



TapeStory:

Exploring the Storytelling Potential of Interactive Tapestries

Abstract

Our ancestors communicated stories through tapestries, using them to adorn both public and private spaces. Traditionally, these tapestries were static artworks hanging on walls without any interaction from the audience. Nevertheless, textiles offer a versatile medium, which can be crafted from various materials and colours and manipulated to produce unique, touch-responsive textures. Our vision is to integrate the tactile capabilities of weaving with capacitive sensor technology to create a media-immersed interactive art installation that explores the negative impact of noise pollution on marine life ecosystems. Marine animals, particularly cetaceans, heavily rely on sound for communication, navigation, and hunting, and noise pollution can disrupt these essential functions. By harnessing the storytelling potential of tapestries and the power of capacitive sensors connected to microcontrollers, we developed a storytelling experience with a unique embodied interface that aims to educate the general audience about pressing issues such as marine noise pollution.

Authors Keywords

Tapestry; interactive art installations; tangible interfaces; marine biodiversity awareness; noise pollution; e-textiles; conductive electronics; capacitive sensors.

CSS Concepts

- Human-centered computing~Interaction design~Interaction design process and methods~Interface design prototyping
- Applied computing~Arts and humanities~Media arts

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Introduction

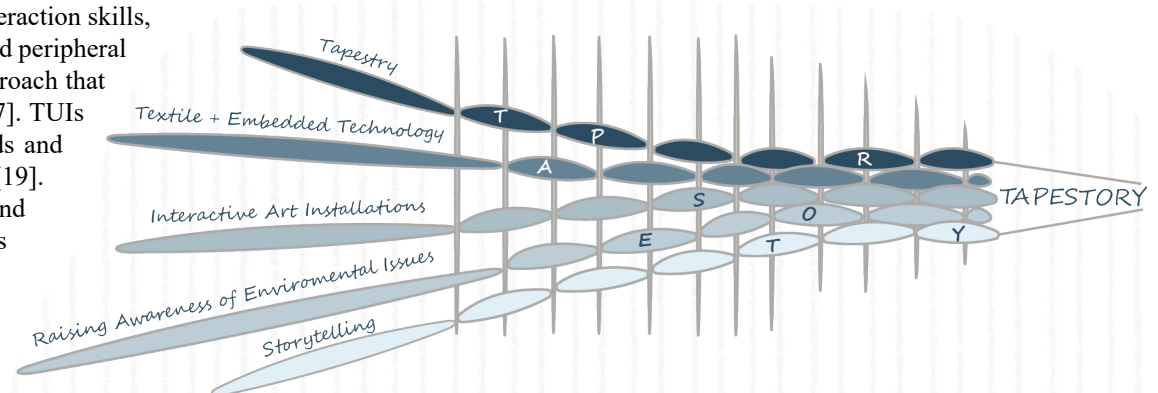
A tapestry can be a contemplative art piece to entertain or to have a purpose, such as covering a wall, providing insulation from the cold, or decorating the interior of a home. Weaving tapestry is a craft from our ancestors worldwide [26] that often portrays Bible passages and mythological or classical stories [50]. Tapestry is increasingly appreciated as a reflective work of art, inviting viewers to contemplate [39] its intricacies and themes. In this research, we want to revive the idea of tapestries that used to tell stories, educate, and entertain but with an added modern twist – using interactive technology, in the hope that through shared exploration and contribution, these tapestries become living embodiments of collective creativity, reflecting the diverse perspectives and experiences of those involved. Usually, people are not allowed to touch the art pieces in exhibitions because curators want to avoid seeing the exhibition as a playground or because visitors' touch can damage the artwork. However, in contemporary art, there are instances where interaction with the artwork is encouraged or even required, and this is the approach that we want to explore: a tapestry that people can interact with.

Interactive technology progressively integrates physical objects without the traditional keyboard and mouse or display interaction style. This is where the embodied interaction design emerges, requiring different and new approaches to explain bodily action, human experiences, and physicality to interact with computational technology [27]. Humans have always explored and interacted with their environment through touching surfaces. The sense of touch is integral to human interaction and communication [3]. Quoting Hiroshi Ishii: “We are tangible beings, not digital. Human evolution has endowed us with advanced abilities to sense and interact with the physical world using our hands, skin, bodies, and minds” [21]. However, modern times have shifted much of our information to digital devices displayed on flat screens, limiting the practice of these natural human skills. Tangible User Interfaces (TUIs) seek to bridge the gap between the digital and physical realms by giving data a physical form. TUIs leverage haptic interaction skills, allowing direct manipulation of digital information through our hands and peripheral senses, in contrast to the traditional Graphical User Interface (GUI) approach that relies on a mouse or keyboard as an intermediary to the display [21][27]. TUIs enable the direct manipulation of digital information through our hands and perception through our peripheral senses by its physical embodiment [19]. Furthermore, previous research sheds light on the potential of creative and interactive approaches, emphasising the importance of engaging makers and interpreters in creating meaningful and personalised data narratives and how integrating technology with culturally significant crafts can attract new audiences [12][15][37].

Hence, this project motivation emerges at the intersection of the tapestry potential as a TUI for interactive storytelling [15], the maker movement, and several contemporary projects and art pieces, such as Vanessa Barragão coral reefs [49] and Alexandra Kehayoglou landscapes [2], that highlight critical environmental messages. By integrating technology seamlessly into the tapestry fabric, we aim to blur the lines between the physical and the virtual, creating a unique and captivating interface.

Our aim is that this approach not only breathes new life into traditional art forms but opens up an avenue for artistic expression and human-machine/tapestry engagement. Additionally, we believe that by leveraging a tapestry art piece as an embodied interaction interface, there is an opportunity to address complex social and environmental issues in an engaging and thought-provoking manner. For instance, the artwork can catalyse meaningful conversations and introspection by incorporating interactive elements related to climate change, human environmental impact, or societal challenges. Our research endeavours yield contributions at the level of our interactive artefact and process design as it can inspire new ways of thinking, challenge preconceived notions, and create transformative experiences that leave a lasting impact not only on those who engage with the artwork but also on researchers who seek to engage in the research space of tapestry as an interface medium.

This document is the result of our exploration of Human-Computer Interaction (HCI) combined with storytelling and weaving techniques and we hope to inspire and empower designers to conceptualise and design TUI that uses traditional weaving techniques creatively for narrative purposes.



1. Research and Understanding

Tapestry weaving once thrived as a manual craft, cherished by elites for adorning spaces with biblical, mythological, and classical motifs. Today, weavers are venturing into new materials and innovative techniques, breathing fresh life into these ancient art forms [50]. We are particularly interested in exploring these new techniques since it is possible to create different pieces with various materials, textures, and shapes creatively after learning the basic rules [26]. Current research in the HCI domains [4][13][32][36] has showcased the potential of technology's impact on textiles and its potential use in embodied interaction. The design space for e-textiles has been expanding to ensure active participation from end-users in creating personalised garments that suit their specific needs [23][24]. However, it has also expanded to showcase diverse weaving techniques, materials [8], and their interface potential [17][38]. A recent review on woven eTextiles [32] highlights the need to explore their sensory potential and surface features for meaningful interactions, particularly in contextual applications. We see potential in the role of woven eTextiles as interfaces for tangible storytelling interventions, considering how our approach should emphasise understanding the interplay between material, touch, and emotion [3][44]. In particular, we foresee that this material selection and shaping efforts will enhance interaction and playfulness within a storytelling weaving installation, fostering participant integration into the narrative.

