to the digital method by noting: people tend to focus more on the paper during the traditional method where as people organized closest to them during the digital method. When there were five people participating she felt that at least one participant at a time stepped back otherwise it would be too crowded around the device. On the other hand, when there were just three participants that seemed to work best. She suggested having some clear space initially for the participants to have room to work and begin grouping the sticky notes. In addition, she suggested having the software create a tile effect if a sticky note was placed on top of another note. The Moderator believed that the multi-touch environment caused them to have to pay attention to what others were doing more. They needed to be sensitive to where others were gazing. Although she observed the participants tended to pull sticky notes to form groupings, from the screen closest to them. They tried hard not to bump into each other. She pointed out that she had never completed an Affinity Diagram exercise that quickly on paper. Yet, she expressed that the lag on movement of the items appeared to require more thought from the participants before moving items versus going with their first instinct. The moderator was surprised that the second higher level of groupings was not needed and wondered what the optimum ratio of original data items typically was compared to first level higher groups and second level higher groupings.

4.1.3.2. <u>Data Collection Round 2 (R2)</u>

Round two interviews were conducted with all three participants who were able to perform the entirety of the Affinity Diagram exercise.

4.1.3.2.1. Researcher Epoché from the R2 Interviews

As with round one, the participants of round two appeared to enjoy the process of performing the Affinity Diagram exercise. The two female participants were observed "giggling" during the exercise. During this round of testing the software application did not crash.

The two female participants seemed to have difficulty with the amount of pressure placed upon the device when creating a touch point. The male participant did not appear to have too much difficulty and was even giving suggestions to the other two participants. The greatest frustration was when the digital sticky notes would "disappear."

First, the amount of necessary pressure to apply with their finger when moving items on the device's screen was a major issue. Currently this is a limitation of the hardware of the system being optically based, through further experimentation an optimal setting requiring less pressure could possibly be achieved. Second, some of the digital elements would "disappear" as they would click on them or try to move them. This seems to be an issue with the open-source software, Community Core Vision (CCV).

Just as with round one, the participants of round two have currently worked together in the same department so there was a pre-existing established rapport. The participants joked prior to starting the activity that the two female participants would understand each other's actions and placement, while the male participant would not. Overall during the exercise they all appeared to work well together on the common task. There were only a few times when the rule of no verbal communication during the Affinity Diagram exercise was broken. The male participant gave verbal support to the other participants, mainly regarding the amount of pressure necessary to apply. I did not observe any level of frustration regarding the participants interacting with each other.

There were a few line-of-sight issues that occurred with the participants' arms blocking each other's view of the digital item they were moving. One occasion was when two participants were moving digital items and crossed paths; the software was unable to determine which digital item belonged to which users' touch point.

Just as with round one, the participants of round two would move a digital item as far as they could reach. Then, at times another participant would take over and finish moving the item.

4.1.3.2.2. Participant 6 – Textural Description

Having the least amount of prior knowledge of the Affinity Diagram process or of a similarly documented process, Participant 6 described her initial feelings of performing the sorting activity as:

> I think it went pretty well. I had no idea what I was doing before I got there, so I did not know what to expect at all. But I think it went pretty quickly. We were able to kind of put things together pretty well. I think had we maybe had a little bit more of an idea what we were doing ahead of time, we may have been able to put things on the post-its that may have been a little bit more relevant –or some things just did not really fall in to being as relevant. I mean that was fine not, everything needed to be relevant. I think it was good.

When asked about her experience using the multi-touch interface and device, she described:

> I think it worked really well being able to visually see them and move them pretty easy. Sometimes we had trouble like they would bounce across to the other side [or] a little difficult to move at times. Maybe if it had been a little bigger or if the sticky notes had been a little smaller or maybe we needed less sticky notes – I think sometimes there were so many we were able to see necessarily what was under a stack. Once they were there we did not necessarily have enough room when we were doing it to spread them out, to see what was under them.

In describing her experience with pressure and touching the display output of the multi-touch device, Participant 6 expressed:

To move… we had trouble making them physically move at times, but it may have been that there were three of us just touching it at once. Getting them to more or it would jump and it would be a different one – like it would hop them. Do you remember – it would kind of hop? I would be trying to move one and [another participant] would be trying to move one and all of a sudden mine would jump over or jump across. If you were working on the corner it would jump across to the other side.

For the purpose of completing a common task in the shared work environment of the multi-touch device, she described her experience as:

It was fine. For us since we all know each other very well, so when it comes to that, as far as working together, I think it was fairly easy. I think it could be just as easy with people you do not know too. All of us have been working on the task for some time, so it was not like we were new because all of us have actually been on selection now for two years. So I think we were all kind of on the same page to begin with, doing the activity was not something necessarily something that all of us had not talked about in some point in time before.

When asked to elaborate to see if performing the exercise helped to reinforce what had been previously discussed, she replied "I think so, I think it puts in… compartmentalize or put things into categories of things that: this is where we are, or this is what we need, or this is what we think."

There were a few occasions when participants would hand over to Participant 6 or she would hand over to other participants some of the sticky notes they were trying to move, her feelings on this were:

I do not really remember what had happened exactly. But I know a couple times we were trying to move opposite directions of each other - I do not know if we

actually crossed each other. We were both going and we did not know where the other one was going.

To communicate with each other, the participants used hand gestures to motion to each other:

Because what we were trying to do was to be able to see them all at once to know what was all in one but yet to know that it was all one group. I think if I remember right, we may have had interview things that were in two groups at one point in time but they both were around interviews. So to say this is one and this is one, but we need these 2 to go together.

She expressed that she would have liked to be able to quickly move an entire stack of sticky notes that had already been grouped together, rather than moving each sticky note separately. She felt this would have been helpful when they realized two similar groups had been formed and they wanted to merge to two categories but they were on opposite ends of the device display. Also, she stated that it would have been nice to create additional ideas on sticky notes during the sorting process.

Her overall thoughts on the experience were:

I think it worked pretty well and I think it was pretty quick. To get everything and then to compartmentalize things… put things into categories [and] to say that all of this goes together. To visually see what things needed to go [into each grouping]. I think was good. Being able to group them and visually see worked well.

4.1.3.2.3. Participant 6 – Structural Description

Participant 6 expressed having the most uncertainty when she initially started performing the Affinity Diagram exercise. She had the least background knowledge of a qualitative data sorting activity, such as an Affinity Diagram exercise. Overall she thought the process went very well and quickly, once she felt comfortable with what they

were doing. She believed that they could have provided a better set of data to perform the activity. On numerous occasions, she would tap a sticky note when going to move it and the sticky note would relocate to a touch point of another participant. From the work that the group has been doing regarding their prompt question, she expressed that it helped to "compartmentalize ideas." The visual ability to see were items were and where they needed to go was very beneficial for her.

4.1.3.2.4. Participant 7 – Textural Description

Participant 7's initial response from describing his experience with the sorting exercise alongside his fellow participants as:

> You just had to pick one area and go, and trust that everyone else was sorting correctly. I did not know what they were reading or seeing, or how they were organizing the different sticky notes.

He expressed that he found it difficult to manage with the number of sticky notes displayed. He suggested having a secondary display away from the multi-touch device. This would offer a computer projector displaying the sticky notes onto a projection screen somewhere else within the same room. Regarding the number of participants for his specific user testing round, he felt that three users was the limit. He stated "I think in my opinion, any more people looking around it would have been harder. It was really hard looking at it upside down."

When asked about his experience touching the interface displayed on the multi-touch device, he explained:

> It was kind of hard to press down. The actual function of it, idea of it, I thought was great. At some point, you cannot have it too sensitive. I liked the device in and of itself; I liked the idea of being able to touch and drag to where you want it. The sensitivity could be a little lighter so you did not have to press as hard – that would be the only improvement in that. It seemed like if you did not maintain your certain pressure, you lost it or it would jump to the corner instead of just dropping it to where you last left it. So that could get confusing. Sometimes it would jump

over to someone else who was also touching the screen. If it just dropped to right where you last left off, I think would be very linear, very smooth.

Participant 7 described his experience working with his fellow participants on the exercise as:

It was kind of fun. In your exercise, being silent and not being able to talk, was kind of fun and playful. At times just grabbing somebody else is note and putting it somewhere else. Even if somebody would put a sticky note one place or the other, after you get to the further stages you sit down and look how you grouped them, you could spark up a conversation of why was this here, does it belong over there, and if you have the ability to go back and move those to another area – I think that would help. And that is probably one of the points of any task like this, is that you want to have that conversation, you want to ask your team member why you think this belongs in this area, why do you think that belongs in that area – and you are probably getting at some point that you need to discuss it.

Occasions when Participant 7 would either pass a digital sticky note to another participant or receive one from another participant, he described this to be:

Sometimes as you start organizing in different groups you see how other groups may pop up or other ideas for groupings pop up. And you are like wait a minute, what if we group it like this? So you can grab someone else is that they had already moved and move it to a different group and start organizing a different set – even as a sub group almost, like you are splitting one group into smaller ones. You are just reorganizing in a different frame of mind set, of why these groups should be different – for example there was a lot following underneath 'interviewing' but some of the questions had to do more with the logistics of interviewing rather than the interview so moving them over to the 'logistics' side. I think sometimes the sticky notes where just being moved into a category and then they would later go back to the category, and look at it again and figure out

whether they really needed to move it. Other times, I think they were not actually categories, they were just piles of 'well I will deal with that sticky note later, I am looking for sticky notes to go into this grouping' and the other sticky notes were in the way, so they were just moving them out of the way. What I did was when somebody was unable to, for whatever reason, get the sticky note to move across the whole screen to another area, enabling them to focus and not forget what they were trying to do, I just grabbed it for them and let them go back and start moving other sticky notes. I obviously agreed with where they were moving it to.

During the exercise, Participant 7 realized a method of moving the sticky notes on the display of the multi-touch device and shared that verbally with the other participants, which the Moderator allowed. His comments on this were:

With the plastic screen on top of the plastic screen, I noticed that when you were using your finger the obvious direction is going up-to-down, and potentially left-to-right or right-to-left, if you are left-handed, and if you tried to go down-to-up, specifically with down-to-up, it is going to stutter, your fingers are not going to slide smoothly. But if you use your thumb it is easier to move it in the direction you need it, so that the fingernail is pointing in the opposite direction of where you want to go – it would slide it smoother.

He suggested making a larger display screen for the multi-touch device to accommodate more people at once:

I think that is very… the whole handing over is easy. If you wanted to make a screen that was [larger], almost as big as this table. I think that would be an amazing project. You are ability to twist and move, allows you to not have to look at everything upside down and you can pass it left or right. And you can have a table a 3 foot table, 2 and a half – rounded even, if you could do it that way – so you could just work with each other around the table and have sticky notes and pass them back and forth. And as you pass them to somebody, they get it and

flip it around, size it up however they want it. I think in my perfect world, utopian society, I would love to be able to sit down in a chair around a table, like this a circular table with 4 or 5 people, and because I think with the application we had was small enough that 3 people was max, if you had 4 would have made it more difficult, anything more would have been more difficult. If you had a bigger table like this you could easily have 5 or maybe 6 people passing them around to each other.

From his comment about being able to sit, when asked if he would prefer to sit or stand he explained:

I think that depends. There are some theories about, they call them 'walking meetings,' where you are actually walking – the blood is flowing, you maintain… you are engaged for a longer period of time, you do not zone out, thoughts come more readily – all this different things, actually being up and moving during the meeting versus sitting down. The reason I said this, if you are having a meeting that is lasting longer than an hour or a half hour, whatever you want it to be, it would not be bad… especially, if you are having a long dragged out meeting and how you want to do a lot of things and need lots of people there, I think an application where you are sitting around a table with a bigger screen and be able to move things around. I think most people would probably throw a screen up on the wall and look at it, and have one person move things around, which could be done. But I think it is more interactive and much more engaging if everyone has their hands on. I would prefer, if it was a longer meeting and there were more items to talk about, the table would offer you the ability to look at more items for a longer period of time and engage in a longer meeting would be my guess. I do not think there is a preference, it just depends on the amount of material and how long it is going to take. Which if you want to have a bunch of different subgroups on the same material, so you are managing and you want 4 or 5 different subgroups of 3 or 4 people to go through the same material and see how it all shakes out – standing up would work perfectly, in my humble opinion.

4.1.3.2.5. Participant 7 – Structural Description

When performing the Affinity Diagram exercise, Participant 7 found this to be difficult to manage all the sticky notes on the screen. He stated that he decided to start in one area and just go with it. He was not sure how his fellow participants were organizing the sticky notes and he was not too sure on how to reach the end goal. He suggested displaying the activity on another screen to be able to step back and watch the sticky notes being sorted. He believed that having three users was good for the size of the device, but that was the limit. The suggestion was offered to have a larger display size. He expressed that it was hard to press down on the device and have the interface respond, yet over all he lived the concept, especially the idea of dragging the items on the screen. He found that if the touch point was not maintained the sticky note would jump to another touch point on the screen. He would prefer that it if the interface software was unsure of where to place a digital item it should be placed at its last known location. When interacting with the other participants on the common task, he described the experience to be fun and playful – highlighting the ability to grab someone else is sticky note. He discovered that, in his opinion, moving the sticky notes worked better when using a thumb and by pointing the fingernail in the opposite direction of the movement. Also, Participant 7 suggested having either a round table or a table where the participants could sit around.

