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Triple Helix: AI-Artist-Audience collaboration in a performative art experience

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Abstract

Imagine an art exhibition that morphs its content according to the audience's experience like a chameleon, reflecting the audience's mind and culture and turning the artist's exhibition into the viewer's. But when the viewers leave, the work fades back to the creator's original work and waits for the next audience. In this project, my team introduced an interactive exhibition called "Triple Helix," where audience members were provided the opportunity to alter the artworks created by the artist, thus imbuing them with their own perspectives. This interactive exhibition was held at three physical-locations and online, and a comprehensive user study was conducted, exploring changes in creative confidence, i.e., an individual's willingness to create and to share. This project includes three main contributions. First, my team proposed an innovative exhibition system, allowing audience members to actively modify artworks in real-time using AI technology. Second, the results of the user study demonstrate the multiple individual factors that appear to influence creative confidence, such as an individual's art knowledge. Third, by analyzing participants' feedback after the "Triple Helix" exhibition, certain shortcomings in current generative AI systems have been identified, including the weakness of current text-to-image transformation methodology in non-representational pieces and the cons of rapid image generation. These insights can serve as valuable guidelines for improving the human-AI co-creation experience in the future. I hope this work will serve as a step toward a richer and more comprehensive understanding of the application of generated AI into the realm of art.

Teamwork Statement

The original "Triple Helix" exhibition sponsored by Hopkins Center for the Arts at Dartmouth includes three members: Xuedan Zou, Yen-kai (Kyle) Huang and Ziang Ren. This thesis is fully written by Xuedan Zou and the contributions for each of the members in this project are listed below:

Xuedan Zou: conceptualized the exhibition ideas and details, designed and implemented the exhibition software, generated the idea to use distinguished routes to display separate artworks, came up with all the research questions, designed the exhibition setups/posters/user guide/questionnaire, contacted local communities to hold exhibitions, organized the user study phase during the exhibition, edited exhibition video, designed and conducted the online study, analyzed data, wrote thesis

Yen-kai (Kyle) Huang: conceptualized the exhibition ideas and details, prepared artworks for the exhibition, assisted in finding exhibition venues, assisted in holding exhibition, shot exhibition video

Ziang Ren: discussed the exhibition details, purposed the hardware architecture using two layers of adapters, assisted in holding exhibition

Acknowledgements

The very beginning of this project starts from the SART25 Painting1 I took in the X22 term, when I was thinking about the difference between AI generated artworks and the real painting. Then I discussed with the artist, Kyle (Yen-Kai) Huang for an art project idea to apply for an art grant in December 2022, and we came to this “Triple Helix " concept. This art project then gradually turns into this thesis.

I’d like to first thank my teammates: Kyle(Yen-Kai) Huang, for discussing the initial idea and creating those amazing artworks in my exhibition, and Ziang Ren, for joining my later project discussion and helping solve my hardware problem. My appreciation then goes to my advisor, Prof. Elizabeth Murnane, for giving me the freedom to pursue the topic I want to do and Prof. Lorie Loeb to teach me the importance of communication in a unique way. I’d like to thank Bruce D. Laferriere for assisting in purchasing equipment, Samantha Davidson Green and Cedar O'Dowd for helping me with the exhibition at JAM, and Samantha Eckert for supporting the exhibition at AVA Gallery and Art Center. I’d like to thank the Hopkins Center for the Arts at Dartmouth and Leslie Center for their research fundings. Next, I’d like to thank everyone in Empower Lab, especially PhD student Dylan Moore, for bringing me into the world of full stack development. I want to say thank you to Dr. Elizabeth C. Tremmel and Zhiyan Zhong for assistance in English writing. Further, I want to say thank you to all of the professors I met during my two years’ master study, especially to Prof. Daniele. M. Genadry for her painting class, and to Prof. Temiloluwa O. Prioleau for her HCI class. To be continued, I’d like to also thank my neighbor at Sachem Village, and also my best buddy at Dartmouth College, Ke Lou. There are too many unforgettable moments I shared with you during these two years! Together, I’d like to thank everyone who helped me during this amazing journey in the United States, and I want to say thank you to this amazing land! Finally, as always, I want to say thank you to my family, my parents Peng Zou and Ying Liao for supporting me both financially and mentally in this trip, and my great uncle, Jian Liao. Despite you are still in a wheelchair, you are the person with whom I can always share and discuss my thoughts. You are the one who introduced me to the amazing computer world through that WIN98 desktop when I was about three. Thank you!

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Chapter 1: Introduction and Backgrounds

1.1 Motivation

Artificial Intelligence (AI) has experienced remarkable growth since its inception at a workshop held at Dartmouth College in 1956 [1]. If we categorize human tasks into the three levels: of manual labor, logical reasoning, and creative thinking (see Figure 1.1), AI has demonstrated proficiency in both manual labor and logical reasoning tasks. The former primarily relies on conventional automation techniques rather than the advanced AI recognized today. In contrast, the latter showcases AI's capabilities, as it has surpassed top-tier GO players, marking a significant achievement in competing against humans in one of the most challenging competitive games [2].

This thesis explores how AI fares in the realm of open-ended creative tasks, which represent the highest level of human intelligence tasks and often involve a deep connection to human personal experiences; this aspect has long been considered a crucial difference between humans and machines. Notably, a significant breakthrough occurred in 2014 with the invention of Generative Adversarial Networks (GANs) [3], enabling AI to produce creative outputs such as poems, music, images, and paintings. Nevertheless, a longstanding debate persists regarding whether AI-generated artworks can truly be considered genuine art [4, 5]. Unlike the clear criteria used to evaluate labor and reasoning abilities, assessing the creative merit of artworks remains challenging, since art is, to a degree, subjective. However, rather than dwelling on the ongoing controversy surrounding AI's ability to create art and potentially surpass human artists, my goal is to broaden the boundaries of artistic creativity by fostering collaboration between humans and AI. Traditionally, individuals without any formal art training often face challenges when attempting to create intricate works of art, such as music or paintings. However, AI has the capability to generate music and visual artworks based on people's instructions. I aim to demonstrate how AI can serve as a tool to enhance people's creative confidence,

that is an individual's willingness to create and to share [6], even if they lack formal art training. This approach is what people term HAI — "Human-AI Collaboration."

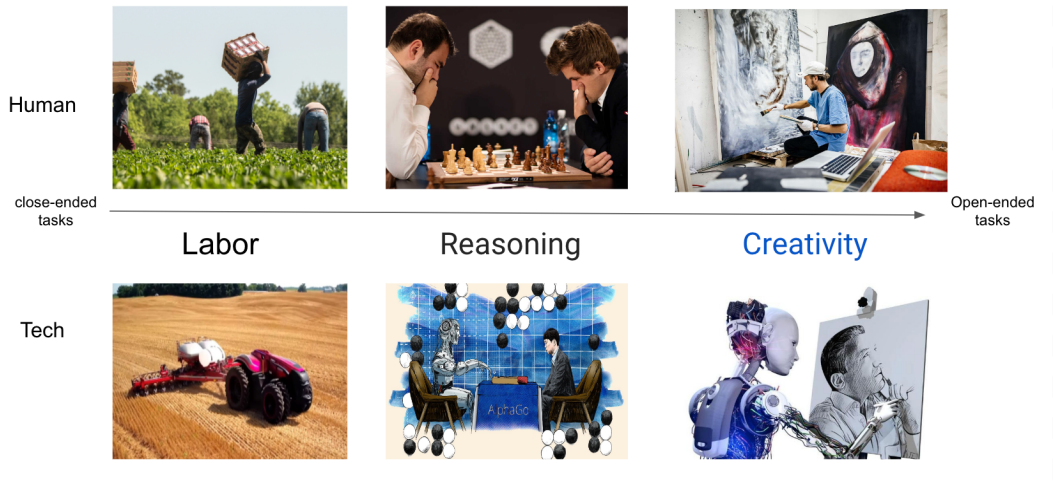


Figure 1.1 *Three Levels of Human Tasks*

Now, let us contemplate an art exhibition housed in a formal setting, featuring numerous artworks that invite audiences to linger and appreciate them, fostering an ethereal form of communication with the artist. Historically, this communication process has been unidirectional, with the artist encoding their experiences and culture within the artwork, and the audience decoding these messages from the same piece [7]. In the past, audiences had no means to reflect their own thoughts on the artwork or express their own voices within an exhibition. However, with the advent of AI, this has become feasible. Imagine an art exhibition where the audience can use AI to modify artworks according to the audience's experience. It reflects the audience's mind and culture and turns the artist's exhibition into the viewer's. This dynamic interaction involves three key roles: the artist, the audience, and AI, collectively shaping this triple helix interactive exhibition experience.

In order to test this idea, I, along with my team members Kyle Huang and Ziang Ren, organized three exhibitions within the local community. (For a detailed list of each team member's responsibilities, see the Teamwork Statement) I further explore what impact being able to modify artworks using AI tools in an exhibition like this has on a person's sense of individual creative confidence, the emotional responses of people when utilizing AI as a tool for artwork modification in an exhibition, and how AI's performance varies across different types of artworks.

