IASDR Conference Series

Dec 2nd, 9:00 AM - Dec 5th, 5:00 PM

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## Citation

Yue, W.,and Tan, J.(2025) E-broidery in Wonderland: A pilot study on tangible narratives with interactive e-textile, in Chang, C.-Y., Chen, C.-H., & Hsu, Y. (eds.), *IASDR 2025: Design Next*, 02-05 December, Taipei, Taiwan. https://doi.org/10.21606/iasdr.2025.659

# E-broidery in Wonderland: A pilot study on tangible narratives with interactive e-textile

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While tangible narratives (TNs) move intangible stories into the physical world, research has often prioritized technological novelty or external goals over the narrative itself. To address the gap, this paper presents "E-broidery in Wonderland", a collection of interactive e-textile artifacts for storytelling. Four electronic embroidery prototypes were created for the story of Alice in Wonderland to explore how prior knowledge of stories influences user interaction (RQ1) and to assess the impact of e-textiles on a familiar story in TNs (RQ2). Through a mixed-methods pilot study with 12 participants, a critical pattern emerges between users' familiarity and their primary interaction with the tangible narrative artifacts, demonstrating that narrative familiarity is a powerful yet double-edged tool in tangible narrative framework.

***Keywords: tangible narratives; storytelling; e-textile; embroidery***

## 1 Introduction

Over the centuries, storytelling has been an important part of human culture, serving both entertainment and educational purposes. They have transitioned from physical spaces, such as dictation and the printed page, to digital screens (Mazalek et al., 2002). Nowadays, researchers apply tangible user interface (TUI) techniques for storytelling purposes to bring intangible stories back into our physical environment (Zhou et al., 2004; Echeverri, 2022).

Embroidery is a traditional technique for textile decoration. In the context of storytelling, embroidery techniques have a rich history as a visual method in which stories can be told and documented over time (Segalo & Fine, 2017). E-textiles are fabrics that integrate electronic circuits and components. It introduces a novel approach to TUIs that leverages the inherent properties of textiles to offer intuitive and engaging experiences with everyday artifacts (Buso et al., 2023; Pouta et al., 2024). As one of the foundational techniques for fabricating e-textiles, embroidery provides a low-cost method for constructing highly durable, flexible electronic circuitry on a wide range of fabrics (Selm et al., 2001; Li et al., 2019). In contrast to the automation of machine work, hand embroidery is highly valued for its aesthetic and material qualities (Perner-Wilson et al., 2010). The hands-on process enables



https://doi.org/10.21606/iasdr.2025.659

researchers to work with a wide variety of textures—from rough to smooth, matte to shiny—to create endless design variations.

Such an approach brings attention to tangible narratives (TNs) in the field of storytelling, where e-textiles become the medium through which a story is told and experienced, creating a novelty experience for people to record, express, and consume stories (Hamdan et al., 2018; Buso et al., 2023; Pouta et al., 2024). It enhances the experience by supporting a stronger psychological and physical connection to the story world than is supported by more traditional graphical interfaces and other rigid TUIs. Ibrahim and Nabil (2025) created a tote bag that merges embroidery with personal narratives, where conductive threads are sewn into embroidered characters. When a character is touched, a pre-recorded personal story will be shared via audio, fostering a deeper connection between users and the creators.

This project introduces "E-broidery in Wonderland", a collection of TNs that explore a well-known story through the e-textiles approach. Four prototypes were created from Alice in Wonderland, merging the traditional craft of embroidery with technology for storytelling. With the implementation of light-emitting diodes (LEDs) and polymeric optical fibers (POFs), these prototypes respond to user actions, inviting them to engage with and discover meaningful experiences in a pre-existing classic literature.

# 2 Background and related work

## 2.1 E-broidery and craftmanship

Post et al. (2000) first demonstrated e-broidery, using conductive thread to create functional electronic components, such as resistors and keypads, thereby establishing embroidery as a key method for integrating electronics directly into textiles. Apart from carrying functional tasks in e-textiles, electronic embroidery becomes a key solution for manufacturing illuminant textiles with LED components (Mecnika et al., 2014). The conductive yarns perform as electro-conductive tracks for power supply and transmission. Lo et al. (2016) introduced the concept of aesthetic electronics, where electronics are considered as both functional and visual design variables. Traditional textiles gain new functions through the integration of light-emitting components. By stitching LEDs onto the textile with conductive yarns, e-broidery textiles utilize light and color to enhance their performance and aesthetics (Lam et al., 2022; Lan & Jeanne, 2024).

While embroidery machines have made the creation more automated, hand embroidery is frequently celebrated for its unique aesthetic impact and material richness. Jones and Nabil (2022) emphasized that the conversation with materials is fostered through the experiential process of goldwork embroidery, allowing for valuable insights into the potentials and limitations of e-textile hybrid craft for HCI audiences. Endow et al. (2022) introduced the Embr framework, which provides tools and models to support the creation of hand-embroidered liquid crystal displays, using conductive thread as resistive heaters to activate thermochromic pigments. They stated that hand embroidery provides finer control of stitching.

