TattooDoodler: An Iterative Sketchpad and 3D Projection Tool for Enhancing Tattoo Design Efficacy

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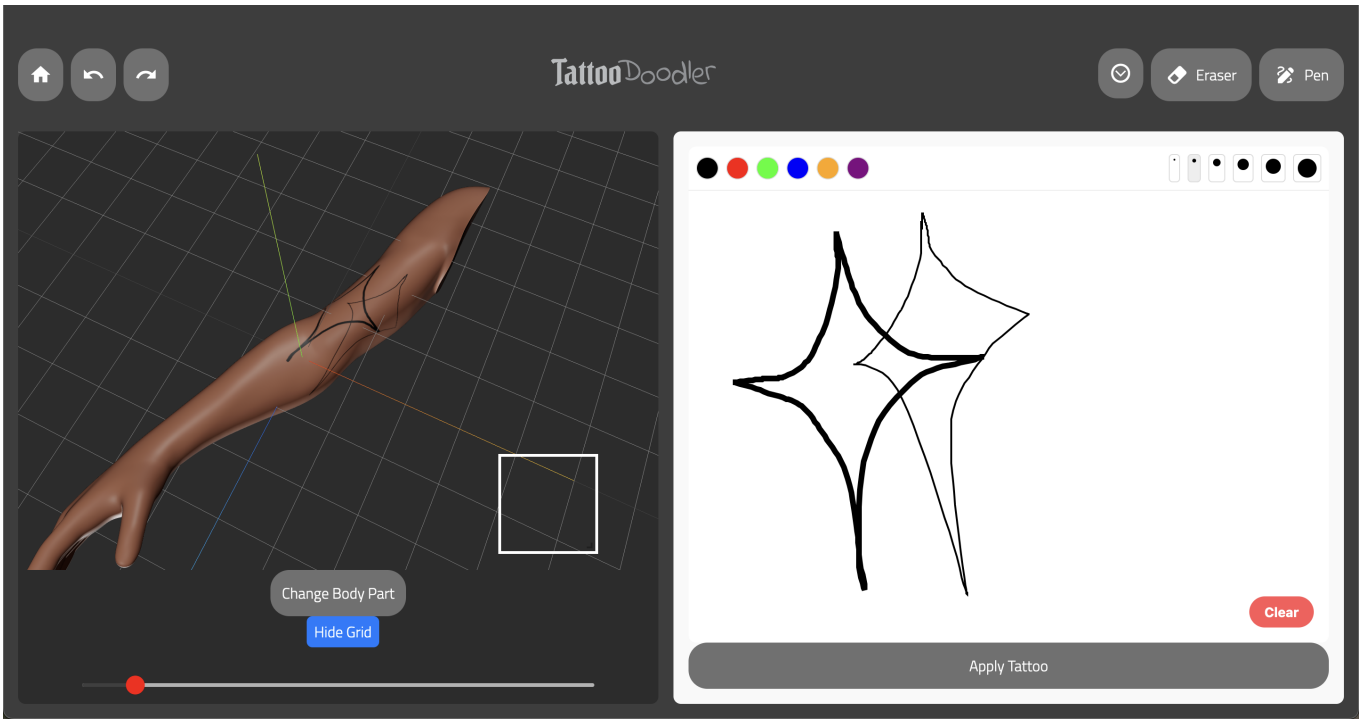

Fig. 1. A screenshot from users drawing and projecting a tattoo design in TattooDoodler

Previous creativity support tools have suffered limitations through either inhibition of total creative autonomy due to guidance based on a corpus of external inputs, or the creation of a digitally-enhanced creative medium that while allowing full user autonomy, is not directly translatable to more traditional, analog artistic mediums. TattooDoodler aims to bridge the gap in solutions resulting from these limitations specifically for tattoo artists and clients. TattooDoodler provides a digitally-enhanced medium for rendering 2D tattoo drawings and designs onto a 3D modeled body part, and critically, the iterative revision and/or re-placement of these designs based on the projection. TattooDoodler enabled users to iteratively observe how a potential tattoo would appear on the contours of the human body with an approachable user interface, increasing user's perceived freedom to explore designs and placements. This iterative design process enables users to have more autonomy and agency over any potential tattoos they may receive as a result of their prior perception of its appearance being enhanced by TattooDoodler.