1.2 Creativity Behaviors with AI

Figure 1.2 *Examples of Creativity Projects with AI*
(from left to right, first row: [8][9], second row: [10][11])

In general, creative behaviors with AI can be categorized into two primary approaches: result-focused behaviors that involve AI as an integral part of the work itself, and process-focused behaviors where AI serves as a supplementary tool in the creation process.

In result-focused creative behavior, many contemporary artists now embed AI in their works as a primary factor and thus their artworks can not exist without the support of AI [8, 9, 10, 11, 12, 13]. A prominent feature of such AI-infused artworks is the fine-tuning of AI algorithms using specific training data to generate AI-driven artworks [8, 9]. For instance, this involves incorporating real-time audience data to fine-tune systems during exhibitions, resulting in the creation of average portraits [10], or applying style transformations inspired by famous artists to generate entirely new artworks [12]. Furthermore, numerous interactive installations incorporate sensors within exhibition spaces to detect and respond to audience behaviors, facilitating meaningful interactions with viewers. Some other notable works include Kyes's work [11], which employs AI to

swap the faces of two participants, sparking discussions on self-identity, and Marios's project [13] aiming to create a decentralized autonomous AI artist that generates art based on community feedback. In all of these cases, artists maintain dominant control over the creative process, with audiences exerting limited influence on the final outcomes.

In process-focused creativity behavior, AI serves as a tool and garners attention in HAI research, which is dedicated to designing these AI tools in an interactive system to to improve the quality, accessibility, controllability, predictability and efficiency of the creativity process, and expand the possibilities of the creative results. These research endeavors intersect with a variety of other fields, including design, cognition, human factors, and psychology. In recent research, Kim's work [14] has sought to stimulate human ideation on two dimensions—conceptual and visual similarity—by using AI to provide feedback each time a human submits a design sketch. Similarly, Changhoon's work [15] has developed an AI interface that enables collaborative drawing between users and AI agents, revealing that humans tend to keep leadership in creative tasks when they collaborate with AI. Additionally, Jeon et al. [16] have endeavored to integrate AI into the fashion design process by externalizing three cognitive operations (extension, constraint, and blending) associated with divergent and convergent thinking within the creative process. Janin et al. [17] have presented cooperative contextual bandits as a machine-learning technique for interactive ideation support, and Yun et al. [18] also developed AI fine-tuned on the Red Dot design award winners' data to help early design ideation. Beyond assisting in design ideation or the design creativity process with AI, Nur et al. [19] have introduced how experienced designers incorporate AI as a design material in the UX (User Experience) design process. Notably, most of the current HAI research primarily revolves around design rather than art, with AI predominantly influencing human creative decisions. This process can continue seamlessly without AI, marking a significant distinction from result-focused creative behaviors.

However, sometimes the boundary between result-focused behavior and process-focused behavior is not clear, and there is also a possibility for a project to lie between these two categories. For this "Triple Helix" project, the exhibition itself is focused on "result-focused behaviors", because the exhibition could not exist without the involvement of AI. The user study, which requires audiences to interact with AI in modifying the artworks, is clearly "process-focused behaviors". As a result, this project involves both types of behavior.

1.3 Creative Confidence

There are various definitions of creative confidence [21] but they usually contain two aspects: creative self-efficacy [22] and creative agency. In other words, creative confidence refers to an individual's self-perceived capability and their expectations of the results, encompassing their overall creative self-concept and their capacity to engage in creative endeavors [23]. Creative confidence is a term frequently emphasized in today's design thinking education, with the goal of cultivating this confidence effectively. Rauth et al. [20] even propose a definition of "design thinking" as a learning model aimed at nurturing creative confidence.

Research has demonstrated that creative confidence can undergo transformation as a result of engagement in diverse creative processes. Kelly et al. [24] contend that creativity is not solely a born talent but rather a skill that can be cultivated through practice, such as breaking down challenges into manageable steps and progressively building confidence by succeeding in each one. Prior studies have concentrated on enhancing an individual's creative confidence. Some found specific tools that could help. Sadler et al. [25] discovered that the modularity of tools in creative prototyping can notably enhance a designer's degree of perceived self-efficacy, self-reported creative feeling, and cognitive flow. Verena et al. [28] applied Sketchnoting, a visual noting method, to engineering students and found they became more freely sharing ideas and having more ideas. Others found design education is helpful. Ulibarri et al. [26] held design thinking training workshops to doctoral students at Stanford University and found after participating in these series of workshops most students agreed they have successfully built more productivity, creativity, and confidence in their research, which are all key components of creative confidence. Laurens et al. [27] proposed Speculative and Critical Design practices (SCD) courses in a 2-year interaction design master’s programme and believed such SCD courses can foster students’ creative confidence potentially. Jae [29] studied a group of first-year-college students’ creative perception changes after taking an interdisciplinary creativity course and found their creative confidence were built.

Altogether, these prior works establish diverse creative processes to boost creative confidence in the realm of design, which is focused on “problem solving”. However, understanding is still limited regarding the change of creative confidence in the realm of art and after using AI tools during the creative process. These studies also primarily examine individuals in related fields of engineering and design, particularly students. Therefore the current thesis pursues an approach in the tradition of conducting a set of creative processes while examining the change of creative confidence after using the AI tool in the realm of art, expanding the focus beyond students to the general public.

Chapter 2: Implementation

2.1 System Overview

Triple Helix provides an interactive exhibition experience that empowers audiences to make modifications to the artworks created by the artist and displayed in the gallery. The artist's creations are showcased across multiple digital screens, and attendees are encouraged to utilize my software system that sits on top of the DALL-E 2 generative AI system on a designated laptop terminal to make personalized alterations to their chosen artwork. Upon completing their modifications, the updated results will be instantly showcased on the corresponding digital screen.

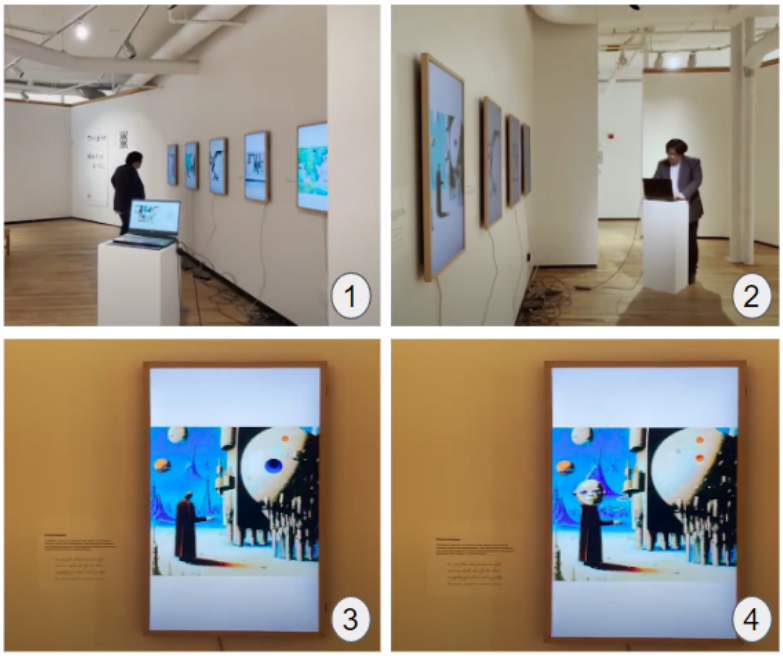


Figure 2.1 *A Glimpse of the Exhibition System*
(Image 1: Audience members viewing artist's works. Image 2: Kiosk for AI modification. Image 3: Artist's original artwork. Image 4: Audience's AI-modified artwork.)

2.2 Software Implementation

My software system is developed using web technology that includes both frontend pages and backend server. I utilized React tech stack (React, Typescript, CSS, HTML) to build the frontend pages and Express tech stack (Express, Node.js) to build the backend server. The artist's artworks are stored in the backend server , along with a copy of these artworks data that can be modified by the server. The original artwork data is read only and provides a source to initialize the modified data. Communication between the frontend and backend occurs via Axios requests to retrieve data. The backend server actively listens to manipulation commands sent from the frontend, passing these parameters to an online AI service by calling the provided API. Subsequently, the server received AI generated results and transmitted back to my frontend pages for display.

