Virtual Artistry: Virtual Reality Translations of Two-Dimensional Creativity

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Abstract
This study seeks to provide insight into two-dimensional (2D) artists' approach to three-dimensional (3D) creativity within a virtual environment. Specifically, this research investigates the widespread assumption that Virtual Reality (VR) provides a natural interface by which traditionally 2D-centric artists may explore 3D content creation. Using a prototype of Canvox, a VR tool that uses voxels to represent 3D space with a single stroke [1], we performed a qualitative study in which artists were observed producing familiar assets in a virtual space. Here, we present data on 2D artists' expectations for the User Interface (Space, Navigation, Scale, Tool Accessibility, Lighting), Functionality (Tool Functionality, Materials, Brushes, Primitives), Applications (Communication Mechanisms, Use Cases), and User Mindset (Ideation, Creation, Opportunities) for VR creation. Our results offer insights into the bifurcations between artists' mental models of 2D and VR creativity: in VR, artists expect to create content, while in 2D, artists expect to render representations of content. We also demonstrate the potential use cases of this emerging creative platform.

Author Keywords
Virtual Reality; Human-Computer Interaction; Artistic Processes; Creativity; Spatial Design; Perception;

Design Applications; 2D art; XR art; Virtual Environments; User Experience

CSS Concepts

- Human-centered computing~User studies
- Human-centered computing~Virtual reality
- Human-centered computing~Gestural input
- Human-centered computing~Empirical studies in HCI
- Human-centered computing~User-centered design
- Computer Graphics~Virtual reality
- Applied computing~Arts and humanities

Introduction

3D content creation has traditionally been associated with a steep learning curve, making it difficult for those new to 3D to express their creativity in this medium [2]. Some factors that contribute to these difficulties are related to 3D tools' user experience (UX, i.e., vast interfaces, a daunting range of functionality, [2]), and user interface (UI, i.e., manipulation and control of the position of 3D content on a 2D screen, [3]).

There may be additional barriers that are cognitive in nature. Traditional 3D content creation occurs on a 2D computer screen. Conceptualization and subsequent manipulation of this content on the z-axis (in addition to the x and y axes) arguably requires mental rotation and mental registration (i.e., the spatial relationship between views, [4]). Both mental rotation (e.g., [5]) and mental registration [4] have been associated with increased cognitive demands.

There have been past efforts to reduce the learning curve associated with 3D content-creation. For example, there is a rich literature on how technology can leverage one's existing 2D drawing skills to ease the 3D-content creation process. 3D modeling systems like Teddy [6] have users generate 2D sketches from multiple views, to subsequently create a 3D model. Such systems are based on (a) common workflows that have a user create 2D drawings of content prior to modeling it in 3D, and (b) those users' unmet needs to have their existing 2D work aid in the 3D modeling process (e.g., [7], [8], [9]). However, these solutions are arguably targeted to those with 2D sketching abilities. This leaves room to explore opportunities to translate other types of 2D skills into 3D content-creation abilities. At present, we explore how virtual reality (VR) could facilitate this translation.

Interestingly, many of the cognitive barriers associated with traditional 3D content creation are also addressed in VR environments. As summarized by Evans [10], VR environments have been found to support spatial awareness [11] and aid in user comprehension of complex 3D content [12]. Therefore, VR, combined with a simplified UX/UI for 3D content creation (ideally, building off skills the artist may already have in 2D), may serve as an environment in which non-3D artists could easily create 3D content.

This study focused specifically on two-dimensional (2D) artists and their conceptions of VR content creation. Perhaps, we hypothesized, VR would enable a 2D artist to naturally translate their 2D creation skills (e.g. painting) into 3D. This could serve to seamlessly enhance the creative repertoire of 2D artists by allowing a natural foray into 3D creativity. This hypothesis was informed by previous pilot research conducted by one of the authors of [1], with two team members who are employed at the present authors' company. These two individuals had previous, professional experience as 2D digital artists, used Canvox, and provided feedback that the tool helped translate their 2D creation skills into 3D.