We delved into interactive digital storytelling to discover that it is predominantly centered around narrative systems driven by algorithms and displayed on screens; however, a couple of emerging narrative explorations tap into various lesser-known traditional forms of storytelling that leverage tangible interaction [16]. Crafting Stories [31] incorporates smart and electronic textiles in the context of an interactive book to create a tangible story. The work shows promising reports of its use in the context of children's play. Letters to José [9] contribute to the body of works in

tangible storytelling, where the story unfolds through paper mechanisms and visual, performative, and auditory features. The work is exciting for the intersection of TUIs and relevant aspects found in theories of narrative and interactive narrative. Ongoing research endeavours to merge traditional techniques with technology, craftsmanship, and storytelling to offer immersive experiences that enrich communities and cultural practices. Examples include KaavadBits [34], a tabletop art installation revitalising Indian storytelling traditions through interactive branching narratives. Similarly, RENATI [5] combines oral storytelling and immersive art with sensing technologies to craft tangible narratives reflecting South African perspectives. Additionally, Shiva's Rangoli [14] transforms the Indian cultural art form of Rangoli into a tangible storytelling installation, enabling visitors to sculpt the emotional tone of a narrative through their interaction with the space.

Searching for explorations that reinvented tapestry as TUIs yields results like the PeR project [7], where conductive yarns and lights integrated into rugs create perceptive behavior, such as reacting to the music and people's movements. Nevertheless, we found that most initiatives originate from the maker/artisan community, incorporating varied materials, textures, and colors, such as Judit Just wall-hanging weavings [40] and Felicia Murray's textile textured projects [1]. Some ventures into e-textiles involve conductive threads creating electrical circuitries [25][33], enabling interactive experiences like Sophie Daniels' nature-connected healing cube [41] and Hyojin Yoo's musical interactive tapestry [20]. These efforts aim to enhance the multi-sensory experience of tapestries by integrating sound, contributing to the evolution of e-textile technology and its integration into traditional tapestries for storytelling and exploration of visual and tactile surface affordances in contextual applications.



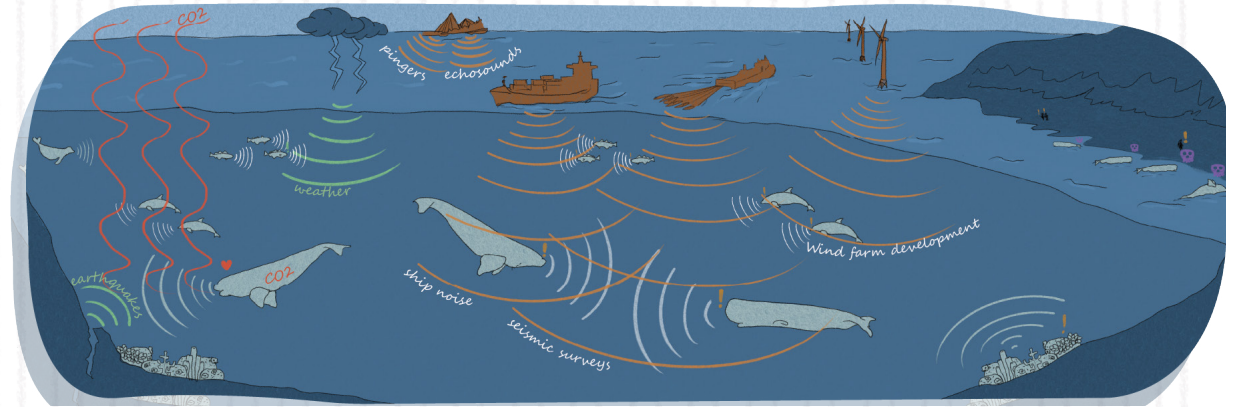
2. Theme Conceptualization and Message

The initial motivation behind this endeavour stemmed from: 1) how tapestries' rich storytelling history and their visual storytelling capabilities can be a rich medium to raise awareness about critical issues; 2) how, through embodied interaction, we can transform art into a living, interactive experience, where viewers become active participants in the creation and exploration of the artwork;

However, after our initial research, it became clear that we also wanted to leverage the touch and visual allure of a tapestry with the immersive and evocative nature of audio. As it was critical for us for these factors to interweave (and after much research and ideation), it became clear that the subject of our piece would focus on marine noise pollution and its effects on marine biodiversity.

Cetaceans, including whales, are highly affected by anthropogenic sounds [28]. Whales communicate using high-pitched sounds that can travel significant distances. However, the sounds generated by human activities are louder and more disruptive, impacting the marine ecosystem. Despite this, whales are crucial to the marine ecosystem and hold significant ecological and cultural importance [22]. They act as remarkable carbon sequestrators, with their massive bodies storing carbon for extended periods. When whales die, they sink to the ocean floor, removing carbon from the atmosphere and mitigating climate change by reducing atmospheric carbon dioxide levels [28].

Through our interactive tapestry, we can amplify the voices of marine life suffering from marine noise pollution to highlight this critical issue, foster dialogue, and encourage positive action in a more sustainable marine environment.



3. Design Iterations of the Interactive Tapestry

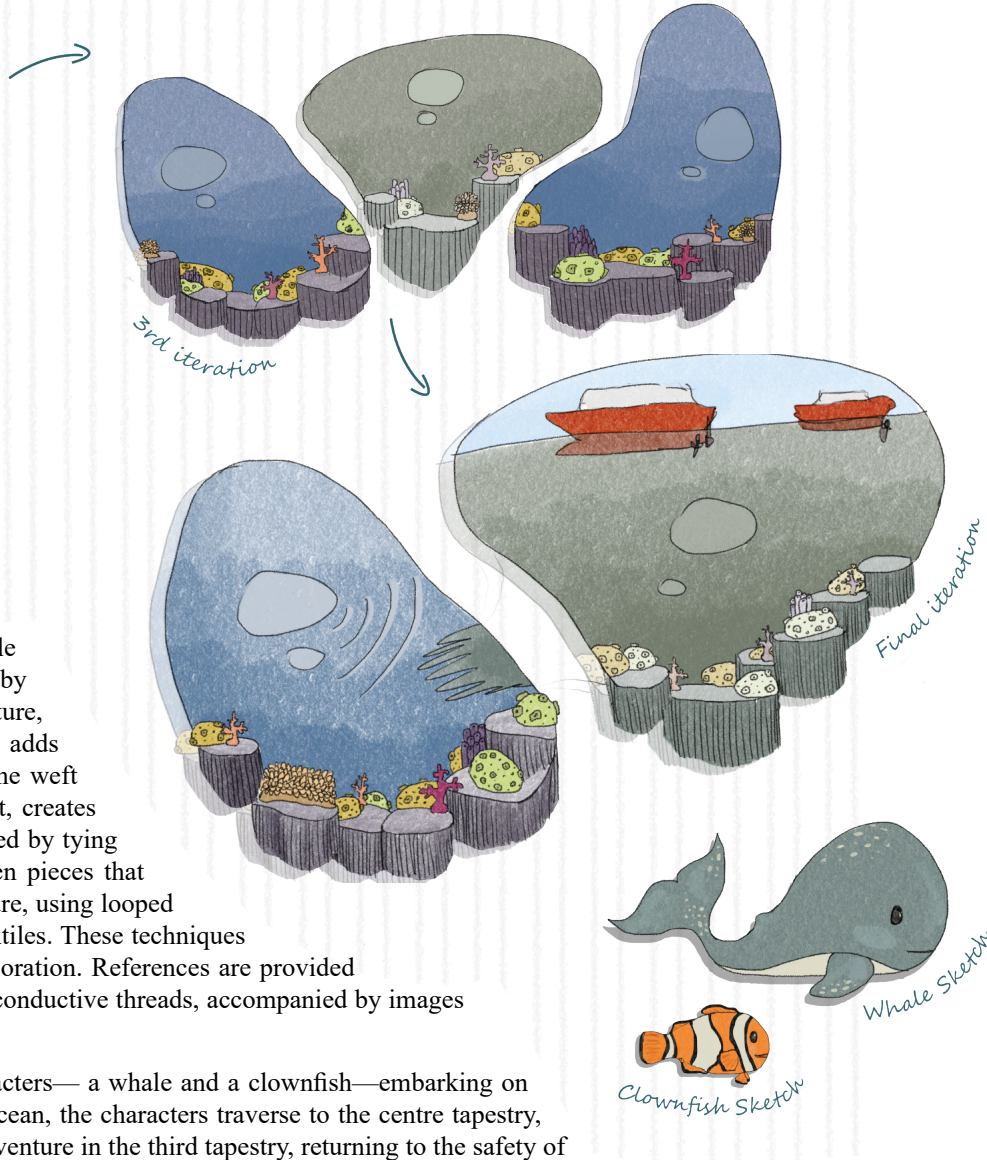
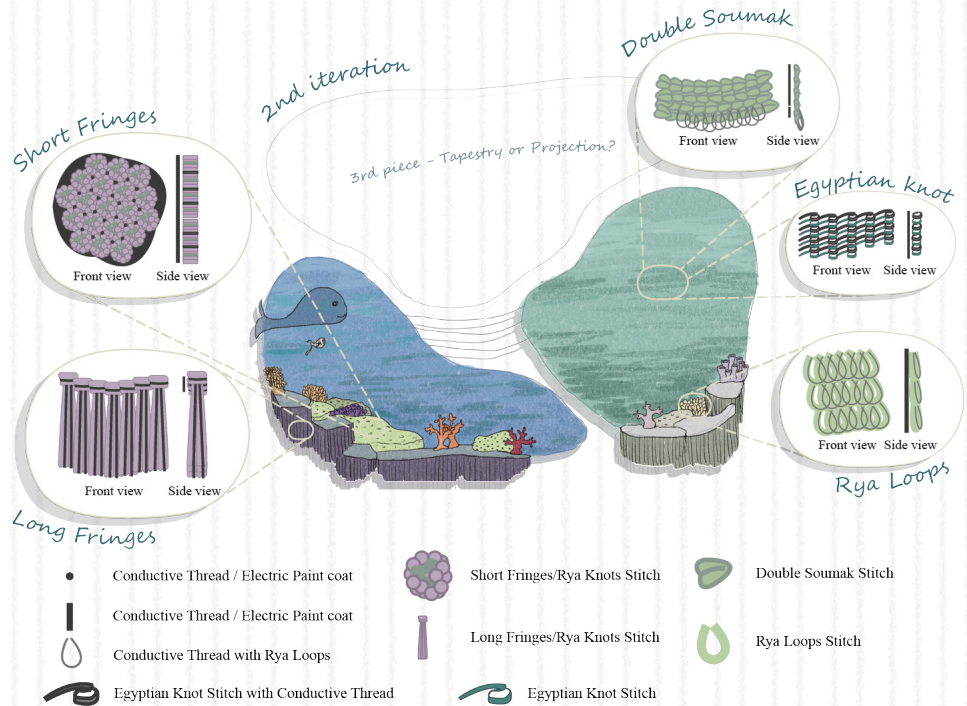
The interactive storytelling tapestry installation underwent multiple iterations alongside our concept and narrative shifts. These stages blend the overall design, weaving techniques, textures, and our evolving vision for the narrative's progression.