## 2.2 Alice and storytelling

The selection of Alice in Wonderland is not arbitrary. The book written by Lewis Carroll was first published in 1865 with John Tenniel's illustrations. It celebrates curiosity, imagination, and play. The story's unique image-textual dynamics encourage readers to visualize the unimaginable (Iché, 2018). Through the years, the story has been introduced to audiences via various mediums, including picture books, films, cartoons, video games, and merchandise; this variety of adaptation results in the ambiguity of the original story that creates a "web of new interpretations" (Kérchy, 2021) as a foundation for new designs and creative works, including interactive experiences.

Unlike TNs designed as story-authoring tools, where users generate new content, using a pre-existing narrative allows storytellers to make a forgotten history or cultural practice tangible and accessible (Segalo & Fine, 2017). Rosner et al. (2018) presented an interactive quilt to tell the forgotten story of the women who hand-woven computer memory for the Apollo missions. However, a few challenges have shown up. Sullivan et al. (2018) questioned whether players' prior knowledge of the narrative would become a barrier to meaningful and engaging interaction. Loominary was introduced as a tangible narrative game in which players engage with Greek mythology by weaving, with their choices creating a tangible record of their path through the story. Knowing how the narrative proceeds may lead to over-constraining for narrative development and result in less variation in the final product. Shashwat et al. (2024) aimed to address a core challenge of how to keep the experience compelling when the narrative is no longer novel to the user. They designed KaavadBits, an interactive installation inspired by the traditional Indian storytelling form of kaavad baanchana. It uses ancient animal fables from the Panchatantra as its source material, inviting users to engage with the collection of classic tales through tangible tokens and interactions with a narrator embodied as a tree.

### 2.3 Framework for tangible narratives

In order to ensure the design elements align with the established theory for tangible storytelling, the framework for Tangible Narratives presented by Harley et al. (2016) was used to guide the development of “E-broidery in Wonderland” in the following four categories:

**Primary user(s):** Alice in Wonderland is celebrated worldwide as a classic literary and has been adapted into popular culture, including films, cartoons, and stage productions. Many people hold a memory of Alice in Wonderland, even if they have not read the original book or watched it in other formats recently. Although the pilot study was conducted with adults, this design can be applied to any and all age groups.

**Media and material:** The material choices—the base fabrics, embroidery threads, textures, and colors—are crucial in conveying narrative information of the characters and scenarios into tangible objects. To enhance the experience with TNs, LEDs and POFs are integrated with the textile, providing an interactive luminescent effect. The components can seamlessly blend with the delicate look of embroidery via various embroidery techniques.

**Narrative position:** The project aims to shift the users' narrative position toward an internal-explorations position, where they feel as though they look at the story world through the eyes of Alice. Therefore, the main character, Alice, is deliberately removed from each scene to create a first-person perspective for the users.

**Narrative function of tangible objects:** Instead of embroidering the whole settings of the stories in Alice in Wonderland, the characters or objects are presented as a metaphor for the story; hence, the story will not be revealed to the users all at once. These tangible objects serve as navigational tools that lead users to unfold the story through interaction.

# 3 Research questions

While prior research with TNs often focused on technological features, cultural heritage, or educational goals external to the story, "E-broidery in Wonderland" posits the narrative itself as the primary justification, aiming to explore the interplay between narrative familiarity and user interaction. This study seeks to answer the following research questions:

**RQ1:** How does prior experience with the story shape the way users engage with the e-broidery artifacts?

**RQ2:** How does an e-broidery artifact influence the user experience of a known story?

# 4 E-broidery in Wonderland

Four stories were drawn from Alice in Wonderlands and summarized below:

**The Garden of Live Flowers:** Alice encounters talking flowers who mistake her for a flower that can move.

**Advice from a Caterpillar:** A hookah-smoking caterpillar advises Alice on how to change her size by eating a mushroom upon which he is sitting.

**A Mad Tea-Party:** While exploring Wonderland, Alice comes across the Hatter and is trapped at teatime.

**Queen of Hearts Rose Tree:** Card gardeners frantically paint white roses red to hide their mistake from the Queen of Hearts.

The design process began by sketching the iconic characters or objects with narrative meanings to develop TN objects. The illustrations in the original book and the 1951 Disney animation film provided rich imagery source as the reference for outlines and colors. Various sketches were created through careful consideration of the balance between aesthetic and functional needs. The final selected sketches are: a pansy flower from The Garden of Live Flowers, a mushroom and the smoke from Advice from a Caterpillar, a teacup and a teabag from A Mad Tea-Party, and a rose tree from Queen of Hearts Rose Tree.

Once the sketches were finalized, a list of required colors, materials, textures, and electronics was prepared for the production process. Apart from cotton embroidery threads, other non-yarn materials, such as beads and sequins, were also incorporated into the embroidery to create rich texture and visual effects (Jones & Nabil, 2022). Electronics were considered as design variables, in addition to their functions. Different types of LEDs and POFs were selected depending on their appearance and color effects. They were not just sewn on but seamlessly blended into the embroidery textile. Conductive silver yarns and conductive fabric were utilized to create the necessary electrical circuits and establish connections to the batteries, as specified in the design.