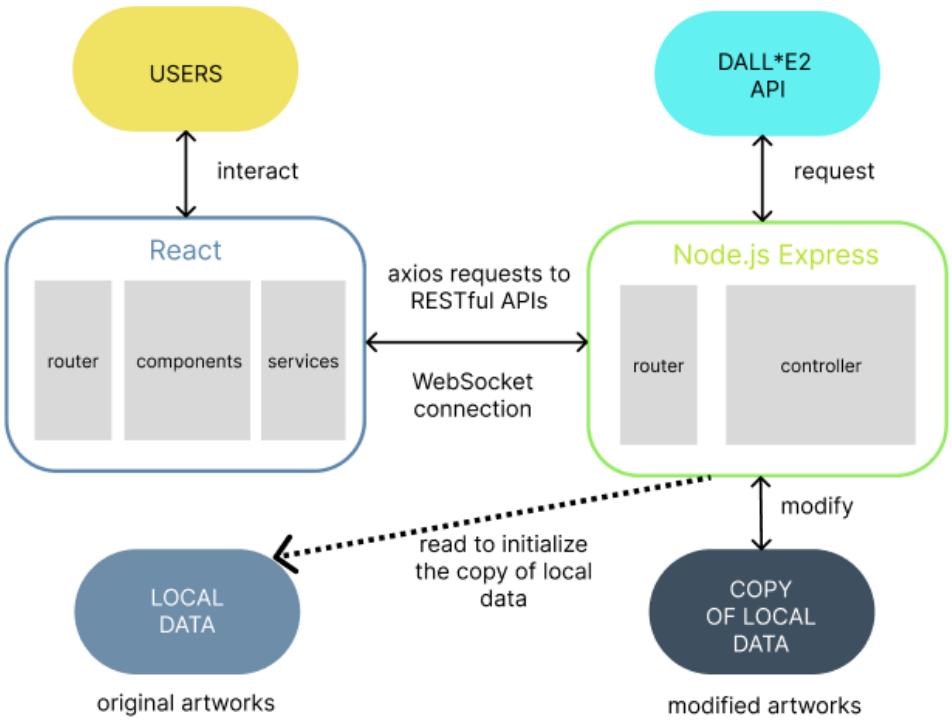


Figure 2.2 *The Framework of the Software System*

Currently, there are several highly-performing AI models available on the market, such as DALL*E2, Stable Diffusion, MidJourney, and DeepDream. Many of these AI models offer features such as text-to-image generation, image-to-image transformation, and image upscaling. After a comprehensive evaluation considering factors like cost, stability, inclusivity, speed, and result quality, I have chosen DALL*E2 as the AI server. However,

unlike some other AI platforms, which provide some other options for users to modify images, like allowing audiences to transfer their motions into visual language, DALL*E2 is restricted to two ways of image manipulations: Change by mask and Variation.

Feature Name	AI Type	User Control of Result	Description
Change By Mask	Text-to-Image	Strong	AI-generated modified the image based on the user's masked image and user's prompt.
Variation	Image-to-Image	No	AI generates the new image, keeping in general the same style and contents based on the current one.
History	No AI	Determined	Users browse the history of the image and choose to convert back to any status.

Table 1 *Three Main Features in the Software System*

The main feature in my software to modify the image is "Change by Mask", which utilizes a text-to-image transformation method provided by DALL*E2. In this approach, users begin by masking the specific area they wish to modify in a painting image and then provide textual prompts describing the desired changes. How to come up with correct prompts to get a satisfied result in text-to-image AI is a challenge and previous research has given out some guidelines like focusing on subject and style keywords instead of connecting words when picking the prompts [30]. However, I have intentionally refrained from including these tips to come up with prompts in my system. My aim is to offer users a more exploratory and protogenic experience when engaging with AI.

In addition to the text-to-image feature, my system also includes an image-to-image feature. With this functionality, DALL*E2 generates a similar image based on the current one. A drawback to the image-to-image feature is that, unlike the "Change by Mask" feature, users do not have any access to use prompts to control how DALL*E2 generates images by this feature. However, it allows users to be not only limited to the original artwork but get much more possibilities.

Furthermore, the software provides the third feature named "History" where users have the option to browse through the image history and revert to any previous state of that image if they wish to continue from a particular point.

A primary challenge my system faces is the independent real-time control of artworks displayed on multiple digital screens using a single terminal. To address this challenge, I have implemented a separate route path for each artwork. Multiple browsers can be simultaneously opened, each assigned to a distinct route path. I have employed socket.io to establish WebSocket connections [31], enabling two-way interactive communication between the user's browsers and a server. Consequently, once a user utilizes my system to modify one of the artworks, the server will promptly notify the corresponding browser to refresh and display the modified artwork.

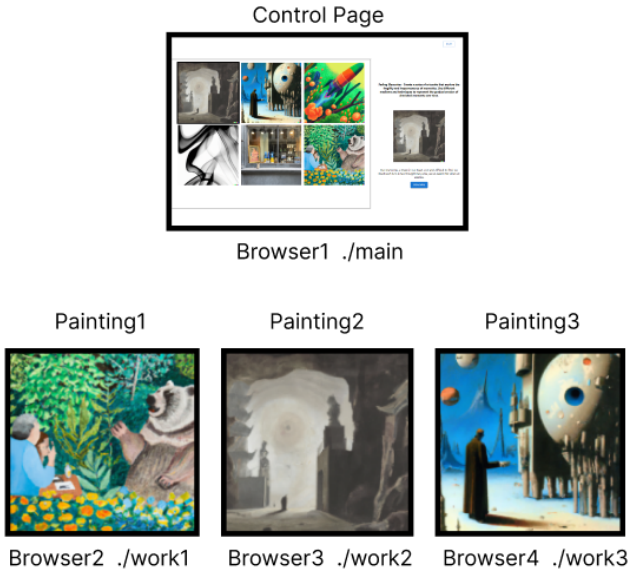


Figure 2.3 *Artworks Display Method*
(each artwork is displayed in an individual browser window via a distinct route.)

2.3 Hardware Implementation

The biggest challenge of my system in hardware is to use one laptop independently and simultaneously to control multiple digital screens at the same time. A swift resolution to this challenge involves employing the screen expansion feature, which extends multiple digital screens as additional spaces of the primary screen. As explained in section 2.2, I have designed software systems that facilitate the display of artworks through distinct routes, achieved by opening multiple browsers to exhibit these artworks separately.

Throughout the exhibition, one browser will be open, displaying my software interface, alongside other browsers, each showcasing one of the artworks. The browser with artworks can then be projected to distinguish digital screens.

My team opted for the SAMSUNG 32-inch Class "The Frame (2022)" series TVs as the digital screens for displaying artworks. This choice was made considering their high-resolution, non-reflective screens and compatibility with HDMI connections. To enhance their appearance and make them resemble real frames, my team has added customizable bezels to these TV screens.

To establish a connection between the terminal laptop's screen and these digital screens, thus achieving screen expansion, my collaborator suggested utilizing the "Plugable 7-Port USB 3.0 Hub with 36W Power" adapter, which permits the connection of up to seven USB C devices to any computer with USB 2.0 or 3.0 capabilities, and connected it with multiple "Plugable USB C to HDMI" adapters which each with each adapter linked to a digital screen. These adapters provide support for HDMI monitors capable of extended or mirrored displays, boasting resolutions of up to 1920x1080 @ 60Hz (see Figure 2.5).

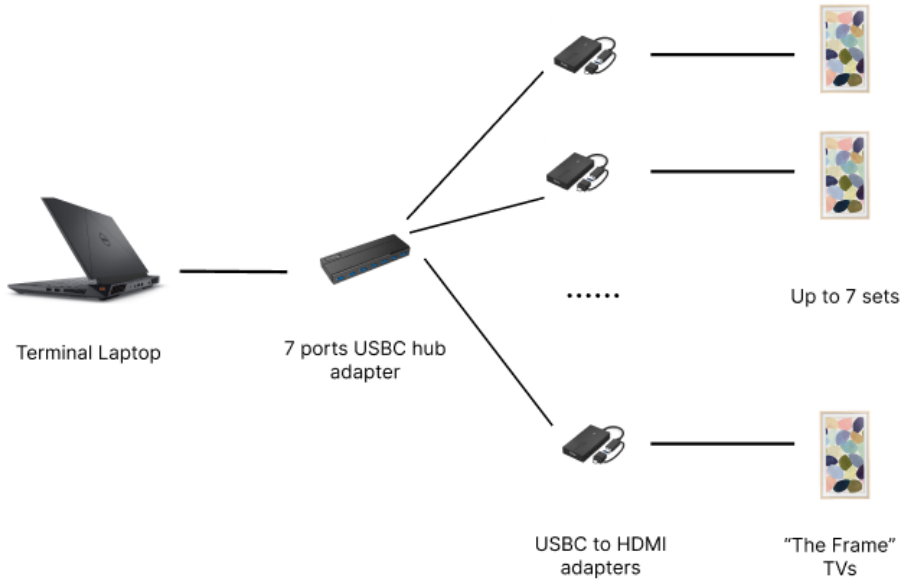


Figure 2.4 *A Glimpse of Hardware System*

Chapter 3: Exhibitions

3.1 Artwork

As previously discussed, the exhibition format entails two stages. First, the users view a collection of artworks created by artists in an art gallery (i.e., the original exhibition). Users are then introduced to the system so they can modify the artist's original artwork based on their interpretation of the artist's intention and infused with their individual understanding and thoughts. This unique approach creates an innovative triple helix exhibition experience, fostering collaboration among the artist, the audience, and AI.

Traditional artists draw inspiration from their culture and personal experiences to create artworks, and many artists who implement AI use it as a mere tool, much like a paintbrush. However, given that AI, such as ChatGPT, is now capable of generating poems and novels, we contemplated a different approach: What if we reversed the order and utilized AI as the primary source of inspiration? This line of thinking led us to formulate the theme for the exhibition (see Figure 3.1).