4.1.3.2.6. Participant 8 – Textural Description

One of the main benefits Participant 8 described about the Affinity Diagram exercise was:

> It was really helpful for me, because I am a visual person. I need to see everything. Instead of just talking about ideas, to be able to see them and actually move them into groups was very helpful. It was not as difficult as I thought it would be, not being able to tall.

Regarding the ability to touch and move the digital sticky notes on the screen, Participant 8 expressed this as something that she liked very much, especially that the sticky notes were not "set in stone" once they were placed into groups and the participants still had the ability to move them.

As with the other participants, she experienced difficulty with the needed pressure to touch a digital item on the screen. She also highlighted having challenges when the sticky notes would overlap each other:

> I had a little bit of trouble getting use to how you would move things and then trying to figure out exactly how you click on something that is under something to be able to see the text on there. I know that we did that ourselves, we could have grouped them easier so you could see the groups easier but just trying to figure out what was underneath everything and how it was stacked.

When asked about the challenge she experience with the pressure, she stated that she was very used to using an Apple iPhone which requires very little pressure:

> I think probably because we are so used to using devices like an iPhone, you are expecting things to slide over. It felt like you were touching an older TV screen. It would bunch a little bit every once in a while and sometimes you would lose the sticky note you had on your finger and it would go other places. But it just takes some getting used to, and once you are used to it – it works just fine. It was not overly frustrating at all. It was just learning a new device and getting used to that as we do with everything else today that is a technology device.

In describing her experience working with the other participants on the common task, she stated that she believed the size of the testing group worked really well with just the three of them. She continued stating, that if there had been more, it could have been more complicated. Since the participants of that specific round have worked together for quite some time, she believed that they were able to understand each other fairly well or "if we do not understand we can guess why the other is thinking something

or doing something a certain way… it was really nice to have an understanding of the very different personalities but knowing how then all work together."

Referencing handing the sticky notes over from one participant to another, she described her experience as:

> I thought it was helpful. We usually understood where the person was going with it. To have someone who caught on sooner to how to use the device was nice because it was less frustrating for us still trying to pick up and move it. I think sometimes we also did it out of impatience, when we saw the other person trying to move it and it is not working so somebody would just jump in and do it. Depending on the situation that can either be beneficial or detrimental.

There was one point in particular when the Participant 8 and another participant closely crossed-paths when moving stick notes:

> That was one time it was difficult because we could not talk. If we could, we would have just said, you go here and I go here. We had to use either non-verbal communication or just trial and error to figure it out who was going where. I think we just stood there for a second and looked at a couple of categories we thought it was going towards so we could try to figure out what the categories we thought it was going towards so we could try to figure out what the other person was thinking and see if that would logically fit. I do not think it took up a lot of time or made anything difficult. I think it was just that we both saw something that we thought should go somewhere and we were trying to do it very quickly – and we did not pay attention to what the other person was doing and therefore we crossed paths. Had we taken our time, we could have let the other person go first and let the other person move their sticky note.

As one of the final steps of the exercise, the sticky notes were grouped into categories and color coded. The results of the groupings from the exercise were provided to the participants in an Excel spreadsheet. Of these topics, she commented:

I thought at the end it was really cool how you were able to group them into different colors and move them into smaller groups for voting. And then be able to see how, something that to me – again because I am a visual learner and I like to be organized – kind of looked jumbled and it was hard for me to get my head around but you were able to put that into an Excel file and that gave us a very near and clean list of everything that we had talked about. For us that will help a ton by giving them a breakdown of the different areas of where we need to focus, and we can actually put this into a timeline.

Overall her final thoughts about the experience were:

It was fun. I feel like we got a lot done in a short amount of time. For us if we had sat in a committee meeting and tried to brainstorm all those things and try to put them into groups… I cannot tell you, even if it had been just the 3 of us how long that would have take - to be able to get that done in just a half hour was amazing. It cut down on a lot of non-worthwhile discussion, and back and forth, and little details, so I think it was something we could use.

4.1.3.2.7. Participant 8 – Structural Description

Participant 8 expressed a level of enjoyment performing the exercise. She valued the ability to have the visuals of the ideas/concepts on sticky notes which could be continuously moved categorized. While she did have some difficulty with the pressure, she said that she believed it was because most people, such as her, are more familiar with an Apple iPhone which requires very little pressure for the user to interact with the touch capabilities of the smart phone. Furthermore, she appreciated that amount of work they were able to accomplish in such a short timeframe by eliminating the ability to talk during the exercise.

4.1.3.2.8. Affinity Diagram Moderator – Textural Description

The session Moderator's initial thoughts from round two of user testing about how the participants performed when conducting the Affinity Diagram exercise, included:

I thought it worked out really well because it was 3 of them – I thought that was useful. It seemed like they had more trouble moving them around from a physical perspective. It seemed like with the last group after 5 minutes they were pretty comfortable sliding them all over the place, and it seemed like they were still struggling with that, I do not know what that has to do – it just seemed like they were not as comfortable moving things around on the page.

She expressed how she felt that the participants did not have a clear understanding of what their end goal was, which caused some initial difficulty as they were trying to sort the data items on the sticky notes. Her thoughts on this were:

I felt like they just wanted to collapse everything into just a couple of big groups. And I did not look at the data close enough from a context perspective to say, how well did they do that? Because the goal was for them to decide what it was for them. I felt that they had in their head what the groupings were before they went in and for whatever reason the dynamic between the three of them they were perfect – as soon as someone put it in a grouping, they were fine and they did not really want to change it. And that is fine that is up to the group, so that was my observation from a process perspective which made me think from a facilitation perspective is there more reason to do more before they start in terms of talking to them about focusing more clearly on what is the question they are trying to answer.

She went on to elaborate about the participants' knowledge of sorting qualitative data:

They had a mixed bag – one of them did not know anything about Six Sigma at all, and the others had some knowledge but not extensive. And that makes a difference if you have not used it, kind of the first time through that is a little more challenging – even though they do that kind of decision making it is a different way of thinking about it.

Looking more specifically with the interaction between the participants and the multi-touch device, she commented:

From a tool perspective, they seemed to pick up really quickly of what to do. Now you did not have those issues of it gawking out so other than a couple that flew up to the corner – and even those they figured out pretty quickly what was happening. Other than that I do not think they seemed to have any trouble with it at all. They seemed to know what to do, they just physically were having trouble moving things around; loose something and it would fly off to the other aside and even when that would happened they picked it up pretty quickly, so I do not think it caused any issues with them.

Regarding to the issue of pressure for touching the device surface, she commented on her observations:

I think they felt like they had to push so hard and just kind of the frustration in that 'I want to be able to tap it and move it.' And they had to work at that physical, mechanical motion; they had to work at it a little more than they had anticipated to, so I do not think it was a high level of frustration. But I would be curious to see what they say.

The Moderator's perspective on the participants interacting with each other to complete the common task with the shared environment of the multi-touch device, including passing digital sticky notes to each other, was:

I thought they did really well, because I thought based on their conversation at the beginning they thought it would be really hard not to talk which they did not seem to have any trouble with. And I did note a couple of times, I saw them point to something and this here – that is ok, but as long as you are not saying this should be here and why – I felt they really did not push that too much. I thought that was good because it kind of fostered them working together in a way they would not have in the paper environment. So they seemed to be pretty comfortable, once they saw what someone was trying to do if they could not physically do it, they would do it for them. And that seemed to work pretty well and it did seem to foster collaboration. To get a feel for what are they thinking and pick on cues of what they were doing, I was impressed. I had expected based upon the conversation at the beginning, that there would be some squabbling at the end about where something goes. Now what I do not know is how much of that was because they just wanted to get down or how much was it 'yes that is ok' and it is not worth arguing about or was it 'yes just whatever.' I do not know them well enough to know, I guess based upon their earlier conversation I had expected there to be more moving things back and forth. And the one time I noticed, that someone had moved a couple things out of something where someone else had put it, the other person did not take them back – and what I could not tell was it because they agreed or just did not want to argue about it.

The finals thoughts of the exercise from the Moderator's perspective for round two of user testing were:

I think it went a lot smoother. The data content, obviously because of how it was gathered, probably was not as rich, but the exercise itself went very smoothly. I was amazed when I stepped out of the room to take that call, and then walked back in and it had not been that long – but in that short period of time, they were like, "doot doot doot," they got all the stuff that was in the space and put them where they needed to be and they were nicely grouped. It was like "wow they did

that really fast" and I think we saw that with the last group – it starts of slow and once they get the hang of it, it is just like "bump bump bum" and they are done, so that is an advantage I think.

An additional thought that she had, which she acknowledge is not specifically related to this research study, but never the less, a very valid idea:

I would be curious, and it is not for your research necessarily, but I think it would be interesting to see what would happen a second time with the same group but with different data needed to do the exercise again, would the things they learned on terms of using it the first time and how comfortable, because it seems like there is a curve of how comfortable and the learning curve – the question would be, the second time they would do it how fast after that learning curve do they start? Do they forget it all or do they jump right in? Maybe not quite were they were in the last 5 minutes, is it closer to where it was 10 minutes into it?

4.1.3.2.9. Affinity Diagram Moderator – Structural Description

This round of testing, the Moderator felt, worked well since there were just three participants. Her perspective was that this round of participants had more difficulty moving the digital sticky notes on the multi-touch device display. She seemed to believe that the participants needed more facilitation on her part at the beginning since they had difficulty formulating their ideas and prompt question. She acknowledged recognizing that these participants had trouble with the multi-touch interface and often the interface software would relocate the sticky notes. From her observations, the participants tried hard not to use verbal communication and tried to resort to non-verbal communication such as pointing and looking at each other. She expressed that this fostered them to work together more and increased collaboration. Compared to round one, she thought this round went smoother despite the data content not being as rich. Overall, she noticed that it seemed the participants would start off slow building a comfort level with the multi-touch device, then once they were comfortable with it they would interact at a faster pace. Also, she expressed a curiosity of having the same group do the exercise

again with the multi-touch device, but with a different data set, if they would overall interact faster with the device.

4.1.4. Data from the Focus Groups

Each round of user testing ended with a focus group of the participants. This was to provide an opportunity for the participants to share their experiences once again with the Researcher and to share their experiences with each other. The focus groups were recorded with the permission of the participants and the audio recordings were later transcribed.

4.1.4.1. Round 1 (R1)

The focus group for round one included only two of the three participants (Participant 2 and Participant 4) who were able to participate for the entire Affinity Diagram exercise. However, Participant 5 also joined and contributed during the focus group. The Affinity Diagram Moderator was also present and a contributor for the focus group.

4.1.4.1.1. Researcher Epoché from the R1 Focus Group

The users all seemed to enjoy the Affinity Diagram process. A few of them commented during the one-on-one interviews the ability to see what other participants were doing. Furthermore, they described during the interviews that seeing the actions of others made them think about their actions more prior to moving a digital sticky note.

Some participants described how since they had difficulty moving some of the sticky notes on the screen they thought longer about where they wanted to move a sticky note before making their move. The most common frustrations were when sticky notes would seem to vanish for the participants as well as a level of difficulty moving the sticky notes based upon using the correct amount of pressure.

Each of the participants highlighted that they had a fairly good working knowledge of the other participants since they had served on other projects together. This pre-existing relationship led some of them to make some intentional actions that

appeared to be a joking/teasing manner, which to some degree caused interference between participants.

None of the participants described any interference that greatly impacted them. However, from my observations of the testing exercise I did notice at least two specific situations where there was interference: first was when the participants' arms would crossing each other which led to line-of-sight issues; and second, was a few occasions when participants would deliberately stealing sticky notes from other participants.

A few participants described handing over sticky notes to other participants, as well as taking control of sticky notes from other participants, as very institutive to reach out and help a fellow participant move a sticky note to the original intended destination. During the interviews, only a few participants commented on how their actions impacted others participants. One of the two main occurrences was when one participant deliberately stole a sticky note from other participant, as previously mentioned. The second main occurrence was when a participant helped a fellow participant move a sticky note to the original intended destination.

As previously stated, some participants described during the interviews that seeing the actions of others made them think about their actions more prior to moving a digital sticky note. They described how it was helpful having the visual of not only moving pieces but also seeing what others were doing at the same time.

4.1.4.1.2. R1 Focus Group – Textural Description

The R1 focus group started with the Researcher asking those in attendance about their thoughts on the Affinity Diagram exercise. Participant 2 initiated the conversation by sharing "I liked it – to have a group of us around… I liked the set-up, I liked looked down at the table top and all of us together around it and begin about to interact, even without speaking." He went on to state: "You could kind of see what people were getting to through moving things around, it seemed like a very easy and natural way to do it for me." Participant 5 agreed with the statement and added "I thought it was a really interesting way to interact. I thought it was faster in a way than having to talk to somebody because I can think faster than I can talk, mostly. I could think about what I was doing but I could still visually see what other people were doing."

Regarding the device itself, Participant 5 added the comment "The idea is slicker than slick, I would really like to see that developed." Both Participant 2 and Participant 5 agreed that when computer issues started to arise, such as the software appearing to not be able to keep up with them, their initial thought was to prefer the physical sticky notes or index cards.