The final design stage involves incorporating a narrative function with embroidery and electronic components. This process focused on brainstorming how user interaction with the prototypes logically flows with the original story, enhancing participants' embodied engagement (Nam & Kim, 2011). Physical interaction is used to express the movement or property of action that the character or object has. This approach prioritizes the knowledge of the original story and encourages intuitive exploration rather than relying on immediate, explicit instructions. The four prototypes are referred to as TN1, TN2, TN3, and TN4. Figures 1 to 4 illustrate the working principle of tangible narrative systems, visualizing the design details.

Table 1 provides a concise overview of the prototypes, detailing their functional objects, interaction, and feedback.

*Table 1. Overview of the interaction of prototypes*

| **Prototype** | **Story** | **Functional Objects** | **Interaction** | **Feedback** |
|---|---|---|---|---|
| **TN1** | The Garden of Live Flowers | Pansy padel | Rotation → Contact/Press | LED filaments (yellow) light up intermittently/consistently |
| **TN2** | Advice from a Caterpillar | Mushroom | Magnetic Switch | LEDs (multi-color) light up |
| | | Smoke | Button Switch | POFs light up and change color with every switch press |
| **TN3** | A Mad Tea-Party | Teabag | Put in → Contact | / |
| | | Teacup | | LEDs (yellow) light up |
| | | Water | | LED filaments (blue) light up |
| **TN4** | Queen of Hearts Rose Tree | Roses | Magnetic Switch | LEDs (red) light up |