Additionally, we hypothesized that virtual painting might reduce the discrepancies between 2D artists and their 3D collaborators. In our past professional work studying creative professionals, we learned that there are many use cases in which 2D renderings are

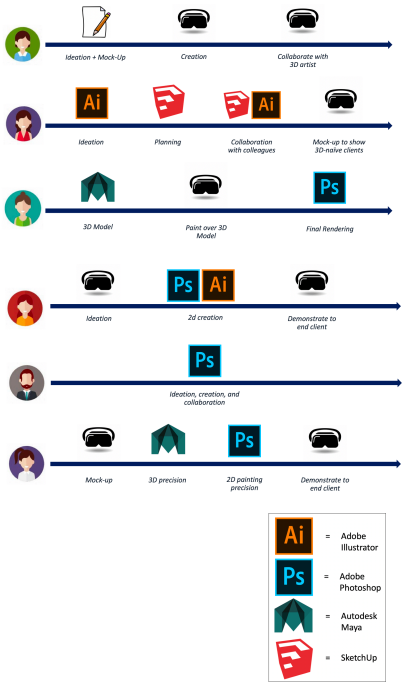

Figure 2: Representation of participant-generated workflows for the potential integration of VR painting.

creatively reconstructed in 3D. For example, character artists at gaming companies often provide two-dimensional artistic renderings of a proposed character. Later in the design process, this character must be imbued with three dimensionality, inherently requiring additional information to be added. This information may or may not cohere with the artist's initial conception of the character. This use case harnesses the power of virtual painting to enable artists to safeguard their creative direction against final rendering changes.

In order to understand how artists might engage with a virtual painting tool, we must first understand the mental models with which they approach the experience. By conducting in-depth ethnographic interviews and hands-on concept testing, we sought to discern 2D artists' understanding of and expectations for a virtual painting tool. Given the aforementioned pilot observations, we proceeded with conducting the ethnographic interview and the hands-on concept testing in the same research session. The interview allowed us to understand the unmet needs of 2D digital artists, and compare those with the pilot observations.

UI	Functionality	Applications	User Mindset
Space	Importing + exporting	Communication between 2D → 3D content creators	Ideation
Navigation	Tools (paint color mix, recolor, color picker, color cylinder)	Communication with end client	Creation
Scale	Material	In-engine viewing	Sculpting vs. Painting
Tools	Brushes		Comparison with similar Tools
Lighting + Shadows	Primitives		

Figure 1: Representations of the categories and topics covered in this study.

Methods

We recruited six participants of varied age, gender, industry, and role. All participants consented to the study and were compensated for their participation. Though they varied in specific role, all participants identified as 2D digital artists that create designs for 3D platforms. Additionally, all participants were VR-naïve, with no experience using VR in a professional setting, and little to no exposure to VR in non-work environments.

Amongst the six artists, the following professional toolsets were identified: concept art, art direction, 2D art, character design, environmental design, texture art, UI interaction design, and spatial design. Three of the participants work at gaming studios, one works at a large technology corporation, another works at an immersive design studio, and one is a freelancer for several different industries.

The procedure included one-on-one sessions with each participant, conducted by a trained moderator. Each session was observed by a minimum of one observer, watching the session via a live video stream. The observer was located in a different room than the participant. First, each participant completed a structured ethnographic interview, which probed the artist's workflow, collaborative process, motivations, tools, experiences, and concluded with a step-by-step walkthrough of a recent project of theirs. These methods are aligned with rapid ethnographic techniques for human-computer interaction field research [13]. Each participant showcased a 2D artwork that was subsequently translated into 3D by their collaborators.

Next, in order to understand both how and if artists would engage in a VR creative tool, we performed a concept user test using a prototype of Canvox, a voxel-based VR tool that allows users to represent 3D space with 2D interaction models, such as brushstrokes [1].

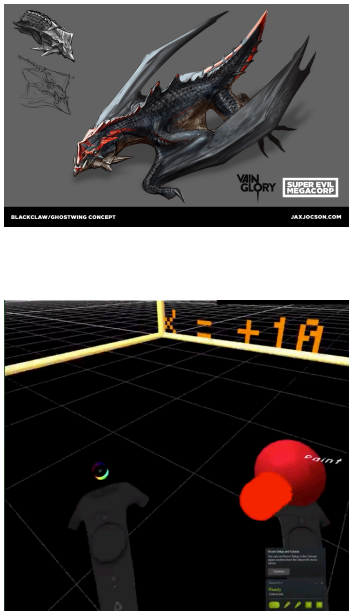

Figure 3: A participant's original 2D drawing (above), and the participant's VR sketch of the same concept (below).