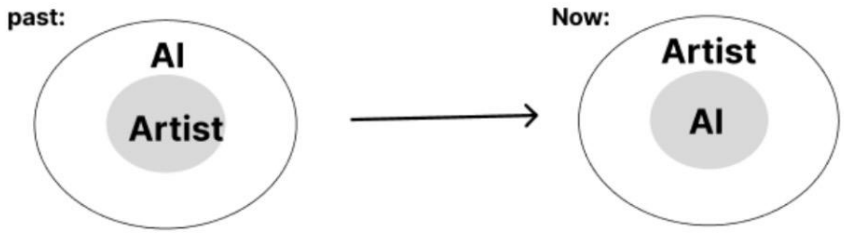


Figure 3.1 *Theme of "Original Exhibition"*

We used ChatGPT as the generative AI to generate intriguing titles and creative tasks, called themes. Subsequently, the collaborating artist followed these AI-generated themes

as prompts to create his artworks (see Table 2). By reversing the order, conceptually, AI is the inspiration source and the artist serves as a tool to create.

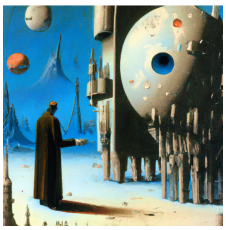
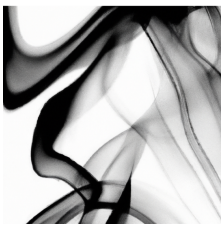
AI Generated Theme	Artist Artwork
Dreamscapes: Transport viewers to otherworldly realms by creating surreal, dream-like landscapes. Use fantastical elements and striking imagery to draw parallels between the dream world and the viewer's subconscious.	
The Illusion of Reality: Push the boundaries of perception by creating optical illusions or pieces that challenge viewers' understanding of the physical world. Explore the idea that our reality is shaped by our unique perspectives and experiences.	
Fading Memories: Create a series of artworks that explore the fragility and impermanence of memories. Use different mediums and techniques to represent the gradual erosion of cherished moments over time.	
Echoes of the Past: Delve into history and culture by reinterpreting iconic moments, objects, or figures in a contemporary context. Use your artistic expression to draw attention to the enduring impact of these elements on today's society.	
Spectrum of Emotions: Develop a collection of pieces that express a wide range of emotions, from euphoria to despair. Each work should evoke a specific emotion, yet subtly hint at its connection to the broader human experience.	

Table 2 *Themes and Artworks*
(themes on the left were generated by AI and artworks on the right were then created by the artist)

The collaborating artist successfully created 5 pieces of artworks inspired by ChatGPT generated themes: “Dreamscapes”, “The Illusion of Reality”, “Fading Memories”, “Echoes of the Past”, and “Spectrum of Emotions”. Noticeably, among these artworks, “Dreamscapes” is an abstract digital painting, “Echoes of the Past” is a real photo, and the others are more narrative concrete representational digital paintings. I intentionally requested the artist to create artworks encompassing these three distinct forms (i.e., abstract, realistic photography, and representational), which represent different levels of similarity to reality (see Figure 3.2). This choice was made to facilitate a comprehensive examination of the performance of generated AI across various art styles and genres later.

Figure 3.2 *Different Types of Exhibition Artworks*

3.2 User Study Questionnaire

Throughout this triple helix exhibition, I aimed to address the following research questions:

1) What impact does being able to modify artworks using AI tools in an exhibition have on a person’s sense of individual creative confidence?
2) How does Generative AI perform differently when applied to diverse types of artworks?
3) What is the participants' experience during this exhibition? (Are there any challenges encountered when using generated AI tools? What effect does utilizing AI to modify an artist's artwork have on an individual's co-creation identification? etc.)

3.2.1 Measure of Creative Confidence

There are multiple ways to measure creative confidence according to previous research like Questionnaire on Creative Self-Efficacy(QCSE) scale [32] and Competency-Based Creative Agency(CBCA) Scale [33]. In my study, I developed a creative confidence measurement questionnaire based on the QCSE scale. However, I made modifications by adapting and altering certain statements from the original QCSE scale, shifting the focus from problem-solving in design to the study's more art-related context. The resulting scale comprises seven positive statements regarding an individual's confidence in their artistic creative abilities, and respondents are required to provide their answers on a 5-point Likert scale [34]. Each statement carries equal weight in terms of scoring, ranging from 1 (strongly disagree) to 5 (strongly agree). The resultant score, reflecting an individual's creative confidence, falls within the range of 7 to 35.

Statement
I trust my creative abilities.
I am a creative person.
I identify as an artist.
I am not afraid to show my artworks to others.
When it comes to being creative, I have a positive self-image.
Compared to others my imagination is outstanding.
I feel very self-confident doing creative tasks even when others are present.

Table 3 *Scale to Measure Creative Confidence*

3.2.2 Measure of AI Performance

While evaluating artwork is inherently subjective, there exists a relatively objective method of measurement, which includes three levels of assessment: technical, semantic, and effectiveness levels [35]. The technical level emphasizes objective visual techniques such as color, accuracy of objects, and layout. The semantic level provides a more

profound assessment of how participants interpret the artwork's tone, content, and setting. The effectiveness level represents the highest tier of evaluation, measuring aspects like creativity, emotional resonance with the participant, and overall likability.

In my study, I drew inspiration from Lyn et al.'s work [7] to implement a 5-point Likert scale for each artwork. I invited the participant to assess each of their own AI-generated final results across nine attributes, reflecting the three levels of measurement. The scoring for each artwork's attributes ranged from 1 (lowest) to 5 (highest), and the final score for an artwork was determined by calculating the average score across all attributes. Notably, in the case of abstract artwork where no real objects are depicted, I omitted the attributes "Element Accuracy," "Content Matching," and "Scene Matching" from my assessment of the "Fading Memories" painting.

Technical Level	**Semantic Level**	**Effectiveness Level**
Color Harmony What are your thoughts on the color usage in this generated result?	**Tone Matching** Do you think the atmosphere/tone in this generated result matches your thoughts?	**Emotional Matching** Do you think the emotion conveyed in this generated result matches your thoughts ?
Element Accuracy If there are any objects present in the result, how precise do you think the AI is in drawing these elements overall?	**Content Matching** Do you think the contents/objects in this generated result match your thoughts?	**Creativity** What do you think of the creativity of this generated artwork?
Layout Coordination What score would you give to the overall layout of the generated result?	**Scene Matching** Do you think the scene in this generated result matches your thoughts?	**Preference** How do you like this generated artwork overall?

Table 4 *Scale to Measure AI Generated Artworks*

3.2.3 Measure of Exhibition Experience

To measure the exhibition experience of audiences, I posed six questions on a 5-point Likert scale and included four open-ended questions that encouraged the participant to write down their thoughts. The questions are as follows:

Questions on 5-point Likert scale:

1) Do you ever desire to recreate artists' works when you go to exhibitions? (required score from 1: “I never think about recreating art seen in an exhibition” to 5: “I always think about recreating artwork seen in an exhibition”.)
2) Do you believe that you can sketch images from your imagination quickly using only pen and paper? (required score from 1: “Not at all”. to 5: “Absolutely”.)
3) For this exhibition, how do you think the artist's work fits with the themes (e.g., "Fading Memories", "Dreamscapes", etc.) overall? (required score from 1: “They do not fit with the themes at all” to 5: “They fit the themes extremely well”.
4) For this exhibition, how well do you think your AI-modified artwork fits with those themes? (required score from 1: “They do not fit with the themes at all” to 5: “They fit the themes extremely well”.)
5) How easy was it for you to use AI to assist in expressing your artistic ideas? (required score from 1: “Very challenging” to 5: “Very easy”.)
6) How much do you think of yourself as the co-creator of these final artworks? (required score from 1: “I do not feel like a co-creator at all” to 5: “I feel very much like a co-creator”.)

Open-ended questions:

Any other thoughts on the experience of using AI that you'd like to share?

1) What was your initial thought of the artist's works before you modified them with AI?
2) What are your thoughts on the artworks after you modified them using our AI? Do you feel that you have gained a deeper understanding of what the artist was originally trying to convey?
3) Any other thoughts about this whole experience that you would like to share?

3.2.4 Personal Characteristics

The questionnaire collected basic information from the participants, including gender, age range, education background, and career. Considering that the audience's understanding of both AI and art could impact their responses, the questionnaire required participants to self-assess their knowledge in the fields of art/design and AI using a 5-point Likert scale.

Question	1 point statement	5 points statement
Self-rate your ability in the field of art/design.	I have no experience in art/design.	I make a living on art/design.
Self-rate your knowledge in the field of AI	I know nothing about AI.	I am an expert on AI.