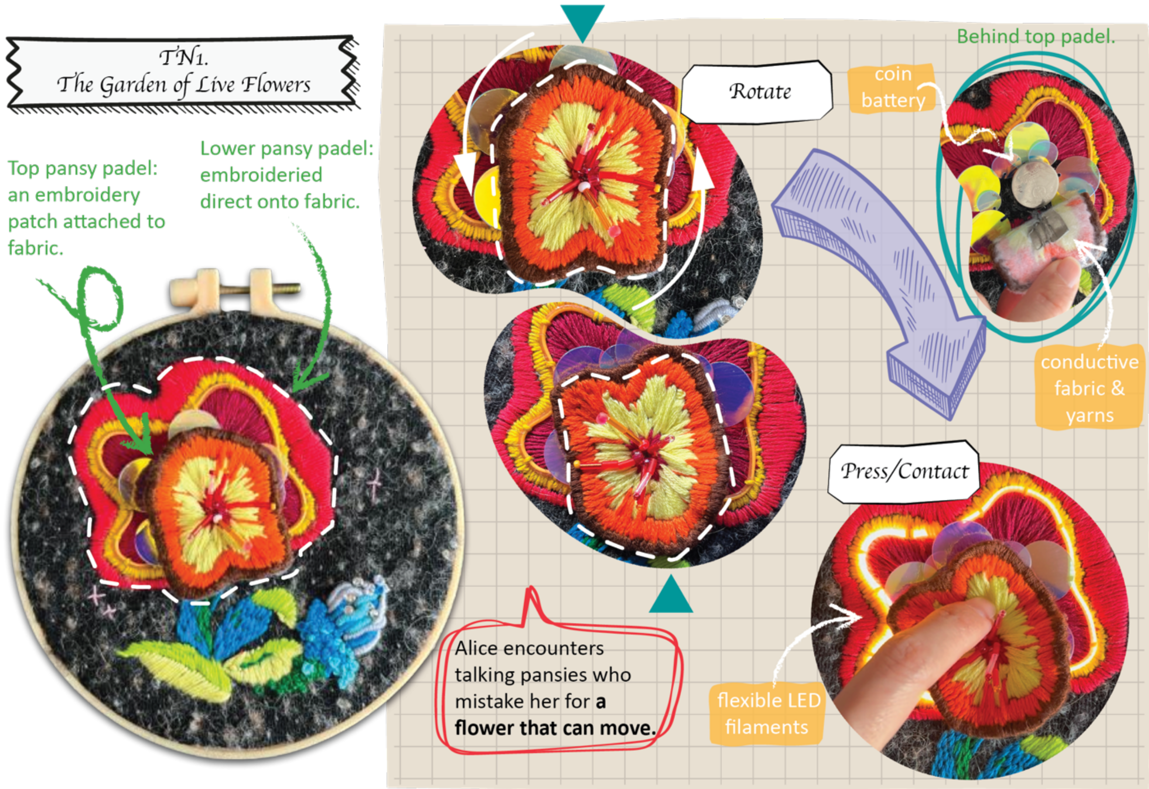


*Figure 1. Introduction of prototype TN1.*

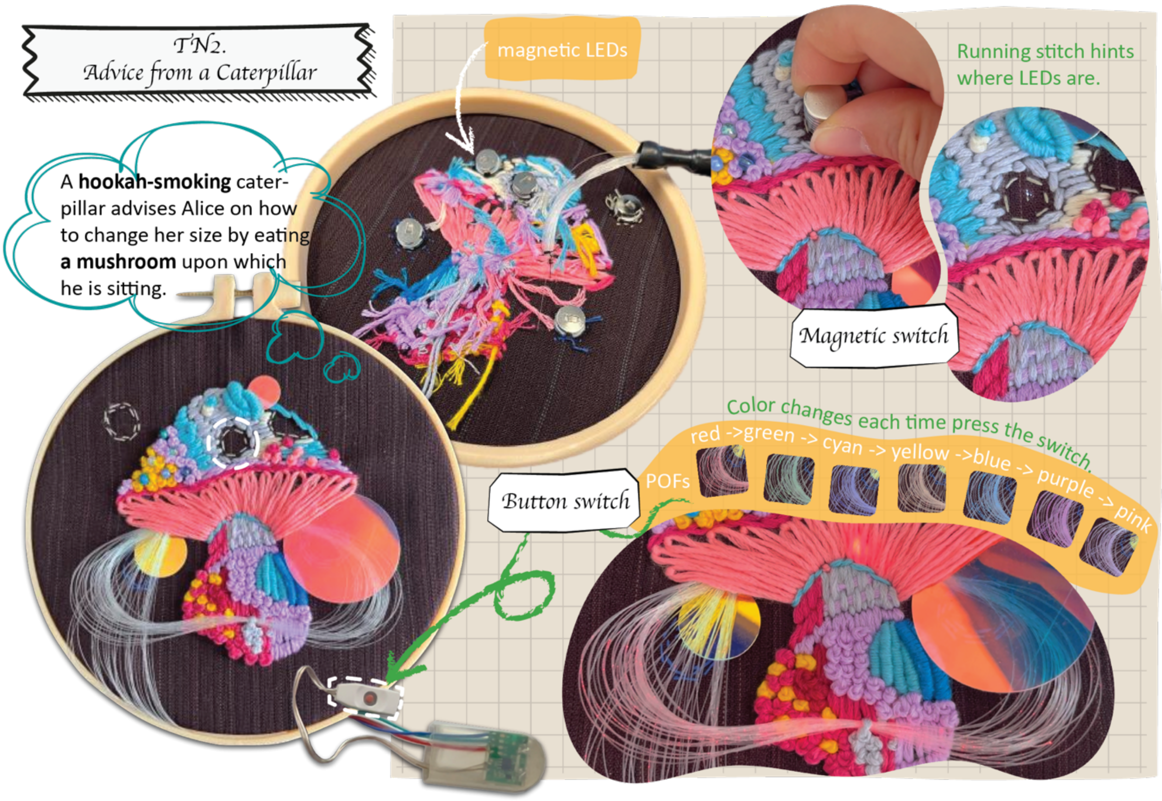


*Figure 2. Introduction of prototype TN2.*

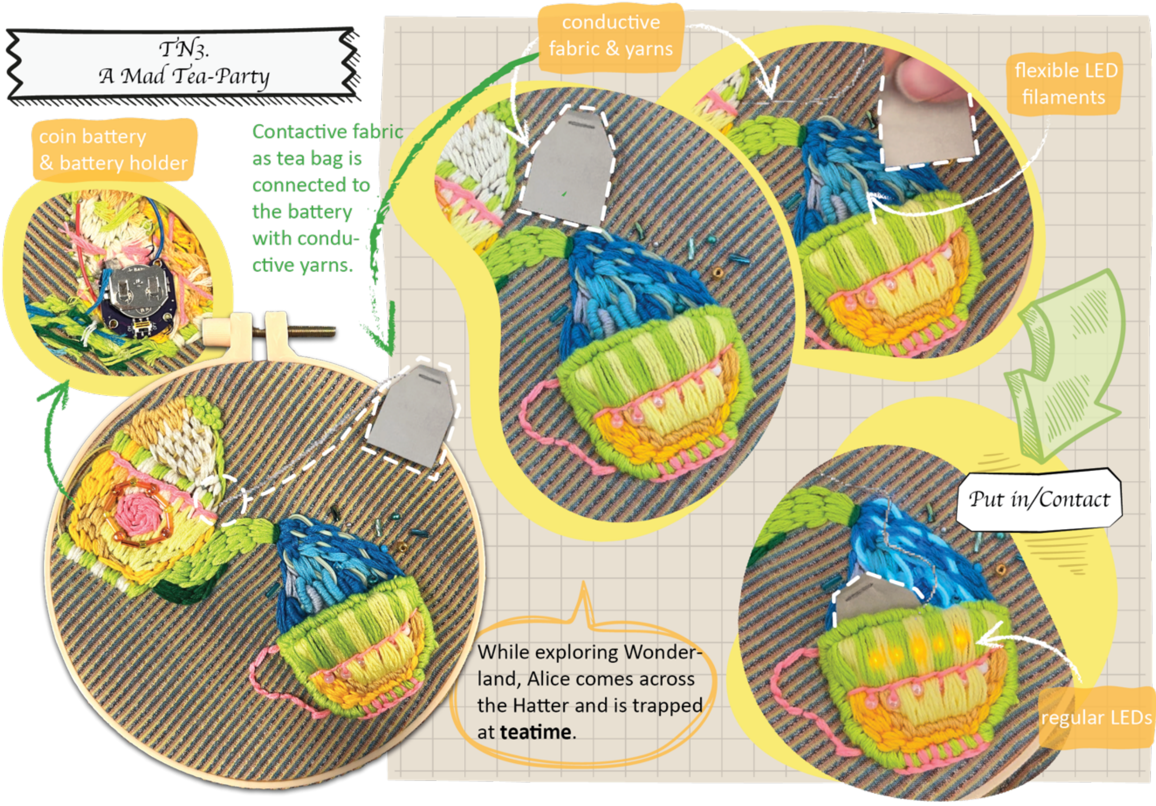


*Figure 3. Introduction of prototype TN3.*


*Figure 4. Introduction of prototype TN4.*

## 5 Methodology

A mixed-methods pilot study was conducted to examine the approach and gain valuable insights from user experience. A group of 12 gender-balanced adult participants (aged 20-32) were recruited from the university community. Participants had various levels of familiarity with the original story, and none were familiar with e-broidery technology. The research was approved by the Human Research Ethics Committee of the author's institution, and all participants signed consent forms before participating in the study. To ensure confidentiality, all data was stored securely and anonymized, with participants referred to as P1 through P12 during analysis.

The user study combined quantitative data from pre- and post-session questionnaires with qualitative data from think-aloud protocols, interviews, and open-ended questions. The four stages of the study are:

1. Pre-study questionnaire: Administered online. The purpose is to gauge the demographic profiles of the participants and their familiarity with the story of Alice in Wonderland.
2. Interaction session: Conducted face-to-face. This stage was divided into two experiments:
   **Unguided exploration & think-aloud.** All four prototypes were presented to the participants at the same time. Participants were explained that the prototypes were inspired by Alice in Wonderland and informed that the objects used LEDs for interaction. They were encouraged to freely explore the prototypes and verbalize their thoughts, observations, expectations, and any feelings that arose during their interaction. A facilitator maintained a quiet presence, taking detailed notes. The facilitator only prompted participants if they fell silent for extended periods.
   **Matching activity.** Following the unguided exploration, participants were given a set of four cards with the story titles. They were then asked to match each prototype to its corresponding card based on their experience, as shown in Figure 5.

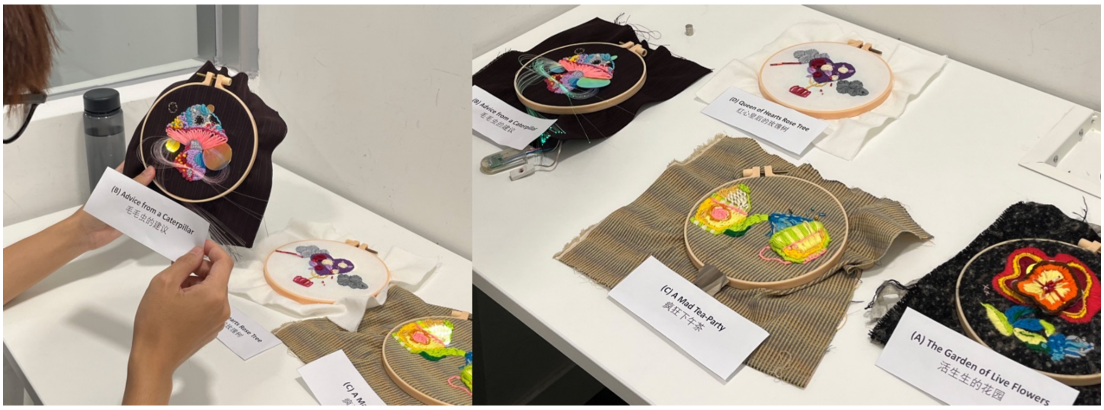


*Figure 5. Snapshot of matching activity.*

3. Post-study interview: A semi-structured interview with open-ended questions was conducted immediately after the interaction session. The interview aimed to gather more profound insights into participants' overall experience, their perceptions of craftsmanship and materiality, and their engagement with the interactive elements.
4. Post-study questionnaire: Administered on-site. A comprehensive semi-structured questionnaire (including Likert scales and open-ended prompts) was conducted after the interview.

All of the questionnaires and interviews were designed in Chinese. English was not the native language of the interview. All interviews were recorded and transcribed into English to facilitate further analysis and interpretation.

# 6 Findings

The unguided exploration session finds a pattern that emerges between participants' familiarity of the original narrative and their primary interaction with the tangible narrative artifacts. The results are summarised in Table 2.