Participant 5 described his experience standing around the device as "it was crowded around the screen – that was ok, but I was very conscious of rubbing the shoulders of everybody else." He jokingly added "at one point, I am like 'ah do not put that there' and to do a little hip check out of the way." Participant 2 confirmed that with five people around the device there was a feeling of being crowded; with four it was still a little tight but with three it was better. The suggestion was offered by Participant 5 to have a larger screen size to resolve the feeling of being crowded, by stating "what if the screen had been… the primary dimensions of the screen had been twice, it had four times the area – that would solve that problem completely." He went on to suggest a scenario of the table being round and everyone was in agreement that it was a good suggestion. Participant 2 added a joking comment that it would then be difficult to place items in a corner if it was round.

"Just improving the technology to where it is more responsive is the only thing I can think of… it sort of worked the way I am sure you envisioned it would," suggested Participant 4. In agreement of that statement Participant 5 included "if you are going to have a problem, that is the one to have – that is the easiest to fix…" Participant 4 continued on to state "it was slow to move things and not always… you had to keep a hold of the thing and to get it to where you wanted it to go."

When asked by the Researcher about describing their experience using the multi-touch device interface and hardware, the consensus was that the amount of pressure needed with a finger touching the screen was surprising. They were expecting to be able to lightly brush it and once they realized that they had to push a little it was ok. The group indicated that some of them were afraid to push too hard and cause damage to the screen. Participant 5 expressed a question he had come to mind during the exercise of "was I pushing on the sensitive part or was I pushing on a piece of Plexiglas?"

Participant 4 said that once the full mechanics of the device were explained to him, it made more sense and I thought he would then be able to operate it better. Participant 5 described the device as "a big optical fiber" and that he wished he had also known more about the complete mechanics of the device at the beginning since he thought he was going to damage it. He suggested providing the instruction initially: "look this is a piece of plastic; you are not going to damage it if you push on it." He pointed at the tablet computer with him and expressed that he is more used to that type of touch screen which requires a level of care to prevent damage from occurring.

Regarding the topic of working with each other on the common task of the exercise in the shared environment of the multi-touch device, there was already a pre-existing relationship established between each of the participants. Participant 2 said that he found himself defaulting to the other participants who he felt was more of an expert related to the ideas on the sticky notes to move and group those ideas. Although, he added a disclaimer that if he had not known the other participants as well, then there may have been a different level of interaction. He expressed that he might have been more defensive on the groupings he had creating if another participant had tried to make a modification. "Again, I thought the interaction was pretty good," he added.

The Researcher verified with the moderator that when typically performing an Affinity Diagram exercise the participants already know each other to some degree. She confirmed that was accurate. Furthermore, even if the group had been recently congregated they mostly likely had gone through a process together prior to performing the Affinity Diagram exercise. Each of the individuals performing the exercise would at least know the expertise of each other or "what they were bringing to the team." Participant 5 offered his perspective which varied from Participant 2's mind set, by stating that he if they only wanted the experts in each relative topic area to sort the ideas, then each of them would be individually asked to do so. But as a group since they are all asked to do it other, then they wanted his opinion even regarding topic areas outside of his expertise. He added a thought: "it was so fast… trying to keep track of everything that was moving. I was not watching who was doing what." Participant 4 said "I kept going to where I had put something and I went back to put something else

with it…" The group joked at Participant 4's statement of attacking the person who had moved the sticky note.

Participant 5 shared that although he was not present for the full activity, he did find himself spending "just a moment watching what other people were doing." There were times when he was looking at a sticky note trying to figure out where it would group it when "all of a sudden it started moving and I wondered where it was headed." He added that he would not spend time looking at who's finger it was moving the sticky note. At least at one point, someone had moved a sticky note to a grouping that he would not have initially thought to categorize it, however he thought "oh ok, I could see that."

Since each of the participants knew each other, Participant 2 believed that there was a level of trust between them regarding where each of them were usually placing the sticky notes. The consensus among the participants was that there existed a level of respect and no one individual was territorial.

The Moderator interjected a thought of a combination of the "cost" of moving a sticky not because it was not as easy as picking up a physical sticky note and moving it in addition to the trust that existed between each of them. She wondered if they saw a sticky note placed into a grouping that they did not necessarily agree with, if they would just leave it there because of the pressure difficulty of moving them. Participant 5 stated that he did not recall observing someone move a note and another participant waiting until they were finished before then moving it to another location. The Moderator responded by saying "That happens pretty regularly with the sticky notes… what seemed to be happening that was different from what I was expecting, it seemed like there was much less of 'move it here, move it here'." Participant 5 then asked "what happens when you get a group of people, where not everyone trusts each other, or not everybody likes each other?" "You definitely get some of that, and that is where the facilitator has to what for that starting to happen and then you have to say 'timeout'," replied the Moderator.

Participant 2 noted that the biggest interference that occurred was when they were trying to cross physically, which would then result in issues with their line of sight. Participant 4 recalled an occurrence when another participant was trying to use

gestures to communicate something to him; however he did not understand the message trying to be communicated.

If the screen size was larger, they collectively agreed that reaching across the screen would be a problem. Participant 2 indicated that walking around a larger screen would present huge challenges. This would especially be the case if he had to walk behind someone and take his eyes off the screen. He felt it would interfere with his focus and his process of thinking. Participant 5 then suggested having more than one screen, such as having two or three people each on a multi-touch device that were networked together. "The only problem would be if two people grab the same one… on a millisecond time scale, you cannot… nobody is that close, somebody is going to be first. So a note starts moving on its own, you lift up and it [is] still moving from someone else and you are like 'hey get over here'," he stated. Participant 2 interjected that someone causing a sticky note to move from another screen would be distracting. Participant 4 agreed that seeing "notes moving on your screen with no fingers on them" would be distracting. "Which would be a little disconcerting, but there would not be big hairy arms in your way," said Participant 5. "I am not sure which would be a bigger problem," responded Participant 2. A suggestion was provided by Participant 5 to have something similar to a laser point for each participant to be able to control the objects on the screen, because "then you could cross with people all you wanted."

The Moderator suggested that a real benefit and practical use of the technology would be if an organization had teams in different locations. Each location would have a device and they would be performing the same task. Participant 5 stated that his suggestion was more for the multiple devices being in the same room. All of them could be performing the activity without getting in each other's way.

An additional thought from the Moderator was by having a larger display version would mirror the traditional method more closely. She said, "When you are working on the walls, you are walking behind people all the time and ducking your head." Participant 2, who was earlier concerned about walking behind other individuals, then agreed with the observation. The Moderator continued to describe, "That is part of it. And you walk by to get [a] full visual, even though at that point you cannot read what is on the little notes, you might be able to read the headlines." She continued to explain

that people will step back to get an idea for the high level groups and to verify that the groupings are making sense. The Moderator offered an additional thought:

> As we found out with this one (referring to the multi-touch version), you have to have somewhere to move them to [as you group them]. You have to have clear space to start grouping, then you can start grouping where the other ones were [before] you move[d] them. So what generally happens, and I think I saw a little bit of this happening, I saw if you were on this side of the screen you kind of worked more with the ones right in front of you, if you were on the other... that is exactly what happens [in the paper exercise], you are not always walking back and forth. A bigger screen would mimic the physical aspect of the paper exercise more.

Participant 5 suggested having a projector going on the wall to be a second visual display by not interactive. Then participants could step back from "participating on the touch screen, just watching what is happening to see if patterns emerge."

To elaborate more on the desire to have a clear space at the beginning to start sorting, Participant 4 added a request to "give some area to work with… so with a bigger screen keep the sticky notes the same size and you go it. I would not make them any smaller as the screen size goes up."

The idea was then proposed by the Moderator to have the sticky notes initially tiled rather than randomized across the display. Then she wondered, out loud, if it "made your brian more constrained because it looked so neat… the way that it is randomized, it makes you kind of think more freely about it." Participant 5 agreed and stated, "I thought it was pretty cool… I do not think I would have liked it as much." However, Participant 4 disagreed by saying, "There were some issues. I found myself, when I was grouping them, I was piling them just to have enough space and you end up covering up most of your notes. So just leave a little label – that was the way I found worked best to organize them." Participant 5 proposed giving the sticky notes momentum as them were moved across the screen. Others seemed to like this proposed idea.

The final topics discussed included a conversation about how each participant's actions affected the others, as well as how the other participants' actions affected them. Participant 2 described this as:

> There were some, [which] to me, were pretty obvious of where they needed to be. Once those got situated either by my hand or someone else's hand – whether I wanted them there or not exactly – the rest of them took a little more thought. So mentally I did take a step back and said 'oh where should that go' [and] it got a little harder. One time I did step back mentally to re-think a grouping when I saw what was going there by others and I thought maybe I do not have the right picture or the same picture of what that topic is. So that was a learning experience.

4.1.4.1.3. R1 Focus Group – Structural Description

Focus Group for R1 overall liked the experience, especially the ability to visually see the items moving and the actions of their fellow participants. At the beginning with five participants around the device they felt crowded and would have preferred to have a larger display screen in which to interact. Several suggestions came out of the focus group: first, including having more than one multi-touch device within the same room that is synchronized; second, having a secondary visual display such as a projection onto a wall just to be able to watch and not interact with. During the activity there were occasions when the participants realized they were pausing to watch the movements of the other participants before making an action themselves. There were mixed feelings about having a clear area initially when the sticky notes are displayed to provide an area to start working, but most seemed to prefer that idea.

4.1.4.2. Round 2 (R2)

The R2 focus group included all the participants from that round of user testing, in addition to the Affinity Diagram Moderator.

4.1.4.2.1. Researcher Epoché from the R2 Focus Group

Most of the participants had never performed an activity similar to the Affinity Diagram exercise. There was some sense from some of them, of not knowing exactly what they needed to do at the beginning of the exercise. Some felt that the number of data items displayed was difficult to manage at first. Others seemed to feel that a better list of ideas could have been generated.

Two of the three participants seemed to have difficulty with the amount of pressure that needed to be applied to the surface of the screen when pressing it with their finger. IT appeared to take them several minutes before feeling comfortable interacting with the device. The participant who caught on the fastest was trying to, even through verbal communication; help the others by providing suggestions. That participant specifically had realized that in their own perspective the touch pressure worked better if the individual's thumb was used rather than a pointer finger, as well as if the fingernail was pointing in the opposite direction of where the participant was moving their finger – the rear projection screen material would not 'bunch up' as much – which added to the level of difficulty. Some participants described how since they had difficulty moving some of the sticky notes on the screen they thought longer about where they wanted to move a sticky note before making their move.

As previously identified, most common frustrations were when sticky notes would "disappear" and the difficulty moving the sticky notes based upon using the correct amount of pressure. Each of the participants highlighted that they had a fairly good working knowledge of the other participants since they had served on other projects together. This pre-existing relationship led some of them to make some intentional actions that appeared to be a joking/teasing manner, which to some degree caused interference between participants.

None of the participants described any interference that greatly impacted them. However, from my observations of the testing exercise I did notice at least two specific situations where there was interference: arms crossing each other which led to line-of-sight issues; and deliberately stealing sticky notes from other participants.

A few participants described handing objects over to other individuals as very intuitive to reach out and help a fellow participant move a sticky note to the original intended destination.

During the interviews, only a few participants commented on how their actions impacted others participants. The two main occurrences of this was when one participant deliberate stole a sticky note from other participant, as previously mentioned; and when a participant helped a fellow participant move a sticky note to the original intended destination.

As previously stated, some participants described during the interviews that seeing the actions of others made them think about their actions more prior to moving a digital sticky note. They described how it was helpful having the visual of not only moving pieces but also seeing what others were doing at the same time.

The majority of any frustration level that may have existed was with the pressure applied to the surface of the screen. Once participants had established a level of comfort, they were able to interact with the device more easily.

Each of the participants knew each other very well from pre-existing working relationships. Furthermore, from their past experiences together, they each had developed a level of understanding with each other and being able to understand or rationalize each other's thought patterns – in terms of placement / groupings of the sticky notes.

There were only two situations were discussed where interference occurred. One was when immediately after a participant finished placing a sticky note, another participant purposely moved the note to a different category. The other occurrence was, accidental, when two participants closely crossed paths with each other's fingers as they were both moving sticky notes. The software seemed to have difficulty determining which finger each sticky note belonged to.

Some participants described this as a very natural thing to do when noticing that the other participants were experiencing difficulty moving the sticky notes. Others, who were on the receiving end of the assistance, described it as very helpful. From my observations, it appeared that as the participant was moving their finger with a sticky note across the screen they would lighten up on the amount of pressure applied as they

were approaching their intended destination. This would result in their finger ending up at the intended destination but the sticky note had been left behind. Other participants would then grab the sticky note and complete the movement of that specific sticky note to the original participant's intended destination. Some described this occurrence as them agreeing with the original participant, which is why they jumped in to help.

From the interviews some participants highlighted how their actions caused an effect to their fellow participants. Some of this was acknowledged to be intentional and on a fun level. Just as with the first round, some participants indicated that through seeing the actions of the other participants they were led to think about the actions they were planning on taking. Several commented on the benefit of seeing the sticky notes moving in the shared environment and how quickly the process went because of seeing what each other was doing without the ability to speak to each other.