Table 5 *Scale to Measure Individual's Art and AI Backgrounds*

3.3 Three Gallery Exhibitions in Local Community

The "Triple Helix" exhibition took place across a total of 12 days and attracted over 100 audience members at three different locations within my local community, the Upper Valley Area in New Hampshire and Vermont, United States. Specifically, the exhibition was hosted at the following venues (see also Figure 3.3):

1) JAM, White River Junction, VT: April 28, 2023, to May 3, 2023 [36]
2) Dartmouth College, Hanover, NH: May 26, 2023, to May 27, 2023
3) AVA Gallery and Art Center, Lebanon, NH: June 6, 2023, to June 9, 2023 [37]

Figure 3.3 *Exhibitions at JAM, Dartmouth College and AVA Gallery and Art Center (from left to right)*

During the exhibition, the artist would commence by presenting the concept of the "original exhibition" to the audience, explaining how AI-generated themes inspired and

guided the creation of the artworks showcased in this exhibition. The audience then took some time to look at the artist's works, after which I would introduce the AI modify software system to the audience and invite them to modify the artworks. They were encouraged to try the system multiple times till they were satisfied with the results. After generalizing the observed audiences' behaviors during the exhibitions, a user journey map is created to illustrate the general steps taken during this process and the emotional changes experienced by typical participants. (see Figure 3.4).

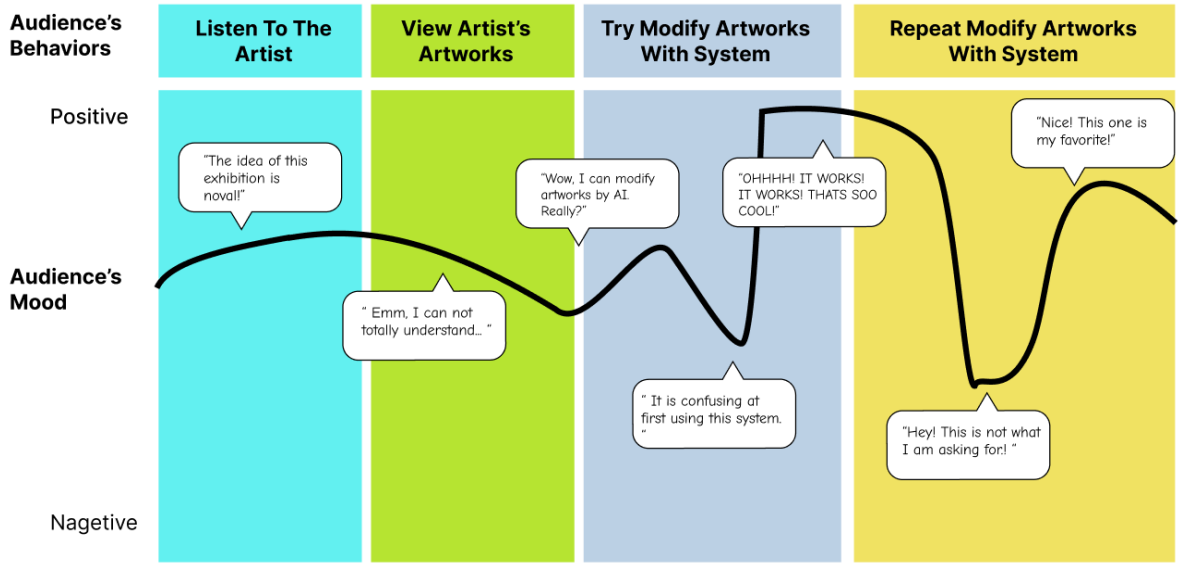


Figure 3.4 *Typical User Journey Map for the Exhibition*
(made after generalizing audiences observation results during exhibitions)

3.4 Online Comparison Experiment

In the study regarding the relationship between the change in creative confidence and the triple helix exhibition in section 3.2.1, there are various independent variables like 'being able to modify artworks', 'exhibition setting', 'generative AI', and 'artworks source'. Each of these factors has the potential to influence the dependent variable: 'change in creative confidence'.

Among these variables, "exhibition setting" raises particular interest, as it challenges the notion of whether a physical onsite gallery experience is necessary, given that attendees

can also experience the whole exhibition online. How does such a physical gallery setting influence the individual's change in creative confidence in reality? An additional experiment was designed to answer this question.

In order to draw comparisons with the gallery-based experiment in Section 3.3, the online format maintained consistency in all other independent variables that were present in the Triple Helix local community exhibition (see Table 6).

This experiment tries to replicate the original gallery study. The same explanatory materials were displayed to attendees to explain the concept behind the "triple helix" exhibition. The same software system in the gallery study was deployed online, enabling attendees to access the same artist's artworks featured in the initial study and make modifications using the DALL*E2 AI remotely. The same 5 point Likert-type creative confidence measurement scale (as presented in Table 4) was used here. The attendees were asked to complete the scale before and after the online exhibition, which is the same approach taken in the original gallery exhibition study.

Independent Variable	**Gallery Exhibition**	**Online Exhibition**
modify artworks	allowed	allowed
generative AI	DALL*E2	DALL*E2
artworks source	collaborate artist's	collaborate artist's
exhibition setting	physical gallery	online

Table 6 *Different Independent Variables and Their Conditions in Both Exhibitions*

Chapter 4: Results and Analysis

4.1 Analysis of Gallery Exhibition

4.1.1 Data Collection

During each of the exhibitions, I initially approached the audience members when they entered and inquired if they would be interested in participating in my research by completing the prepared questionnaire. This questionnaire consisted of two parts:

> Pre-survey: Audiences were asked to complete the creative confidence scale based on their everyday experiences.
>
> Post-survey: After attending my exhibition, audiences were requested to complete the creative confidence scale once more, reflecting their current feelings. Additionally, this section included questions pertaining to AI performance and their exhibition experience.

Audience members who agreed to participate in my research were offered a $10 gift card. I employed Google Forms as the platform for my questionnaire and received a total of 38 valid responses (N = 38) (11 male, 21 female, 1 no gender specified, 3 non-binary, 1 transgender, and 1 hybrid) across three exhibitions from late April to early June, 2023. Specifically, 14 valid responses were collected in JAM, 16 from Dartmouth College and 8 from AVA Gallery and Art Center. Most participants(60%) fell within the age range of 20 to 30.

Throughout the exhibitions, I attentively observed audience behaviors and engaged in post-exhibition discussions with select attendees to gather further insights.

4.1.2 Analysis of Creative Confidence Changes

I calculated the difference in participants' creative confidence levels before and after the exhibition. As mentioned in Section 3.2.1, an individual's creative confidence score ranges from 7 to 35, resulting in difference values spanning from -28 to 28. In practice, my findings reveal that the change in values ranged from -8 to 10, with the majority of values clustered around 0. More specifically, 52% of the data fell within the range of 0 to 2 (see Figure 4.1). Among the 38 samples, 19 exhibited a positive improvement in creative confidence, while only 8 showed a negative decrease in creative confidence. This indicates that the majority of the participants experienced a slight enhancement in their creative confidence after participating in the exhibition.

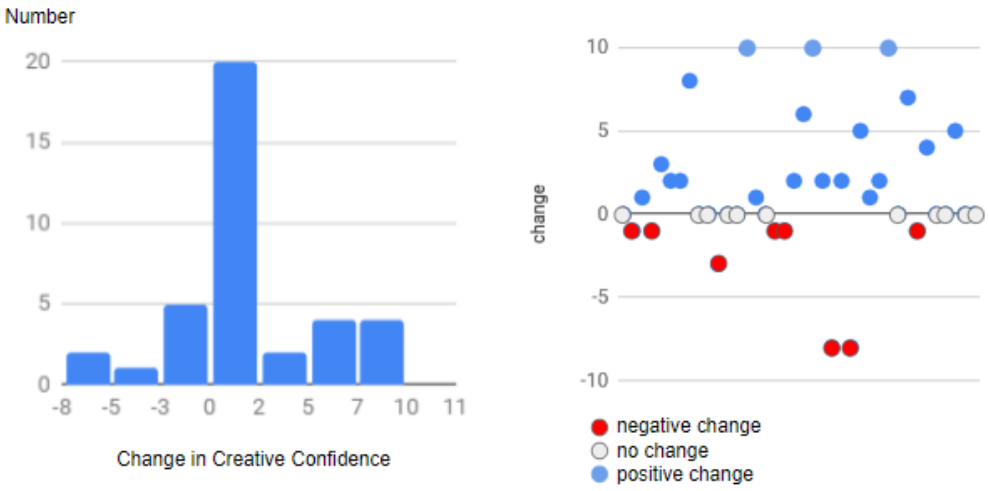


Figure 4.1 *Changes in Creative Confidence*

In addition, I observed that the average change in creative confidence for males was 0.45, whereas for females, it was 2.19. This observation suggests that, in comparison to males, females tend to experience greater changes in creative confidence after participating in the exhibition.

I also investigated the relationship between the change in creative confidence and an individual's knowledge level in art and AI. Given the fact that the ratio of individuals' who received a positive enhancement in creative confidence after the exhibition for participants with the lowest art level is 66%, while the ratio for those with highest art level is only 37.5%, creative confidence of participants tends to increase more frequently among individuals with lower levels of art knowledge, whereas it remains more stable for those with a high level of art knowledge. One possible explanation for this phenomenon is that it can be assumed that people with a relatively low art knowledge tend to have a

lower creative confidence in their daily lives, and tend to have a weaker art creating ability. Consequently, they may have a greater space for growth once they acquire the ability to craft the artworks they envision.