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1 Introduction

Tattoo design as art is unique because it involves considerations that other art forms don't – such as how colors and lines will appear on skin, the effects of the physical tattooing process, and how tattoos will change over time. But one particularly complex and critical factor is how a tattoo's placement across the body's natural contours affects its final look. Unlike traditional art on flat canvases, tattoos interact dynamically with the human body's curves, creating both challenges and possibilities. Given the permanent nature of tattoos and the countless design choices that go into each one, it is vital for

artists and clients to have tools that provide an accurate preview of how a tattoo might ultimately look on the body.

Currently, artists and clients often work on flat surfaces, like sketchbooks or iPads, only to encounter complications when translating the design onto the body. Any necessary adjustments often require a return to the 2D workspace, making the process frustrating, time-intensive, and inconsistent. This disconnect creates limitations, especially for larger, custom tattoo designs, and has led many artists to rely on making "sticker-like" designs or smaller pieces that can more easily fit on various areas of the body without needing as much adjustment. Clients, on the other hand, often face anxieties and uncertainties when considering a new tattoo, as there is not currently a straightforward way for clients to visualize what a tattoo may look like in the fuller context of their body or next to their existing tattoos. For both parties, a more traditional iterative artistic process is also inhibited by the final nature of tattoo art; the canvas cannot be shelved and replaced, nor can the paint be scraped away or the graphite erased.

These problems remain unsolved because of the inherent complexity of translating flat digital or hand-drawn designs onto the three-dimensional, moving surface of the human body. Traditional approaches to tattoo design – sketching on paper or using basic digital software like Procreate – do not bridge this 2D-to-3D gap effectively. For clients, it's also difficult to visualize the tattoo's appearance in context with their own body and existing tattoos, resulting in a time-consuming trial-and-error design process. While apps like Inkhunter allow users to preview a tattoo on their body and apps like Procreate allow for complex designing, no tool exists for an integrated, iterative design and projection process that allows real-time adjustments based on placement and contours.

Instead of following existing strategies, we propose re-working the process of designing and imagining tattoos. Our method respects and utilizes both an artists' intuitive knowledge and the human body's unique contours and movement, bridging the gap between flat-surface design and the final body-specific art form. By shifting focus from a static canvas to a body-centered approach, our method enables designs to be envisioned as they will appear closer to their final context. This approach makes the transition from concept to body more natural and enhances the accuracy and cohesiveness of the tattoo as a wearable piece of art. Embracing the body as part of the design process itself allows for tattoos that are integrated with the individual's form, creating a more informed artist and client throughout the tattoo design process.

Our proposed solution is a mobile app that combines tattoo design and body visualization in a single workflow. By allowing both artists and clients to position, resize, and adjust tattoo designs on a 3D model of the human body, users can better visualize how a design will appear on curved areas like the shoulder or thigh. The proposed tattoos can either be designed in the app-provided sketchpad or imported from industry standards like Procreate. The app provides a range of body models and allows users to rotate and zoom in on these models, simulating how the tattoo might look when applied to a specific area. This integrated approach enables artists and clients to collaboratively refine placement, reducing the need for back-and-forth adjustments between a flat design and the body. Our app makes the tattoo design process more accurate, informed, and collaborative by bridging this gap between traditional 2D design tools and the final real 3D placement.

To evaluate how our solution makes digitally placing a tattoo easier and makes digitally designing tattoos more enjoyable for tattoo artists, we compare our tool to other popular methods, such as Procreate or analog drawing. We look at how much time it takes to learn and design or place a tattoo, the general ease of use, the feeling of satisfaction vs frustration, and the likelihood of use in the future. To evaluate whether our solution can help clients feel better informed about the placement of a tattoo and better able to communicate with artists when going to an appointment, we qualitatively assess a client's confidence in determining and communicating placement with our tool based on a user demo.

2 Related Works and Motivation

The quickly emergent popularity of both amateur and professional digital drawing tools like Microsoft Paint, Adobe Illustrator, and Procreate has imbued a basic digital drawing software vocabulary into the definition of digital literacy. Numerous HCI systems have sought to expand the bounds of this vocabulary through creativity support tools for analog artistic processes like drawing and sculpting. TattooDoodler builds upon this extensive corpus of literature by integrating the ends of drawing assistance and 3D projection into a single system to enhance creativity.