4.1.4.2.2. R2 Focus Group – Textural Description

Participant 8 started off the focus group for R2 by providing her thoughts on the Affinity Diagram exercise. She believed that not talking was a little difficulty however since they knew each other they were able to figure out where people were going with some of the sticky notes during the sorting process. But there were still times when they would be confused as to why someone was placing a specific idea with a certain grouping. Participant 6 agreed with the difficulty of not talking. The Moderator added in that usually the individuals performing the exercise now each other to some degree. She provided an example of a group she works with doing this activity twice again.

"Not knowing that there were more steps of grouping," added Participant 7, "I did not know whether to have many little groups or a few big groups… so going in, I did not if my counterparts go for many groups or bigger broader groups. If I had known we were going I think we would have split it up to make more smaller groups together." Participant 6 commented on her agreement with his statement. Participant 7 went on to state that for his first time, it was intuitive to make the groupings and he could definitely see this as something rolled out to other groups to use. He felt that if they would be "more efficient at it and have a better idea," as well as seeing a use for this exercise again in the further for other brainstorming activities. The Moderator offered the thought

that the exercise is something they could easily replicate even without the tool or with having a facilitator.

On the topic of interacting with the multi-touch device, Participant 8 described her experience as needing some initial practice to figure out when pushing on the screen how much pressure was required, as well as "how long you needed to keep your finger on there to get it to the right space, but after a few moments we kind of figured out how to move things." "It was kind of rough at first but you are only limited by the technology at the time, so I could see it being much smoother," said Participant 7. He went on to describe how the plastic layer on top of the acrylic would bunch up at times and it would be better if there was a way to prevent it from moving or shifting. Participant 8 added the observation that at times when two people were moving items on the screen, the items would stop tracking the finger which was trying to move it; then they would have to find where it had jumped to in order to finish moving it to the intended destination. The other participants agreed that it was an issue and confusing, especially if they would relocate to the other side of the screen. Participant 7 included "to have the default location in the center of the screen." "It seemed that the default location was the corner at the one-one point," stated the Moderator. "At the time, just because of how it was laid out, the corners seemed to be a little rougher to get things in and out of," added Participant 7.

"When you laid a sticky note on top of each other, you could only see wording on the first one so you had to go through and tap the other ones to bring them up to the front to see what else was behind there – but that was probably the way we were grouping things, I do not know if there is a way to make them see through," said Participant 8. "Change the level of transparency," added Participant 7, "you cannot read it but if you can see enough to know what it was." The Moderator suggested having the sticky notes automatically tile when they would move one note on top of another, so that it would be easy to determine that there was more than one there.

"It made it kind of hard because they were all scattered to begin with," said Participant 6, "but there was not necessarily room to group them. They were all over here and then you are trying to find spaces to start groups. I do not know if half of them on one side and the other half open - would make it easier. There was stuff everywhere… you were moving things to move things." The Moderator compared this to

the traditional process using paper flip charts to place the sticky notes by having some flip charts covered with sticky notes at the beginning and other flip charts open to begin grouping on. As you move sticky notes over then you create move blank space to continue grouping. Participant 6 offered the concept of having the ability to be able to move multiple sticky notes at once. Participant 7 then suggested a concept similar to Spider Solitaire, to have an initial set of sticky notes populate the screen and add the remaining notes in batches, so "then you can process them as they come on the screen." The Moderator mentioned that she has done something similar to that through the traditional Affinity Diagram exercise. She continued on to state, "that might be a way, because we had talked about what happens when you have so much data – if it does not fit." Participant 7 then suggested having two modes: one which they are all thrown up there and a second where they would be displayed to batches to be grouped. The Moderator said that is a valid way of doing it with having pre-populated groupings and either adding new sticky notes to the existing groupings or having them form new groups. She counterbalanced her statement, by saying "well maybe someone could theoretically argue that you would look at it differently, because you would not see them all together."

When asked about working together on a common task with the other participants, Participant 7 sarcastically stated "it was terrible." He continued on stating, "I thought it was kind of fun, watching [Participant 6] struggle trying to get them across the screen – that was pretty funny to me." Participant 7 said:

I thought it was interesting to see how people grouped them, because I thought I could guess what the other two would do. For the most part I think I was right but then it was interesting to see a couple different times where one of the two of them would move something somewhere else then I realized where their line of thinking was in that area – which helped me understand their thought process better.

"I think most of the things were things we had talked about before [they were displayed] on there, so we did not have to try to interpret what the other one meant by

what they had put on there," said Participant 6, "but if we had not talked about it, it would have been a little more difficult."

"I was surprised at the end was that what we thought was the most important item and everyone voted differently," said Participant 7. He also offered the thought that if they had been given top-down instructions to prioritize that they "needed to increase the applicant pool or have a more quality pool despite the size," the voting would have been different. The Moderator then highlighted that is the next step in the Six Sigma process for an entire project.

When discussing helping each other during the exercise, they agreed that it was mostly Participant 7. He acknowledged that he is more of a big-picture thinker whereas they are more detail oriented. He wanted to read the sticky notes and think about it more before moving them into groups. He described that at times, since they could not talk, he would try to figure out quickly when the other participants thought some sticky notes would belong in certain categories. At one point they had realized they had two common groups built, but they were on opposite sides of the screen. Participant 7 described:

> I was thinking to myself, just because it has the word 'interview' in it does not mean that it belongs in the group for 'interviewing', and so that was what I was seeing – 'interview' and 'interview' – let us just put them together. But I was like, wait a minute, what is it… what does it really have to do with it? But fortunately it was not very confusing."

The Moderator explained that was part of the purpose for having no talking to prevent one person's thought on an idea dominating the group, whereas the not talking allows the group to self correct through various interpretations. She continued on, comparing the ability to move things quickly in the traditional version, but with the multi-touch version since there was an issue of touch pressure, people may have been more thoughtful in moving some of the sticky notes without having to move them again. Participant 7 stated, "My cost was not making it look pretty, it would be too much effort to get them all filed… I would have liked to make them look pretty." "It just takes me

longer to wrap my mind around it," added Participant 8, "I look at it and kind of freak out for a minute, and then I have to start figuring out the process I am going to use in order for it to all make sense." Participant 6 included, "And that is where I think it would be easier if there was open space to start in, I think it would be easier to make them a little more organized." Participant 8 stated:

> I think it did make me think more about where I was moving things though, because I usually I would probably be a little more impulsive and play around with it until it made sense. But I did not want someone else to have to move it again for me, so I wanted to be sure about what I was doing.

On the topic of how a participant's actions impacted the actions of others, Participant 8 described a time when she had moved a sticky note into a particular grouping but someone else disagreed and moved it, but she could not verbally explain why she thought it did. She did not try to move it back however she recalled that someone partially moved it for her.

Regarding the effect that the actions of others had on each participant, Participant 7 commented that he found some humor in seeing Participant 6 struggle with the touch pressure on the device, especially trying to move a sticky note then having it stop tracking her finger and having the sequence repeat. He did offer support to Participant 6, that she was finally able to get it to where she wanted it to go. Participant 8 said

> I do not think we really did anything really to discourage another person nor did we really encourage one another. We were kind of each doing our own thing and kind of being aware of what everyone else is doing, but thinking through our own groupings.

Participant 7 added in "everyone treated everybody with the same level of respect, and there was not any dominate person in the group that was looking over everyone else or on the flip side, scared to move because somebody was looking over them."

The Moderator shared her perspective regarding the start-up time that occurred both times as they learned how to move things around. She offered that one idea is to have the participants struggle initially to discover how the device operates. A second thought was to have some form of a game or activity to have the participants become acclimated to how the touch pressure sensitivity works prior to starting the exercise. She went on to describe:

In the previous group there was a fair level of frustration at the beginning. And actually, we lost it twice and had to start over but when we started over the second time though, it went really quickly; partly because they had already moved things and partly because the familiarity of how to move things. I just do not know... I would be curious if you thought that was an advantage or if you would just start by moving the tiles and yes you lose a few then you have to find them and that is not a big deal. I do not know if that caused people to have a little more, negative is too strong, but have a feel of the tool being frustrating, versus if you were more confident moving things before you started the actual exercise – if that would be a benefit.

Participant 7 stated:

For a big group of people, it would be too much time investment – I would think. But if it was one person doing a demo for a room and moving them for me with everyone talking but one person is moving – it would be a quick way to get on there. My thought is that having something would be beneficial because everyone is so used to their own touch screen phones now with the iPhone so prevalent, and everything else, and since it is such a little touch. It is a different… [we] talked about the different technology used. So everyone is going to be expecting that kind of a touch and this one is different than that, then there needs to be. I would think you would want to have something to let them get used to it.

Participant 6 included that the experience would be less frustrating if there was more clear space initially. She felt this would be better due to some difficulty she had

experienced when she was trying to move a sticky note and she would get one under the one she wanted.

Participant 7 discussed having a round table would allow the participants to move around the device more easily. As well as having a secondary display would allow more people to watch and see the actions occurring while the other participants were interacting with the multi-touch device. Then he wondered if hearing the comments from an audience would cause a distraction. From this suggestion, the Moderator provided a thought comparing the traditional and multi-touch versions. During the traditional exercise some people physically step back to see the whole collection of sticky notes on the wall to get the 'bigger picture.' So having a secondary display for the multi-touch version could be beneficial by providing the participants a way to see the whole screen without the arms of the other participants going across it. She acknowledged that a possible challenge for the facilitator would be to ensure participants do not stay for a long duration looking at the secondary display rather than interacting with the multi-touch device. Participant 7 highlighted that some people have the personality preferring to have more time to review information before taking action and the secondary display could provide an aide for those types of individuals. They could be allowed to sit back and watch the process. Then at the end of the exercise the facilitator could call on them to share their thoughts on what they had observed with all the participants. "They need that time to watch and process before they are even able to bring any input," he added.

Participant 6 agreed that having a round table for the device would be helpful. She commented had not realized that the sticky notes were able to be rotated and scaled. The Moderator then added the thought that after rotating the sticky notes, at one point they are need all in the same orientation to group them in addition for potentially causing difficulty for other participants to read them upside down. Participant 7 suggested having an overall square display, but keep all the sticky notes within a central circle. Then in the outside corners, additional data could be displayed pertinent to the exercise such as statistics of the number of sticky notes grouped. He continued on to provide the perspective that if the multi-touch device is round and the same image is being displayed on an overhead projector which is rectangular. Therefore the extra space in the corners could be used for something. He also highlighted that the

secondary display projected on to a wall would need to be large enough for the text on the sticky notes to be legible. Then he suggested having a larger table with more people and each person would have their own miniature multi-touch screen in front of them, but they were all synchronized. Participant 6 suggested having some form of numerical or color indicators for each participant touching a sticky note in that particular setting. Having an avatar character representation of the user with a line drawn to the sticky note being selected by the user was suggested by Participant 7. Who then also suggested, the avatar character, similar to a Nintendo Wii Me character, could even walk across the screen to pick up and move the selected sticky note then the user would tap on the screen to the destination the character needed to move the sticky note to. Then the Moderator provided the perspective of having the sticky note be colored or shaded differently to indicate it was being moved by someone else. Participant 6 said that she had, during the exercise, wanted to ask Participant 7 why he had moved a sticky note to a specific group but did not because she was not permitted to talk. Participant 7 then suggested having the system track the movement and placement of each stick note by each participant.

When asked which would be preferred having individual multi-touch displays versus sharing a single display, Participant 7 stated "I think in a bigger setting where there were more people looking at it, yes [individual displays], if it a smaller group… I do not know maybe five or less, it would be more beneficial to be in a circle around [one display]." If the group was larger as well as having a larger single multi-touch display, he shared the perspective:

> At some point too many people are looking at it upside down and that becomes… at different levels you are going to have different issues. If you have a big group around a small one the main issues then, is too many things upside down. But for us, our main issue was dragging and dropping. If there is a large group… if it is a small group, then looking at all the different screens just does not bring us together, but if there is a big group it does do a better job at bringing us together.

The Moderator discussed her thought of the practical application of the technology by being able to perform an activity on multiple screens with users in remote locations. When companies have teams in different locations, they could perform an activity together and see each other's actions in real-time on each display. Participant 7 then added having the capability for each location to see the display in their respective language. He continued to include that the avatar characters could even have the native attire of each country.

Participant 7 then realized having lines drawn from a representation of the user to the sticky note the user was touching would be the easiest visual for him to understand the actions that are occurring. He also included it could cause an issue when there are "multiple people touching things, you have multiple lines and now it is covering the text that you are trying to get at, so I would say it is not the most beneficial… it would be distracting."

All the participants agreed if there was an indicator, such as color change, would work well. Participant 7 then referenced hearing about research project sponsored by Apple Incorporated where elementary students, each with a laptop, would go to learning stations and they would perform an activity on their laptop which was also being presented to them. He stated that the study results indicated that students quickly were catching on with a high success rate. So this could be a way," he added, "to integrate group work into elementary education type learning format."