Furthermore, the evolution in creative confidence and various indicators of exhibition experience is shown in Figure 4.2, where red points refer to the decline in creative confidence, gray refers to no change, and blue refers to increment. It appears that individuals who exhibit a stronger sense of co-creator toward the modified artworks, who find AI usage more accessible, and who perceive a greater alignment between the modified artworks and the original themes are more inclined to experience a drastically positive boost in their creative confidence. On the contrary, those attendees who express a lower sense of co-creator and find AI usage challenging in modifying artworks often encounter a marked decrease in their creative confidence after the exhibition. This pattern is understandable, as individuals who gained a higher sense of co-creator, who found it is easier to use AI and to do theme matching tend to have a better exhibition experience. Their AI-modified artworks are better able to manifest their intentions, leading to a greater likelihood of them encountering several adapted pieces they are extremely satisfied with and proud of. These participants' creative abilities were enhanced greatly by AI and that likely boosted their creative confidence. Conversely, those who struggle with AI usage tended to receive modifications that deviated from their original intentions, further undermining their creative confidence, as their initial artistic vision remains unexpressed and they are reluctant to showcase these unsatisfactory modifications to the public within the museum setting.

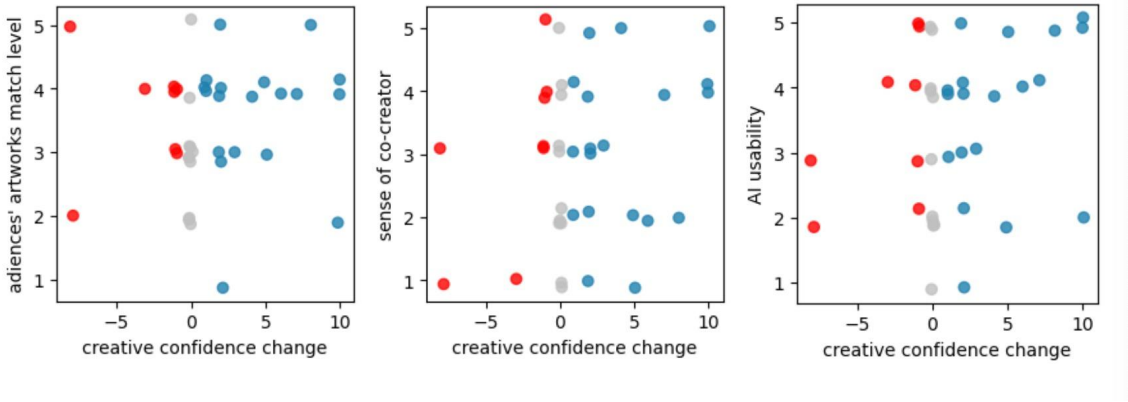


Figure 4.2 *Relation Between Change in Creative Confidence and Other Factors (from left to right: audiences' artworks match level, sense of co-creator, AI usability)*

As a result, other than allowing people directly to exhibit their creative works in a museum-like public environment, using more user-friendly and immersive art-creating AI systems, which facilitate a heightened sense of co-creation and greater control over outcome to the users, can bolster an individual's creative confidence. Furthermore, the positive impact of implementing such exhibition systems could be particularly

pronounced when introduced to audiences with limited art knowledge or during the early stages of art education.

4.1.3 Analysis of AI's Performance

I computed scores for all three categories (technical, semantic, and effectiveness) individually and then averaged these scores to obtain an overall score for each artwork, ranging from 1 to 5. This overall score provides an average assessment of how participants perceived their final modified artwork using AI, shedding light on the performance of the AI across different types of original artworks.

Based on my results (see Table 7), the average score for all of the artworks is 3.29. Examining specific pieces of art,"Dreamscapes" (overall score 3.25) falls around this average, two artworks, "Fading Memories" (overall score 2.81) and "Echoes of the Past" (overall score 3.06), scored below the average, while two artworks, "The Illusion of Reality" (overall score 3.43) and "Spectrum of Emotions" (overall score 3.91), scored above the average (see Table 7). To interpret the reason why specific pieces had specific scores here, I analyzed the ranking of final scores, which demonstrates that artworks containing a richer narrative and imaginative content tend to receive higher scores. There is a lack of narrative in the original "Fading Memories" and "Echoes of the Past" paintings; the former is an abstract painting while the latter is a photograph that just includes some daily objects but without any connection between. In comparison, the two original paintings that received a significantly higher score both include a stronger sense of narrative. Meanwhile, no matter whether it is "The Illusion of Reality" which is in the universe or "Spectrum of Emotions" which is the communication between human and the bear, they allow ample room for imagination in their content compared to pure reality, which potentially raised audience's emotions more.

Notably, the abstract, non-representational artwork "Fading Memories" received the lowest overall score. Its semantic and effectiveness scores were significantly lower than those of the other artworks. This suggests that participants found it challenging to use descriptive prompts to instruct AI on how to modify an abstract artwork. Though the AI generated modified abstract painting result might seem acceptable visually, it could not match participants' intentions and emotions. Based on observations made during the exhibitions, it was evident that the majority of attendees encountered difficulties when attempting to employ natural language to describe non-representational visual elements while modifying abstract paintings, and thus the AI-generated artworks they did not want to have. A significant number of participants found themselves feeling disoriented and

made efforts to incorporate specific objects into the original painting, inadvertently transforming the abstract artwork into representational ones.

Title	Artwork	Techni-cal Score	Seman-tic Score	Effecti-veness Score	Overall Score	Mean Signed Difference
Dreamscapes		3.38	3.12	3.18	3.25	**- 0.04**
The Illusion of Reality		3.25	3.60	3.44	3.43	**+ 0.14**
Fading Memories		3.14	2.72	2.57	2.81	**- 0.48**
Echoes of the Past		3.21	3.05	2.90	3.06	**- 0.23**
Spectrum of Emotions		4.08	3.92	3.73	3.91	**+ 0.62**

Table 7 *Table of AI's Performance on Different Artworks*

In contrast, the artwork with the strongest narrative style, "Spectrum of Emotions," received the highest score. All three levels of scores (technical, semantic, and effectiveness) were significantly higher than those of the other artworks. During the exhibition, more than half of the participants expressed a strong interest in modifying this artwork. They attempted to change elements such as the bear's head and the gestures of the bear and the old man, consistently producing results that harmonized with the original work while adding a humorous twist. This demonstrates that text-to-image AI performs

notably better with concrete, narrative artworks that can be easily described using language.

Figure 4.3 *A Glimpse of Parts of Participants' Modified Artworks*

In conclusion, it is believed that current text-to-image AI works relatively well when applied to representational artworks, especially for those with richer narrative and imagination content, yet it presents greater challenges when attempting to modify non-representational pieces. Designing an AI assistant that effectively collaborates with users in the creation of abstract paintings remains a great challenge.

4.1.4 Analysis of Exhibition Experience

Based on my sample, it appears that certain factors may have influenced participants' responses regarding "attendance at exhibitions with the purpose of recreating artists' artworks", "their agreement on being co-creators of the final artworks", and "their confidence in rapidly sketching images from their imagination using only pen and paper" (see Figure 4.4). For some participants, being able to easily use AI to modify artworks seemed to result in giving them a stronger sense of co-creation when collaborating with AI. It is not surprising to observe the positive correlation between the AI use experience

and the sense of co-creator. Additionally, participants' art level and their belief to rapidly sketch images from imagination using only pen and paper seemed to be at play with their willingness to modify artworks when they go to exhibitions. Among those in my sample with the lowest level of artistic expertise, the average willingness score to modify artworks, as measured on a 5-point Likert scale, stands at 2.66, while for those with the highest level of artistic proficiency, it rises to 4.13. Similarly, the average willingness score is 2.14 for individuals with the lowest belief in their ability to quickly sketch images using pen and paper, but it climbs to 3.6 for those with the highest confidence in this skill. Considering the interplay of these three factors, individuals with a greater level of art knowledge tend to believe they can more effectively convey their ideas through rapid sketches. Their creative capabilities, coupled with their deeper understanding of art, compel them to contemplate artworks more deeply, enabling them to better capture their own intentions and potentially compare them with the original artist's, which finally raises their willingness of re-creating the artworks.