Three foundational systems in this strain of HCI research are ShadowDraw, Projector-Guided Painting, and Sculpting by Numbers. ShadowDraw [4] is a system for guiding a user's input as they draw through a "shadow" that guides the direction of their pen. This guidance is based on a large image database that recognizes what the user is trying to draw, allowing novice drawers to more accurately depict their target image. Projector-Guided Painting [1] is an aid to novice artists that improves both technical aspects like brushstroke quality as well as overall compositional quality. The system accomplishes this by providing layer-by-layer guidance based upon a layered image, photograph, or 3D model. Sculpting by Numbers [7] presents a similar system for sculpting, with guidance projected onto the block of where the user should carve away negative space to create the final form. While these systems self-evidently support creative artistic processes, all do so on the predicate of pre-determined artistic input. Sculpting by Numbers and Projector-Guided Painting's guidance is based upon a 3D model or image that may not be the user's own design, and ShadowDraw bases its guidance on edge matching from its known image database [1, 4, 7]. In all three cases, the guidance provides direction to the user's creative process, but presents the possibility of inhibiting total creative autonomy through suggestion or imposition of methodical and computational guidance based upon other's output.

More recent 2D and 3D artistic systems have sought to mitigate this imposition through tools which more wholly encourage and enhance creative autonomy and exploration. Feather [3] is a 3D sketchbook that allows users to intuitively create 3D art in a pen and tablet interface by making 3D projections generated by the user's 2D pen strokes. These 3D projections can interact with each other to create complex 3D models. Conversational Composites [2] is a method for facilitating dialogue through multimedia sketching

in both analog and digital processes. Two users exchanged initial sketches, adding onto each other's in watercolor and Procreate among other mediums. Then, they discussed their illustrative dialogue afterwards to explore new creative and intellectual insights based upon their exchanges. Both of these systems sought to keep the creative impetus of the user at the forefront by creating digitally-enhanced mediums for creativity rather than digitally-enhanced creativity (which was inherently based upon others' output). As HCI creativity support tools apply to tattoos, Skintillates [6] is a technology that provides a technologically reinterpreted temporary tattoo. Skintillates is capable of gauging user strain based on posture and capacitive sensing, and also allows users to create a digitally enhanced temporary tattoo with LEDs. Skintillates successfully reinterprets the tattoo to provide novel solutions and creative possibilities to the medium, but its direct application back to permanent ink tattoos is strained at best.

TattooDoodler seeks to fill the gap that exists between guidance systems like Conversational Composites and ShadowDraw, and novel mediums like Feather and Skintillates. These previous creativity support tools have experienced limitations through either inhibition of total creative autonomy due to guidance based on a corpus of external inputs, or the creation of a digitally-enhanced creative medium that is not directly translatable to more traditional, analog artistic mediums.

Rather than entirely reinterpreting the medium of a tattoo and allowing users to create their own reinterpreted tattoos (as Skintillates did), TattooDoodler aims to provide a new iterative medium, similar to Feather and Conversational Composites, specifically for tattoo artists and clients who intend to get a traditional ink-and-gun tattoo. TattooDoodler will facilitate the translation of 2D tattoo art by users onto 3D-rendered body parts, allowing for an digitally-enhanced iterative design process that allows users to better understand how their drawings will look on the natural contours of the human body once actually tattooed. This is with the ultimate goal of widened possibilities for tattoo creativity, facilitated by TattooDoodler's iterative, bidirectionally communicative design process: users can project a 2D drawing onto a selected 3D body part, observe how the potential tattoo appears on their selected body part, and then iteratively revise the drawing and/or change the selected placement based upon these renderings.

3 Methods and System Description

The development of TattooDoodler followed a process drawing from human-centered design principles, which focused on incorporating user feedback and needs throughout each iteration of the tool, ensuring that TattooDoodler was built to the needs of the end user.