4.1.4.2.3. R2 Focus Group – Structural Description

The participants of the focus group for R2 valued the visual capabilities provided by the multi-touch device by seeing each other's actions during the exercise. The touch pressure required when the participants were using their fingers to interact with the device was definitely an issue. One even highlighted that the plastic layer on top of the acrylic layer would bunch up at times, therefore increasing the difficulty of moving their finger across the display. However, the largest challenge was when a sticky note would stop tracking a finger and "jump" across the screen. The suggestion to have the sticky notes transition to a level of transparency when they would overlap with each other was presented. As well as a suggestion to be able to move a group of sticky notes all at

once. Several of the participants felt that there needed to be more clear space initially so they could have some blank space to be able to start forming groups. From that, the concept was offered to have the sticky notes displayed in batches. The Moderator indicated that would be perfectly acceptable by most standards for performing the Affinity Diagram exercise.

Some expressed that the exercise made them think more about where they wanted to group the sticky notes before taking action. They agreed that there was a cost to moving the sticky notes due to the touch pressure issue. Also some of them wished they could have made the sticky notes "look pretty" as they were placing the notes into groupings. A few expressed the learning curve of the touch pressure of this device versus the pressure required for smart-phones, such as the Apple iPhone. The suggestion of a round display and a secondary projected display were also offered. As well as an idea to have an avatar representation of the user on the screen, especially if there were multiple multi-touch display screens. Some expressed if there were more users, there should be several multi-touch display screens all synchronized rather than a single multi-touch display for all the users to share.

4.1.5. Summary

Presented in this section were the primary data sources for this study: the Researcher's notes throughout the study, the interviews of the participants, and the focus group sessions. In the next section, an analysis of all the data collected will be provided.

4.2. Analysis and Themes

Following the collection of data, all of the captured data was reviewed and analyzed to find common themes relevant to the research question posed by this study. The data from the various sources were bracketed and cross-examined.

4.2.1. Themes Across All Data Sources

There were several themes which emerged through the various data sources of this study. In this section each of the emergent themes will be individually discussed.

4.2.1.1. Pressure Applied on Multi-touch Device Surface

The largest issue that the vast majority of the participants expressed was the amount of pressure needed to press when touching the multi-touch device's screen. Several participants described this as frustrating.

By going slow, as Participant 4 found out, he was able to maintain control of the sticky notes he was moving:

> Some of it was learning to go slow and I was going way too fast at first and did not realize it. I would get so far and it would be tracking me, and then all of a sudden it would just disappear and I did not know where it went. Then I started going a lot slower and holding a steady pressure.

Some of the participants would exaggerate their manual actions when touching and moving the digital sticky notes on the multi-touch device display output. This relates to Hornecker's (2008) metric for awareness work indicators of "exaggerated manual actions." However, these exaggerated actions, in the opinion of the Researcher, were primarily caused by the issue of the participants having difficulty determining the amount of pressure to use when touching the multi-touch device display screen. Several compared the higher touch pressure required versus the lightness of touch needed for a smartphone device, such as an Apple iPhone. There was a definite learning curve, where some participants were able to become more comfortable with the device faster than others. Participant 1 expressed this difficulty as an "experimental level." The Moderator suggested to either let the participants learn the required touch pressure through discovery by interacting with the device performing the specified activity; or to provide the participants with an initial game or walk-through tutorial to help them become familiar with the touch pressure. The study did provide a very brief overview verbally explaining how the touch pressure for the device worked. Then the participants

were able to interact with the screen and see how the display would respond to their finger touch points. However it was not in the form of a game or a walk-through activity prior to starting the Affinity Diagram exercise. This could certainly be an improvement to the study design for future research endeavors to allow the participants more time to become acquainted with the specific device versus any other touch devices in which they may have past experience.

From R2, Participant 7 discovered that using a thumb versus his pointer finger allowed the device to respond better to his touch point. He verbally expressed this to his fellow participants during the exercise and the Moderator allowed it since the verbal communication was about the logistics of learning the device and not about the sorting exercise.

On a technical level, since the device uses infrared light to recognize the touch points of the users, using a thumb versus the pointer-finger would increase the infrared light captured by the infrared camera reflected off the user's thumb, thus allowing the device to respond better. Although to some people using their thumb may or may not be as comfortable since presumably most people are more familiar with pointing at objects with their pointer-finger.

4.2.1.2. Visual and Organizational Benefits of Multi-touch Display

Across both user testing rounds, the participants found the ability to have the visual opportunity to see not only the same entire display output that all the other participants were seeing, but to also be able to observe the movements and actions of their fellow participants. Participant 2 described viewing the actions of others as:

> That to me was revelatory of the fact that the real advantage of this is that the data stays in front of you and everyone sees it being organized and it does not move around on anybody you can always go back and look at it. You can actually see them slide and see them moving. There is something very organizational, almost scaffolding, that visual translation of the sticky notes.

Participant 6 described about seeing the entire screen and the actions of the sticky notes being moved "instead of just talking about the ideas to be able to see them and actually move them into groups was very helpful." On the note of organizing the sticky notes and having trust that the other participants were organizing correctly, Participant 7 expressed, "You just had to pick one area and go, and trust that everyone else was sorting correctly… I did not know what they were reading or seeing, or how they were organizing the different sticky notes."

The statement from Participant 7 addresses one of the metrics from Hornecker (2008), regarding the positive awareness indicator of "parallel work on same activity without verbal coordination." Participants were able to perform their own actions in parallel within the shared work environment without verbal coordination. This will be discussed further in the following section.

Participant 8, who did not have prior knowledge of Six Sigma Affinity Diagrams, depicted her experience as "I think it worked really well being able to visually see them and move them." Several other participants made general comments describing the organizational process as "I like this method" and this was an "excellent organizational tool." From a technical perspective pertaining to the user interface, providing the visual capabilities to the participants, in the opinion of the Researcher, was easy to do since the software was an Adobe AIR application built on the Adobe Flash Platform. Participant 2 supplied the comment "I found it to be quite user friendly [and] usability was excellent."

The "lag-time" that was expressed by some participants can most likely be a result of the Community Core Vision software receiving the image from the infrared camera, interpreting the image and sending data packets of the touch points to the Adobe Flash Player running the AIR application. If there was the ability to streamline this process, it is believed by the Researcher that this lag-time would no longer be experienced. On the forums and blogs of the NUI Group, others have experienced similar lag-time issues and have expressed hopes to have this resolved by either the creators of the open-source Community Core Vision software or by Adobe with the Adobe Flash Player.

The apparent response from both rounds of testing indicated that the visual benefits of the multi-touch screen with all the participants performing together was beneficial. While there were ideas to further improve it, the majority of participants liked having a single, shared environment where they could perform the task and sort the sticky notes, while monitoring on some level what the other participants' actions were on the same display.

4.2.1.3. Collaboration with Fellow Participants in Shared Environment

The perspective of the Moderator was that "it caused them to have to pay more attention to what the other people were doing because it was a smaller space then we would normally have." Highlighting the combination of the visual benefits and the size of the screen may have helped to increase awareness of each other's actions and therefore, theoretically, increasing the collaboration between them.

As the participants of each round were performing the exercise, on several occasions they would offer assistance to each other. Participant 2 had noticed other participants having difficulty moving the notes, "it stopped near a group but it did not look like a group he was trying to get it to… it did not seem to fit from my perspective" so he moved the sticky note for them. He described his actions as, "maybe that is instinctive… but you could tell if the others were having an issue with something, once or twice it was pretty natural for me to just reach over and take the sticky note and put it in the pile that I thought… or help make that decision." Participant 7 confirmed Participant 2's description of "instinctive" by sharing his thoughts that "the whole handing over is easy… I think it is more interactive and much more engaging if everyone has their hands on." The ability within the multi-touch environment to touch any object on the screen the participants appeared to share the thought that it was not only easy but also basic human-nature to assist someone they saw having trouble. These actions relate to "reaction without explicit request" from Hornecker's (2008) awareness indicators referring to interference. Participants would appear to react to the actions of their fellow participants without a request for their reaction to occur. As someone on the receiving end of assistance from another participant, Participant 8

described this as "I thought it was helpful… to have someone who caught on sooner, to how to use the device was nice because it was less frustrating for us still trying to pick up and move it."

On the level of Hornecker's (2008) negative awareness indicators for interference there were incidences from both rounds of testing when the arms of the participants would become crossed and the line of sight of participants would be blocked. Our Moderator noted her observations as:

I think this caused them to be a little more spatially aware of what was going on other than just the place they were moving from and to. I think it was paying attention to what they were doing. I think it was more physically so they would not bump into each other. But as a result I think it made them more aware of where people were putting things which I think made the process go a little faster.

Participant 2 described his experience crossing arms with others as "once or twice we got tangled up and one person would switch under or take their hands off for just a second." The Moderator shared the comment that "they needed to watch when they were moving something they had to see where someone else was, and that was probably helpful." Awareness of other participants was important while working within the multi-touch environment to try to minimize the incidents of becoming tangled with each other. "Once or twice we got tangled up and one person would switch under or take their hands off for just a second," explained Participant 2.

Despite the instances when the participants would become tangled or bump into each other with their arms, the majority of the time they were able to simultaneously interact with the multi-touch device as they were sorting the sticky notes for the Affinity Diagram exercise. This level of interaction in a team setting, with the added rule of no talking – which limited the amount of verbal communication - Hornecker defines as a positive awareness indicator since participants are empowered to perform "parallel work on same activity without verbal coordination" (2008, p. 170).

An interesting point to note, during both rounds of user testing participants suggested, in addition to the multi-touch device for the participants to interact with,

having a secondary display with a computer projector connected to the system projecting the same video output onto a wall screen. At a technical level this configuration would be easy to provide participants. As participants described, this could provide an additional display for participants to be able to step back from interacting with the multi-touch device to be able to see another visual to get a sense of the "big picture." For the specific activity of the Affinity Diagram, the moderator mentioned that at a facilitator level they would need to ensure the participant did not spend too much time watching the secondary display and not interacting with other participants on the multi-touch device. On that note of participants stepping back from interacting with the multi-touch device, during both rounds of testing, the Moderator noted, as did the Researcher, that some participants would appear to pause their actions for a few moments to observe the actions of their fellow participants. Participant 5 described his experience of this as:

> I did spend just a moment watching what other people were doing… but I was looking, if I was going to take that and move it over here and all of a sudden it started moving and I wondered where it was headed. And it would be off, somebody would be moving it off with their finger but I did not really look up to see whose finger it was, where are they putting that. At least somebody had moved one of the boxes somewhere, where I was not going to put it and I went 'oh ok, I could see that.'

Also during both rounds of user testing, participants mentioned they had pre-existing working relationships with the other participants of their specific user testing round. Most commented that due to this existing working relationship it was easy for them to work together within the shared environment created during this study. A few commented that they would try to guess the actions of the other participants, based on understanding each other's thought patterns from past experiences together. From the pre-existing relationships the Moderator highlighted that during most Affinity Diagram exercises the participants have, to some degree, knowledge of the other participants or at least know what the expertise is of each participant that they contribute to the whole

of the group. Several also expressed a level of respect and trust which had already been established between them each of them. During both rounds of testing at least one participant from each commented that they felt no single participant was trying to dominate during the exercise.

Throughout the interviews and focus groups, numerous comments were made about desiring more open space initially to start grouping the sticky notes. From a user interface design stand point for the specific software application of the Affinity Diagram exercise. Participants and the Moderator indicated that when the sticky notes would overlap it was difficult for them to read the text on the sticky notes. "I was trying to clear out a side so we could start, people seemed to agree with that, so that we could open up a space… so we could do some 'affinitizing'," stated Participant 1. The Moderator described this as: "there were times that people lost; they could not find them because they were buried under something else; that was a little difficult, not a huge issue, because eventually they found it." Two suggestions were offered to resolve the specific issued of overlapping, in addition to the suggestion to provide more open space. First, was to have the sticky notes automatically tile if the software indentified that the notes were overlapping. Second, would be to have the software recognize overlapping notes and change the transparency level of the upper sticky notes so it would be, presumably, easier for the user to realize that there were other sticky notes underneath. The Moderator posed the question if the sticky notes were initially tiled in rows and columns versus randomly, if they would then look too organized from the start and if participants would have more difficulty starting to sort the notes. While she did express that this does mimic the traditional version more, however most participants indicated that if the sticky notes were too orderly at the beginning it could be a deterrent. They described a scenario setting such as that might present less freedom to start sorting, even if there was not open space.

4.2.1.4. Characteristics of Multi-touch Display Effect of Participants' Interactivity

Overwhelmingly the main effect of the device on the participants was the issue of the touch pressure. Participant 2 described this as "surprising." "I found it frustrating,"

stated Participant 4, "because the little sticky notes would not track my finger." In both rounds of user testing, participants experienced instances when the sticky notes would stop tracking their finger and "jump" across the screen. Participant 7 stated it was "hard to press down."

This issue primarily occurred from participants not keeping a consistent pressure on the display when they were moving their finger across the display. This was observed by both the Moderator and the Researcher from both rounds of user testing. "I did notice that I would push and then as I started to slide I would let up," described Participant 2. Also Participant 7 realized this and stated: "It seemed like if you did not maintain you certain pressure, you lost it or it would jump to the corner instead of just dropping it to where you last left it." From the Researcher's observations, Participant 2 and Participant 7 seemed to be the two participants that became the most comfortable with the touch pressure of the device the fastest for their respective rounds of user testing. While the technology is still emerging, the Research acknowledges that this is an area that needs to be calibrated more to provide a better experience for the user. Given the device hardware the Researcher had to work with, which was built at the expense of the Researcher on a limited budget, this was a limitation of the study.