*Table 2. Demographics of user profile and self-reporting familiarity*

| Participant | Gender | Familiarity | Interaction |
|---|---|---|---|
| **P1** | F | Very (3) | Puzzle-solving |
| **P2** | F | Moderately (2) | Sensory experience |
| **P3** | F | Slightly (1) | Puzzle-solving |
| **P4** | F | Slightly (1) | Puzzle-solving |
| **P5** | M | Not at all (0) | Technical curiosity |
| **P6** | M | Moderately (2) | Free play |
| **P7** | M | Moderately (2) | Technical curiosity |
| **P8** | M | Not at all (0) | Technical curiosity |
| **P9** | F | Moderately (2) | Free play |
| **P10** | F | Not at all (0) | Technical curiosity |
| **P11** | M | Slightly (1) | Technical curiosity |
| **P12** | M | Slightly (1) | Technical curiosity |

*Note. Familiarity levels are mapped to a 0-3 scale (0=Not at all, 1=Slightly, 2=Moderately, 3=Very) based on demographic data from the pre-study questionnaire; Interactions are based on self-reporting data from the post-study questionnaires.*

**High familiarity group: A blend of interactions with a narrative core.** The High Familiarity group consists of participants who reported being "very familiar" (P1) and "moderately familiar" (P2, P6, P7, P9). The five participants selected a variety of approaches: one chose "puzzle-solving" (P1), one "sensory experience" (P2), two "free play" (P6, P9), and one "technical curiosity" (P7). Despite the diverse set of interactions in self-reporting, their actions were consistently framed by the narrative through their comments and observed interactions. P1, who chose "puzzle-solving", immediately began to interpret the embroidery content and establish connections with the original work. P9, who chose "free play," shared a thought that reveals a puzzle-solving mindset. She suggested a story plot before each sample to help her recall the context of the story because she would wish to "use the content as a guide to explore the prototypes". The thought shows that her "play" was not random but guided by narrative expectations. P2, who chose "sensory experience", recalled the tea party from the original story while exploring TN3, which ultimately led her to discover the "making a cup of tea" interaction. The finding suggests that the interaction in the high familiarity group is narrative-driven. Even when their approach felt like "free play" or a "sensory experience", their ultimate goal was to capture how the interactive elements represented and enriched a story they already knew.

**Low familiarity group: A focus on technology curiosity.** The Low Familiarity group consists of participants who reported being "slightly familiar" (P3, P4, P11, P12) or "not familiar at all" (P5, P8, P10). Among the seven participants, five (P5, P8, P10, P11, P12) explicitly chose "technical curiosity" as their primary motivation for interacting with the prototypes. Both P5 and P10, who reported being "not familiar at all" with the original story, stated that their primary interest was in exploring how to trigger interactions and understanding the principles behind them. When stuck on TN4, P11 tried to "recall the interaction of other samples to find a way", demonstrating a clear focus on learning the system's mechanics rather than its narrative. For this group, the experience was a technical puzzle. Their goal was to understand the working principles of e-textiles.

## 6.1 The interplay of familiarity and interaction

### 6.1.1 Awakening memories for familiar participants

For participants familiar with the story, their narrative knowledge formed a cycle from action to understanding. The design successfully transformed their memories into a tangible experience, deepening their connection to the story through the interaction.

The high familiarity group achieved an overall interaction success rate of 80% (see Table 3). These participants could read the implement from prototypes, immediately connecting the visual motifs to specific scenes and interpreting the interactive elements within the story's context. P2 shared that the experience made her "recall more details and scenes from memory, and my understanding of the original work became richer", comparing the feeling to "returning to a familiar city and seeing familiar scenes evoke childhood memories". Even P12 from the low familiarity group remarked that interacting with the physical objects makes one "recall and pay attention to the objects in the settings that you have ignored, making the whole story more complete in three-dimensional".

*Table 3. Success rate of interactions by narrative familiarity*

| Prototype | Overall (N=12) | High Familiarity (N=5) | Low Familiarity (N=7) |
|---|---|---|---|
| **TN1** | 50% (6/12) | 80% (4/5) | 28.6% (2/7) |
| **TN2** | 100% (12/12) | 100% (5/5) | 100% (7/7) |
| **TN3** | 25% (3/12) | 60% (3/5) | 0% (0/7) |
| **TN4** | 66.7% (8/12) | 80% (4/5) | 57.1% (4/7) |
| **Overall Success Rate** | 60.4% | 80% | 46.4% |

*Note. The "success rate" in this table refers to the successful activation of the luminescent effect as designed.*

The process of connecting an interaction to a known plot created powerful "Aha!" moments of discovery and satisfaction. For instance, after P1 triggered the lights on TN2, she immediately identified the POFs as the caterpillar's smoke, which she had not thought of before. P6 had a similar moment of insight during the matching activity. Initially confused because he couldn't find a caterpillar, he suddenly realized the narrative connection, exclaiming, "Are the LED threads (POFs) supposed to be smoke?".

A perfect 100% success rate was achieved in the matching activity (see Table 4). The results suggest that the prior familiarity with the narrative formed a coherent loop: seeing a familiar object → performing a corresponding action → triggering an expected effect → validating a scene from memory.