Prior to the prototyping and development of TattooDoodler, four needfinding interviews were conducted, two each for the two primary envisioned stakeholders of the tool: tattoo artists and tattoo recipients/clients. The goal of these interviews was to utilize a human-centered design approach to uncover common pain points in the tattoo design and placement selection process for both artists and clients, ensuring that TattooDoodler addressed issues actually experienced by the end users.

The needfinding interviews revealed two key considerations, which motivated the two guiding design principles for the development of TattooDoodler. First was that for both artists and clients, it was difficult to translate and visualize flat drawings onto the organic contours of the human body, resulting in murky expectations for both parties. Artists found it difficult to accurately render and translate the 2D designs brought by their clients onto their body, and clients expressed difficulty visualizing what the final product would look like on their body. The design goal spurred by this finding was the support of real-time, 3D visualization of tattoo placement.

The second key consideration was that for both artists and clients, while visualizing a potential image on the human body presented its own challenges, it was equally difficult to be able to experiment with how the tattoo looked on the contours of the human body, limiting the information with which clients could make their final decision for a tattoo. Thus, the second design goal prompted by this finding was the support of experimentation with size, orientation, and placement of a tattoo on the human body.

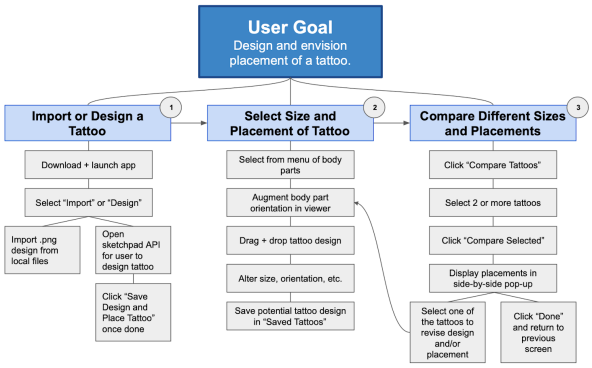

Fig. 2. The task analysis created for TattooDoodler.

The first iteration of TattooDoodler was a low-fidelity paper prototype highlighting the most basic functionality of the application. This prototype outlined the initial visualizations of TattooDoodler's basic user interface and functionality: a home screen and menus for selection of a body part, placement of the tattoo on the body part, and augmentation of the tattoo on the body part. This was complemented by a task analysis (Figure 2) diagram, which provided an ambitious overview of the key user goal for our tool: design and envisioning of placement of a tattoo. The functionality in Tasks 1 and 2 is completely present in the final application, but much of the advanced functionality in Task 3 (Compare Different Sizes and Placements) is absent from the current version due to development and timeline constraints. The functionality for Task 3 can be almost entirely emulated by the user saving the images directly to their machine and comparing them side-by-side in a third-party image app. As a result, this task's functionality was deprioritized, as it did not directly contribute to either of the stated design goals, and the completion of the first two tasks was deemed critical to achievement of the goals.

The next iteration of TattooDoodler was a breadth-focused, medium-fidelity wireframe designed in Figma and a closely-related state diagram. The wireframe consisted of 34 unique screens and focused on

creation of an initial visual hierarchy and layout of menus (Figure 3). The state diagram (Figure 4) made this hierarchy more concrete by clearly outlining the relationship between the home screen and functionalities like importing users' drawings, exporting users' tattoo designs, opening and closing the drawing canvas, and selecting body parts. After completion of the Figma wireframe and state diagram, development of the full TattooDoodler application started, guided by the hierarchies and overarching layout outlined by these prototypes.