Our first iteration showcased three pieces: the bottom two depicting flourishing marine life and a healthy ocean, crafted using tapestry technique to offer comfort with smooth textures. The third piece, situated atop, symbolised human intervention. While deliberating about a mixture between tapestry and animated projection, we aimed to incorporate rough textures coupled with anthropogenic noisy sounds to unsettle the user's experience.



Noise Pollution Sketch
1st Iteration

In the second iteration, we maintained the three-piece structure but adopted a new approach: each piece symbolised a distinct life stage of the ocean. The initial phase depicted a healthy ocean and then portrayed disturbing elements and their subsequent consequences. Additionally, we began incorporating drafts of various weaving techniques and conductive materials into this iteration.



Weaving encompasses a wide variety of techniques, each contributing its unique flair to textile artistry; in this context, we concentrated on handmade free weaving techniques like 1) Tabby weave [30], also known as plain weave, forms the simplest and most fundamental structure, where each weft thread alternates over and under each warp thread; 2) Soumak stitch [35] adds intricate texture and depth with its distinctive braided appearance, achieved by wrapping the weft yarn around pairs of warp threads; 3) Egyptian Knot [45], originating from ancient Egypt, creates plush pile surfaces through looping yarn around warp threads; 4) Rya knots [46], are formed by tying pieces of yarn onto individual warp threads, lending a playful and tactile quality to woven pieces that might look like a fringe or a pom pom; 5) Rya loops [47][48] stitches further enhance texture, using looped yarns to create soft, undulating surfaces, perfect for adding warmth and visual interest to textiles. These techniques highlight the artistic flexibility of weaving, opening up boundless avenues for creative exploration. References are provided for each technique, facilitating learning and replication. [Section 5](#) offers further insight into conductive threads, accompanied by images showcasing the weaving samples.

The third iteration of the design aligns with the narrative progression, centred around characters— a whale and a clownfish—embarking on a journey alongside participants. Starting in the left tapestry with a depiction of a healthy ocean, the characters traverse to the centre tapestry, encountering the adverse effects of anthropogenic sounds. Ultimately, they conclude their adventure in the third tapestry, returning to the safety of a restored, healthy ocean on the right.

In the final design iteration, we made notable adjustments to align with the narrative, logical coherence, user interaction constraints, and tapestry size logistics.

We removed the third piece of the composition reflecting the characters’ return to the safety of their home depicted in the first tapestry. Additionally, we introduced representations of anthropogenic sounds, symbolised by red ships, highlighting the significant threat to marine life. We decided to exclusively use audio as the storytelling medium to enhance the narrative delivery. Further elaboration on the final narrative decisions is provided in the subsequent section.

4. Narrative and Symbolism Design

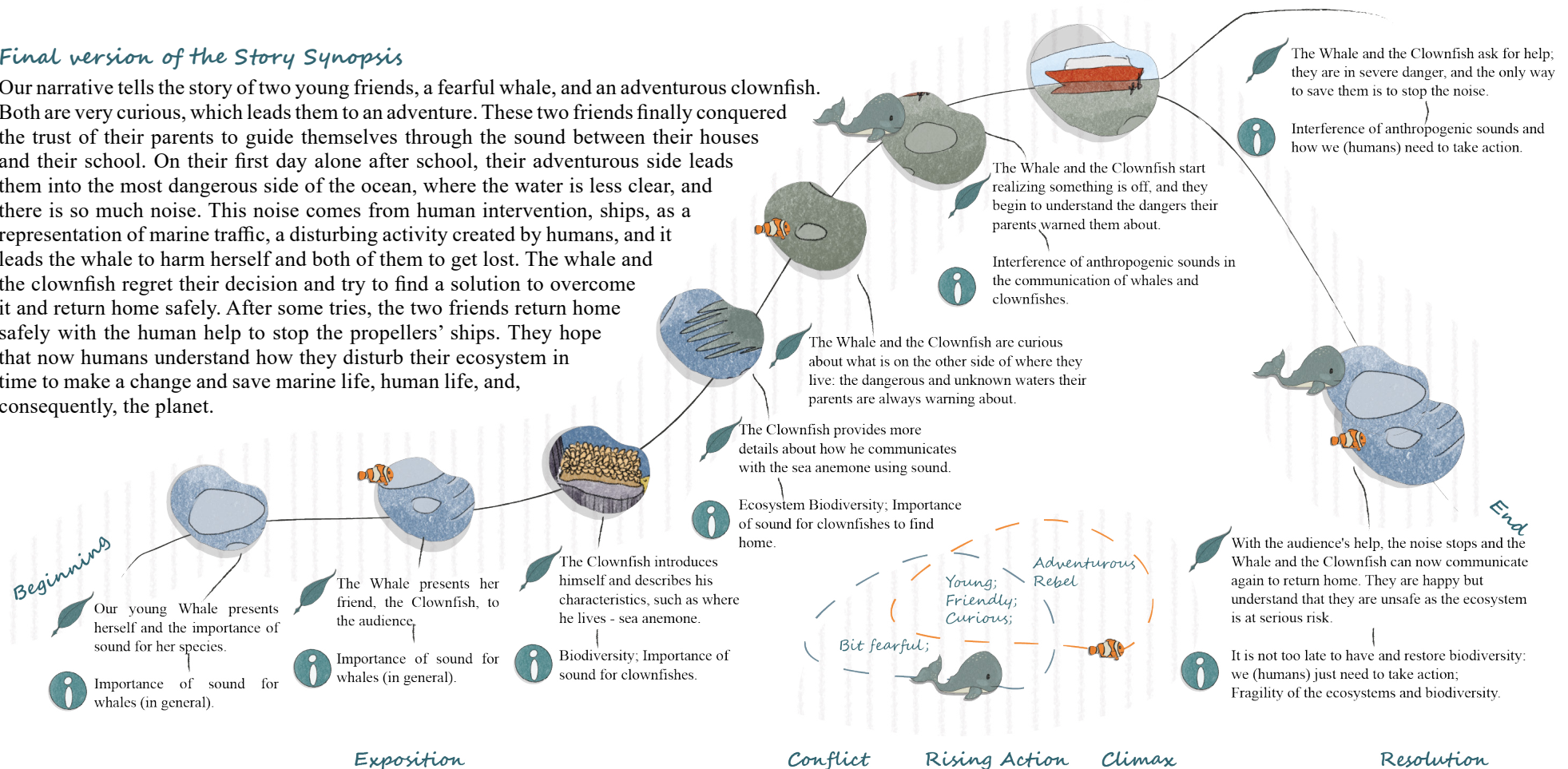
As we wanted to explore the potential of tapestry as a narrative tool, we started the brainstorming process of leveraging narrative persuasion to make people aware of the impacts of marine noise pollution. In our search for inspiration, we discovered that whales and clownfish are examples of marine animals that suffer from marine noise pollution. So we thought about engaging the audience in the story of two improbable friends (a whale and clownfish) and thought their adventures show how they are affected by marine pollution. Giving marine creatures like the whale and clownfish human-like qualities in the narrative can humanise the impact of marine pollution. Our rationale is that when viewers see these characters facing the consequences of human actions, it can evoke empathy and compassion and serve as a poignant reminder of our responsibility to protect the oceans.