This Canvox prototype contained several tools, including a paintbrush, eraser, color picker, eyedropper, and a recoloring tool. Canvox's virtual environment is a simple black background containing a white grid and a gold cube, both offering spatial reference cues. Canvox ran on an HTC Vive VR headset with two 6-DOF SteamVR Tracking controllers, and a GPU-enabled desktop computer.

Within Canvox, participants first completed a brief onboarding tour. Subsequently, they performed an orienting exercise to familiarize themselves with the tool. Then, for the core task, participants were instructed to re-create the 2D piece that they had brought with them. By nature of Canvox's voxel-based framework, all of the resulting recreations were three dimensional.

Participants were instructed to "think aloud," verbalizing whatever came to mind during task performance [14]. Throughout this experience, participants were recorded and observed. Participants were questioned about their understanding of each tool, as well as their subjective experience using each tool and interacting with the virtual environment. Natural reactions were monitored and recorded.

To conclude the session, participants completed a post-task interview, in which they were asked about their experience using Canvox. Participants discussed workflow integration, use cases, confusion, difficulties, and mental models surrounding virtual painting.

Results

Although participants were generally excited by the experience of using Canvox, no participants indicated that they would replace their current workflow with a VR painting tool. However, participants did highlight points in their workflow at which a virtual painting tool might be helpful, as illustrated in Figure 2. In addition to providing insights into artist's expectations of VR, these workflows outline novel multi-step creative workflows for VR.

Applications.
For many participants, VR offered an improved communication model. While we expected that VR might improve communication and collaboration between adjacent 2D and 3D artists, the artists offered a surprisingly different communication opportunity. Artists have persistent difficulties communicating spatial context to their end clients. Many participants indicated that a VR tool would aid in client communication, serving to offer a more realistic representation of the end result. While 2D artists are adept at situating their artistic ideas within the "real world," clients are not equipped with decades of translating creative sketches into 360-degree experiences. VR can serve to bridge that communication gap: one participant mentioned, "Right now, it's three dimensional in my head, and they have to do these 2D drawings or maybe a model on a computer to communicate that. But this is more one-to-one. It's the same experience for both people."

On the other hand, most participants did not exhibit communication gaps with their 3D collaborators. Typically, they are accustomed to working together and collaborators understand one another's references to 3D space. In the words of one participant, "They can just call me over and ask, 'Does this look right?' There's a lot of open communication…So yeah, things are generally the way that I intend them to be."

Workflow Use Cases.
The participant-generated within-workflow use cases for virtual painting varied; for some participants, they found the tool to be ideal for experimentation and ideation, due to the imprecise nature of 3D movements. As one participant indicated, "It's definitely looser and sketchier…I think it would definitely be great for ideation because it kind of forces you to be less

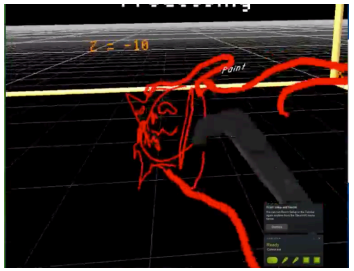

Figure 4: Canvox UI from a user's perspective when in the "Paint" tool.

precise, so it's more envisioning where things would be in a more abstract way."

Other participants indicated that VR makes their ideas more concrete. Therefore, they found VR to be best suited for the creation phase of their cycle: "I would still like to draw some 2D sketches. I would get the ideas and composition…and then use this tool to make it real." In this way, virtual painting can bring 2D creations to life.

However, creatives are not willing to do away with other creation-oriented programs: many participants envisioned importing and exporting files from other creative software. For example, participants would "clean up" their creation in Adobe Photoshop, or import 3D models from Autodesk Maya to virtually paint atop.