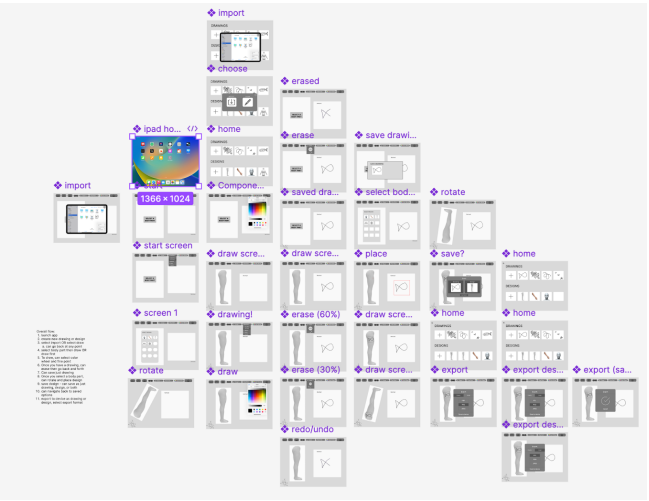

Fig. 3. TattooDoodler's Figma wireframe

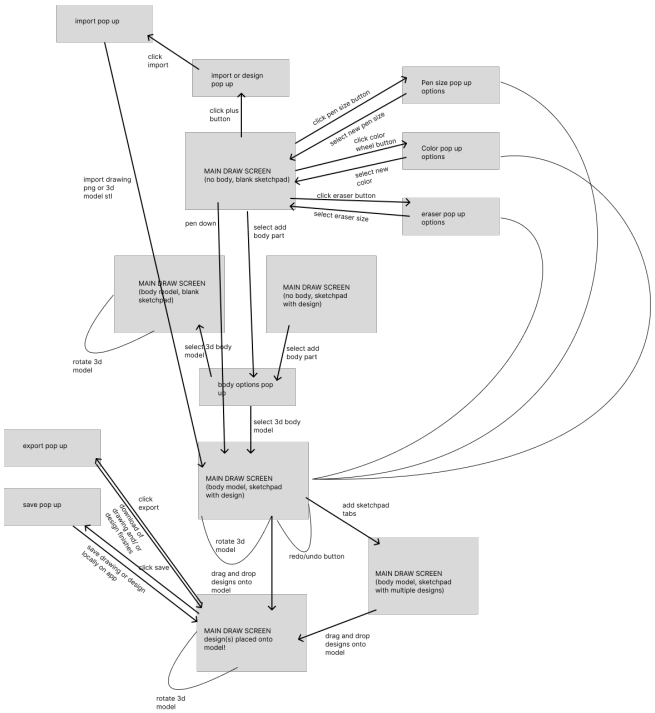

Fig. 4. The state diagram for TattooDoodler.

Development of TattooDoodler involved a combination of web and mobile technologies. React Native, React, and various stylistic and font libraries were utilized to build the core interface, ensuring a smooth, user-friendly experience. For 3D modeling, react-three/fiber and react-three/drei were implemented, allowing for the rendering and manipulation of 3D models directly within the application. The drawing functionality was achieved using html2canvas and react-native-svg, enabling users to draw on a canvas and convert these drawings into scalable vector graphics.

A significant development challenge was integrating the drawing features with the 3D model to apply them as textures. This required overcoming technical hurdles related to dynamically resizing, moving, and adjusting the drawing on the 3D model—a process that was more complex than traditional drawing applications. The solution involved customization of existing libraries, ensuring that the design could be accurately visualized and manipulated within the 3D environment. This unique integration of drawing and 3D modeling sets TattooDoodler apart from other drawing apps, delivering a more immersive and practical tool for tattoo design.

Upon opening TattooDoodler (Figures 5,6), users are presented with the option to start a new drawing or load an existing one. They can then upload or select a 3D model body part, such as an arm or leg, from the library. From here, users have the ability to either upload a pre-designed tattoo or draw their own directly on the canvas. The tool offers a range of customization options for the tattoo, including choosing the color, adjusting the thickness, and using undo/redo functions. After completing the design, users can apply it to the 3D model, positioning and resizing it to fit perfectly. Finally, they have the option to download the completed tattoo or save it locally for future use. This streamlined process allows users to seamlessly and iteratively blend digital tattoo designs with 3D modeling, offering a practical and interactive way to visualize their ideas before taking the next step in the tattooing process.

4 Evaluation

The evaluation of TattooDoodler involved five groups of our classmates serving as participants. These groups were each comprised of 3-4 students, offering a range of skill levels and perspectives. The primary goal of the evaluation was to assess TattooDoodler's usability, effectiveness, and overall satisfaction among its intended users. The evaluation process was guided by the following user tasks and evaluation questions:

USER TASKS:

Draw and project a tattoo, upload an image

EVALUATION QUESTIONS:

- How intuitive is the TattooDoodler user interface?
- Did TattooDoodler give you a better idea (versus having no digital rendering/tool on hand) of how a potential tattoo would appear on your body?
- Did TattooDoodler provide a widened range of creativity for you to experiment with and visualize tattoos?