Our first approach to creating this narrative was to follow a simple and traditional structure; however, we wanted our audience to actively participate in the narrative to foster a deeper emotional connection, so the process of designing the narrative had to consider the interactivity points. The narrative development was a highly iterative process between this phase and developing the user experience journey (following phase).

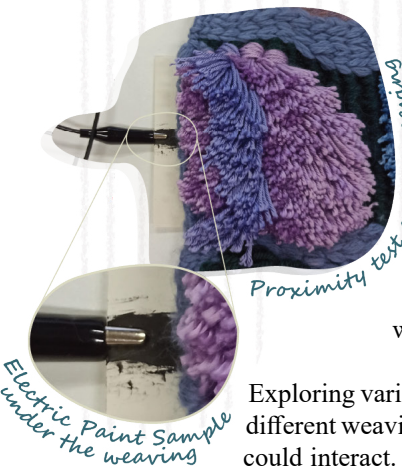
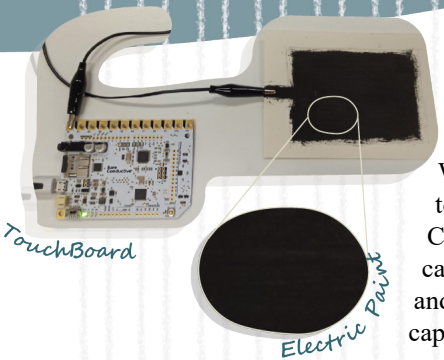
This strategy aims to immerse the user in this experience while learning more about narrative, giving him a special mission while helping the whale and the clownfish.

Final version of the Story Synopsis

Our narrative tells the story of two young friends, a fearful whale, and an adventurous clownfish. Both are very curious, which leads them to an adventure. These two friends finally conquered the trust of their parents to guide themselves through the sound between their houses and their school. On their first day alone after school, their adventurous side leads them into the most dangerous side of the ocean, where the water is less clear, and there is so much noise. This noise comes from human intervention, ships, as a representation of marine traffic, a disturbing activity created by humans, and it leads the whale to harm herself and both of them to get lost. The whale and the clownfish regret their decision and try to find a solution to overcome it and return home safely. After some tries, the two friends return home safely with the human help to stop the propellers' ships. They hope that now humans understand how they disturb their ecosystem in time to make a change and save marine life, human life, and, consequently, the planet.



5. Materials Experiments: Weaving, Conductive Materials and Paper Prototype



While drawing the possible tapestry's design, it was also essential to understand how to integrate the sensors on the textiles and know its limits. We decided to use the Bare Conductive Touch Board (BCTB) [42] for its resources and easily applicable cases, capacity to store audio files, programming logic resources, reprogramming ability, and the results we saw in the maker community [6]. The BCTB is equipped with 12 capacitive electrodes that respond to a touch. These electrodes can be extended with conductive materials, like electric paint or conductive thread, and they can be used as touch sensors or touchless sensors (proximity sensors), depending on how they are programmed. The BCTB is based on the Arduino Leonardo and works with Arduino's integrated development environment (IDE) software [43].

To understand the different conductive materials and how to integrate them with the BCTB, we successfully tested different materials: 1) copper tape (both 9Ω and 50-60Ω), 2) a metal clip, 3) electric paint, 4) graphite, and 4) conductive thread). The copper tape, metal clip, and conductive thread were all from a kit from DFRobot [11], the wool used was Merino wool twist [29], and the electric paint was from Bare conductive [10]. We conducted experiments dyeing wool with diluted Electric Paint, a water-based ink, aiming to make it conductive. Despite multiple trials varying the ink concentration, we ultimately abandoned the idea due to the inability to achieve the desired balance between dyeing the wool and maintaining conductivity.

Exploring various weaving samples was crucial to test the conductivity of different materials across different weaving techniques [26], aiding in understanding how multiple sensors and their proximity could interact. Tests were conducted with techniques like Tabby, Double Soumak, Egyptian Knot, Rya Knots, and Rya Loops stitches, incorporating both 9Ω and 50-60Ω conductive thread. While most stitches performed well, the Rya Knot presented a challenge as cutting the wool and conductive thread disrupted its conductivity. To address this, each Rya Knot was connected behind the weaving with another piece of conductive thread, allowing the area of the Rya Knot to function as a distinct sensor area. We experimented with creating a sample of Needle Felt using wool and conductive fiber. Felt is a technique that is traditionally made from wool fibers that involves layering and entangling the fibers until they interlock and bind together, forming a cohesive material without the need for weaving or knitting [18]. Despite initial concerns about balancing conductive fiber and wool while maintaining color and texture, our experiment proved successful, with the conductive felt sample functioning effectively as a sensor.