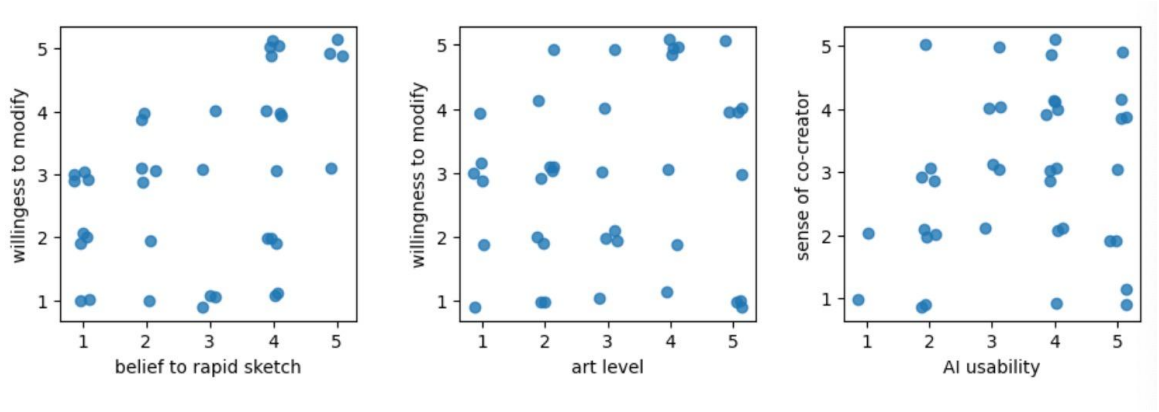


Figure 4.4 *Interrelationships Among Different Variables*

Over 60% of the sample somewhat agrees that both the original artist's artworks and their AI-modified artworks have a strong connection to AI-generated themes. However, overall, the match level between the artist's original artworks and the themes receives a higher score, suggesting that the original artworks align more closely with the themes. More than 70% of the collected sample indicated that it is somewhat easy to use AI to assist in expressing their personal art ideas, demonstrating the strong usability and accessibility of today's AI tools for creative purposes.

When it comes to the feedback received from the open-ended questions on the questionnaire, there is a mix of positive and negative responses. While it has received numerous positive comments such as:

"I'm really enthusiastic about this Triple Helix concept! The identity of artists has evolved significantly with the development of AI. It's time to revisit the definitions of authorship, amplification, and the boundaries of digital art."

"This is quite intriguing and unsettling in ways that are challenging to articulate at this moment."

particular interests lied on the negative feedback. It is believed that negative responses hold valuable insights that can help identify the current obstacles in AI generation and steer the future efforts. Some noticeable negative responses include criticizing the loss of control over AI generated results:

"I feel like sometimes the AI didn't create what I wanted. I still think I have much more control over images if I draw them."

"It felt like dall-e was refusing my additions in favor or preserving the original image."

"It was fun. I could play around with this for much longer with the hope that with more time and practice, I could learn to feed the AI what I need to in order to create the results I want. I can also see this getting fairly frustrating however, if there isn't nominal improvement in the translation from my words to AI created images."

These statements reflect current text-to-image AI cannot fully understand users' natural language prompts and the generated work would create something the user did not intend. Consequently, users may perceive a loss of control over the resulting image. Though it is hard to avoid these misunderstandings by AI, better user interaction design for such co-creator softwares could surely help improve user experience when such errors happen.

Also someone mentioned the challenge when coming up with prompts:

"The limitation in words I could use to effectively create my vision definitely impacted the final results. I also feel as though the AI struggled to represent the intended tone and mood of what I wished to create."

This reveals that during the text-to-image process, describing non-representational elements such as mood and visual effects through natural language can be a challenging task for users. Taking into account the earlier discovery in the "triple helix" exhibition, which demonstrated the current limitations of generative AI when modifying non-representational artworks, it prompts consideration of an alternative approach to effectively assist users in modifying such pieces using AI. Perhaps it's necessary to acknowledge and embrace the inherent constraints of the text-to-image conversion process, and explore other interactive methods that can empower users to collaboratively

create non-representational elements with AI. For example, using a camera to capture participant behaviors during the exhibition and developing a generative algorithm to transfer these behaviors into non-representational elements. Or directly giving participants access to draw on the painting, rather than relying solely on text-to-image transformation, to provide a more detailed control option for creating behaviors.

Some other criticisms are more focused on this form of rapidly generated artworks and the potential lack of sense in co-creation and ownership of results:

"This made me realize how easy AI is and how not fulfilling it is to create with it. I don't feel any pride or ownership of the work"

"I feel they are not so transitional and serious any more, it has more variations, just like some second hand creating funny videos from YouTube or 4chan."

"The art work appears to have sourced existing artworks . So it is difficult to establish these as authentic"

These statements reflect current shortcomings of state-of-the-art generated AI including: a lack of originality and authenticity of the generated contents since the generated results are sometimes similar to AI's training data, which are some existing artworks; and the lack of user's sense of co-creation and ownership of results since the rapid image generation by AI destroys the seriousness form in traditional art creation. As a result, the Human-AI co-creation process should contemplate the integration of traditional art creation methods into the existing rapid image generation process. This integration is crucial to provide space for users' individual artistic expression when designing AI co-creation softwares. Such an approach ensures that the generated outcomes are not merely composites of diverse training data but also encompass authentic artworks that resonate with the user's distinctive artistic voice. Simultaneously, this process could potentially foster greater user involvement in the creative process and promote a sense of ownership over the results.

4.1.5 Other Findings

By observing audience behavior during the exhibition, I noticed that audiences who got satisfying results in the very first few rounds of trying the system tended to enjoy the exhibition more and try more times changing artist's artworks. Most audiences would stop trying the system once they got two to three times of unsatisfying results from AI in

succession. Some participants noticed they could mask out the whole original image and regenerate the whole contents fully followed by their prompts. As a result, their results had no connection with the original artist's artworks.

After communicating with some participating audiences after they experienced my system, I found there were a few audiences who mentioned they were more enjoying observing real oil paintings on canvas rather than AI generated works on digital screens. They mentioned that digital paintings might lose some elements of the creation process like brushstrokes, which affects their enjoyment viewing a painting. This reflects the previous research result showing if elements of the human process are visible can increase the creative value of an artwork [38]. A few participants also express their hope to use the prompts to control the image transferring process of the whole image. One participant mentioned she found trouble making the front part of the painting clear, while the back part of the painting moody by using the system. There is no way to add filters to the whole image by software. Almost all of the audiences agreed the exhibition setting in physical galleries makes the process much more formal and they could feel the art atmosphere during the process.

4.2 Analysis of Online Exhibition

The questionnaire for the online comparison experiment was designed using the Qualtrics XM platform, and participants were recruited through the online user study platform Prolific. Participants were filtered to include only fluent English speakers located anywhere in the world. Prior to the formal study, a pilot test was carried out on Prolific with 6 participants to ensure the clarity and comprehensibility of each step in this additional unsupervised study. After conducting the formal tests, small adjustments like replacing the online platform link in text to in hyperlink were made to ensure a smoother experience, while the main construction kept the same. The formal testing phase took place from October 24th to October 25th, 2023, and received a total of 57 responses. Because the pilot study demonstrated that a 10-minute period was necessary to ensure participants would fully test all key features, formal study participants were asked to spend at least 7 minutes doing the study. Therefore, only individuals who exceeded the 7-minute threshold and completed all study questions were considered valid data samples, making them eligible to receive a $5 reward for their participation. Out of the 57

responses received, a total of 40 valid data samples (N = 40) were successfully collected and utilized for subsequent analysis.

Before comparing the creative confidence changes in the gallery study and the online study, it is crucial to confirm that their baseline data regarding creative confidence before attending the exhibition are approximately equivalent. To achieve this, first, a Shapiro-Wilk test was conducted on the "creative confidence value before the exhibition" data from these two sets of data, revealing calculated W values of 0.96 ($p = 0.26$) to the gallery one and 0.97 ($p = 0.37$) to the online exhibition one. These W values approximate 1, and the associated p-values exceed 0.05, indicating that both sets of data adhere to a normal distribution. Subsequently, a t-test was performed, and the outcome (t-value = 1.59, $p = 0.12 > 0.05$) demonstrates that there is no statistically significant difference in the pre-exhibition creative confidence values between these two groups. Consequently, any subsequent variations in creative confidence values can be attributed to differences in the exhibition settings: physical gallery exhibition and virtual online exhibition.

Upon subjecting the "creative confidence change value" data to the Shapiro-Wilk test, the results revealed that both the change values in the prior study ($W = 0.90$, $p = 0.0029 < 0.05$) and in the additional experiment ($W = 0.90$, $p = 0.0023 < 0.05$) deviate from a normal distribution. Consequently, a Mann-Whitney U test is conducted to further investigate their relationship, and the outcome ($U = 838$, $p = 0.431 > 0.05$) indicates that there is no statistically significant difference. In essence, this implies that the independent variable "exhibition setting" does not exert a statistically significant effect on the dependent variable "creative confidence change value".

However, “exhibition setting” still may have influenced the change of individuals’ creative confidence, but just in a not statistically significant way. The average value of change in creative confidence in this additional study is +0.750 while in the gallery study is +1.552. In this additional experiment, 47.5% of the data received a positive change (increase) in creative confidence and 22.5% received a negative change (decrease), while in the gallery study it was 50% positive and 21% negative. These differences (+0.750 vs +1.552, 47.5% positive, 22.5% negative vs 50% positive, 21%negative) show the exhibition's physical setting can somehow boost the trend in increasing creative confidence. This is not surprising as having discussed in section 4.1.5, people acknowledged the immersive art atmosphere caused by the physical gallery setting. Further research with a larger data pool is needed to establish statistical significance for this trend.