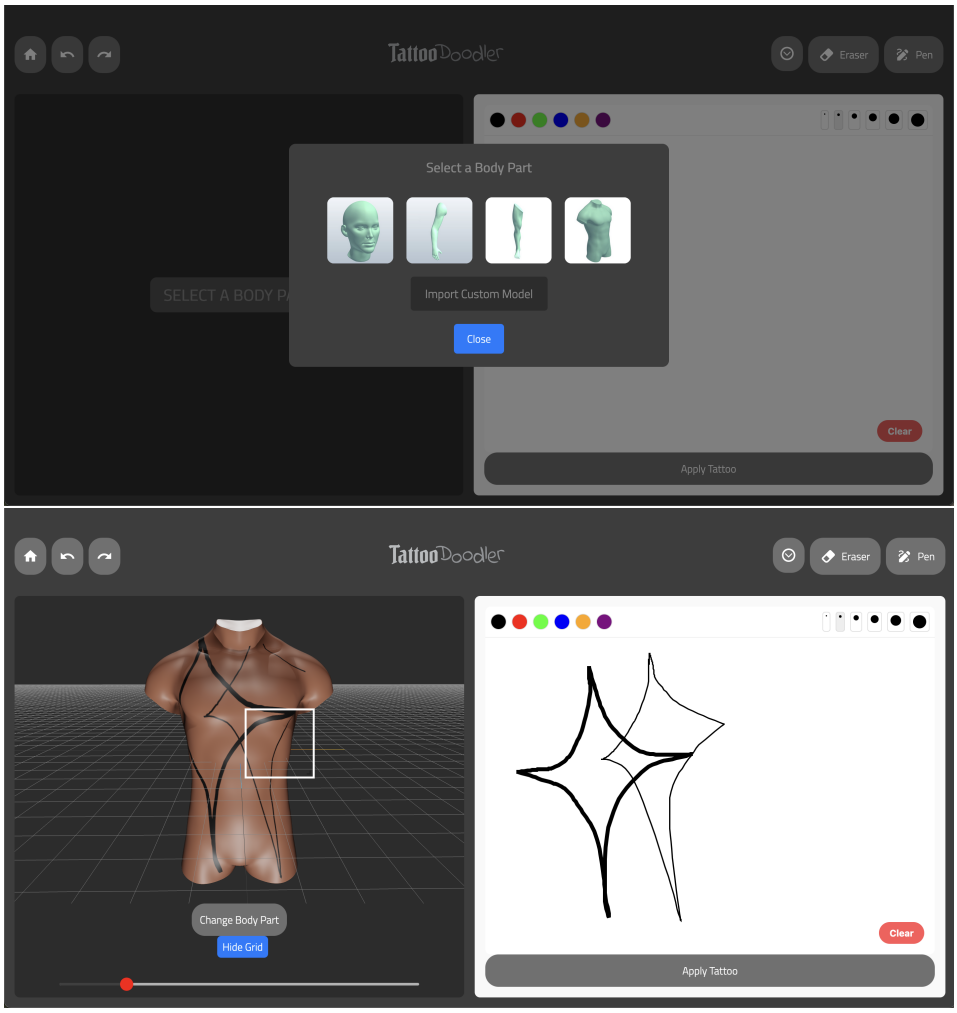

Fig. 5. TattooDoodler allows users to select a body part or import a custom model, and then project a drawing they create on the sketchpad onto this model.

Participants found the tool's interface to be intuitive and easy to navigate. The controls for positioning, resizing, and rotating designs were particularly appreciated for their simplicity, making it easy for users to start creating without a steep learning curve. The ability to preview designs on a 3D model was also a significant highlight, helping users visualize how a tattoo would appear on different body parts. Many noted that this feature was beneficial in understanding the proportions and placement of tattoos, which was not possible with traditional 2D sketches.

While the basic features were generally well-received, some participants expressed a desire for more advanced capabilities, such as texture mapping and finer control over shading, to enhance the level of detail in their designs. The tool's ability to support multiple iterations of a design with minimal effort was also appreciated, as it streamlined the planning process by allowing users to experiment with various design options without requiring much time or effort.

