

NC STATE College of Design

FINAL PROJECT DOCUMENTATION
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SECTION B: Project Abstract:

We are in a new age of simple and accessible tools for remote collaboration, but XR applications that enable collaboration are sorely lacking in their implementation of social presence features. Better social representations are needed to make remote collaboration in XR applications feel more natural. This investigation explores visualizations of social presence that break the typical convention of full-body, stylized avatars. The potential of gestural control, and the effects it has on the social aspects of remote collaboration is also explored.

SECTION C:

Project Document: 

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SECTION D:

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COLLEGE OF DESIGN FINAL PROJECT DOCUMENTATION

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The written documentation will consist of, at least, the following:

1. Title page including: student's name, department's name, college, university, date of submission, degree name, committee names with chair indicated.
2. Abstract, approximately 100 words, describing the project.
3. Table of contents.
4. List of illustrations.
5. Report text.
6. Footnotes/endnotes.
7. Bibliography, using standard form.

Virtual Presence: Supporting Collaboration

Social presence with hand-based gesture control for collaborative interfaces

Virtual Presence: Supporting Collaboration

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Abstract

We are in a new age of simple and accessible tools for remote collaboration, but XR applications that enable collaboration are sorely lacking in their implementation of social presence features. Better social representations are needed to make remote collaboration in XR applications feel more natural. This investigation explores visualizations of social presence that break the typical convention of full-body, stylized avatars. The potential of gestural control, and the effects it has on the social aspects of remote collaboration is also explored.

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Thank you to my committee members for all your guidance and insightful feedback.

Thank you to my loving parents, who helped get me to where I am today.

Thank you to Julia for being my home through all of this.

Last but not least, a shout out to the doofuses Bean, Fitzgerald, and Scout.

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Introduction



Without collaboration, our species may not have become the dominant one on this planet. We are a social species and have worked together to survive since our humble animal beginnings. We leave behind evidence of our collaborative nature everywhere we go. We work together as inventors, builders, artists, and thinkers. We leave traces of our collaborative nature everywhere we go, from Stonehenge to the site of the Apollo 11 landing on the moon. One such trace, Cueva de Los Manos (Cave of the Hands), is a beautiful cultural site in Argentina. It is known for containing hundreds of hands stenciled across the rock walls and ceiling, the oldest of which dates back to about 11,000 B.C. Many different peoples and cultures left these representations over thousands of years, overlapping and interacting, making this one of the earliest examples of collaborative artwork in the world. The rock art in Cueva de Los Manos also depicts scenes of collective hunting and gathering; groups of people are shown working together to take down large animals, a representation of primal human collaboration (Ashero, 2018).

Collaboration allows us to achieve things that we couldn't possibly do alone. By working together, we become greater than the sum of our parts. For all of recorded history, collaboration has occurred

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face to face, while being near our collaborators. Only in the last few decades has remote work become a possibility for the average worker. Before the internet, remote collaboration seldom occurred, and when it did, it could only happen via analog means such as markings on cave walls, snail- mail, telegraph, or telephone. Never before have we had the technology for the near-instantaneous remote collaboration that we take for granted daily. With technologies, come new design problems. The things that make in-person interaction so effective for collaboration, such as social cues and non-verbal communication, are mostly lost during remote collaboration. Without being face to face, effective and fluid communications can quickly become difficult.

When the first bits of the internet began to sprout from the seeds placed by the global telephone network, whole swathes of new design research began in an attempt to keep up with the rapidly accelerating pace of communication technology. *Social Presence* (SP) in the field of *Human-Computer Interaction* (HCI) is a term that has been used by researchers since the mid-20th century. At the outset of the theory, SP was concerned with how the sense of social proximity or salience of communication was affected by communication through digital mediums. As people began to communicate via networked computers, many social limitations were made obvious. New telecommunication technology could not transmit information about nonverbal cues, gaze, facial expression, clothing, or posture (Short et al., 1976). All of these elements contribute to the degree that a person is perceived as a “real person” across the network (Gunawardena, 1995). This degree of SP afforded by various telecommunication mediums is a subjective measure, but one that can be directly correlated to the objective quality and efficiency of the communication (Oh et al., 2018). Imagine yourself in any sort of digital environment. Next, imagine that another person is sharing this environment with you. In simple terms, SP theory addresses how real or present that other person may seem to you, and how real and present you may seem to that other person. Picciano (2002) defines SP as “a sense of being in a place and belonging to a group” (p. 22). Text-based communication apps such as *Whatsapp* are generally considered to have lower levels of perceived SP than video-based communication apps such as *Zoom*, or more immersive XR applications such as *VRChat*, because communications feel more natural when you can see and hear the person you are talking to (Oh et al., 2018).

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From Bell System's *Picturephone I* unveiled at the 1964 World Fair in New York, to today's ubiquitous use of *Zoom* in the post-covid education and work landscape, there is more perceived social presence in our remote communications than ever before. Increased SP does not automatically mean that communication is of higher quality. Our computer-mediated communication patterns are still vastly altered from normal, face-to-face interactions (Gunawardena, 1995). The social presence afforded by simple audio-visual teleconference systems is very limited. Systems that incorporate more elements of natural human communication, such as body language, are more experimental, but have been shown to increase perceived social presence (Nowak, 2003). In immersive XR environments, such as *VRChat*, the salience of communication is boosted by full-body dynamic gestures captured by hand and body tracking technologies. It is these new and rapidly advancing body-tracking technologies that will allow future designers to create new systems with high levels of social presence.

1.1. Problem Statement

Although in-person collaboration is natural to the human experience, collaboration with others who are not in our immediate vicinity is not. Communication technology, especially the internet, has ushered in a new age of simple and accessible tools for remote collaboration. On the cutting edge of emerging technology, extended reality (XR), has become a booming field of study ripe for experimentation. Most implementations of XR are focused on individual experiences, and XR applications that do enable collaboration are sorely lacking in their implementation of social presence features. The perception of social presence is often forced upon cartoonish or uncanny avatars. Developers seem unwilling to break the convention of the traditional avatar and experiment with new ways of visualizing social presence. Better social representations are needed to make remote collaboration in XR applications feel more natural.

Most VR software is designed for individual head-mounted units. Although individual VR headsets are often networked together for online multiplayer gaming, there is a lack of useful software for remote collaborative work between multiple participants. There are many design opportunities still left to be discovered for implementing social presence and collaborative work into XR applications.

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What affordances of these technologies are best for groups of people who are trying to achieve a common goal? How can the design of implementations for social presence help reduce the frequency of miscommunications? How often do misread social cues lead to social problems during remote collaboration? This problem is immensely complex, and only the careful design of these systems can solve it.

As designers of these systems, it is our job to improve the remote work experience. Many people complain that working over Zoom and other audio-visual platforms introduces major communication problems – social and emotional cues are often misinterpreted or lost entirely (Gunawardena, 1995). Telecommunication technologies fundamentally change the way we communicate with one another. For example, spoken language is sometimes used to compensate for the disconnect of gestural communication – head nods may be replaced by statements such as “I agree” (Gunawardena, 1995). While communicating over Zoom, many users experience frustration from miscommunications. This loss of empathy or understanding of other users is a sign of low social presence, and this problem needs to be understood and addressed by designers of future systems (Short et al., 1976). In the context of the virtual classroom, many students are likely to feel alienated from their peers due to low perceived SP—just because participation in class or group work occurs does not indicate that a student feels like part of the group (Picciano, 2002).

1.2. Justification

This investigation emphasizes the importance of social presence and its benefits for communication and effective collaboration, and identifies issues and pain points. XR is being used as a social medium more than ever, and will likely only increase in the future. The classic face-to-face mode of collaboration will always be preferred by a majority of people, but as we’ve all begun to realize—due to the Covid-19 pandemic—face-to-face work is not always practical or possible. With the convenience and necessity of remote collaborative tools for the “new normal”, remote work has become part of everyday life for many people. For these reasons, it’s easy to argue that remote work is here to stay.

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We need to bring natural physical communication and body language into our telecommunication systems, simply because it allows us to not only communicate more naturally, but also improve the efficiency of our collaboration. I believe one way to achieve this goal is to design for social presence; the more that we feel our remote collaborators are in the same room, the more natural our communications will feel. A strong sense of social presence helps the technology fade into the background and allows the people we are working with to become the primary focus (Picciano, 2002). With the right design considerations, current technology can allow for the social experience of face-to-face work to be better approximated.

XR technology is ripe for further integration of social presence. Social VR applications such as *VR Chat* and *Rec Room* use avatars with face and hand tracking to create a sense of presence, and communication takes place in virtual spaces through the means of avatars and voices. Online collaboration occurs in apps such as *KingSpray Graffiti Simulator*, where artists can meet in virtual alleyways to paint walls together in real-time. These precedents prove that collaboration is not only possible in XR, but is also advantageous.

This study will have a special emphasis on the use of hand gesture control during telecommunications. Speech is often accompanied by hand gestures, which “illustrate” additional information, by pointing, metaphor, and emphasis (Short et al., 1976). The use of gestures has shown to improve the clarity of communication (Gunawardena, 1995), which is why it is of special interest to this investigation.

1.3. Assumptions and Limitations

Assumptions: Vision-based gesture recognition systems are finicky and require careful calibration and setup to work effectively. This study imagines a future where the hardware and software setup (camera, sensors, and machine learning programs) for vision-based gesture recognition is more reliable and accessible to the average user, with minimal fuss. This approach allows the focus of the study to be on the interfaces that will react to gesture recognition data, rather than the details of how the technology itself will work (Aliprantis et al., 2019).

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This investigation assumes that the addition of indications of physical presence that move beyond the commonplace “face in a box” videotelephony model of remote communication will add an improved sense of social presence for users. It is assumed, based on existing research (Wang et al, 2011), that the addition of visible hand gestures will improve perceived levels of SP. This investigation will also avoid the use of full-body, or mostly full-body, user avatars. Many avatars in XR applications are often perceived as cartoonish, childlike, strange, or uncanny. A simpler, hand-based approach to avatars will avoid such perceptions.

Limitations: Rather than exploring the overall user experience of remote collaboration, this investigation will focus on the implementation of improved social presence in these experiences. The studies in this document will not attempt to reinvent the wheel of remote collaboration and communication, but will rather target specific pain points during these interactions and propose potential design solutions.

These investigations will explore only synchronous remote interactions. The utility of asynchronous collaborative tools is recognized, but these tools are outside the scope of this study. Social presence is less of a concern for asynchronous work, as there is less perceived proximity between users due to the time gaps between interactions (Kreijns et al, 2004).

2.1. Annotated Bibliography

Tangible User Interaction	Tangible bits: Towards seamless interfaces between people, bits and atoms.	Ishii, H., & Ullmer, B. (1997).
	Getting a grip on tangible interaction: A framework on physical space and social interaction.	Hornecker, E., & Buur, J. (2006).

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	Benefits of a Tangible Interface for Collaborative Learning and Interaction.	Schneider, B., Jermann, P., Zufferey, G., & Dillenbourg, P. (2011).
Extended Reality	Why and Who Will Adopt Extended Reality Technology? Literature Review, Synthesis, and Future Research Agenda	Chuah, S. H.-W. (2018).
	VRBox: A Virtual Reality Augmented Sandbox for Immersive Playfulness, Creativity and Exploration.	Fröhlich, T., Alexandrovsky, D., Stabbert, T., Döring, T., & Malaka, R. (2018).
	XR collaboration beyond virtual reality: Work in the real world.	Lee, Y., & Yoo, B. (2021).
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Social Presence	The social psychology of telecommunications.	Short, J., Williams, E., & Christie, B. (1976).
	A Systematic Review of Social Presence: Definition, Antecedents, and Implications.	Oh, C. S., Bailenson, J. N., & Welch, G. F. (2018)
	The Effect of the Agency and Anthropomorphism on Users' Sense of	Nowak, K. L., & Biocca, F. (2003).