Participant 7 was the one to notice that the device was responding better to pressing on the display with a thumb instead of a pointer-finger, as previously discussed in this analysis. Furthermore, he noticed if the fingernail of the finger making contact with the display was oriented in the opposing direction from that which the participant was trying to move. He indicated that at times the top layer of plastic on the device would bunch up as a finger would be moving across it. If the fingernail of the finger moving across the screen was oriented in the same direction as the movement, the fingernail could snag on the top layer of plastic. Participant 8 gave her account as "it was just learning a new device and getting used to that as we do with everything else today that is a technology device… it took a little getting used [to] it."

Comparisons were made by participants throughout the interviews and focus groups to other touch capable devices, such as the Apple iPhone. The highlighted how the other devices require less touch pressure in order to have the device respond.

Participant 4 expressed his feeling that this would need to be the primary modification to make the device "public ready." The Moderator shared her thought regarding this:

On paper there is a really low cost for putting it in the wrong place… on here there is a little bit of a lag in trying to get it moved. If you put it in the wrong place it is kind of a pain to have to move it somewhere else. So I think they were a little bit more thoughtful about where you put it.

During both rounds of testing, participants suggested having a round display for the device. The idea behind this would be to allow the participants to move around the device more freely. However the concern was brought up during discussions on several occasions, regarding rotating the sticky notes and having some sticky notes oriented upside-down, relevant to the location of some participants. This would then present the difficulty of reading, not only sticky notes across the screen, but both across the screen and with the text oriented in an opposite direction. If the device was round and larger, than the device used during this study, the Moderator agreed with the suggestion of a larger screen by stating it "would mimic the physical aspect of the paper exercise more." In the traditional version participants are able to walk around more freely when the sticky notes are typically on a wall, with the participants physically pulling sticky notes off the wall and walking around each other to group them. With a larger and round device, they would feel an increased freedom to walk around the device, even walking behind each other to group the sticky notes.

On the other hand, Participant 2 described regarding to the multi-touch version of the exercise, "if I had to walk behind someone and take my eyes off the screen, it would interfere with my focus and my process of thinking." The Moderator pointed out to Participant 2 that he would be doing that anyway during the traditional version of the exercise, and he acknowledged her observation and agreed with her. Though, several other participants also indicated that with the multi-touch version they did not want to take their eyes off the screen to not miss any of the actions of their fellow participants. Participant 1 stated that there was too much information to try to keep a level of awareness of the actions of all the participants, he was certainly devoting an amount of

attention to the participants standing around the device directly next to him. Later in the exercise from R1, he had verbally stated not seeing a particular sticky note earlier on, which was located on the opposite side of the screen from where he was located. However he did not indicate whether or not he agreed with how it had been grouped. The Moderator commented that the participants' paying more attention to the sticky notes in front of them is common: "what tended to happen is somebody else would start working on the ones on this end and somebody else on this other end."

Another characteristic of the multi-touch device that affected the participants' interactivity, as previously discussed, was the issue of overlapping notes. At a technical level, this was an issue with the interface design. However the concept of providing a means to assist participants in recognizing when items capable of being moved on the screen overlap each other can be applied to the interface design practices for other multi-touch software applications.

The issue of lag-time, as previously described in the analysis regarding the software used in the study, was an issue which impacted the participants' use of the multi-touch interface and device. In addition to the software, the lag-time issue could have been a result of the computer connected to the multi-touch device, which was a Dell Latitude D830 running Windows XP Professional (Version 2002 Service Pack 3) with an Intel Core2 Duo CPU 2.00GHz and 2.00 GB of RAM. This computer was used due to readily availability and convenience to the Researcher. If perhaps a more powerful computer was used, the lag-time expressed by the participants may not have been an issue.

Several participants expressed the suggestion to have a larger display size to accommodate more users and provide more physical space for the users to stand, or sit, around the device. A few comments were provided that if there had been, during each round of testing, any additional participants around the device it would have been crowded. The observation was made that for R1, when the number of participants decreased during the exercise it became easier for the remaining participants. Participant 8 shared her thoughts, "had there been any more it could have been a bit more complicated."

4.2.2. Summary

In this section the themes which emerged from data sources were each identified and discussed. The themes included the perspectives of the participants for using a multi-touch interface and device in a group setting to complete a common task, as well as some of the challenges the participants experienced. The subsequent section will include a discussion of the final conclusions of this study in addition to recommendations for future research studies and possible implications from this research.

SECTION 5. CONCLUSIONS

This section includes future research recommendations, final conclusions and financial implications. Recommendations are offered with changes to improve the methodology of this study as well as for additional research studies.

5.1. Recommendations

Throughout the study, several participants as well as the Moderator shared their ideas of additional directions research could stem from this study. These ideas as well as the thoughts from the researcher are shared in this section.

The primary recommendation for replication of this study would be to ensure the study uses a device that is more sensitive to touch pressure compared to the device used for this study. This issue was the largest challenge for participants during this study. Another recommendation would be to offer a more thorough walk-through activity or game prior to starting the exercise to allow the participants to become better oriented with the touch pressure requirements of the specific multi-touch device used for the study.

As for future studies, the overwhelming suggestion was to do a similar study but with a larger display size. Multiple participants recommended having a multi-touch surface area for the device of 48" x 36", which is about four times the area of the display size used for this study. The second most frequent recommendation to the Researcher was to develop a round display for the participants to interact with.

Participant 2 and Participant 7 offered similar recommendations of the use for this type of technology in elementary education. Participant 2 detailed this as use in developmental mathematics such as grouping sets where students could learn similarity and differences. Participant 2 also shared that he could see this technology being used to help companies determine product families.

Another recommendation presented from both user testing rounds, was the idea of having a secondary display projected by a computer projector onto a wall screen. This could allow participants to be able to physically step away from the multi-touch device to watch a visual of the exercise in real-time without arms blocking their line of sight. However for them to be able to participate in the exercise, they would have to return to the multi-touch device after looking at the secondary device. The idea of having multiple synchronized multi-touch devices was also presented, which could be implemented in several configurations. One configuration would be to have multiple synchronized multi-touch devices within the same room to provide an opportunity for more users to participate in the exercise without the participants being crowded around a single multi-touch device. A second possible configuration involves multiple synchronized multi-touch devices, but in remote locations. This could be very beneficial from companies with remote teams to still be able to collaborate on a task in real-time without the expense of traveling to a common location.

Our Moderator also provided three main recommendations. First, having two or three rounds of participants performing exercise on a multi-touch device and have two or three rounds of participants perform the exercise in the traditional format on a paper. All would need to use the same data set. Then the study would time the groups to determine if there is a distinguishable difference between the two environments as well as compare the similarities between the groupings/categorizations produced from the exercise of each environment. Second she suggested having the same participants perform the exercise twice with different data sets to see after using the multi-touch device once, if they are able to perform the second exercise with a different data set faster due to a familiarity with that specific multi-touch device. Third, if there was a larger data set for the exercise, have no more than half the notes displayed on the screen initially. Allow the participants to sort those notes into groupings, then in batches reveal the remaining sticky notes for the participants to continuing sorting. The participants would be able to add the notes to the existing groupings or to create new groupings.

5.2. <u>Conclusions</u>

The objective of this study was to capture the essence of the lived experience of a specific phenomenon for each of the participants. For this study the particular phenomenon was users interacting simultaneously to complete a common task with the display output of a multi-touch device. The goal was to determine if a multi-touch interface and device is a practical shared environment for a team of individuals to complete a common task. The response from the participants was, in this specific setting for completing an Affinity Diagram exercise, the multi-touch device proved to be a useful tool for team collaboration to occur. Participant 2 summarized this by stating "It was easy for multiple people to be working at the same time."

While both the hardware and software of the multi-touch device created a few challenges for the participants on various levels, including the software failing twice during the first round of testing, they were still able to complete the exercise. This benefited not only this study by collecting qualitative data from the participants, but also the participants were able to take the results of the Affinity Diagram exercises back to their respective organizations since data sets relative to real-world topics were used during this study. "All the early development things, you have a good structure there," was a comment shared by Participant 4. Specifically with the Affinity Diagram exercise, the Moderator was surprised with the speed, despite the learning curve for the participants to become familiar with the multi-touch device, in which the participants of both rounds completed the exercises. She described this as, "I have not done one on paper that quickly."

Participants expressed appreciation for the usefulness the multi-touch device provided by allowing them to see all the data in front of them, as well as being able to, at some level, see all the actions of their fellow participants. Several factors presented in the data analysis section of this document indicated that collaboration was enhanced through the interactivity with the multi-touch device due to the increased context awareness of the participants.

A variety of recommendations were shared to not only further improve the methodology design used for this study but to also pursue additional research studies related to this study. One of which is the potential benefits of remote location team

collaboration through synchronized multi-touch devices. This could have a potential significant impact for corporations as companies expand globally and more teams are separated to remote locations.

Other researchers interested in this topic or project should review Provisional U.S. Patent #62/327,354 was filed in April 2010 by the Purdue Research Foundation with Frank J. Garofalo as the primary inventor. As well as a subsequent article published by the author on the Adobe Developer Connection, in the Education Developer Center category, entitled "Adobe AIR and Multi-touch for Multi-user Collaboration" (http://www.adobe.com/devnet/edu/articles/frank_garofalo.html).

<div align="center">5.3. <u>Financial Implications</u></div>

There are several financial implications to perform a study such as this, in addition to the prospective industry uses of technologies explored in this study. First the cost of performing this study will be supplied, followed by a discussion of possible cost factors to the industry.

First concerning this study, there is an upfront cost of either building or purchasing a multi-touch device. For this study, a multi-touch device was designed and built by the researcher. While this was not originally planned as a component of the study, it supplied the researcher with a thorough understanding of not only how the user interface software functioned but also how the mechanics of the device's hardware operated.

A second cost would include the development of the software for the multi-touch interface. In this study the software for the Affinity Diagram exercise was developed using the Adobe Flash Platform. More specifically coded within Adobe Flash Professional CS 4 and produced as an Adobe AIR application. The cost of developing the multi-touch software can vary, if built by the researcher than it is just the cost of the researcher's time; otherwise if outsourced the price tag can vary greatly. The interface model for a multi-touch environment is very different than that of, for example, a web site where a computer mouse is utilized. Due to the nature of the multi-touch environment events can occur in parallel whereas typically within most computer mouse

environments events occur in a serial sequence. At least from the experience of the researcher for this study, there is a large amount of trial and error through testing that goes into developing the interface.

On the note of testing, the third cost is that of user testing, which can include several line items. One could be, if some form of compensation is given, the cost of the participants. The participants in this study were volunteers and no compensation was provided. However the participants were able to make use of their item to sort through qualitative data by performing the Affinity Diagram exercise and receiving the results from the exercise to utilize within their respective organization. Also, the cost of the researcher's time can be factored in.

Second, taking the knowledge and results gained from this study there can be several directions it can be applied towards the industry. At a very basic level, companies could use a multi-touch device in a lobby as an interactive display. For a more applied business use of a multi-touch device, as discussed in this paper, companies could use synchronized multi-touch devices for teams in remote locations to be able to collaborate simultaneously. This can present an initial upfront expensive of purchasing the necessary equipment, including the web server capacity to synchronize the devices through the Internet. However, over time it could a cost saving to have employees use the devices rather than the expense of having employees travel to a common location.

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APPENDICES

Appendix A. Initial Interview Questions

Initial Interview Questions

- Gender: Male / Female
- Have you heard of Six Sigma?
  - What is your past experience with Six Sigma Affinity Diagrams?
- Have you participated in a process, in the past, where you have had to make sense of a large amount of qualitative data either as an individual or as a group?

Appendix B. Post-Test One-on-One Question Guide

Post-Test One-on-One Question Guide

Duration: Should not take longer than 1 hour

Recording: Audio recording to be transcribed later in addition to notes taken.

- What was your experience performing the Affinity Diagram?
- Can you describe your experience using specifically the multi-touch device?
    - Possible Follow-up Questions:
        - Can you describe your frustration with the device?
- How was your experience working with the other individuals on a common task?
    - Possible Follow-up Questions:
        - How was your frustration level with the other individuals?
        - Can you describe any interference that occurred?
        - What was your experience with handing over objects to other individuals?

Appendix C. Post-Test Focus Group Question Guide

Post-Test Focus Group Question Guide

Duration: Should not take longer than 1 hour

Recording: Audio recording to be transcribed later in addition to notes taken.

- What was your experience performing the Affinity Diagram?
- Can you describe your experience using specifically the multi-touch device?
  - Possible Follow-up Questions:
    - Can you describe your frustration with the device?
- How was your experience working with the other individuals on a common task?
  - Possible Follow-up Questions:
    - How was your frustration level with the other individuals?
    - Can you describe any interference that occurred?
    - What was your experience with handing over objects to other individuals?
    - How did your actions affect the other participants?
    - How did the actions of other participants affect yours?