*Table 4. Success rate of matching activity by familiarity*

| | Overall (N=12) | High Familiarity (N=5) | Low Familiarity (N=7) |
|---|---|---|---|
| **Success Rate** | 75% (9/12) | 100% (5/5) | 57.1% (4/7) |

*Note. This table is based on the success/failure of matching each specific prototype to its corresponding story card, as recorded in the participant observation notes. A failure in the activity could result from a mismatch with just one of these prototypes.*

#### 6.1.2 Barriers and confusion for newcomers

For participants unfamiliar with the story, the lack of narrative knowledge created barriers to forming the loop, resulting in an overall interaction success rate of only 46.4% (see Table 3), nearly half that of the high familiarity group. The 0% success rate for TN3 is the most extreme example of when interaction cues are strongly tied to the story; those who lack the narrative key can become confused. The teapot and teacup are a direct prompt for the act of brewing tea in the original story. Familiar participants, such as P2, P6, and P9, understood the narrative context and completed the interaction. However, every single participant in the low familiarity group failed to perform this action. P8 pulled the teabag, thinking it was a pull switch, while P4 did not recognize the teabag and treated the attached thread chain as a spare thread, trying to get it out of the way. When unable to trigger an interaction on TN4, P5 expressed a "fear of breaking the sample because I would want to press harder," indicating that a barrier to understanding can become a source of frustration and anxiety.

TN2 was the most common prototype for hesitation and error in the matching task, as participants without narrative context could not link the abstract visual elements to the core character or objects. The deliberate abstraction of TN2—omitting the caterpillar to focus on the mushroom and smoke—proved problematic for unfamiliar participants to interpret. P3 thought the mushroom embroidery "looked like a fish". P5 incorrectly matched the prototype during the matching activity, reasoning that a mushroom might be found in "The Garden of Live Flowers". Despite TN2's low matching success rate, a 100% interaction success rate was achieved across all groups. The action with a button switch transcended the familiarity gap as a universal affordance.

### 6.2 E-broidery as a tangible narrative medium

The result indicates that the tangible prototypes created an overall highly engaging and enjoyable experience. Participants rated their overall experience with a very high mean score of 4.5 out of 5 (see Table 5). Eight of the twelve participants gave the experience the maximum possible score of 5 ("Enjoyed very much"). P6 stated that the experience "offered a fresh and interesting perspective on stories I have already known". P2 felt the interaction helped her recall "more details and settings of the story from memory". This comments shows that the experience with TNs offered a fresh perspective to spark curiosity and renew interest.

The mean rating for Craftsmanship Quality was 3.92 out of 5, with eight of the twelve participants rating it as 4 ("Good") or 5 ("Excellent"). It was notably appreciated with continuous comments on the details of embroidery, such as the colors, materials, and patterns. P7 recognized the experience as a "dual experience of sight and touch", valuing both the material and the interactive function equally in the experience.

The Tangibility of Story achieved a score of 4 out of 5 in the high familiarity group, while it was only 3.29 in the low familiarity group. The diversity suggests that when combined with story knowledge, the material was not just abstract textures; they became tangible pieces of the narrative world, making it feel real and immersive for the high familiarity group. For instance, POF yarn in TN2 became the very essence of the caterpillar's smoke for those who made the connection (P1, P6).

*Table 5. Summary of Post-Study Questionnaire Ratings (Likert Scale, 1-5)*

| | **Overall (N=12)** | **High Familiarity (N=5)** | **Low Familiarity (N=7)** |
|---|---|---|---|
| **Ease of Interaction** | 3.75 (0.49) | 3.60 (0.55) | 3.86(0.49) |
| **Craft/Tech Combination** | 4.42 (0.51) | 4.60 (0.55) | 4.29 (0.53) |
| **Craftsmanship Quality** | 3.92 (0.79) | 3.80 (1.00) | 4.00 (0.69) |
| **Tangibility of Story** | 3.58 (1.17) | 4.00 (1.30) | 3.29 (1.11) |
| **Overall Experience** | 4.5 (0.45) | 4.60 (0.45) | 4.43 (0.49) |

Despite the positive reception, the results also highlight a key challenge in e-textile implementation. While the integration of craft and technology was appreciated at 4.42 out of 5, the "Ease of Interaction" received a lower score at 3.75. While the conductive yarns share similar physical characteristics as the cotton yarns used with hand embroidery, the complex embroidery stitches caused instability when using them that functions as the electronic circuit. This instability occasionally led to interaction failures and user confusion, revealing a known gap in material manipulation for producing reliable e-textile interfaces (Chen et al., 2021).

All groups expressed an expectation for the project to be expanded in scale. Through open-ended questions, P1 proposed the development of larger prototypes for "a more immersive experience". P2 also suggested that the "textile works could be made bigger for a more in-depth experience".