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	Telepresence, Copresence, and Social Presence in Virtual Environments.	
	An Examination of a Theory of Embodied Social Presence in Virtual Worlds.	Mennecke, B. E., Triplett, J. L., Hassall, L. M., Conde, Z. J., & Heer, R. (2011).
	Supporting Body Language with Volumetric Visualizations of Hands in a 3D Videoconferencing Environment.	John, C., Regenbrecht, H., Schwanecke, U., Haubner, N., & Teoh, C. (2010).
	Social Presence Theory and Implications for Interaction and Collaborative Learning in Computer Conferences.	Gunawardena, C. N. (1995).
Theory	Learning Theory and Online Technologies	Harasim, L. (2017).
	Meanings Of Place: Everyday Experience And Theoretical Conceptualizations.	Gustafson, P. (2001).
	Gestural primitives and the context for computational processing in an interactive performance system.	Choi, I. (2000).

Tangible User Interaction

Tangible User Interaction (TUI) is a sub-field of research under the broader field of HCI (Human-Computer Interaction). The defining properties of tangible interactions can be described as “tangibility and materiality, the physical embodiment of data, embodied interaction and bodily movement as an essential part of the interaction, and embeddedness in real space” (Hornecker & Buur, 2006, p. 437). Tangible interfaces are a relatively new way of thinking about how users could interact with digital interfaces. A simple way to conceptualize TUI is to think about removing the mouse and keyboard. Instead, the entire human body and the space it inhabits become an input device and used to communicate with the computer. TUI gives physical form to digital information, which allows it to be interacted with and manipulated in embodied and gestural ways (Ullmer and Ishii, 2000). Schneider et al. (2011) found that participants of their study were able to collaborate more efficiently when interacting with TUIs.

Extended Reality

Extended reality (XR) is a term that encompasses virtual reality (VR), augmented reality (AR), and mixed reality (MR) technology. XR augments the user’s physical environment by overlaying it with 3D models, images, text, or data (AR). Alternatively, it can completely immerse the user in a virtual environment separate from reality (VR), or use a mixture of the two (MR). Users can use XR elements to enhance their in-person collaboration or collaborate in virtual spaces using avatars. Extended reality interfaces often utilize TUI elements, such as gesture recognition and haptic feedback. For example, Fröhlich et al (2018) created an XR sandbox in which a virtual environment could be manipulated via tangible interaction with physical sand.

Social Presence

Social presence (SP) was coined by John Short, which he defined as the “degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships...” and “as being a quality of the communications medium” (Short et al., 1976, p. 65). Short defined the two major aspects of SP to be intimacy and immediacy. “...intimacy refers to the feeling of connectedness that communicators feel during an interaction, while immediacy is the psychological distance between the communicators” (Oh et al., 2018, p. 2). Short hypothesized that

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users of a communication medium are always aware of SP to some degree. Users tend to report higher levels of perceived SP when interacting with other users (and computers disguised as users) when those users were represented by some kind of image, anthropomorphic representations were proved to create a greater sense of SP than other forms of representation, such as static images or video (Nowak & Biocca, 2004). John et al (2010) showed that in a 3D teleconferencing context, more lifelike representations of human hands, rather than cartoonish or wireframe representations, provided a higher sense of social presence for users.

2.2. Precedents



Figure 2.2.1: Meta Quest Hand Tracking

Meta, the new name for Facebook's parent company, owns Oculus, one of the leading VR companies. In 2019, Oculus released a free update for their Quest line of standalone headsets. This update leverages the built-in cameras and sensors on the headset, along with machine learning algorithms to accurately track the user's hand positions in real-time, allowing for fluid gestural interaction in VR software.

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Figure 2.2.2: ClearBoard

ClearBoard (Ishii & Kobayashi, 1994) was an experimental system created to support distanced collaborative drawing. Two clear whiteboards were networked together, using pen digitizers, cameras, and rear projection, one user’s marks are projected onto the other board in real-time. This system enables two people to collaborate synchronously with a high level of social presence, and was shown to effectively aid fluid distanced collaborative work—and is an exceedingly early example of a practical TUI.



Figure 2.2.3: VRBox

VRBox (Fröhlich et al, 2018) was an augmented sandbox meant to support “playful creativity” and exploration of a constructed virtual space. Participants of this small study manipulated the features of a virtual landscape through the tangible interaction with a physical sandbox. Kinect depth sensors translated the depth and shape of the sand into hills and valleys. Using VRbox, participants could experience the landscape from a first-person perspective and use gesture and hand tracking to further customize the environment. This is just one of many experiments with “augmented

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sandboxes”. A sandbox makes an effective tangible interface because its tactile nature allows data to be felt and manipulated directly with your hands.

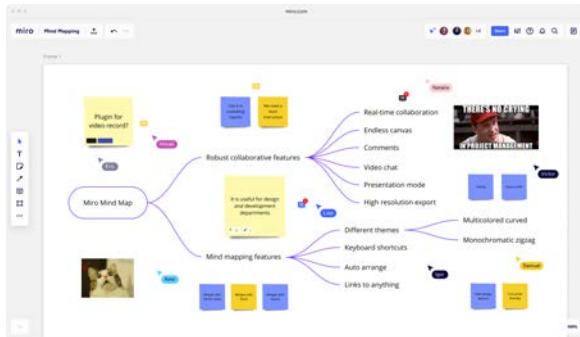


Figure 2.2.4: Miro

Miro is an online visual collaboration platform. It allows for synchronous and asynchronous collaboration or individual work. It is built on a whiteboard metaphor, with virtual sticky notes and connecting lines. Social presence in Miro is limited to a cursor labeled with the user’s name, which moves in real-time on the virtual whiteboard, and an indicator at the top of the screen showing who is currently viewing the board.



Figure 2.2.5: Zoom

Zoom is a video telephony application that supports video conference calls with many participants. Social presence in zoom does not go far beyond the “head in a box” model. Participants can raise their “hand” by clicking an icon that includes an extra layer of textual communication in the “chat” window.

Investigation Plan

3.1. Conceptual Framework

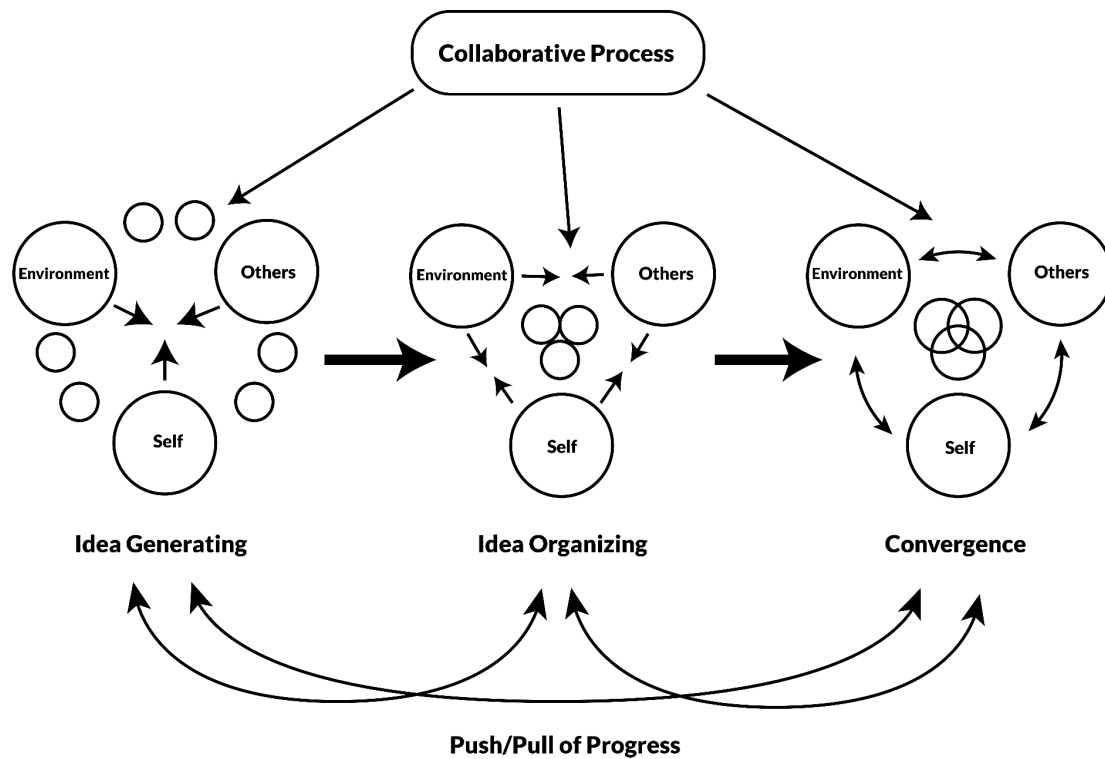


Figure 3.1.1: Conceptual framework for the study.

This conceptual framework is adapted from Per Gustafson’s Meanings of Place framework (Gustafson, 2001) and Linda Harasim’s Three Intellectual Phases of Collaborativism (Harasim, 2017). Gustafson created a framework for identifying and classifying “meanings of place” which he separated into three broad categories, “self”, “others” and “environment” (Gustafson, 2001). Although this framework is about “place,” it seemed to me that these three categories could work

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just as well for describing how collaboration happens in virtual spaces. Self, environment, and others all interact within collaborative spaces. I mapped this framework to Harasim's "Three Intellectual Phases of Collaborativism" framework. The three phases described in Harasim's framework are "Idea Generating," "Idea Organizing," and "Intellectual Convergence." These phases describe the process a group of collaborators moves through toward the goal of a "Possible Application". I placed Gustafson's framework in each of these phases, thus creating a new framework that describes the process that self, environment, and others move through as collaboration occurs. It is important to note that the movement through these phases is not linear; during the collaborative process, there will likely be much jumping between phases, revision of phases, and repetition of phrases. Because of the non-linear nature of collaboration, I have not illustrated this process moving toward a "Possible Application". The focus of the investigation is not on the result of collaboration, but rather, on the details of interactions that occur during the process.

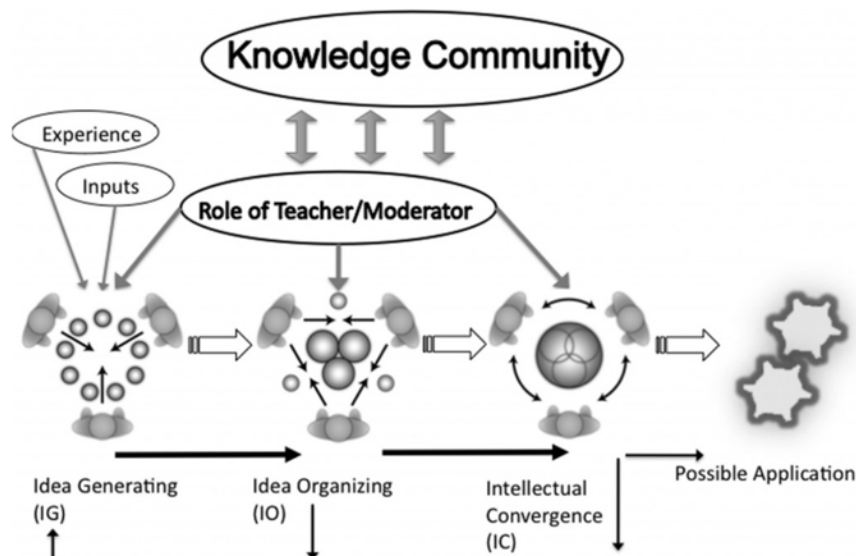


Figure 4.4.2: Harasim's pedagogy of group discussion (from Harasim, 2012, p. 95, with permission)

Figure 3.1.2: Linda Harasim's Three Intellectual Phases of Collaborativism (Harasim, 2017).