In summary, the impact of the 'physical gallery setting' on enhancing an individual's

creative confidence increment is not statistically significant in this study, which may be due, in part, to the small sample size. Despite the small sample size, this finding supports the result in Section 4.1.2 which suggests that participants still increase their creative confidence, even if only slightly, after using AI to modify the artworks. These results suggest that since creative confidence can be boosted in either in-person or online formats, to reduce costs it is more feasible to promote through online exhibitions. Physical onsite costs are various and can include exhibition place fee, instruments fee and poster fee. Meanwhile, by promoting such exhibitions digitally, a broader global population could have the opportunity to try and potentially enhance their creative confidence.

Chapter 5: Conclusions

5.1 Limitations

I acknowledge several limitations in my study:

1) **Limited Sample Size**: My in-person gallery study relied on a dataset of only 38 participants and my online study relied on only 40 participants. In addition, due to constraints related to the local community in in-person gallery study, this may have introduced bias and hindered the representation of diverse perspectives to my results.
2) **Undiscussed Independent Variables**: As mentioned in Section 3.4 there are various independent variables that could potentially impact the change of creative confidence. This study only focuses on the exhibition setting, leaving questions regarding how other variables–like whether participants are allowed to modify artworks, the choice of generative AI, and the choice of displayed artworks–may influence the results.
3) **Singular Artist**: The exhibitions featured only one artist, potentially limiting the exploration of how artists interact with generative AI, a key component of the 'triple helix' idea.

5.2 Main Takeaways and Future Works

Based on these limitations in Section 5.1, below are some avenues for future work:

1) **Larger sample size.** For future endeavors, I recommend considering a broader and more diverse participant group so researchers can better look at how variables

like gender and cultural background might impact the experience of participating in triple helix exhibitions. Specifically, this study has already shown the trend that females demonstrated more of an increase in creative confidence, and a larger sample size could help further investigate that.

2) **More comparison experiments.** More comparison experiments, similar to Section 3.4, that control only one independent variable to differ from the triple helix gallery exhibition should be conducted to measure the influence of various variables to creative confidence. For example, this study has already suggested generative AI performs differently on different types of artworks, even when these artworks are created from the same artist. Future researchers could organize other triple helix exhibitions in galleries, featuring artworks from different artists or even generated by AI, to investigate whether the source of artworks has any impact on participants' changes in creative confidence.
3) **Interactions between artists and AI.** Future works can delve into the artist's creative journey and focus on how artists use AI. Additionally, distinctions between using AI as an inspirational tool to guide artists in creating artworks and artists independently deriving inspirations for their creations can be explored.

Beyond conducting a larger-scale study with expanded sample sizes, implementing more comparison experiments, and studying the artists, future research can build upon some of the notable findings in this work.

As earlier studies on creative confidence discussed in Section 1.3 primarily focused on traditional tools and conventional design thinking education, the discovery of the positive impact integrating a generative AI tool into the artistic creation process has on individuals' creative confidence paves the way for fresh perspectives in research on creative confidence. Since this study has demonstrated the potential impact of involving AI tools in creative tasks on an individual's creative confidence, it is recommended to continue incorporating AI tools when researchers design new creative tasks for participants in future research on creative confidence. To be specific, this study used DALL*E2, and thus the creative task is mostly limited to its core feature: text-to-image. By considering other AI tools, new interactive methods (i.e., video-to-image) could be possible, opening up new possibilities for experiment design.

Given the observation that participants with limited art knowledge experienced a boost in creative confidence, there is potential for integrating this system into children's art education. Education software companies could develop apps for kids that enable the modification of artworks by AI, featuring a child-friendly user interface design. Through engaging with these apps, children could potentially enhance their creative confidence.

This study has already revealed that rapid image generation can make the creation process feel less formal, potentially decreasing users' engagement and ownership of the results. This suggests that faster is not always better when it comes to AI-supported art creation. Therefore, when designers aim to develop future AI co-creation software, they should attempt to purposefully extend the duration of the artwork creation process, such as by breaking down the direct text-to-image generation process into multiple interactive steps, to enhance user involvement.

5.3 Conclusions

In this project, my team introduced an interactive exhibition, taking on both in-gallery and online environments, called "Triple Helix," where we provide audience members with the opportunity to alter the artworks created by the artist, thus imbuing them with their own perspectives. This approach establishes a symbiotic relationship between the artist, the audience, and the AI, fostering a collaborative approach to artistic creation.

This interactive exhibition was conducted within local communities and online, and involved a comprehensive user study, exploring themes such as creative confidence, AI performance, and the overall exhibition experience. The primary contributions of this work include:

1) An innovative exhibition system, allowing audiences members to actively modify artworks in real-time using AI technology;
2) Experiments examining key factors that impact individuals' creative confidence after they actively engage in modifying artists' works with AI assistance in a public exhibition context; and
3) Identification of certain shortcomings in current generative AI systems, such as the weakness of current text-to-image transformation methodology in non-representational pieces and the cons of rapid image generation.

These insights can serve as valuable guidelines for improving the human-AI co-creation experience in the future. I hope this work will serve as a step toward a richer and more comprehensive understanding of the application of generated AI into the realm of art.

Appendices

A. Source code of my software system on Github:

   https://github.com/actbee/Triple-Helix

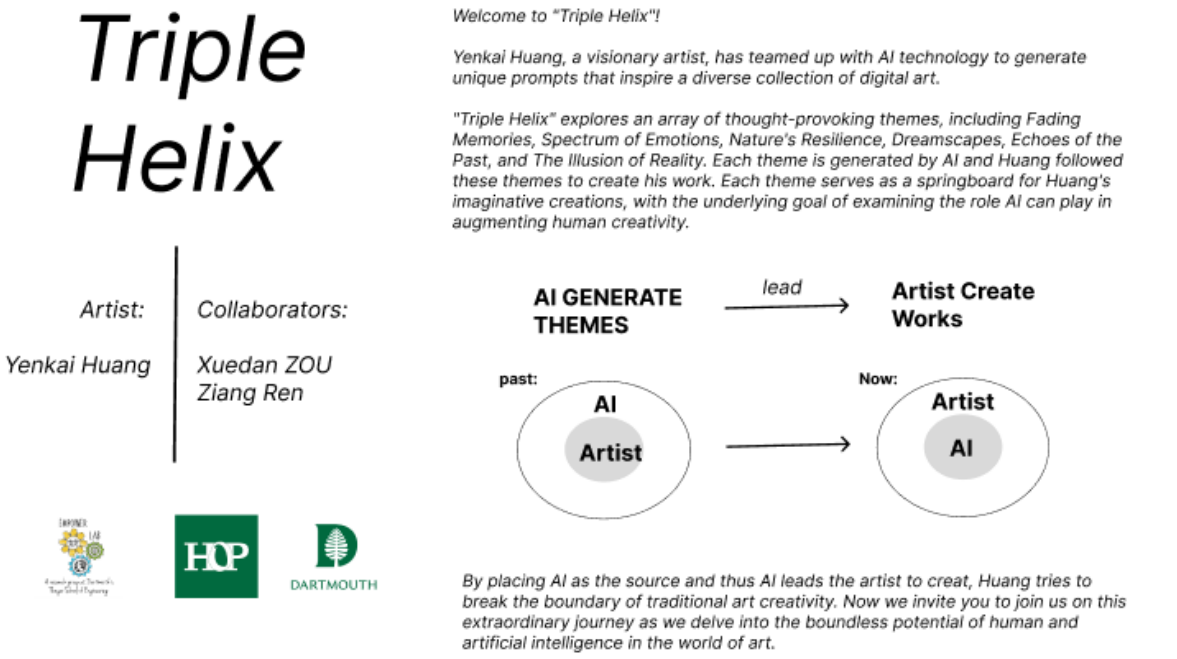
B. Exhibition video:

   https://avagallery.org/video/triple-helix-ai-artist-audience-collaboration-exhibition

C. Questionnaire on Google Form:

   https://forms.gle/tGty65KL5Qmfqmbv6

D. Exhibition Introduction Poster in JAM Studio and Dartmouth College:



E. User Guide that is delivered to audiences during exhibitions:

   See next two pages.

F. The additional experiment study questionnaire:
   https://qualtricsxmjzzzfyytq.az1.qualtrics.com/jfe/preview/previewId/9f573311-b6af-48e3-9f94-340236763701/SV_8Cc7l6El8YURQYC?Q_CHL=preview&Q_SurveyVersionID=current

User Guide

exit button
click when you want to leave and this will reset the system for the next audience.

1. image selection

Here in this page you can always choose the image you want to modify.

Theme
Generated by AI that lead artist Huang to create his work.

Poem
Writen by artist Huang to explain his work

2. image edit

After choosing your image, our system will jump into this page where you can choose three different ways to modify the current image.
We ask you to modify Huang's work to match your understanding of the given theme. You can try multiple times untill you get your satisfied result.

1/2

3. Change by Mask

In this moduel, you should first mask out the area you want to modify on the right image by mouse, then type in the prompt explaning how you want to modify it.

4. Variation

AI will try to generate a new image which is similar to the current image in this moduel.

5. History

You can always review all of those generated images and revert to any edition in this moduel.

References

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