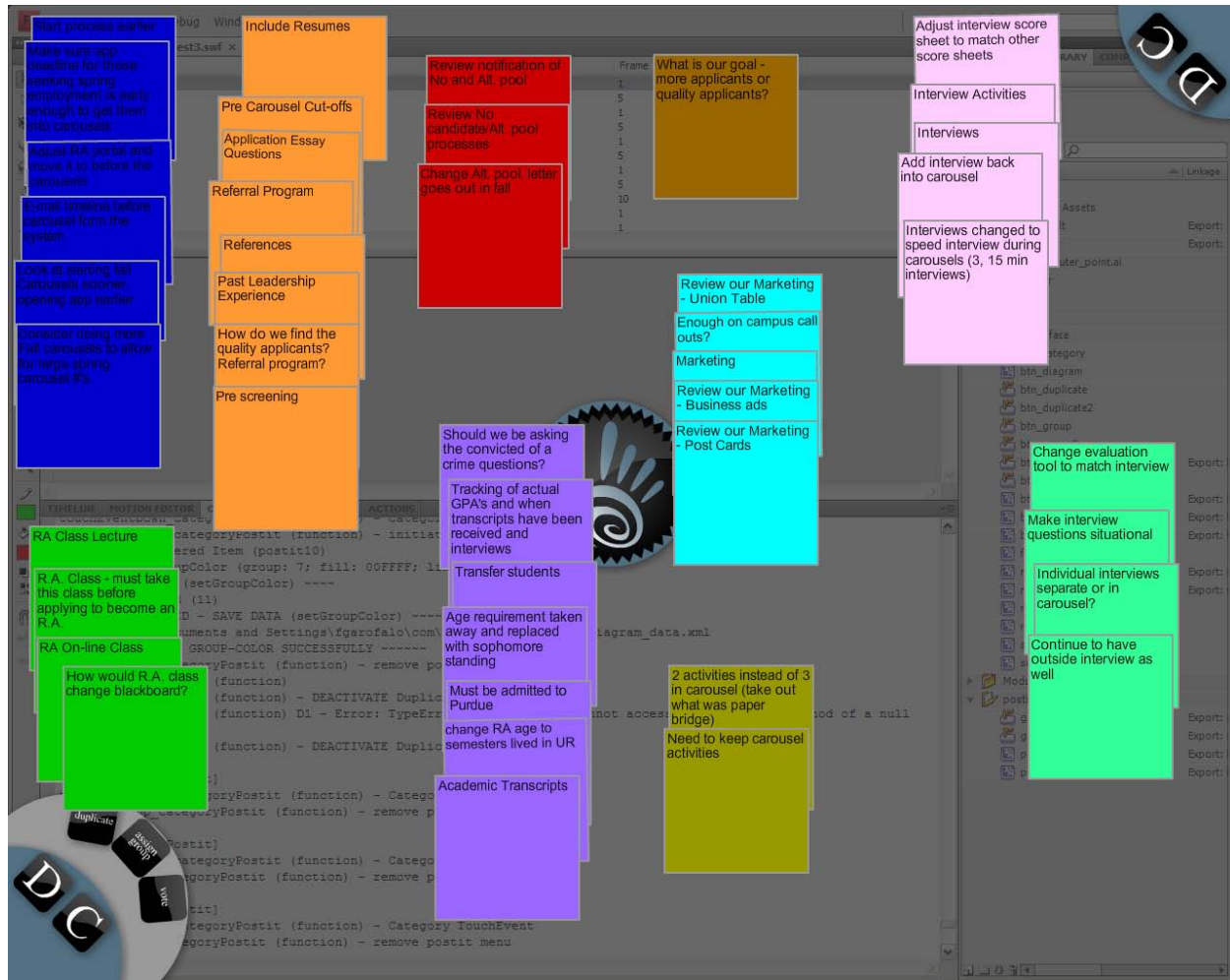Appendix D. Affinity Diagram Visual Display Results R1
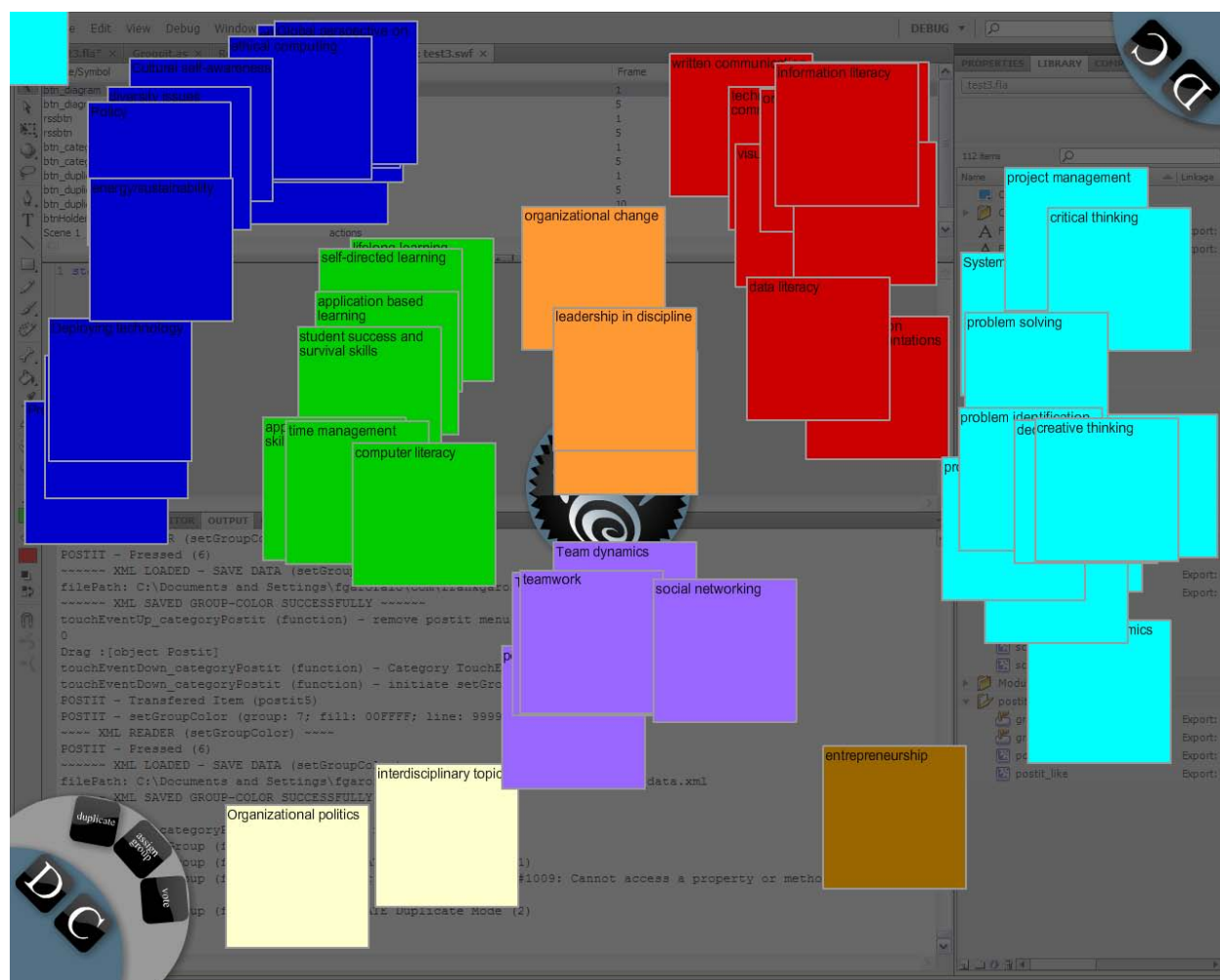
Appendix D Figure: Round 1 Lower Level Affinity Diagram Groupings
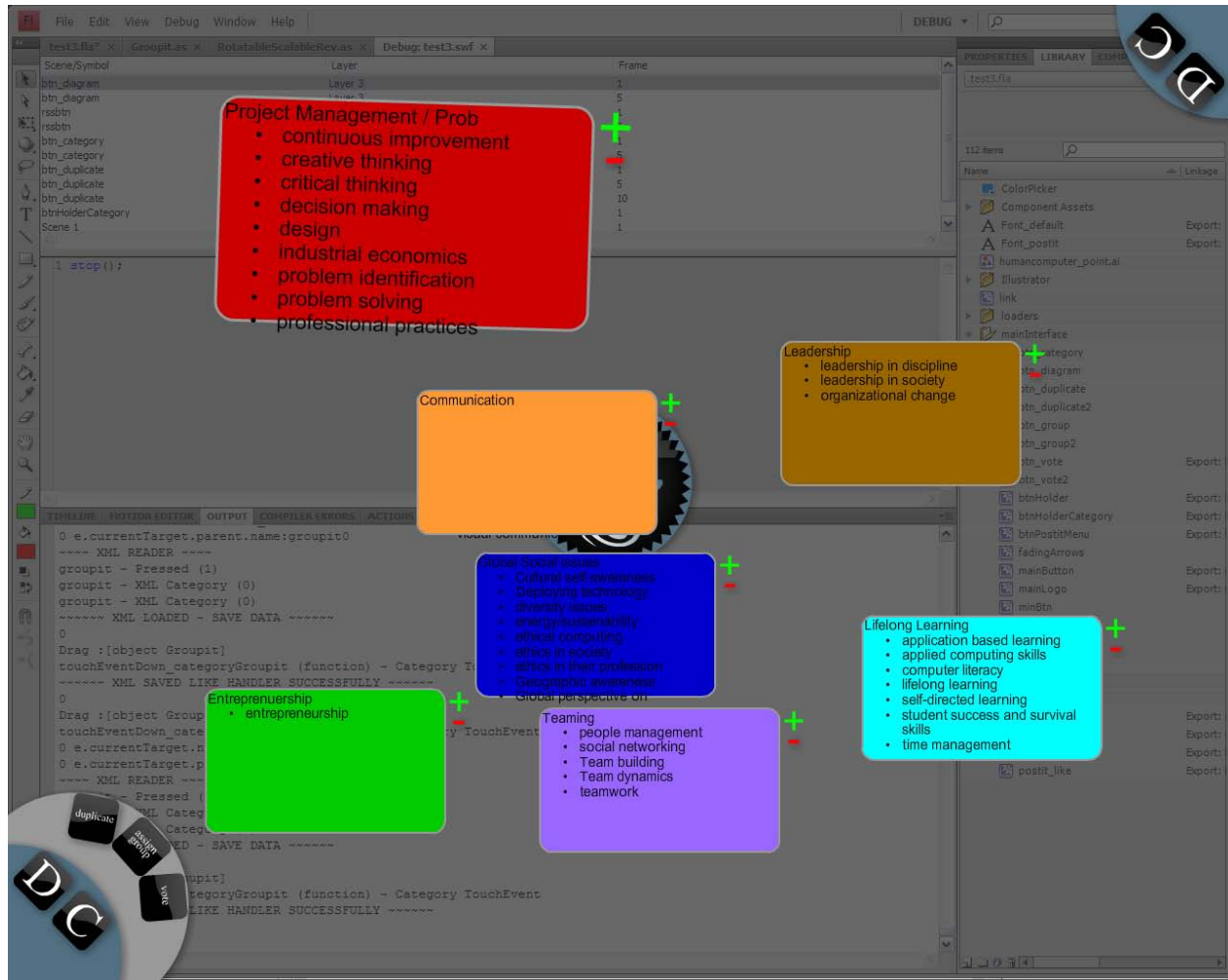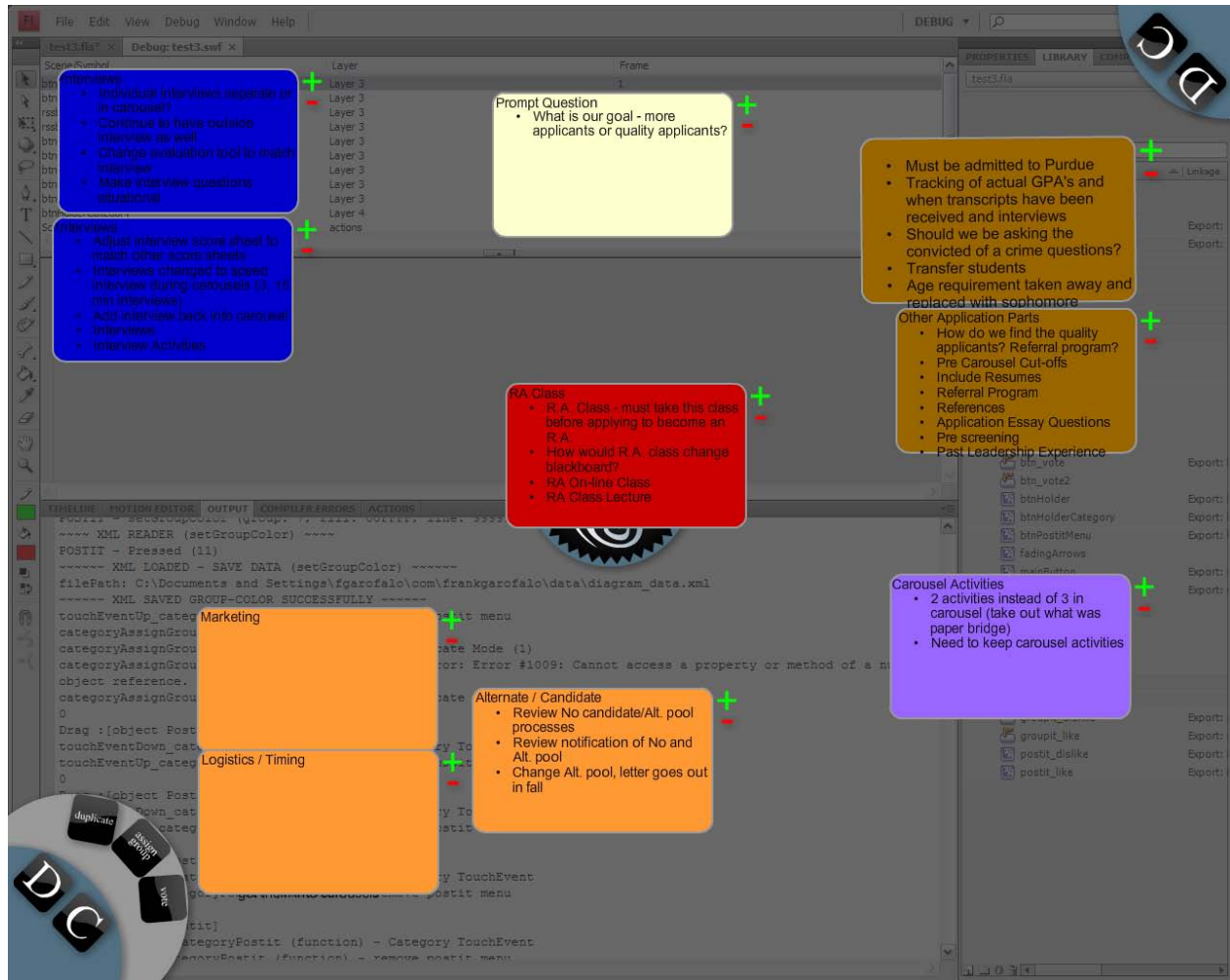
Appendix D Figure: Round 1 Higher Level Affinity Diagram Groupings