Figure 3.1.3: Per Gustafson's Meanings of Place framework (Gustafson, 2001)

3.2. Research Questions & Definition of Terms

Primary Research Question:

How can the design of an extended reality (XR) interface support college students engaged in an **synchronous collaboration** process through the visualization of social presence?

Research Subquestions:

1) *Gesture Key*

How can the design of a set of hand gestures help users control and interact within a collaborative interface?

2) *Idea Generation*

How does the visualization of hand-based social presence, combined with the use of **gestural control**, assist in the early ideation phase of team collaboration by introducing non-verbal communication?

3) *Idea Organization*

How can a **multi-user gestural touch table** interface support the collaborative processes of organizing and categorizing ideas in real-time by visualizing individual and collective

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ranking preferences?

4) *AI Assistant*

How can the design of an **AI assistant** that intervenes as an unbiased mediator help the team generate, eliminate or converge project decisions?

Definition of Terms

Synchronous Collaboration: The process of a team working together towards a common goal in real time, as opposed to asynchronous collaboration, where work is done independently and put together later.

Social Presence: The “degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships...” (Short et al., 1976, p. 65).

XR: Extended Reality (XR) is a term that encompasses Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) technology.

Gestural control: A gesture physical movement used to express meaning. Using machine learning, a system can be programmed to understand a user’s gestures and map them to functions.

AI assistant: An assistant within the interface, powered by artificial intelligence and machine learning, assist the user with simple and complex tasks.

Touch table: A large table shaped digital device, outfitted with a large touchscreen display on the surface and sensors for body tracking.

3.3. Investigation Model

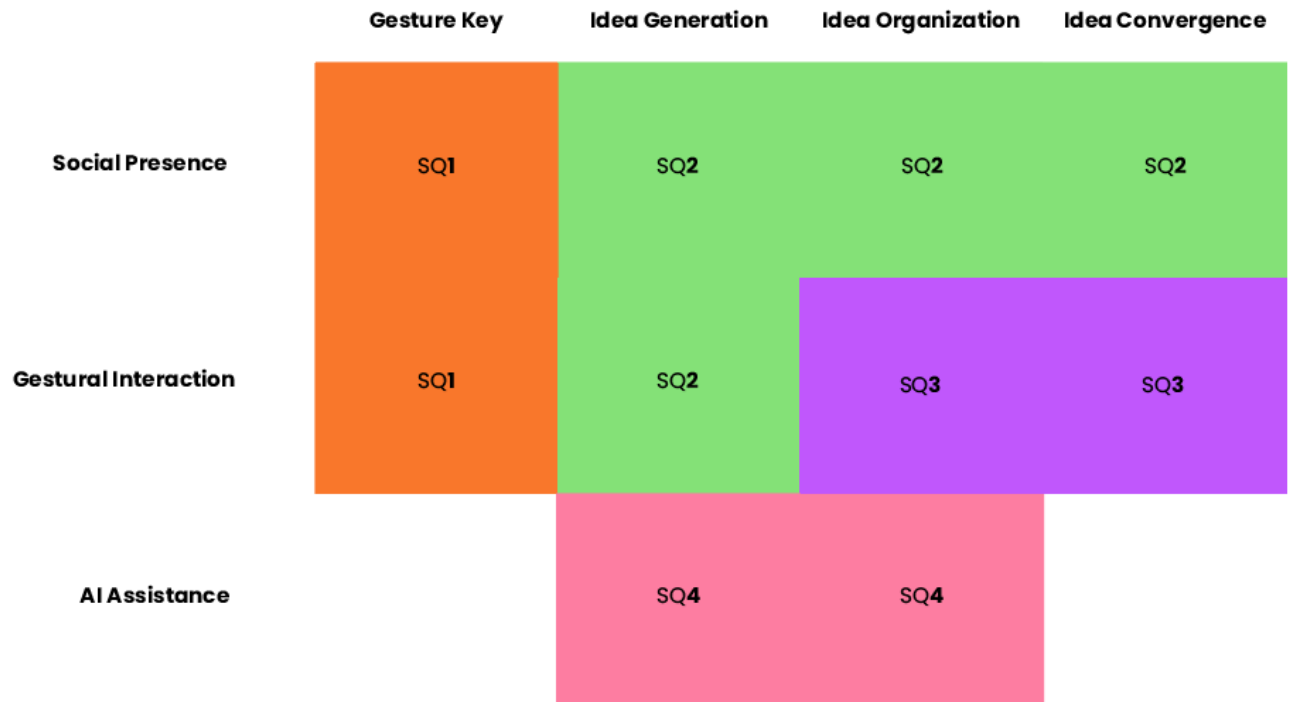


Figure 3.3.1: Investigation Model

The investigation model (Figure 3.3.1) lays out the plan for the prototypes contained in this document. This investigation plan outlines three prototypes, which map directly to my research sub-questions. These sub-questions are derived from the conceptual framework, which moves through three phases of collaboration: idea generation, idea organization, and idea convergence. For the first prototype, I will develop a gesture key that encourages social presence and gestural control of the interface. This taxonomy will lay the foundations for user interaction in the following studies. For the second prototype, I will investigate social presence and gestural interaction during all three phases of collaboration. For the third prototype, I will investigate how the design of gestural interaction systems can aid the idea organization phase. For the fourth prototype, I will investigate the affordances of an AI system with social presence for mediating the idea generation and convergence phase. I reiterate that each prototype will emphasize social presence in its design, with a special emphasis on social presence during the second study.

3.4. Scenario

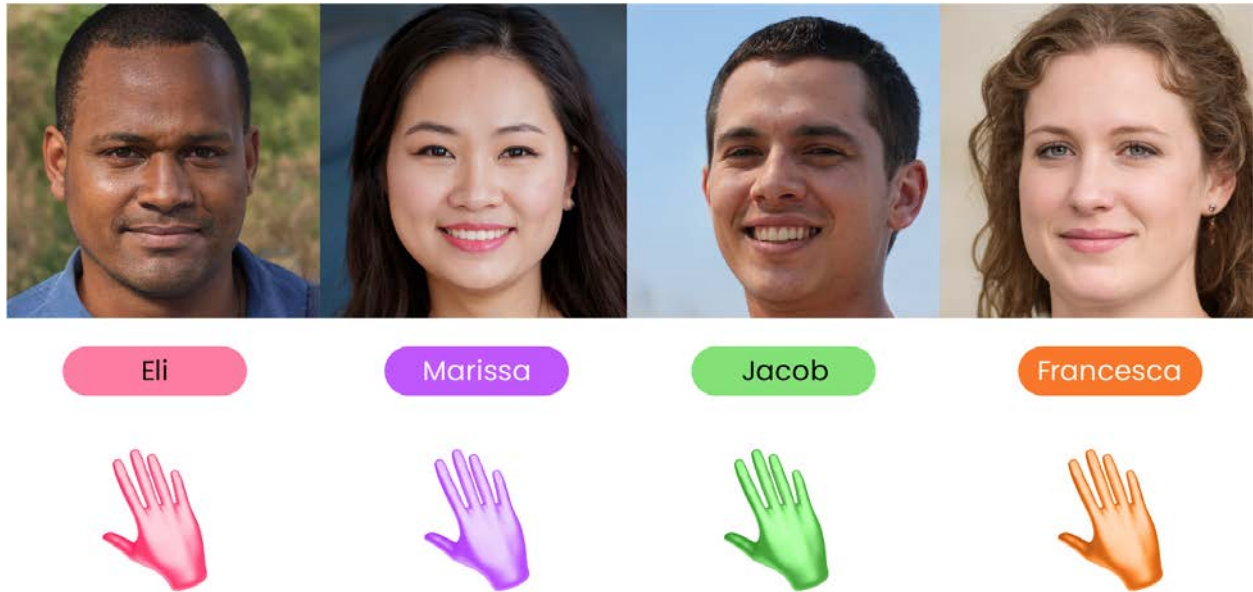


Figure 3.4.1: Personas

Persona Images generated on <https://this-person-does-not-exist.com/>

Four Industrial Design undergraduates (Jacob, Francesca, Marissa, and Eli) are tasked by their professor with designing a lamp together. The team starts to work on the project remotely using synchronous collaborative software with social presence features (similar to Miro, Mural, or Figma). During their remote work session, the team uses the affordances of the interface to move through both the idea generation and idea organization phases of their project. An AI assistant is available in the interface to assist the team with their collaborative process. The next day, the team decides to start the idea convergence phase of their project, but this time in person at the library. They rent an extended reality touch table device. Eli wakes up that morning with a cold, but he can join the group at the touch table as a remote user. Eli's social presence is represented through an avatar, while the rest of the team are together in person. The touch table runs on the same software as their first remote session but offers additional features such as holographic displays, and touchscreen control.

Studies

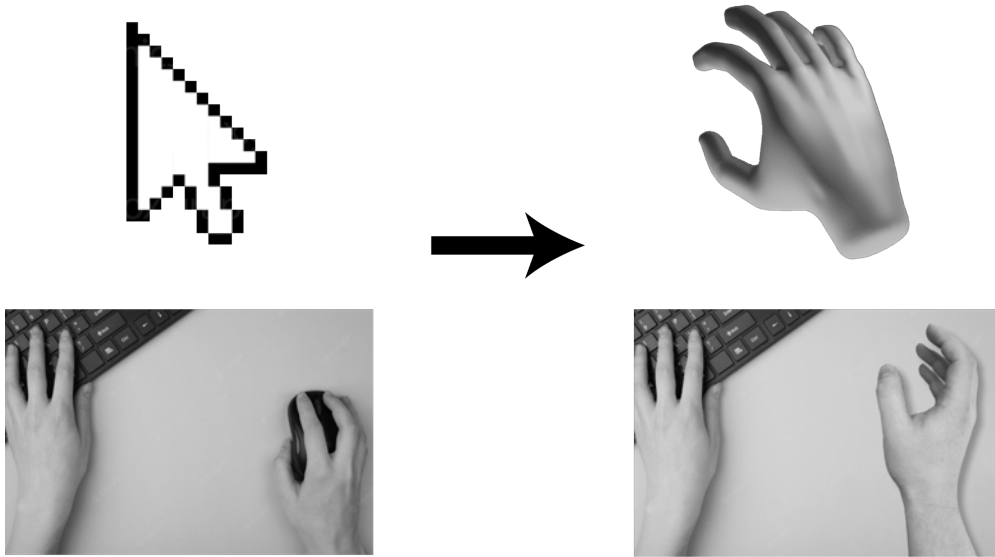


Figure 3.4.2

In the studies that follow, the traditional mouse cursor becomes a hand avatar, which is controlled in real-time by image-based hand tracking. A series of cameras and sensors accurately recreate the user's hand position and translate their hand movements accurately on screen. This makes the traditional computer mouse redundant, replacing it completely with hand tracking.