However, there were suggestions for improvements, such as adding more customization options for body models to accommodate different physiques and more realistic skin textures. Users also recommended better integration with traditional drawing tools, such as importing custom designs or textures directly into the tool. These enhancements would complement TattooDoodler's capabilities, allowing for a more holistic and versatile digital design experience.

Overall, TattooDoodler was well-received for its usability and effectiveness in providing a realistic preview of tattoo placements. The tool's intuitive interface and preview features were particularly valued, helping users visualize their designs more effectively and make informed decisions. The feedback from participants highlights areas where TattooDoodler could be further refined, particularly in enhancing customization options and integrating traditional artistic tools. These insights will be invaluable for refining the tool and better meeting the needs of its users.

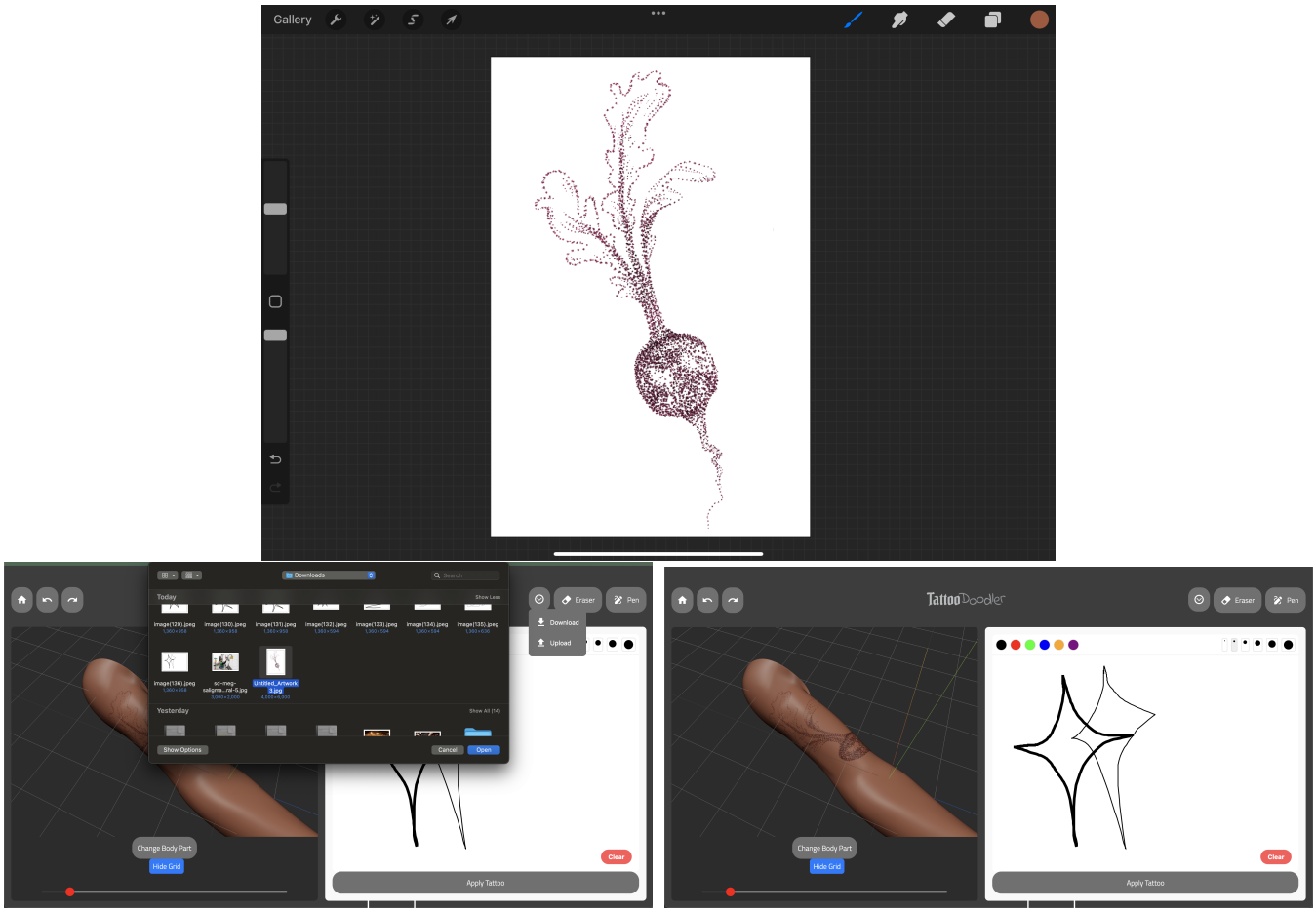

Fig. 6. TattooDoodler also allows users to upload custom designs from programs like Procreate and project them onto a selected 3D model.