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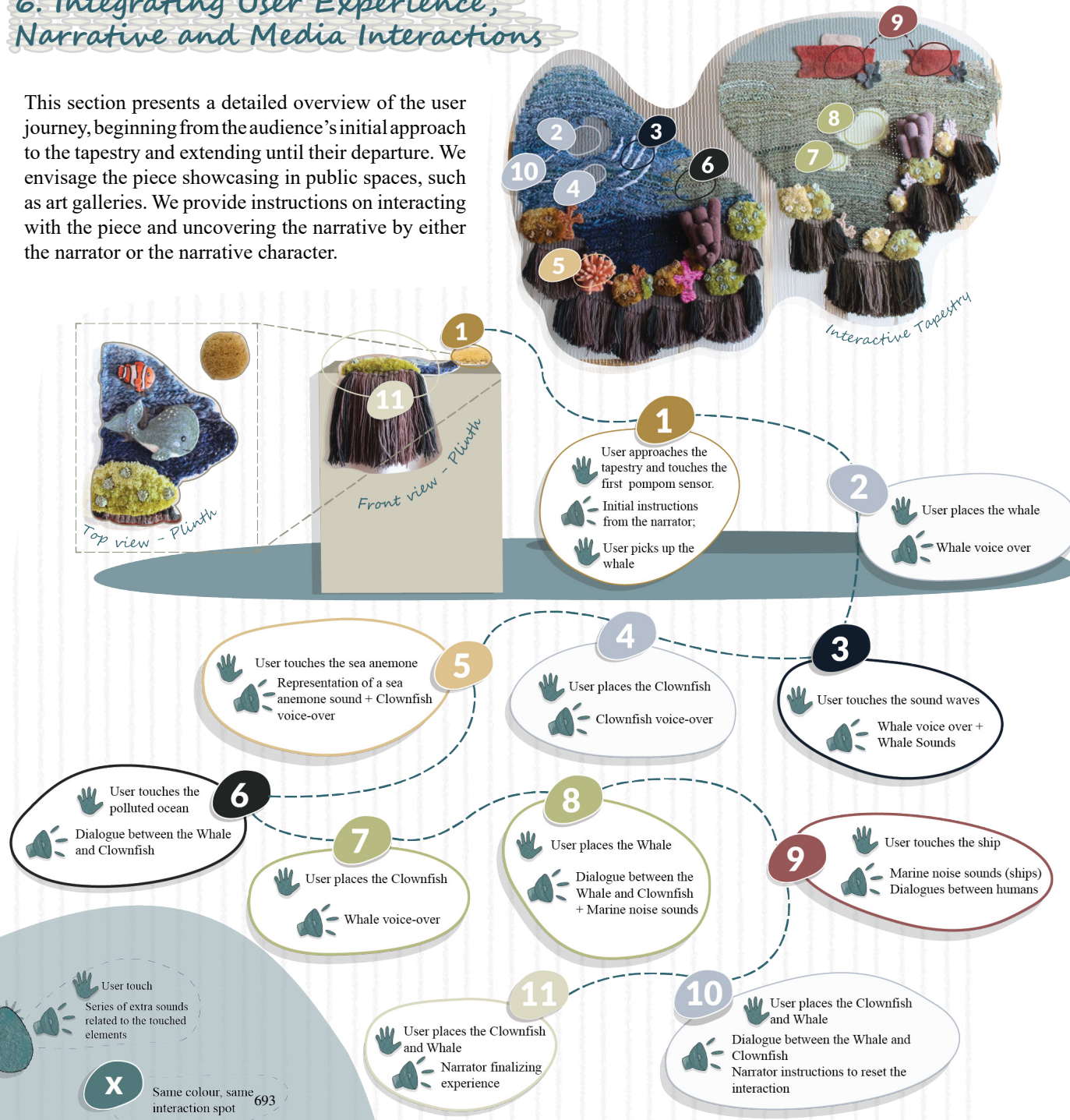
We developed a small paper prototype to test the programming logic and feasibility. The prototype included the printed outline of the tapestry with interaction spots marked using Electric Paint. A conductive thread was sewn onto these marks to connect them to the BCTB Bare. Additionally, we recorded audio files based on the narrative and edited them to determine the duration of the experience, which stands at 6 minutes, excluding any easter eggs.

6. Integrating User Experience, Narrative and Media Interactions

This section presents a detailed overview of the user journey, beginning from the audience's initial approach to the tapestry and extending until their departure. We envisage the piece showcasing in public spaces, such as art galleries. We provide instructions on interacting with the piece and uncovering the narrative by either the narrator or the narrative character.



At the end of this stage, we discovered two essential insights: firstly, connecting two different conductive threads to the bare conductive touch board's different electrodes should be avoided as they cannot touch each other due to potential interference with the programming logic. Therefore, placing interaction areas as far apart as possible for the final piece design is crucial to prevent sensing issues, especially considering potential wear and tear from multiple users. Secondly, while we successfully integrated all weaving techniques with conductive materials, the felt technique demanded more skill, patience, testing, and attention to detail. We must consider this factor within the project's time constraints for the final piece.



7. Final Interactive Tapestry: From Wool and Loom to an Interactive Tapestry

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In this section, we provide a high-level outline of the step-by-step process involved in executing the interactive tapestry.

Wool acquisition and preparation:

With the tapestry design finalised, we compiled a list of required colours, textures, and quantities of materials. Due to budget constraints inherent to a master's thesis project and making the tapestry concept more sustainable by recycling and reusing materials, we launched a crowdfunding campaign for wool acquisition, appealing to the local community through social media for donations. While we received a generous response, the quantities fell short of our needs, leading us to seek additional materials from Instituto do Vinho, do Bordado e do Artesanato da Madeira, the local institute responsible for preserving cultural heritage. Despite this, certain materials, such as fabric for coral details and wool roving for felting elements, had to be bought.

Upon receiving donated wool, extensive preparation was necessary due to dust, entanglement, and varying characteristics. Sorting by colour, tone, saturation, and thickness facilitated ease of access during the project.

Weaving frame loom construction and layout design:

To accommodate our weaving project, which required ample space and lacked a suitable structure, we constructed a frame loom. Opting for dimensions of 1.60m x 1.20m to accommodate both pieces, we built a rectangle using four pieces of wood, spacing nails 1 cm apart to secure the threads. This framework provided the necessary tension for weaving freely on the loom. To maintain fidelity to our conceptual design, we transferred its layout to the frame loom using a combination of freehand drawing on the warp with a stencil based on the paper layout for the tapestry's outline. This process ensured the accuracy and proper positioning of the weaving threads on the loom.

Weaving Process:

The weft process begins at the bottom and progresses upwards along the warp. It entails interweaving threads with the warp threads, ultimately forming a cohesive piece. We crafted both pieces simultaneously, progressing through various stitches and areas.



Step 1: Create a base using plain or tabby weave to define the bottom shape and provide support for subsequent wool layers.

Step 2: Craft Rya Knots

Step 3: Incorporate underwater rocks.

Step 4: Fill both pieces with seawater space using double Soumak and Egyptian knot.

Step 5: Integrate two conductive sensors using tabby stitch with conductive thread (one connecting to the ground electrode and another to an electrode sensor).

Step 6: Develop the sky in the right piece using tabby stitch.

Step 7: Create coral using short Rya knots mixed suffolk puffs for volume and texture.

Step 8: Implement Whale Sound wave Sensor using soumak weave stitch with roving wool mixed with conductive thread.

Step 9: Incorporate non-woven elements (Sea sponges, Corals and Gorgonians) parallel to weaving process, integrating them after tapestry weaving is nearly complete.

Step 10: Craft elements using the Felt technique: Anemone, Ships, Characters - Clownfish and Whale.

(The steps are identified in the following pages)