4.1. The Gesture Taxonomy

How can the design of a set of hand gestures help users control and interact within a collaborative interface?

This study establishes a gestural taxonomy that will be used as a guideline for the interactions between users and interfaces in study 2. All the gestures in this taxonomy are intentional and convey something specific to either people or the interface itself. The categorical system of this taxonomy is based on the taxonomy from Pavlovic (1997).

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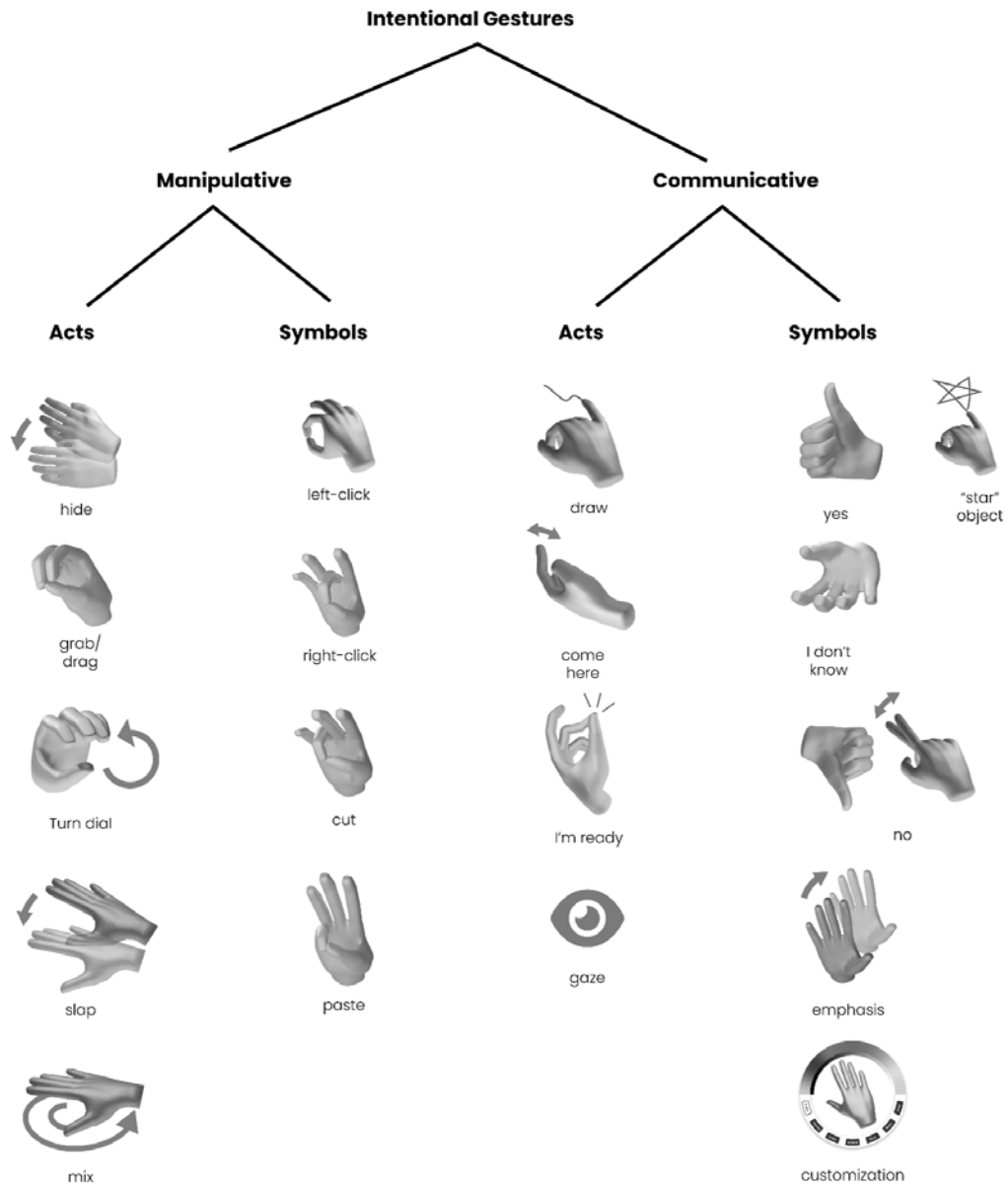


Figure 4.1.1: Gesture Key

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Hide: A hand swipe over an object can toggle the visibility of an object.

Grab/Drag: A grab and drag gesture can pan across the interface.

Turn Dial: A turn of the wrist can be used to rotate objects, or set a timer.

Slap: A slap can break apart, or scatter objects in the interface.

Mix: An downward facing open palm swirling gesture can tell the system to combine a group of objects

Left-click: Touching the index finger to the thumb is analogous to a left-click.

Right-click: Touching the middle finger to the thumb is analogous to a right-click.

Cut: Touching the ring finger to the thumb “cuts” an object, removing it from the interface.

Paste: Touching the pinky finger to the thumb “pastes” a “cut” or copied object back into the interface.

Draw: Extending the pinky finger activates the pencil tool and can be used to sketch. This function can be mapped to any finger.

Come here: An upturned bend of the finger “come-hither” gesture sends an invite to the other participants.

I’m ready: A snap of the fingers tells the system that the user is “ready”. Sends a “ready” message to the chat channel

Gaze: Eye tracking can record the amount of attention that objects receive from users, and change their size accordingly.

Yes vote: A thumbs-up gesture is recorded by the system as a vote “yes”.

Star object: Drawing a star on an object “favorites” it.

I don’t know: An upward-facing palm gesture sends an “I don’t know” message to the chat channel.

No: A thumbs-down gesture is recorded by the system as a vote “no”. A wag of the index finger sends an “I don’t like this” message to the chat channel

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Emphasis: An upward-facing palm pulled upwards can increase the size of the object, and send an “emphasis” message to the chat channel.

Customization: The visual customization of the user's hand avatar communicates something about the user’s personality and social presence to their collaborators.

4.2. The Hand Avatar

How does the visualization of hand-based social presence combined with the use of gestural control, assist in the early ideation phase of team collaboration by introducing non-verbal communication?

This study investigates the affordances of a collaborative system that allows multiple remote participants to work together synchronously using hand gesture control. This system has three channels of communication: voice, text, and gesture interpretation.

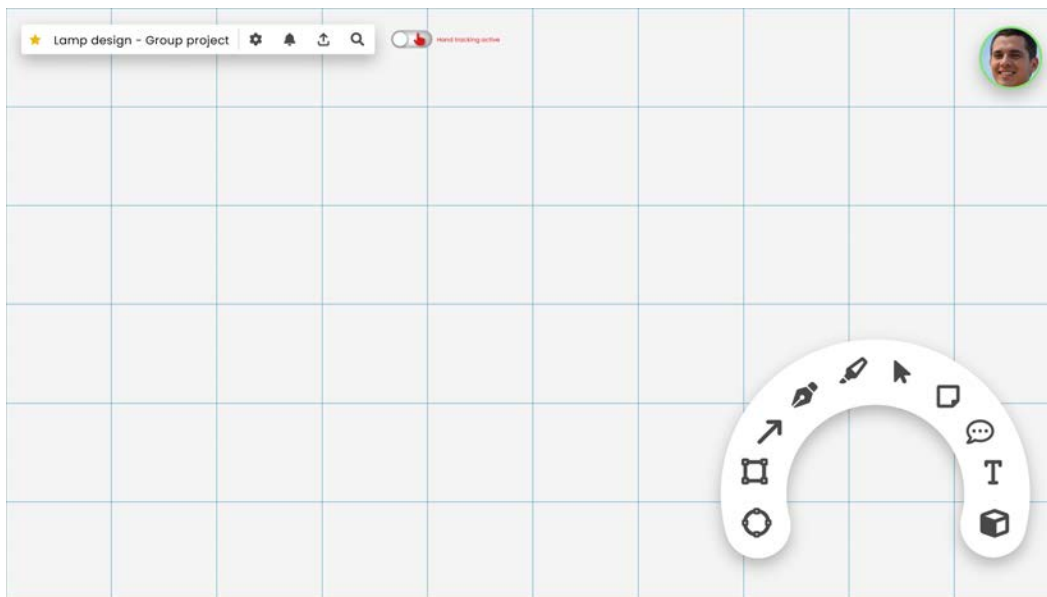


Figure 4.2.1

Jacob logs into Handi and creates a new collaborative document, and shares access to this blank document with his teammates.

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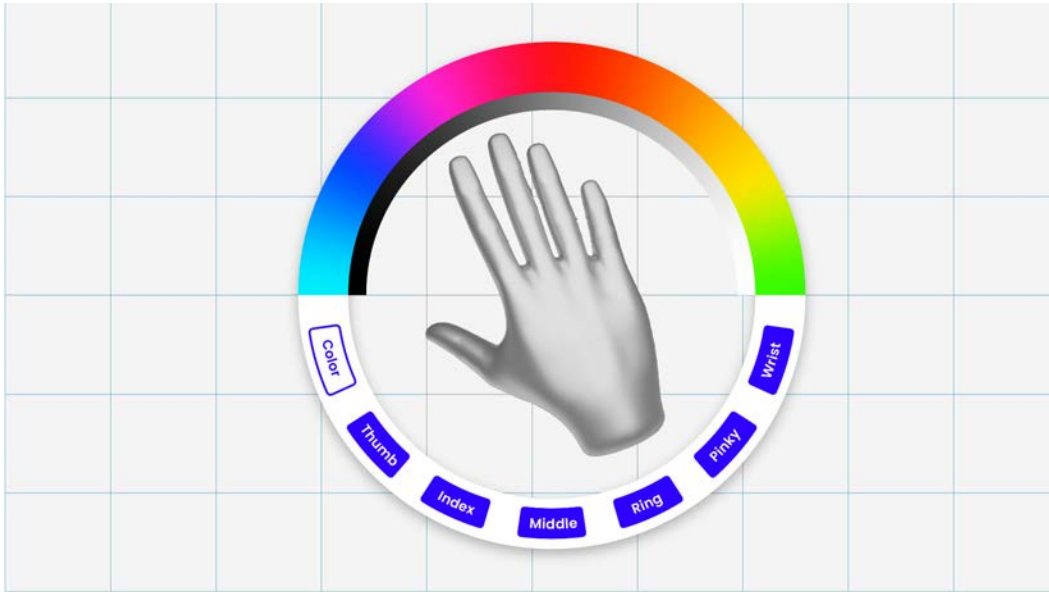


Figure 4.2.2

Each user is prompted to customize their own “Handvatar”, a digital representation of their physical dominant hand controlled by hand tracking. Customizing the color of the Handvatar will be useful for differentiating between group members. The handvatar will be visible to the other team members as they work and serves as an embodiment of each member's social presence on the board.