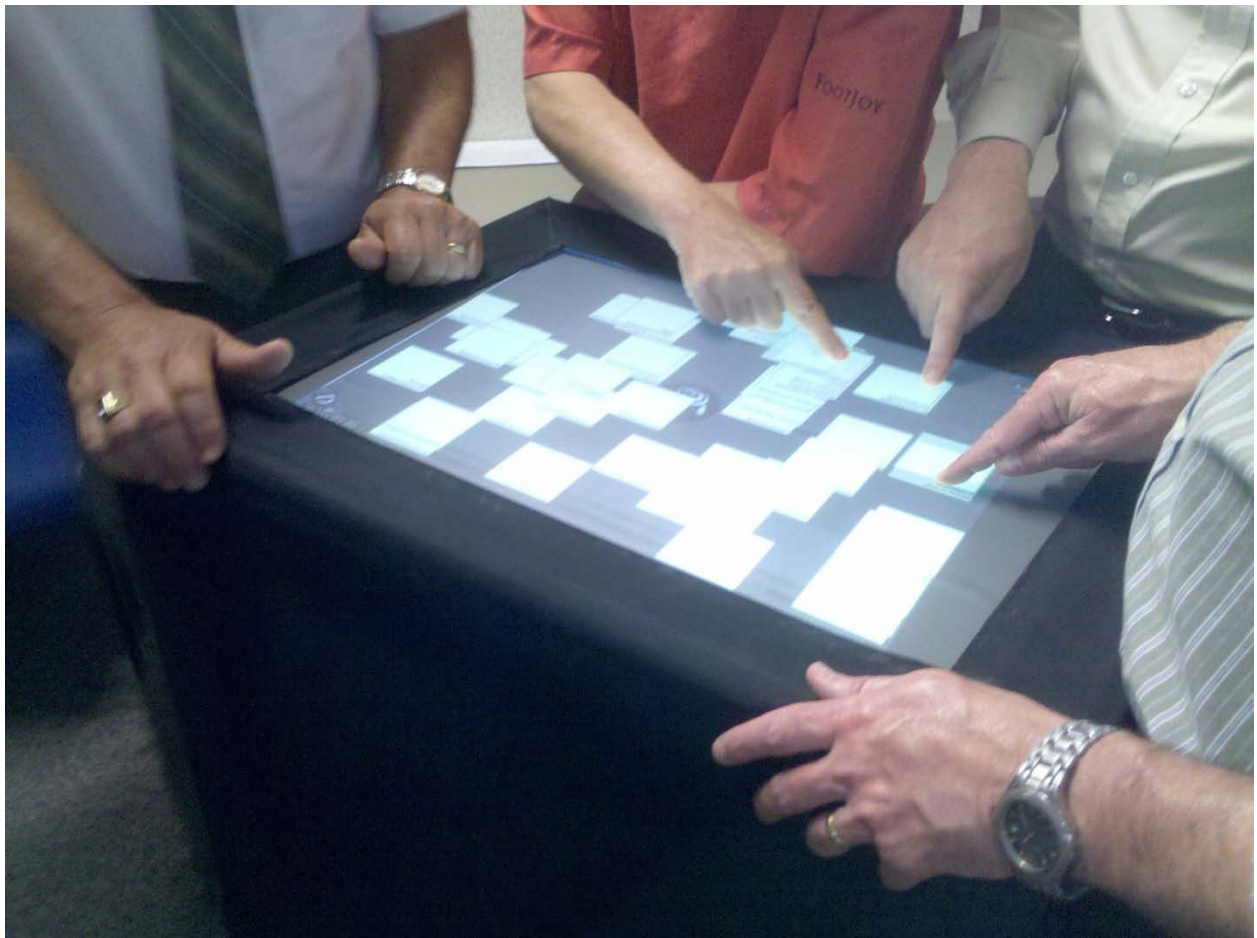Appendix E. Affinity Diagram Visual Display Results R2

Appendix E Figure: Round 2 Lower Level Affinity Diagram Groupings

Appendix E Figure: Round 2 Higher Level Affinity Diagram Groupings

Appendix F. Photograph of Participants Interacting with Multi-touch Device

Appendix F Figure: Participants from R1 interacting with the multi-touch device

RESUME

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Frank Garofalo

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West Lafayette, IN 47906
(502) 216-8734
frankg@purdue.edu
www.frankgarofalo.com

CAREER SUMMARY:
  Creative developer with a focus in on-line / interactive multimedia design &
  development and experience with various media and entertainment companies.
  Quality driven professional with leadership experience and strong work ethic.
  Recognized by leadership for demonstrating adaptability and dedication to
  organizational goals.

EDUCATION:
  Purdue University – College of Technology, West Lafayette, IN
  - 2010 Master of Science in Computer Graphics Technology
    Conducted an exploratory research study of team-based collaboration for multi-
    touch interfaces and devices; Cumulative GPA: 3.36 / 4.0 scale
  - 2008 Bachelor of Science in Computer Graphics Technology,
    specialization in Interactive Multimedia
    Minor: Management Marketing (Krannert School of Management)
    Cumulative GPA: 3.50 / 4.0 scale; Major GPA: 4.0 / 4.0 scale

PROFESSIONAL EXPERIENCE:
  Garofalo Enterprises Inc d.b.a. Cyber View, Louisville, KY
  Founder / Freelance   7/1999 – Current
  - Started my own business in July of 1999 as *Cyber View* at age 14 –
    cyberviewsites.com
  - Incorporated the business as *Garofalo Enterprises Inc d.b.a. Cyber View* in August
    2000
  - Developed a content management system in 2004, called CyberStudio (version 4.0
    released July 2008)
  - Developed a residential life management system in 2007, called ResLife Portal
    (version 3.5 released July 2009)

  The Walt Disney Company: Disney College Program, Orlando, FL
  Campus Representative for Purdue University   1/2006 – 8/2010
  - Designed a marketing campaign to increase awareness of the Disney College
    Program to students and faculty
  - Partnered with Disney College Recruiting to motivate students to attend either a
    live or online presentation
  - Mentored to Disney College Program participants from Purdue University

University Residences, Purdue University

Staff Resident at Cary Quadrangle   8/2007 – 5/2010
- Led a staff of 9 resident assistants in a building of 345 residents
- Coordinated emergency situations, involving police and paramedics
- Planned and led training sessions for 30 resident assistants
- Conducted performance evaluations for staff members
- Coordinated and led panel-based interviews of vacant peer positions

Bank of America, Charlotte, NC

eCommerce Technology Sales & Fulfillment – Internship/Marketing   5/2007 – 7/2007
- Improved internal communication by launching a wiki as a knowledge management repository
- Served as the Technical Delivery Lead to on-board new affinity cards for July & August 2007, budget: $60,000
- Collaborated to innovate new offering of Bank of America desktop widgets using XML and AJAX technology

University Residences, Purdue University

Resident Assistant at Cary Quadrangle   8/2006 – 5/2007
- Established a community environment among 40 residents conducive to learning and personal development
- Developed and initiated programs centered on education, personal development, engagement, and diversity

Louisville Metro Government – Waterfront Development Corp, Louisville, KY

Belle of Louisville Graphic Designer / Marketing   5/2006 – 8/2006
- Designed marketing materials including: brochures, flyers, advertisements, and new signage for office exterior
- Produced a bi-weekly newsletter sent out to over 1,160 subscribers
- Obtained listings on tourism, local, and social web sites for special event cruises

Walt Disney World® Resort, Lake Buena Vista, FL

Marina Operations, Life Guard, and Lake Patrol - Internship   5/2005 – 1/2006
- Recipient of the Silver Whistle Quarterly Award for outstanding job performance, service, quality and dedication
- Established guest service skills in high volume area; displayed adaptability in a diverse work environment
- Increased sales at the Marina by designing a new Specialty Cruise Flyer

GRAPHICS & SOFTWARE PROFICIENCIES:
- Advanced: HTML/xHTML, CSS, PHP, MySQL, Microsoft SQL, XML/RSS, Dreamweaver, Photoshop, AJAX
- Intermediate: JavaScript, Flash, ActionScript 3.0, Adobe Flex, Illustrator, Adobe Integrated Runtime (AIR)

PATENTS / PRODUCTS:
  U.S. Patent (Provisional) #61/327,354 "Collaborative Touch: A Multi-user
    Collaboration Multi-touch Device," filed April 2010

PROFESSIONAL SOCIETIES & MEMBERSHIPS:
  ACM SIGGRAPH Member (www.siggraph.org) – Since August 2005
  ACM SIGCHI Member (www.sigchi.org) – Since September 2008
  Epsilon Pi Tau - Gamma Rho Chapter (www.epsilonpitau.org) – Honorary for
    Professionals in Technology – Since May 2007
  The Order of Iron Key (www.purdue.edu/ironkey) Class of 2008 – A prestigious senior
    honor society whose goal is to create a service project to benefit the Purdue
    community; team raised $110,000; 1 of 14 seniors
  Mortar Board - Barbara Cook Chapter (www.purdue.edu/mortarboard) – Class of 2008
  Adobe Student Representative for Rich Internet Applications at Purdue (2008 - 2010)

AWARDS, HONORS, AND OTHER ACTIVITIES OF DISTINCTION:
  2010 Adobe Design Achievement Awards - Semi-finalist - submission "Multi-user
    Collaboration" within the "Non-Browser-Based Design" category
  Student Ambassador for the Purdue University 2010 Reaccreditation from the Higher
    Learning Commission of the North Central Association
  IT Summit 2008 at Purdue University Poster Competition – Third Place Research
    Poster entitled "*cgCentral: An AIR Application for Managing Course Information
    and Simulation Data*"
  Adobe Dev Connection Content Contributor – Topics: Education, Adobe AIR, Multi-
    touch Interfaces (2008 - current)
  Dept of Computer Graphics Technology Exceptional Performance in CGT 411 Senior
    Capstone Course Award 2008
  Senior Design Research Project initiated the research collaboration between Adobe
    Systems Inc and Purdue College of Technology
  Mortar Board - Barbara Cook Chapter - Graduate Fellowship 2008-2009 Recipient
  ITaP Digital Content Development Grant – Co-authored Purdue grant with Purdue
    University Associate Professor Terry Burton and Purdue University Assistant
    Professor Kellen Maicher for the development of a project entitled: Cogent AIR
    Desktop Appplication using Adobe AIR – Total Funding: $13,100 (2008 - 2009)
  2008 Purdue University Undergraduate Research Poster Symposium: College of
    Technology Dean's Choice Award
  OnePurdue Enrollment and Student Affairs Advisory Committee - for student portal:
    myPurdue (2007 - 2008)
  2007 & 2008 ACM SIGGRAPH at Purdue – Computer Graphics Technology
    Distinguished Student Award
  Cary Quadrangle Resident Assistant of the Year Award (2006 - 2007)
  Walt Disney World Downtown Disney Marina Silver Whistle Quarterly Award (2005)

REFERENCES:
  L.T. Hawkins – Dean of Students, Purdue University
  Robert J. Brophy – *former* Residential Life Manager, Purdue University