Functionality & Affordances.
Indeed, the dimensionality was a creative pain point for all participants; 100% of the participants were unable to align their brushstrokes in order to form a 3D shape of contiguous strokes or surfaces. For this reason, the ability to import primitives became a participant-generated pre-requisite: "Being able to build up directly on an object would be a necessary tool, so that when you're sculpting you only add onto existing geometry and won't mistakenly paint away from the mesh." 4 of 6 participants indicated that they would not consider using a virtual painting tool that did not have 3D primitives or the ability to import 3D models. 2D artists realize that they are unable to create freeform in VR as they do on 2D platforms: guiding tools are necessary for precision.

Spatially, participants had a mixed reaction to the prototype's sense of scale: concept artists and art directors are unaccustomed to accounting for scale in their work. While they acknowledged that virtual painting is well suited for at-scale work, they found this functionality to be irrelevant to their process. On the other hand, spatial and environmental designers found the sense of space to be enormously beneficial. However, in order to engage with the spatial power of VR, participants required benchmarks: precise scalar values. Without this information, participants were left teeming with questions: "Is it a 1 foot by 1 foot grid? Or 1 meter by 1 meter? There's no label. I would like there to be a label. I don't know how I would draw to scale based off of architectural drawings that are provided to me."

A key difference between virtual painting and two dimensional painting is lighting. Currently, 5 of 6 of the participants are responsible for imbuing their two dimensional art pieces with lighting and shadows manually. Surprisingly, these same artists expected that a VR program would automatically provide the lighting and shadows for the forms that they paint within a virtual environment. This is a curious finding that hints at a broader conception: in VR, artists are *creating things*, while in 2D, artists are *representing things*. Across many other metrics, participants indicated that they expected their VR creations to exhibit physicality, permanence, and coherence.

A salient representation of this came from offhand participant reactions to creating within the Canvox environment. 4 out of 6 participants separately, and without probing, came to the conclusion that VR is better suited as a "sculpting" tool than a "painting" tool. In one participant's words, "It almost feels like I'm sculpting…That's the true beauty of VR. Rather than make lines that are representative of 2D space, to actually have the 3D material." In this way, 2D artists step outside of their creative purview when they enter VR.

Discussion

Using Canvox, a research prototype of a voxel-based VR painting tool, we were able to glean detailed insights into artists' perceptions of VR creative tools. Surprisingly, the initial hypotheses were invalidated.

Firstly, the communication between 2D and 3D artists does not appear to be strained. Ethnographic research informs our conclusion that our the user problem we sought to solve simply does not exist in this sample.

Additionally, VR painting does not offer a natural transition from 2D painting to 3D content creation. Although the physical action of making a brush stroke in VR is reminiscent of artists' 2D creativity, the VR interface immediately alters the participants' engagement with the tool. A brush stroke in VR inherently carries the psychological assumptions of lighting, shadows, weight, permanence, and general physicality. By expecting brushstrokes to act as clay, artists indicate that they approach virtual painting with a unique mental model. Furthermore, that mental model is more closely aligned with physical sculpting than with physical painting.

Although virtual painting cannot be neatly categorized into existing artistic mental models (e.g. painting), VR creativity offers its own affordances. Participants found VR to be the answer to an unanticipated pain point: the representation of their piece to its commissioner. This aligns with previous research [15, 16], in which 3D views are used to situate and communicate a qualitative representation of the content. Oftentimes, artists are faced with the challenge of presenting the dimensionality of a 2D rendering. By quickly sketching an art direction in VR, artists are relieved of the need to gesturally and verbally transcribing their visual work. VR offers a multisensory immersion that not only meets, but may potentially surpass, such explanatory methods.

Additionally, virtual painting offers its creators the ultimate ideation platform. With its limitless space and its sketch-like quality, VR painting offers scalar prototyping to artists at the early stages of a three-dimensional workflow. In this way, VR painting may become one tool in an artist's technological toolbox, cooperating with other methodologies to support the next generation of creatives. Future directions could include having 2D artists recreate a new 2D piece in 3D "from scratch" (rather than from an existing 2D piece) to examine how the VR environment may be related to spontaneous creativity activity. Furthermore, studying the collaboration between 2D artists and their 3D counterparts using VR tools like Canvox could provide additional information about the association between VR content creation and workflow.

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