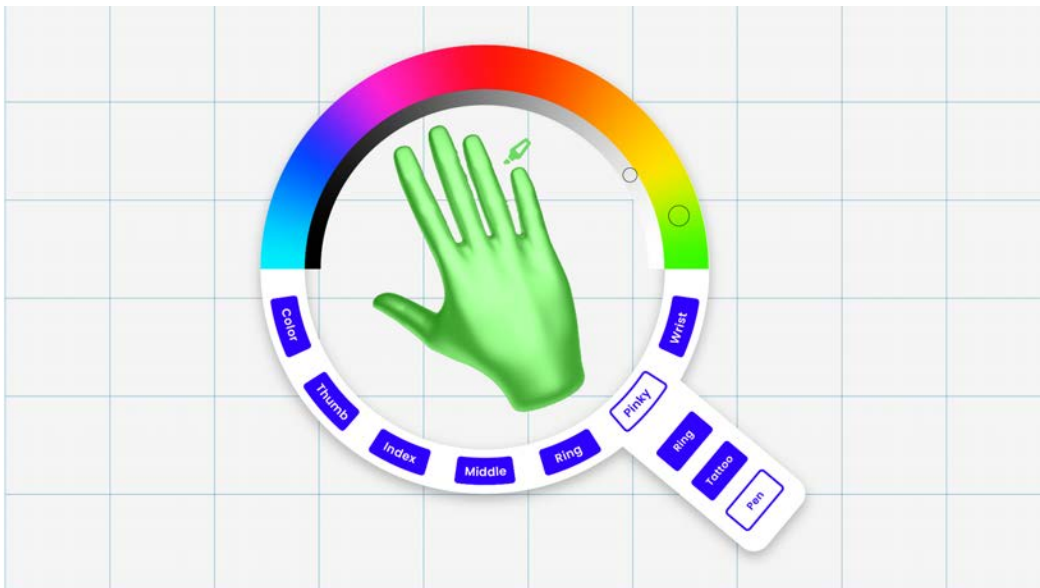


Figure 4.2.3

Jacob picks a green color for his hand and sets his pinky finger as his “pen” finger—meaning this

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is the finger he will use with the pen tool to draw freehand on the board. Any finger can be set as the pen finger, but Jacob chooses his pinky to leave his other fingers free for other tools and gestures. Options for each part of the hand expand to show more detailed customizations.



Figure 4.2.4

Jacob plays with all the available customization options and creates a heavily personalized hand with accessories and tattoos. Jacob ultimately decides that this look is too intense and opts for a simpler, solid green hand. This color will be used by the system to mark anything on the board that has been created by Jacob.

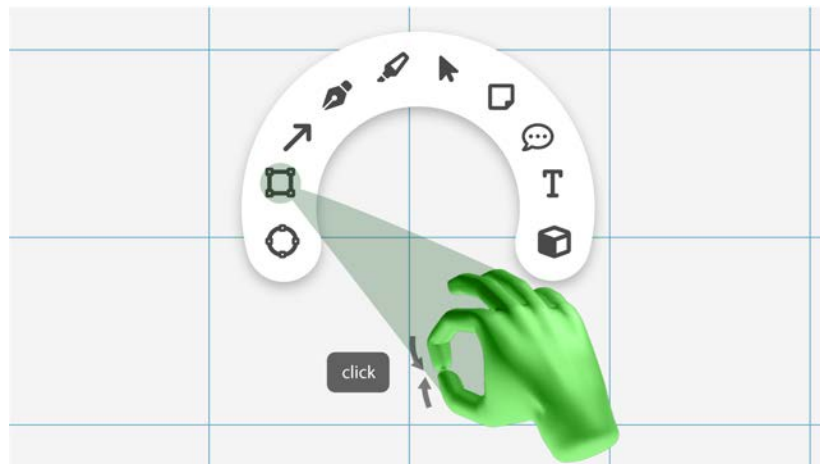


Figure 4.2.5

Jacob selects the rectangular marquee tool from the tool palette using a pinching gesture with his thumb and index finger. This gesture is analogous to a left-click.

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Figure 4.2.6

On the audio channel, the group agrees to begin the brainstorming phase of their collaborative project. They decided to do a fast mood board and sketching session, to get their ideas flowing. Using a twisting gesture, Eli sets a timer for 25 minutes. The group agrees to convene and share work after the timer expires.

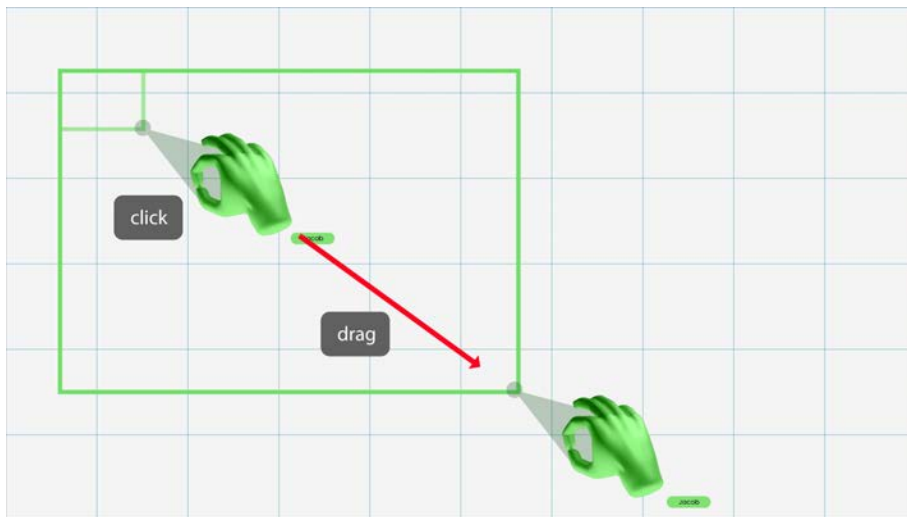


Figure 4.2.7

Jacob creates a new frame in which to create a mood board for the brainstorming portion of the project. He does so by pinching his thumb and index finger (left click) and spreading them back out to drag out the desired frame size.

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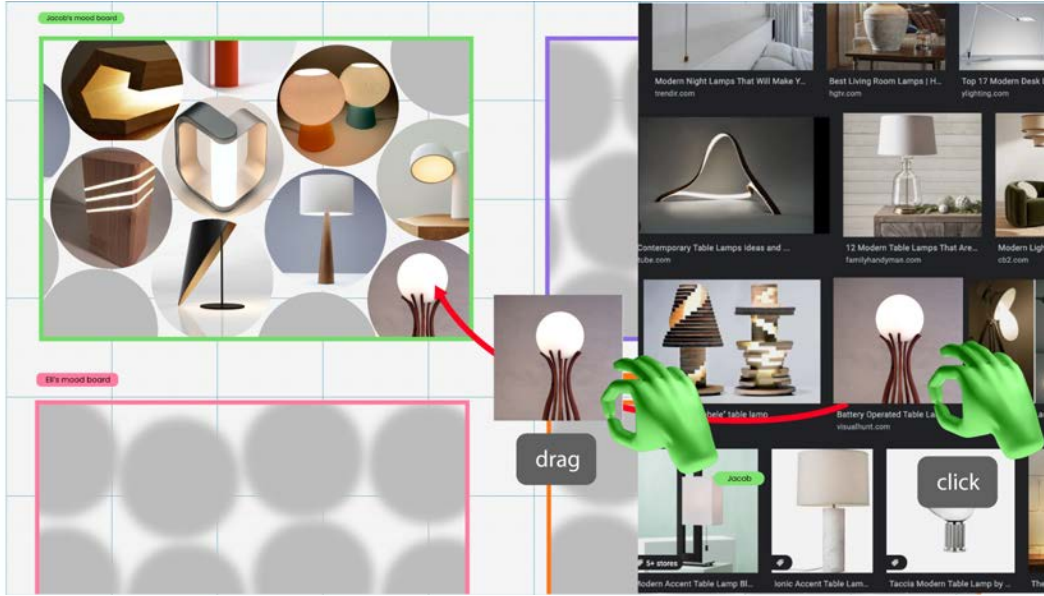


Figure 4.2.8

Using a pinch and drag gesture, Jacob grabs images from his web browser and into his mood board, which automatically populates the mood board in an array of circles.

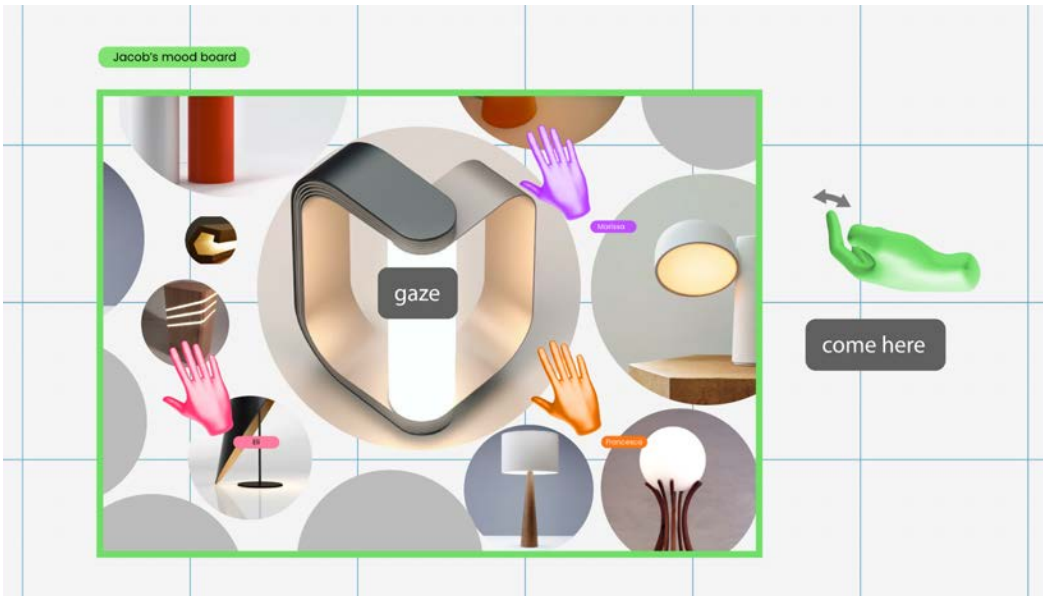


Figure 4.2.9

While still working on his mood board, Jacob realizes he wants feedback from the team. He uses a “come-hither” gesture which tells the system to send a message to the chat channel. The automated message tells the rest of the group to come over to Jacob’s mood board and check it out. As the group observes the items on the mood board, the system utilizes eye tracking to see which objects are getting the most attention from the group. This eye-tracking data is then used

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to make the more interesting (or controversial) objects larger, while the objects that receive the least attention become smaller. This serves as a visual trace of the group's attention and gaze.