5 Limitations and Future Work

As a consequence of the already discussed timeline and development constraints, several notable limitations are present in the functionality and scope of TattooDoodler that restrict users from the full range of intended customization and comparison of tattoo visualization. The functionality outlined in Task 3 (Compare Different Sizes and Placements) of the initial task analysis (Figure 2) is absent from the current version of TattooDoodler. This functionality would allow users to directly compare two or more tattoo designs and/or placements on body parts, allowing for artists and clients to see a range of potential designs and placements in one menu to inform their final decision. Implementing this functionality within TattooDoodler, however, would require the development of a back-end to save user designs, which is currently absent. This comparison functionality was deprioritized as a result of these development limitations, as well as the fact that the same effect can be easily achieved locally by users through side-by-side viewing of saved images on their own machine.

Another key limitation in the current version of TattooDoodler also stems primarily from the lack of a back-end for storing user information and designs. The original vision for TattooDoodler allowed for users to work off of previously saved designs and/or tattoos they already have, allowing for users to envision the multi-layered design of numerous tattoos on a single body part. However, since TattooDoodler stores no user data, this functionality also largely falls on the user to perform locally or by uploading their locally saved designs. The ability to locally perform this multi-layered visualization without a back-end, albeit more tediously, along with the low benefit this functionality created for the ultimate design goal, led to the deprioritzation of implementation.

Perhaps the most critical limitation of the current version of TattooDoodler is the inability to easily customize body parts to accommodate different body shapes. This functionality was not implemented as a result of the time required to develop an effective user interface allowing for wide-ranging customization of 3D models in a web app. However, users are still able to customize skin tone and upload their own .stl or .obj files, which could be user-customized body parts. The lack of this functionality within TattooDoodler, however, stands to pose the most barriers to marginalized groups. While uploading of self-designed files can mitigate this barrier, it

still requires advanced knowledge of 3D modeling software, posing an exclusionary barrier to most potential users. Furthermore, the body part files in TattooDoodler are from pre-existing libraries, and as a result largely follow normative anatomical models. Combined with the inability to customize body shape within the application, these limitations pose significant barriers to users with diverse body types. The current models available in TattooDoodler preclude most users from effectively visualizing a potential tattoo on their own body, thereby indirectly reinforcing normative power dynamics around body image.

Further iterations of TattooDoodler will have development of wide-ranging body part customization as the chief priority; a key underpinning to empowering tool development is making tools widely accessible for users of all backgrounds and translatable to multiple contexts [5]. Back-end development would also enhance the full range of functionality for TattooDoodler by allowing users to iteratively revise and combine their own designs within the tool, widening the possibilities of TattooDoodler.

6 Conclusion

TattooDoodler addresses a practical challenge in tattoo design by providing an integrated platform for artists and clients to visualize tattoos on 3D body models. The tool combines drawing and 3D projection to help users better understand how a tattoo might look on different body parts, reducing the guesswork in tattoo placement.

By centering the unique contours of the human body and the collaborative needs of both tattoo artists and clients, the tool demonstrates how digital technologies can be leveraged to expand creative autonomy. The evaluation showed that users found the interface intuitive and the 3D visualization capabilities particularly valuable in understanding tattoo placement and design.

However, the current limitations of TattooDoodler—particularly around body inclusivity—point to a critical future direction for creative support tools. We envision a technological ecosystem where design tools are not just functionally sophisticated, but fundamentally inclusive, capable of representing and empowering diverse bodies and artistic expressions. Ultimately, TattooDoodler represents a step toward making the tattoo design and decision-making process more intuitive, collaborative, and affirming.

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