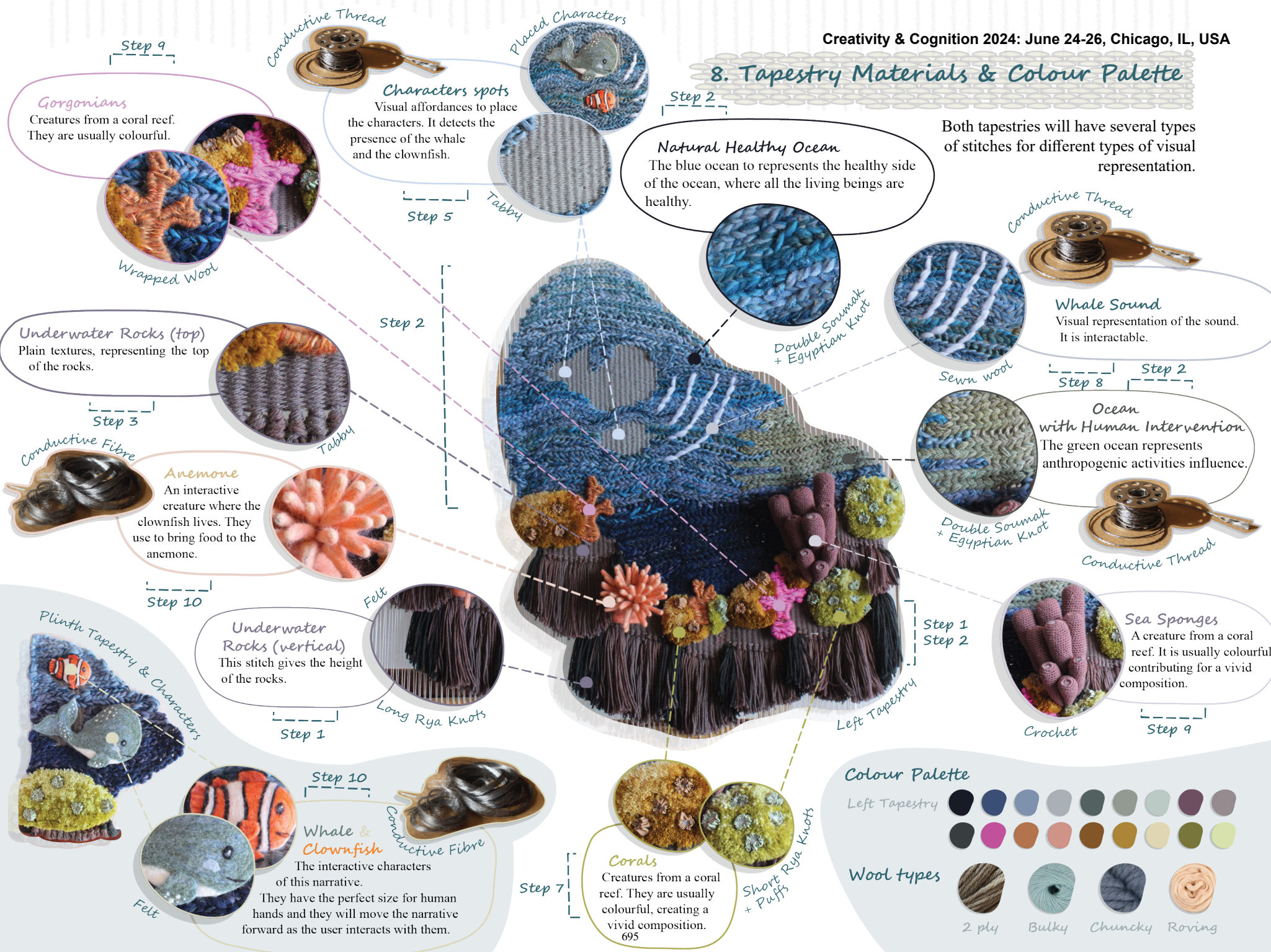
Creation of the interaction spots:

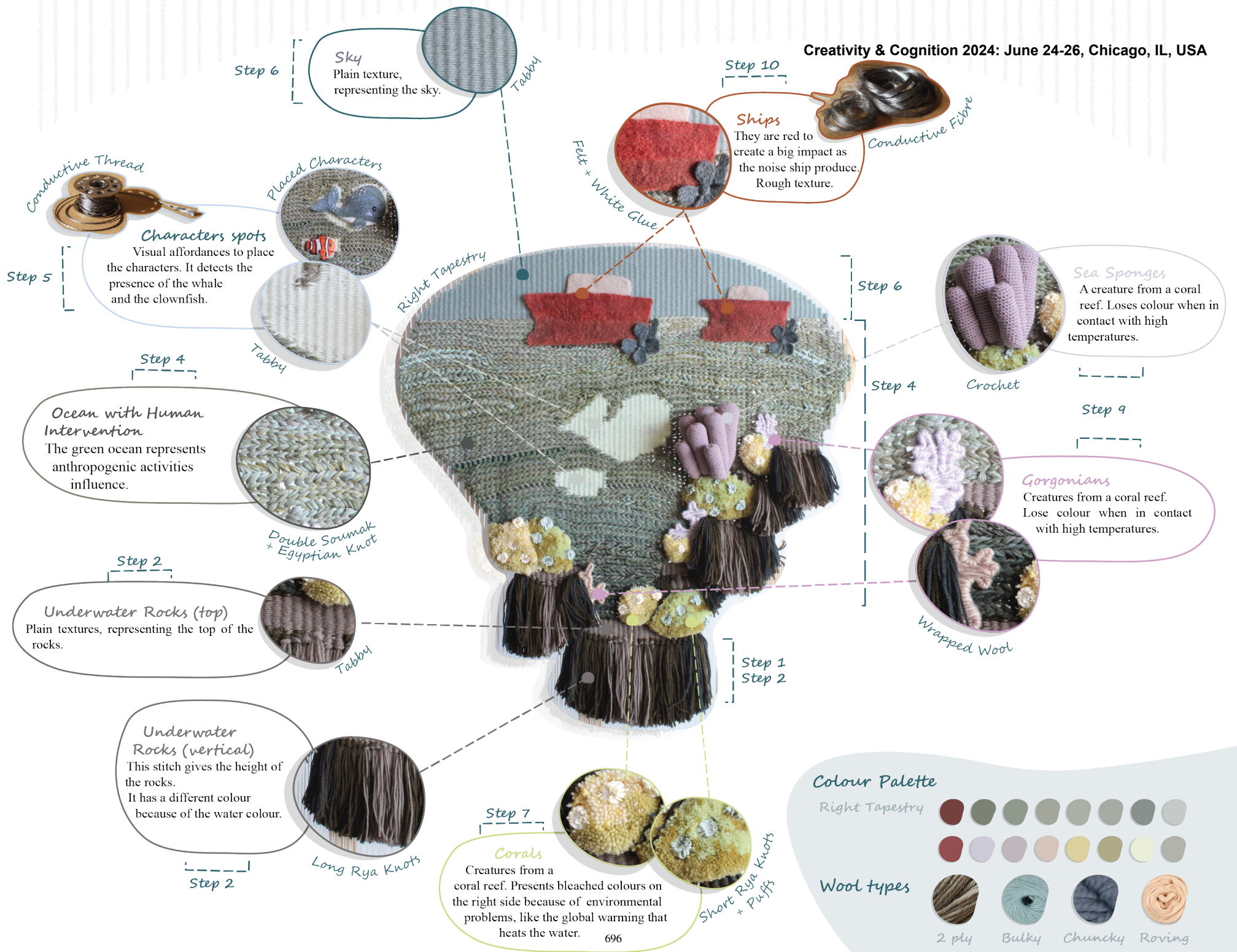
To allow the interaction between the audience and tapestry and the consequence narrative progression explained in the user experience ([Section 6](#)), the tapestry has to hold the characters, and after several experiments, we decided to use two different-sized magnets (approx. 1 and 0,5 cm in diameter for the whale and clownfish respectively), the remaining interaction spots are embedded in the weave and stitches.

Final Touches and BCTB connections:

In the last phase, we connected the weaving threads to the tapestry sensors and the Bare Conductive Touch Board (BCTB)—this involved masking and securing excess threads behind the tapestry using a weaving needle to minimise clutter. The BCTB was discreetly positioned behind the tapestry's centre, simplifying thread connections. Given the proximity of threads and BCTB connectors, meticulous isolation and gluing of threads to the frame loom structure were necessary to prevent sensor interference. Programming logic (which can be consulted in the supplementary materials) and audio source files were uploaded to the BCTB, and following the final conceptual design, we trimmed the bottom fringes to complete the project.

8. Tapestry Materials & Colour Palette





Colour Palette



Wool types



9. Unpacking the Experiential Practice of combining HCI with Interactive Storytelling and Weaving Techniques

This work proposes an approach to enable artists, designers, and HCI practitioners to create interactive storytelling experiences using weaving techniques. Reflecting on our experimental approach of HCI combined with storytelling and weaving techniques, we draw upon the framework for Tangible Narratives by Harley et al. [16]. However, we want to emphasise the importance of sketching and prototyping in our approach. When sketching for a TUI using weaving techniques, four key aspects should be addressed: the tapestry's outline design, weaving techniques, narrative experience, and interaction spots. The first two aspects require a painter's mindset to consider colour palettes, materials, and textures.