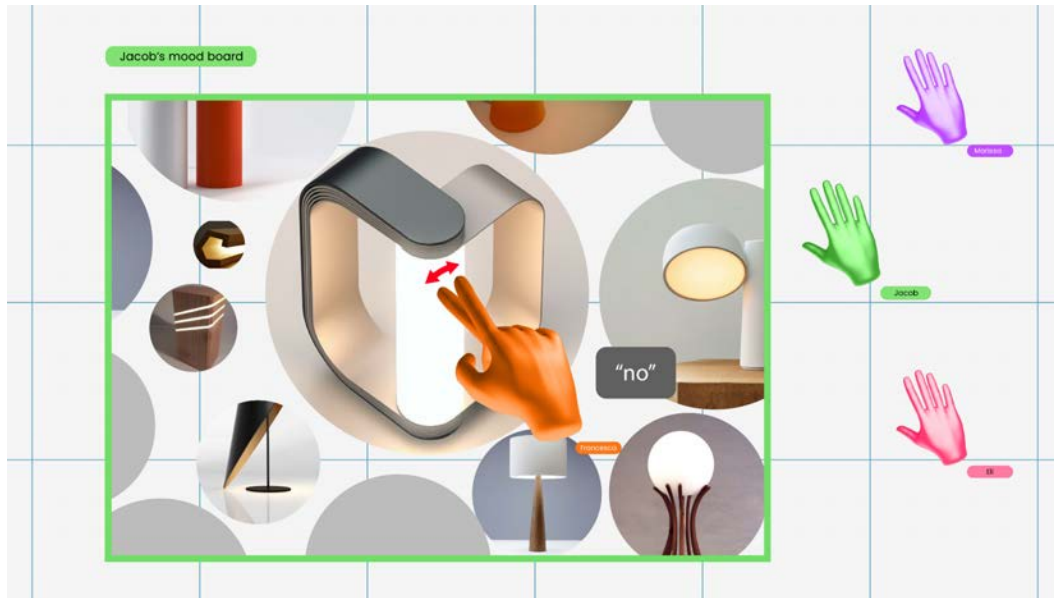


Figure 4.2.10

Francesca expresses that she does not like the biggest object on the mood board. She uses a finger wag gesture to express her disdain. The system reads this gesture and sends a record of it to the chat.



Figure 4.2.11

The chat channel contains a record or “trace” of certain communicative gestures that the system has picked up on. There are a limited number of gestures that the system can understand, so not every social gesture (such as unconscious ones) will be left as a trace in the chat channel.

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Figure 4.2.12

Francesca goes back to working on her mood board. She has a different set of images she is working with, and thus a different design direction in mind.

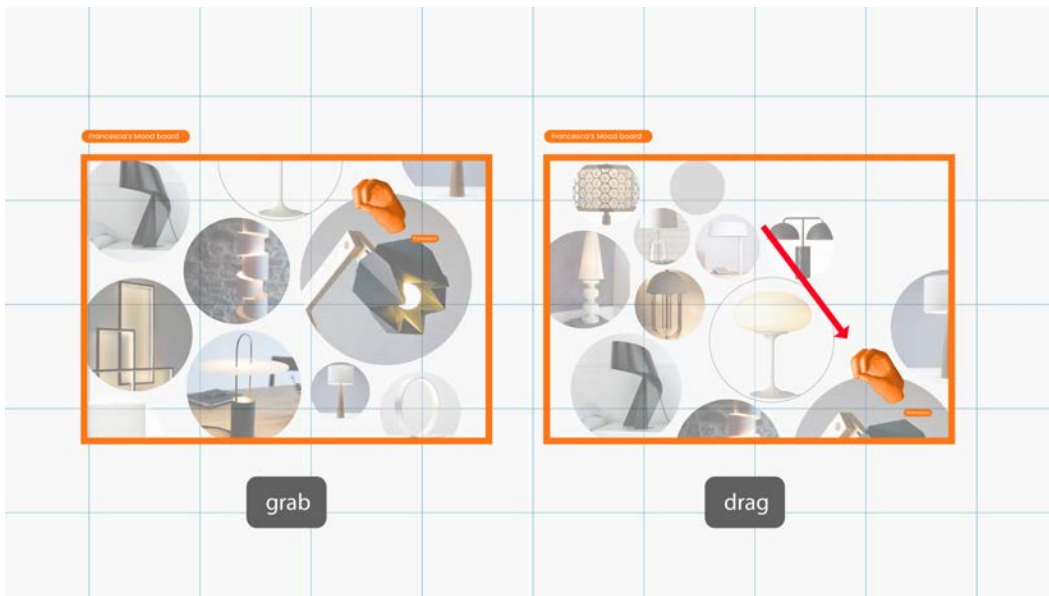


Figure 4.2.13

Francesca uses a grab and drag gesture to pan around and explore the interior of her mood board.

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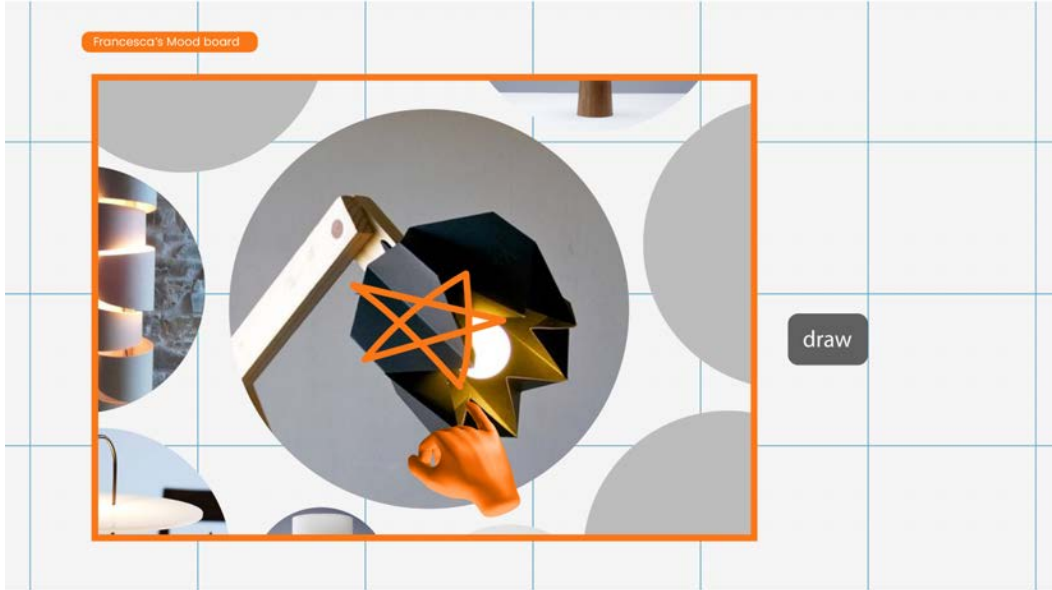


Figure 4.2.14

Francesca decides that this particular lamp is her favorite item on her mood board, so using the pen tool (mapped to her pinky) she draws a star over the lamp.

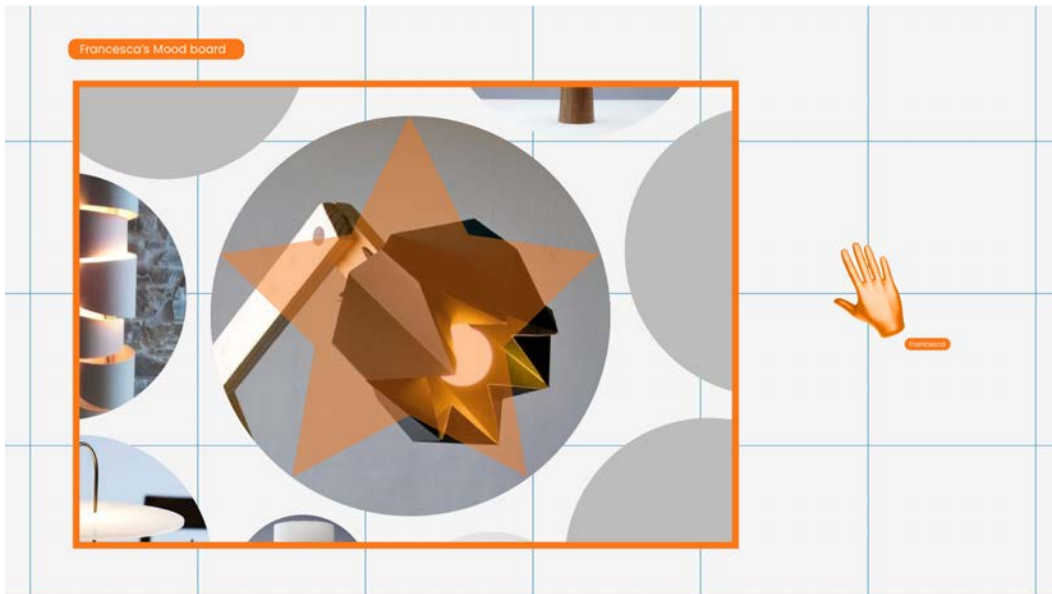


Figure 4.2.15

The system recognizes the star shape and interprets Francesca's intention to "favorite" this lamp design. The hand-drawn star pops to a perfect star shape over the lamp, leaving a trace of the gesture.

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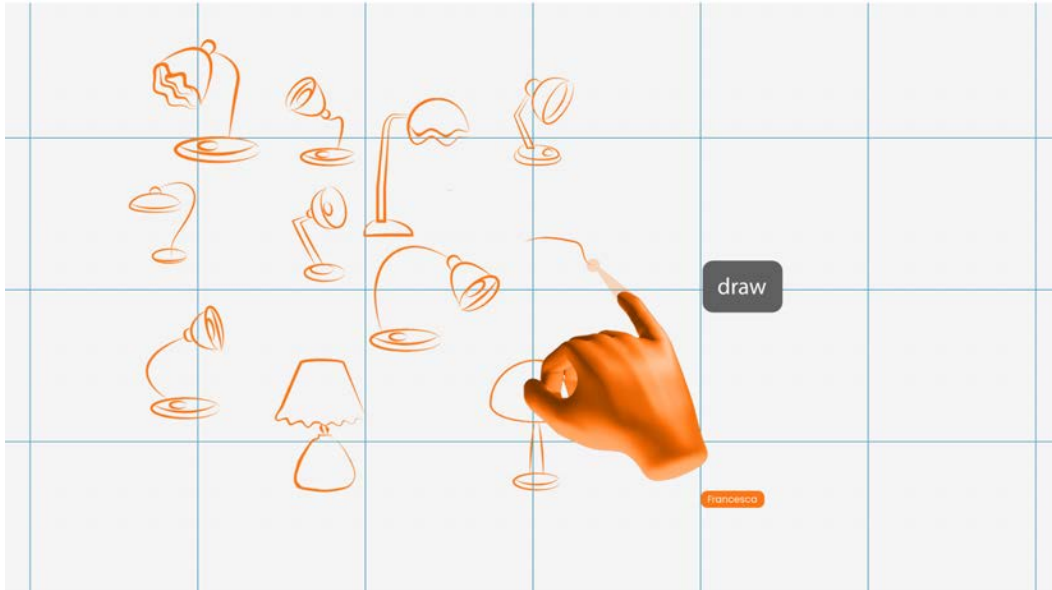


Figure 4.2.16

Francesca moves to another blank area of the board so she can begin sketching. Using her mood board as inspiration, she sketches several ideas with her pinky.

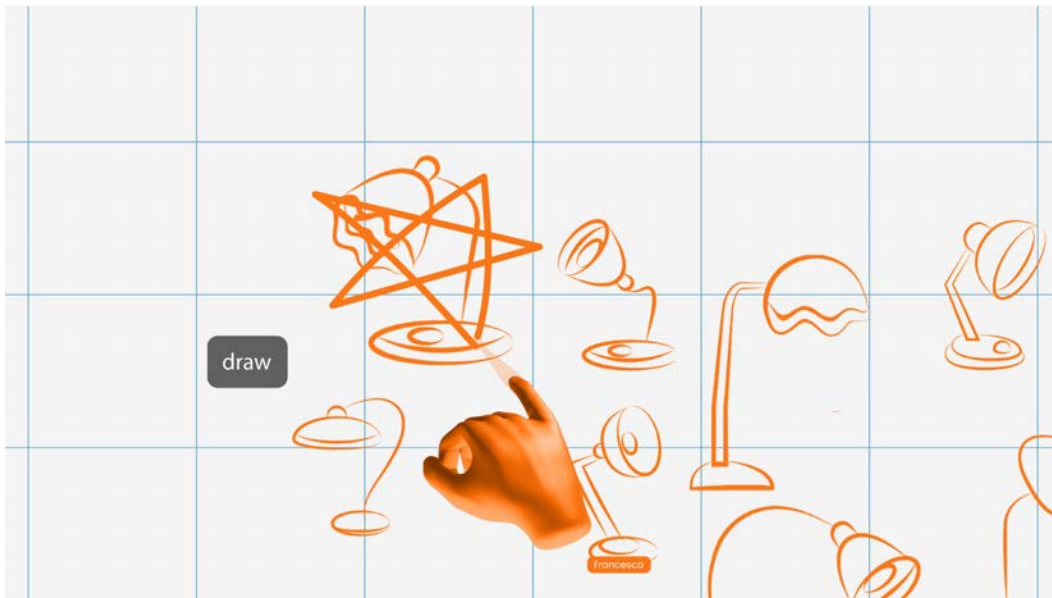


Figure 4.2.17

Repeating the same gesture from earlier, Francesca “favorites” her favorite sketch. This is the sketch she plans to show to the group once they reconvene.

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Figure 4.2.18

The 25-minute timer reaches zero, and a pop-up overlay the interface and tells the group that time is up. Everyone in the group snaps their fingers, and the system reads this as a signal that the group is done brainstorming. The system then initiates the idea convergence phase.

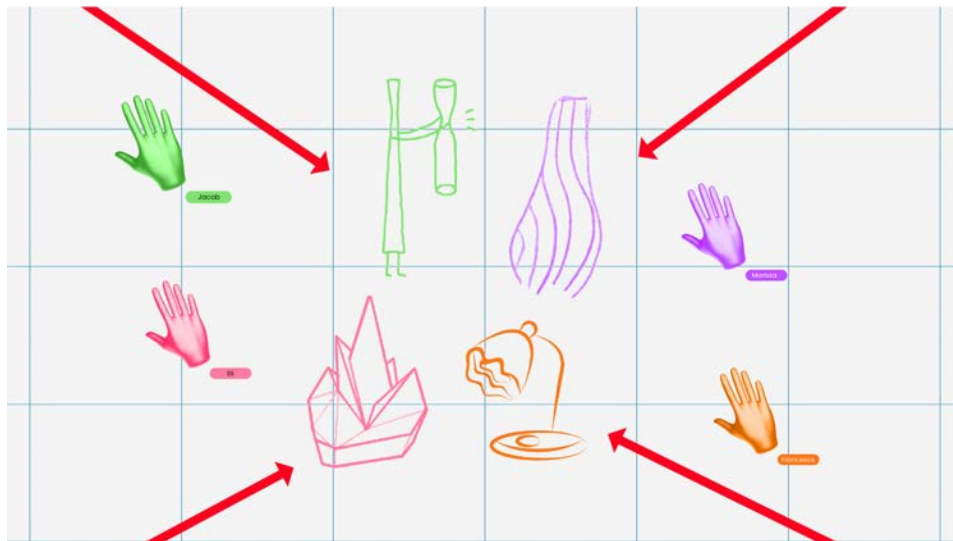


Figure 4.2.19

The system looks for everyone's "favorite" sketches and then pulls them to the center of the board. The group now looks at everyone's sketches, which are the results of the work they did on their mood board mixed with their creativity and skills as designers. The group has an informal critique and then begins the voting process.

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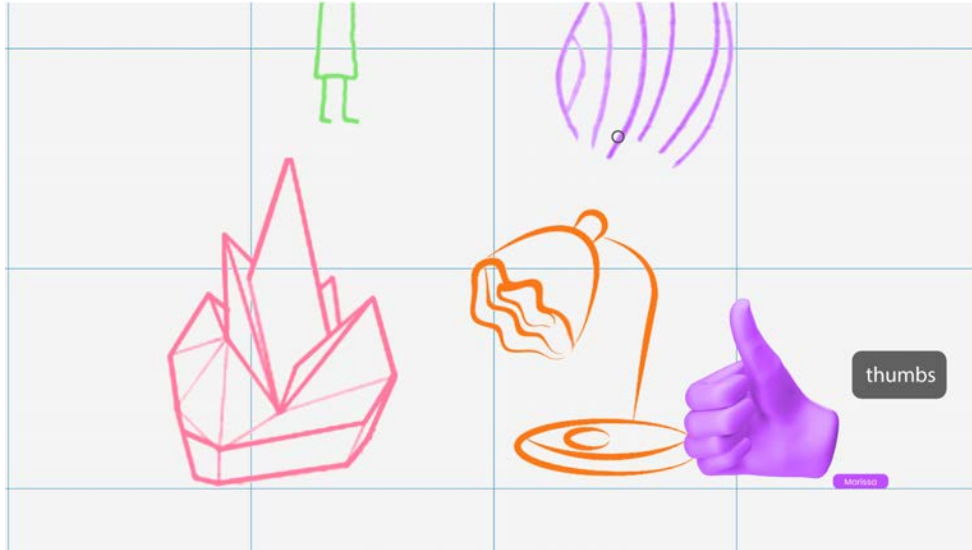


Figure 4.2.20

All four members of the group vote for their favorite sketches by gesturing either “thumbs-up” or “thumbs-down”.

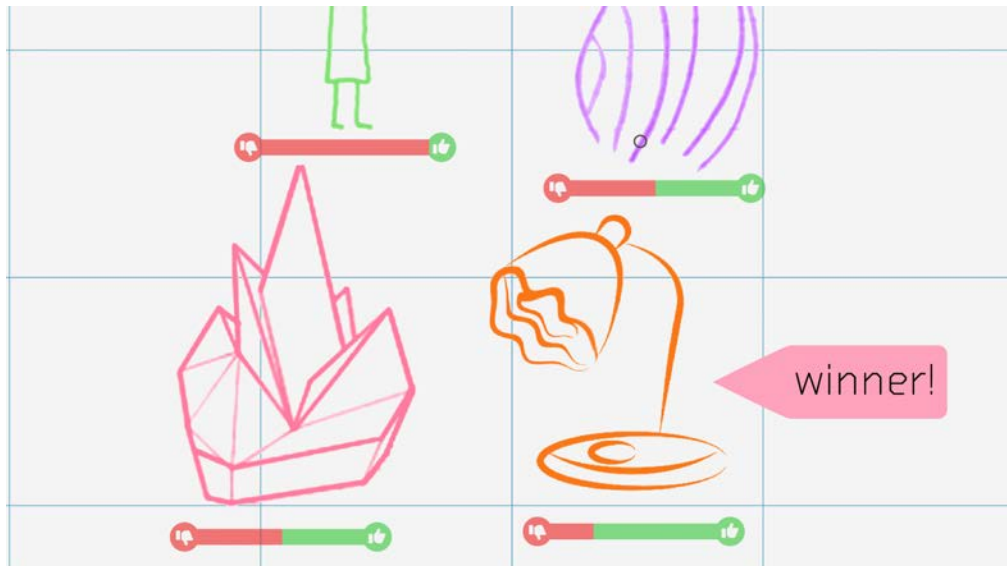


Figure 4.2.21

The system tallies the votes and displays that Francesca’s lamp sketch is the clear winner of the vote.

4.3. The Touch Table

How can a multi-user gestural touch table interface support the collaborative processes of generating, organizing, and categorizing ideas in real-time by visualizing individual and collective ranking preferences?



Figure 4.3.1

The group goes to the library and rents a room containing a high-tech, touch table device, equipped with hand tracking sensors, a touchscreen display, and three-dimensional holographic displays (represented by the glass cylinders above).

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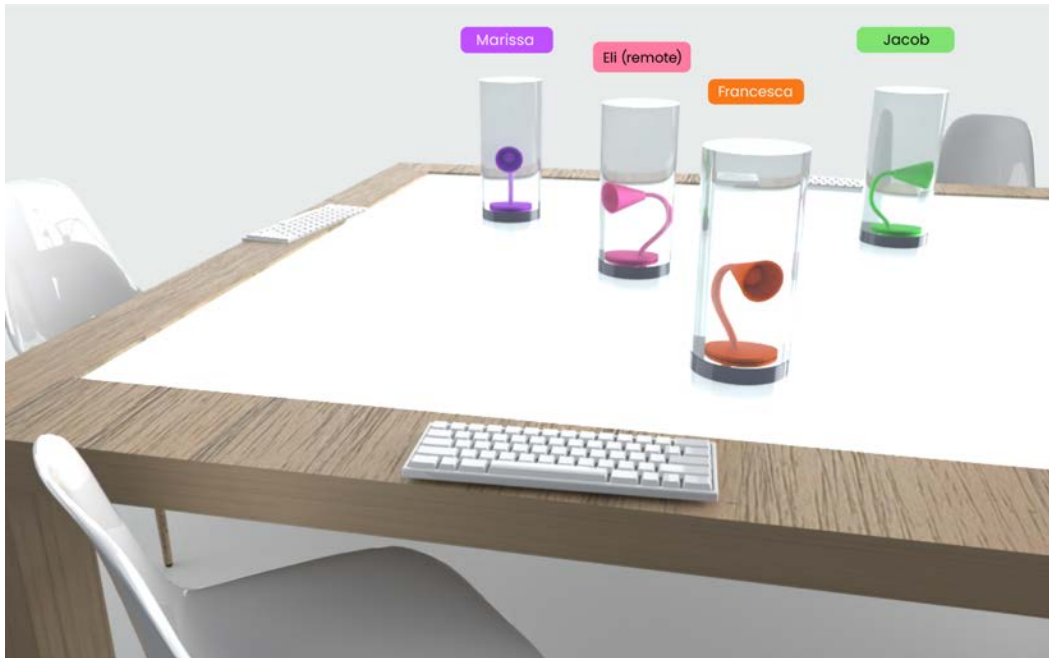


Figure 4.3.2

Here the group will begin creating more lamp variations, this time in 3D on the holographic displays, with a model of the winning sketch from their first collaborative session as a starting point.

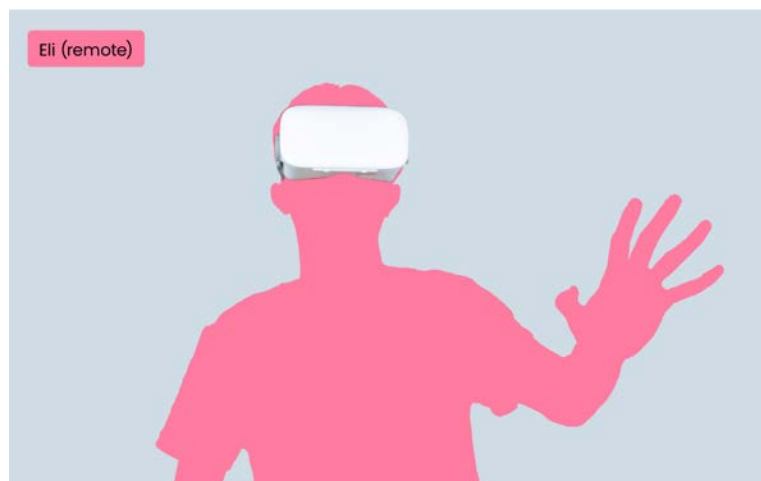


Figure 4.3.3

While three of the group members are working in person at the library, Eli is unable to make it to the session in person. Despite this, he is still able to join in and work synchronously using a VR headset.