Experimentation with materials and weaving techniques is crucial before finalising ideas, involving quick tests to assess feasibility. Techniques like crochet and felting may enhance texture but require patience and testing for conductivity, as seen in the addition of conductive fibre to the felt technique for the anemone. Planning these aspects ensures the seamless integration of the weaving techniques and conductive materials into the design.

We will use the Tangible Narratives Framework categories [16] (with the addition of an extra category of interaction) to reflect how we intersect weaving techniques with the narrative to shape the of a TUI artefact.

Primary user(s): When designing for a broad target audience and the context of a public exhibition, it is essential to consider onboarding the experience and restarting the piece after the narrative flow interaction. To address this, we created the extra tapestry piece to work as an onboarding piece, and it works as a starting and finishing point of the overall interaction flow.

Media: We harnessed audio to unveil a tale portraying how human activity disrupts marine life. In this way, it is similar to other tangible narratives [9][15], we choose audio to communicate significant portions of the narrative. However, we also used audio as a form to give cues on how the user can interact with the weaved elements and how it can progress/interact with the tapestry to progress with the narrative. These cues are present in the characters' dialogue.

Narrative creation and choice: Designing a tapestry as a TUI for storytelling presents unique challenges since all the narrative elements are initially exposed, unlike other mediums where they unfold progressively. We had to strategise on

presenting plot points while preserving suspense and determining the balance between initial exposure and user-driven unveiling throughout the narrative. To fully utilise the embodied potential of the tapestry, narrative points were embedded not only in character dialogues triggered by interactions but also within the other weaved and non-weaved elements, leveraging wool textures to enrich the unveiling of the storytelling experience. While the narrative design currently offers limited choices to users, the focus on placing them at the narrative's centre aims to foster a sense of agency through character movement and implicit and explicit hints. Evaluating user responses to interactions with specific weaved elements and types of hints will be crucial to understanding their effect.

Narrative position and function of the tangible objects: Our design incorporates internal and external roles for the audience within the interactive tapestry, where their role shifts based on the tapestry's design. Initially, the audience maintains an external role on the left-side tapestry, detached from the story's characters. However, upon reaching the right-side tapestry, they assume an internal role, engaging directly within the story world through user interactions. Furthermore, the whole piece is a tangible object contributing to the narrative. All the tangible objects of our tapestry are diegetic, meaning that all the objects exist within the space and time of the narrative's story world [16]. We carefully considered tangible objects' size, shape, weaving technique, and materials to heighten the narrative experience through tactile engagement. The two tangible characters serve as navigation aids, encouraging the audience to interact with them at various points, and by employing anthropomorphism, we hope to foster audience connection and engagement. Furthermore, by symbolically placing the characters (and their future) in the audience's hands, our goal is to reinforce the narrative's agency and environmental stewardship themes. Additionally, we introduced various non-weaved elements such as anemones, corals, sea sponges, gorgonians, and ships, inviting users to explore them while listening to the narrative. Most of the wool texture used is soft, as a medium to feel comfort while exploring the weaving tapestry however, the Red Ships were created with a felt technique combined with white glue to create an unpleasant texture to the touch. The vessel's sounds and the narrative events allied with the ship's textures are designed to explore an unpleasant sensation to the audience – ultimately contributing to the tangible narrative function of understanding the impact of Marine noise pollution.

Interaction: Designing user interaction for the tapestry posed significant challenges due to its traditional lack of tactile interaction (tapestries are usually something the audience does not touch/interact with) and the technology's invisibility. By leveraging soft materials and various shapes, we aimed to create a playful experience and stimulate curiosity for interaction. Still, we felt the lack of conventional interface elements like buttons or mouse hovers to give affordances to the audience. Our narrative required the audience to move the characters to specific spots, triggering audio cues; we tried to leverage the tapestry to add an interaction affordance (placement guide) by having empty character silhouettes. Other feedback strategies to the audience combine tactile and auditory cues, signalling narrative outcomes and interaction guides.

Future Work and Conclusion

We are planning the exhibition of the final piece; future endeavours will involve an in-situ deployment study to assess the user experience and sense-making of interactive tapestries as an embodied interface for a storytelling experience.

With this work, we presented a novel artefact contribution, an interactive tapestry used as a storytelling device, contributing to a scarce body of work in TUIs for interactive storytelling. Furthermore, we contribute novel design processes for other designers who wish to use wool and tapestry techniques combined with conductive thread or electric paint to create an interactive experience artefact.

This research aims to extend the scope of HCI by exploring interactive everyday objects and hybrid craft, fostering creativity, and enhancing material relationships in developing interactive artefacts.

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References

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- [1] About - Felicia Murray: <https://www.feliciajmurray.com/pages/about>. Accessed: 2023-07-28.
- [2] Alexandra Kehayoglou's - Textile Landscapes: <https://www.designerbox.com/en/blog/article/261/tendance-deco-alexandra-kehayoglou>. Accessed: 2023-07-28.
- [3] Bardalai, R. and Underwood, J. 2022. SensAE – A Tool to Explore Material-Touch-Emotions. *Journal of Textile Design Research and Practice*. 10, 2 (May 2022), 141–163. DOI:<https://doi.org/10.1080/20511787.2022.2100170>.
- [4] Castano, L. and Flatau, A. 2014. Smart fabric sensors and e-textile technologies: A review. *Smart Materials and Structures*. 23, (Apr. 2014), 053001. DOI:<https://doi.org/10.1088/0964-1726/23/5/053001>.
- [5] Chenzira, A., Chen, Y. and Mazalek, A. 2008. RENATI: recontextualizing narratives for tangible interfaces. *Proceedings of the 2nd international conference on TEI (Bonn Germany, Feb. 2008)*, 147–148.
- [6] Community Projects: <https://www.bareconductive.com/blogs/community>. Accessed: 2023-08-01.
- [7] Deckers, E., Stouw, B.V.D. and Peutz, J. 2012. An Intelligent and Interactive Carpet Role of Design in A Textile Innovation Project. *Research Journal of Textile and Apparel*. 16, 4 (Nov. 2012), 14–22. DOI:<https://doi.org/10.1108/RJTA-16-04-2012-B002>.
- [8] Devendorf, L. and Di Lauro, C. 2019. Adapting Double Weaving and Yarn Plying Techniques for Smart Textiles Applications. *Proceedings of the Thirteenth International Conference on TEI (Tempe Arizona USA, Mar. 2019)*, 77–85.
- [9] Echeverri, D. and Wei, H. 2020. Letters to José: A Design Case for Building Tangible Interactive Narratives. *Interactive Storytelling*. A.-G. Bossler, D.E. Millard, and C. Hargood, eds. Springer International Publishing. 15–29.
- [10] Electric paint: <https://www.bareconductive.com/collections/electric-paint>. Accessed: 2024-01-28.
- [11] FIT0823 DFROBOT Conjunto de materiais condutores para aplicações Wearable: https://mauser.pt/catalog/product_info.php?products_id=096-3300. Accessed: 2024-01-28.
- [12] Friske, M., Wirfs-Brock, J. and Devendorf, L. 2020. Entangling the Roles of Maker and Interpreter in Interpersonal Data Narratives: Explorations in Yarn and Sound. *Proceedings of the 2020 ACM Designing Interactive Systems Conference (Eindhoven Netherlands, Jul. 2020)*, 297–310.
- [13] Gonçalves, C., Ferreira da Silva, A., Gomes, J. and Simoes, R. 2018. Wearable E-Textile Technologies: A Review on Sensors, Actuators and Control Elements. *Inventions*. 3, 1 (Mar. 2018), 14. DOI:<https://doi.org/10.3390/inventions3010014>.
- [14] Gupta, S., Tanenbaum, T.J. and Tanenbaum, K. 2019. Shiva's Rangoli: Tangible Storytelling through Diegetic Interfaces in Ambient Environments. *Proceedings of the Thirteenth International Conference on TEI (Tempe Arizona USA, Mar. 2019)*, 65–75.
- [15] Guridi, S., Vicencio, T. and Gajardo, R. 2021. Arpilleras Parlantes: Designing Educational Material for the Creation of Interactive Textile Art Based on a Traditional Chilean Craft. *Proceedings of the Fifteenth International Conference on TEI (Salzburg Austria, Feb. 2021)*, 1–11.
- [16] Harley, D., Chu, J.H., Kwan, J. and Mazalek, A. 2016. Towards a Framework for Tangible Narratives. *Proceedings of the TEI '16: Tenth International Conference on TEI (Eindhoven Netherlands, Feb. 2016)*, 62–69.
- [17] Hartman, K., Westecott, E., Colpitts-Campbell, I., Robinson Faber, J., Shao, Y., Luginbuhl, C., Prior, O. and Laroia, M. 2021. Textile Game Controllers: Exploring Affordances of E-Textile Techniques as Applied to Alternative Game Controllers. *Proceedings of the Fifteenth International Conference on TEI (Salzburg Austria, Feb. 2021)*, 1–14.
- [18] How to Needle Felt: Easy Tutorial For Beginners: <https://www.wikihow.com/Needle-Felt>. Accessed: 2024-01-28.
- [19] Huron, S., Nagel, T., Oehlberg, L. and Willett, W. 2022. Making with data : physical design and craft in a data-driven world. (2022), 392.
- [20] Interactive Textile : touch: <http://www.hyojinyoo.com/interactive-textile-touch>. Accessed: 2023-07-28.
- [21] Ishii, H. and Ullmer, B. 1997. Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms. *PAPERS CHI*. 97, (1997), 22–27.
- [22] Johnson, C.M. et al. 2022. Protecting Blue Corridors - Challenges and solutions for migratory whales navigating national and international seas. *Zenodo*.
- [23] Jones, L., Nabil, S., McLeod, A. and Girouard, A. 2020. Wearable Bits: Scaffolding Creativity with a Prototyping Toolkit for Wearable E-textiles. *Proceedings of the Fourteenth International Conference on TEI (Sydney NSW Australia, Feb. 2020)*, 165–177.
- [24] Jones, L., Sturdee, M., Nabil, S. and Girouard, A. 2021. Punch-Sketching E-textiles: Exploring Punch Needle as a Technique for Sustainable, Accessible, and Iterative Physical Prototyping with E-textiles. *Proceedings of the Fifteenth*