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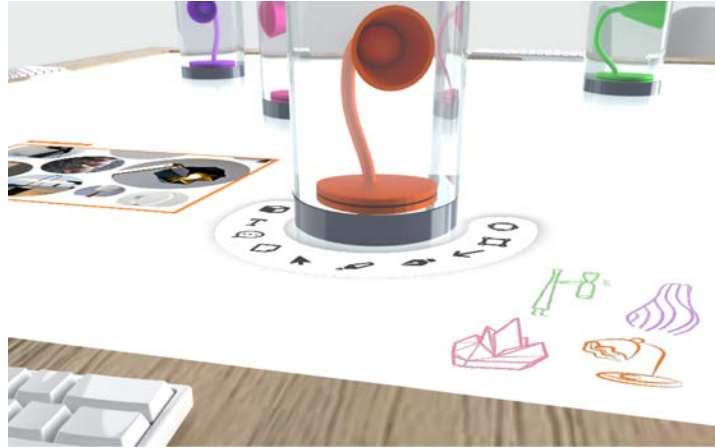


Figure 4.3.4

The group can bring up and view the mood boards and sketches from the first remote session. The interface can be controlled using the same gestural control from the previous studies, as well as commonplace touchscreen gestures used on most phones and tablets.



Figure 4.3.5

The interface of the touch table is very similar, here is the same toolbar from the online session, wrapped around the holographic display, with a pop-out with tools for editing the 3D model.

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Figure 4.3.6

Eli, the one remote participant, has a presence at the table. His hand avatar is visible editing the lamp model within a larger holographic display in the center of the table.

4.4. The AI Assistant

How can the design of an AI assistant that intervenes as an unbiased mediator help the team generate, eliminate or converge project decisions?

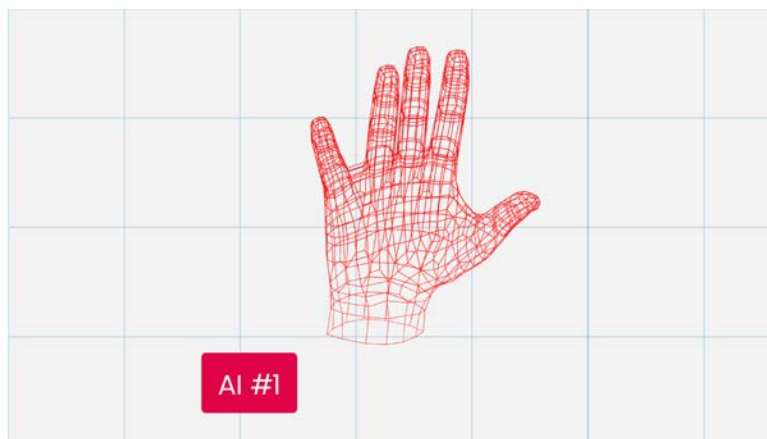


Figure 4., 4.1

This study adds an AI assistant to the interface.

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Figure 4.4.2

Users can ask the AI to help with the ideation and brainstorming process. Using text or voice commands, users can give the AI assistant prompts. Here, Marissa asks the AI to create some sketches based on the input phrase “modern lamps”.



Figure 4.4.3

The AI can use the input phrase and a Generative Adversarial Network, or GAN, to generate unique imagery which the group can then use as inspiration for their sketches.

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Figure 4.4.4

Francesca reaches a creative block after looking at the group's work for too long. She asks the AI assistant to help shake things up by asking "Can you create an interesting grouping of objects?"

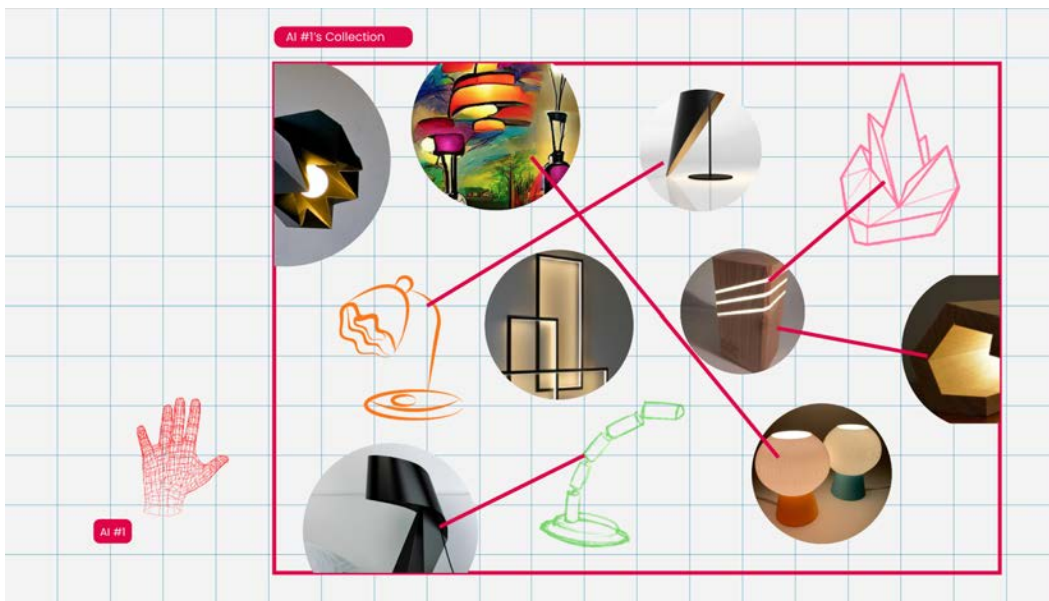


Figure 4.4.5

The AI remixes the content of the board and creates a new collection based on visually similar, or dissimilar objects. This could help the users look at the work they have already done in new contexts and relationships, thus helping the group to move past any creative dead-ends.

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Figure 4.4.6

Jacob wants the AI to remix the group's sketches. He breaks the sketches apart by slapping the touch table. The sketches are broken apart into smaller chunks.



Figure 4.4.7

In the chat channel, Jacob asks the AI to process the shattered pieces of the sketches into a new sketch.

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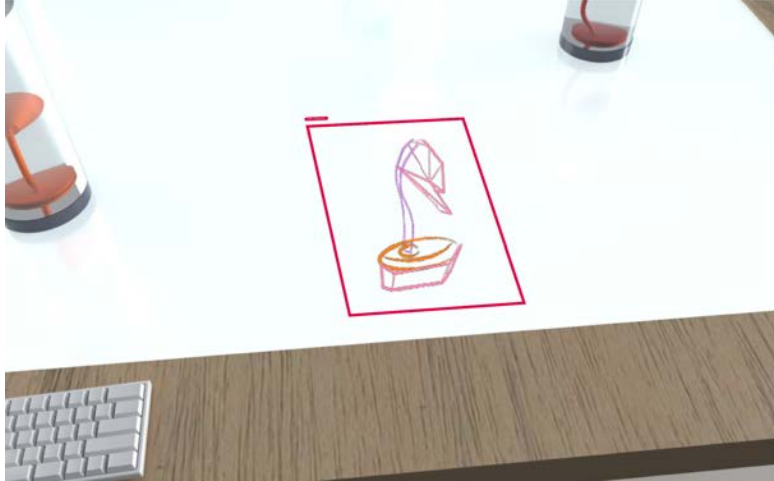


Figure 4.4.8

The AI assistant does its best to piece a sketch back together from the parts. This convergence of sketches could give the group new design inspiration that involves bits and pieces from each member's work.

Discussion

5.1. Design Principles

The Hand Avatar

It is hard to design for social presence in a system without addressing avatars. When many people think of avatars, they often picture a three-dimensional, full-body, on-screen visual representation. Do avatars need to be an image of a user's face or a cartoon representation? Maybe we are stuck in that way of thinking, and I wanted to move away from that paradigm for this project. I chose to focus on the human hand as an avatar rather than full or partial body avatars because cartoonish avatars

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can be distracting. Hands by themselves carry a lot of expressive potential in movement and gesture, and thus afford social presence. How often do you find yourself watching someone's hand movements rather than their face while they talk? Hands can be just as expressive and convey just as much personality as a person's face. As a design principle and limitation of my studies, focusing on representations of hands only let me simplify my scope and focus on what hand movements can afford the system, while not having to worry about the rest of the user's body. I chose to keep the hands relatively realistic looking. I made this choice because research informed me that a more natural-looking hand would provide higher levels of perceived social presence than robotic or cartoonish alternatives (Yoon 2020).

Color Coding

I adhered to a strict color-coding system that distinguished each persona in my scenario, which allowed me to track actions using the color traces that users left throughout the studies. The color coding is connected to the customization each persona chose for their hand-avatar. I could have had them customize their hand avatars in a much more detailed way, but I opted for each persona to pick a solid color for their hand avatar to help simplify the imagery in my studies and provide less distraction from what was important for the studies: the gestural interactions.

Gesture Simplicity

When designing gestures for study one, I tried to keep the gestures very short and simple. I wanted the gestures to be very easy to perform and to become second nature to a user as they gain experience with the system. More complex gestures would require more cognitive load and force the user to pause and think about the gesture, which I wanted to avoid. I also wanted all gestures to be one-handed only. This choice is important because it frees up the other hand to use a keyboard or other input device, which will then allow other shortcuts to be mapped and for keyboard and traditional typing to occur (the gesturing hand can quickly join the keyboard hand for two-handed typing). Enabling a keyboard to pair with the system, rather than relying solely on gestural inputs,

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flattens the learning curve for new users, and lets them rely on shortcuts they already know. For example, a user could hold “shift” on the keyboard to lock proportions while using the rectangular marquee tool, or use the “backspace” button to delete objects. I believe it is important to offer multiple shortcuts and options to perform the same task, thereby allowing the user to decide which input method feels the most natural.

5.2. Future Work

The gesture key (see pg. 25) could be greatly expanded to include many sub-gestures and alternate gestures. The effect of gestures could be altered by adding an element of timing: faster gestures could mean something different than the same gesture performed slowly. For example, nudging an object slowly with your hand would move it a little bit, while nudging it quickly could send the same object flying across the screen. Furthermore, I would like to explore alternate sets of gestures. For example, what would a gesture key look like if the interface was entirely controlled by the user's facial muscles?

The AI assistant could be expanded to become much more involved with the collaboration process, but this is dependent on the future state of the technology: how much of what is happening in the interface will an AI user be able to understand and respond to? I would like to return to the project as AI technology progresses

I would like to expand study 3, specifically the VR aspect. What would the touch table look like through the VR headset for the remote participant? What would it look like if two in-person users were working with two remote users?

Different “modes” would be an interesting addition to these studies. The interface could switch between modes depending on the phase of collaboration the group is currently engaged. What would it look like to switch between idea generation, idea organization, and convergence mode? How would the interface shift and change? Would certain gestures only be available in certain modes?

5.3. Conclusion

This investigation explored what gestural hand control could afford to the collaborative and social features of an interface. The studies explored a scenario with Industrial Design college students, but the implications of the studies could be applied much more broadly to any sort of collaborative work in any field or discipline that requires effective, but remote collaboration. With the right hardware and software, any interface could be adapted to include elements of gestural control. Social Presence is an important element of any collaborative interface, as users must be able to read the social cues and communications of their collaborators with minimal effort. With the right design considerations, online collaboration could be made to feel much more natural with improved Social Presence features.

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