- International Conference on TEI (Salzburg Austria, Feb. 2021), 1–12.
- [25] Kobakant DIY Werable Technology Documentation: <https://www.kobakant.at/DIY/>.
- [26] Maddocks, M. 2020. Weaving: A modern guide to creating 17 woven accessories for your handmade home. Hardie Grant Publishing.
- [27] Maher, M.L. and Lee, L. 2017. Designing for Gesture and Tangible Interaction. [http://dx.doi.org/10.2200/S00758ED1V01Y201702HCI036.10.2\(Mar.2017\).i-111](http://dx.doi.org/10.2200/S00758ED1V01Y201702HCI036.10.2(Mar.2017).i-111). DOI:<https://doi.org/10.2200/S00758ED1V01Y201702HCI036>.
- [28] McCauley, D.J. 2023. The future of whales in our Anthropocene ocean. *Science Advances*. 9, 25 (Jun. 2023), eadi7604. DOI:<https://doi.org/10.1126/sciadv.adi7604>.
- [29] Merino Wool Twist - Woolly White: <https://funemstudio.com/products/merino-wool-twist-woolly-white>. Accessed: 2024-01-28.
- [30] Plain Tabby Weave: Basic Weaving Pattern for Beginners: 2019. <https://fibersanddesign.com/plaintabbyweavepattern/>. Accessed: 2024-01-28.
- [31] Posch, I. 2021. Crafting Stories: Smart and Electronic Textile Craftsmanship for Interactive Books. Proceedings of the Fifteenth International Conference on TEI (Salzburg Austria, Feb. 2021), 1–12.
- [32] Pouta, E. and Mikkonen, J.V. 2022. Woven eTextiles in HCI — a Literature Review. Designing Interactive Systems Conference (Virtual Event Australia, Jun. 2022), 1099–1118.
- [33] Sandler, M.B., Ogihara, M., Kettley, S. and Stewart, R. 2019. Cords and Chords: Exploring the Role of E-Textiles in Computational Audio. *Frontiers in ICT* | www.frontiersin.org. 1, 2 (2019). DOI:<https://doi.org/10.3389/fict.2019.00002>.
- [34] Shashwat, S., Padmagirwar, A., Arora, S. and Srivastava, A. 2024. KaavadBits: Exploring Tangible Interactive Storytelling of Branching Narratives through a Kaavad-inspired Installation. Proceedings of the Eighteenth International Conference on TEI (Cork Ireland, Feb. 2024), 1–6.
- [35] Soumak Braid Weave : Weaving Pattern for Beginners: 2019. <https://fibersanddesign.com/soumakbraidweavepattern/>. Accessed: 2024-01-28.
- [36] Stoppa, M. and Chiolerio, A. 2014. Wearable Electronics and Smart Textiles: A Critical Review. *Sensors*. 14, 7 (Jul. 2014), 11957–11992. DOI:<https://doi.org/10.3390/s140711957>.
- [37] Strohmayer, A., Meissner, J. and Donaldson, K. 2017. The Partnership Quilt: Project Report. Newcastle University.
- [38] Sun, R., Onose, R., Dunne, M., Ling, A., Denham, A. and Kao, H.-L. (Cindy) 2020. Weaving a Second Skin: Exploring Opportunities for Crafting On-Skin Interfaces Through Weaving. Proceedings of the 2020 ACM Designing Interactive Systems Conference (New York, NY, USA, Jul. 2020), 365–377.
- [39] Szubielska, M., Imbir, K. and Szymańska, A. 2019. The influence of the physical context and knowledge of artworks on the aesthetic experience of interactive installations. (2019). DOI:<https://doi.org/10.1007/s12144-019-00322-w>.
- [40] Talk, E. 2016. Juju Just Do It – Embellished Talk.
- [41] THE CUBE (@sophiedaniels_designs): 2022. https://www.instagram.com/sophiedaniels_designs/. Accessed: 2023-07-28.
- [42] Touch Board: <https://www.bareconductive.com/collections/touch-board>. Accessed: 2023-08-01.
- [43] Touch Board: Get Started: <https://www.bareconductive.com/pages/touch-board-get-started>. Accessed: 2024-01-28.
- [44] Uğur Yavuz, S., Veske, P., Scholz, B., Honauer, M. and Kuusk, K. 2021. Design for Playfulness with Interactive Soft Materials: Description document. Proceedings of the Fifteenth International Conference on TEI (Salzburg Austria, Feb. 2021), 1–4.
- [45] Weaving Stitch: Egyptian Knot - YouTube: https://www.youtube.com/watch?v=77Q2Jz6uwc&ab_channel=ShowMeArtStudio. Accessed: 2024-01-28.
- [46] Weaving Techniques || Rya Knots | The Weaving Loom: 2015. <https://www.theweavingloom.com/weaving-techniques-rya-knots/>. Accessed: 2024-01-28.
- [47] Weaving Techniques || Rya Loops | The Weaving Loom: 2015. <https://www.theweavingloom.com/weaving-techniques-rya-loops/>. Accessed: 2024-01-28.
- [48] Weaving Tutorial: Rya Loops: 2018. <https://www.youtube.com/watch?v=CK7OwvIQhtE>. Accessed: 2024-01-28.
- [49] Weaving Watery Worlds: An Interview with Vanessa Barragão: 2022. <https://www.artshelp.com/vanessa-barragao/>. Accessed: 2023-07-28.
- [50] What is tapestry? · V&A: <https://www.vam.ac.uk/articles/what-is-tapestry>. Accessed: 2023-07-28.