# 7 Limitations

**Sample and generalizability.** The study was conducted with a convenience group of 12 participants recruited from a university community. This resulted in a cohort that was relatively homogenous in terms of age (20-32) and educational background. Therefore, the findings may not be representative of the primary users, which include children and older adults. Furthermore, although none of the participants were familiar with e-broidery, some came from technology or engineering backgrounds. Their prior experience with interactive technology may have influenced their satisfaction with the overall experience.

**Prototype fidelity and technical reliability.** The artifacts were early-stage prototypes, and their technical reliability had some constraints that could have influenced the user experience. The rate of "Ease of Interaction" reflects this limitation, scoring 3.67 out of 5 (see Table 5). Participant feedback highlighted specific areas for improvement, such as making the "interactive components...more stable" (P2) and improving the "sensitivity of electronic components" (P8). A critical ambiguity of embroidery was revealed and created confusion, especially when both decorative and functional elements are made of the same materials, as P8 shared that certain non-interactive decorations were "misleading, making people think they will also light up".

**Task design.** The design of the matching task may have allowed participants to succeed without relying on narrative familiarity. The cards used in the activity contained explicit object references in their titles (e.g., "Queen of Hearts Rose Tree"), which could have enabled semantic matching based on the specific name of the object rather than its role in the story.

**Interaction and affordance.** The interactions in the prototypes, such as pressing, rotating, and inserting, were designed to be mechanically intuitive. While this approach likely supported participant engagement, the successful interactions could be attributed to generic affordance recognition rather than story knowledge.

# 8 Conclusion and future work

"E-broidery in Wonderland" is an alternative storytelling device that contributes to extend previous research on tangible narratives with a new design. Four low-fidelity prototypes were crafted using electronic embroidery techniques to invite users to explore the story of Alice in Wonderland through unguided interaction. A mixed-methods pilot study was conducted to investigate how story familiarity influences user interaction (RQ1) and to assess the e-textile's ability to create a compelling and meaningful experience for a familiar story (RQ2).

The findings demonstrate that narrative familiarity not only influences but also determines user affordance and engagement with TNs. Two distinct patterns of user interaction emerged: a narrative-driven one for users familiar with the story, who leveraged their knowledge to interpret symbolic cues, and a tech-driven one for those unfamiliar who relied on technology affordances. While the connection with the story offers a meaningful and embodied experience for the high familiarity group, it distances newcomers who lack the necessary background knowledge. One possible solution is to design dual pathways for interaction. The tangible system embeds not only diegetic interactions but also clear, universal technology affordances – like the simple button on TN2 – to serve as a baseline for easy engagement.

Furthermore, the study presents e-broidery as a powerful tool for creating compelling TNs. On the one hand, it engages people with a known story through multi-sensory experiences, adding a physical dimension to a familiar narrative. The role of users shifts from a passive observer to an active participant, making the familiarity novel again. On the other hand, the prototypes leverage the decorative nature of embroidery, utilizing electronic components to enrich the variety of textures and visual effects of the artifact. The participants highly value this approach, with a rating of 4.42 out of 5 for the craft and tech combination (see Table 5).

In future studies, a more diverse participant group from non-technical backgrounds will be included to explore these initial findings, expanding beyond the university community. Another direct improvement will include high-fidelity prototypes with more robust and solid technical reliability. It is also worth scaling the interaction up to a more immersive experience beyond illumination to include sound, haptic feedback, and kinetic elements. The user study methodology will be refined to better assess the relationship between user action and narrative familiarity. First, the matching task will use card titles that do not contain explicit object references, compelling participants to rely on purely narrative knowledge. Second, interactions will be designed to be less based on generic affordances. The interaction puzzles will be developed where discovering the interaction is dependent on understanding the narrative context, thereby emphasis the role of previous familiarity of the story a measure of user engagement. To address the critical familiarity-accessibility dilemma, future work will include adaptive interfaces or beginner tutorials on background knowledge to scaffold the experience for users unfamiliar with the source narrative and materials, creating TNs that are accessible to all.

## References


Buso, A., McQuillan, H., Voorwinden, M., & Karana, E. (2023). Weaving textile-form interfaces: A material-driven design journey. *Proceedings of the 2023 ACM Designing Interactive Systems Conference,* 608–622. https://doi.org/10.1145/3563657.3596086

Chen, A., Tan, J., & Henry, P. (2021). E-Textile Design through the Lens of Affordance. *Journal of Textile Design Research and Practice, 9*(2), 164–183. https://doi.org/10.1080/20511787.2021.1935110

Endow, S., Rakib, M. A. N., Srivastava, A., Rastegarpouyani, S., & Torres, C. (2022). Embr: A creative framework for hand embroidered liquid crystal textile displays. *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems,* 1–14. https://doi.org/10.1145/3491102.3502117

Harley, D., Chu, J. H., Kwan, J., & Mazalek, A. (2016). Towards a framework for tangible narratives. *Proceedings of the TEI '16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction,* 62–69. https://doi.org/10.1145/2839462.2839471

Iché, V. (2018). Review of *Alice in transmedia wonderland: Curiouser and curiouser new forms of a children's classic,* by Anna Kérchy. *Marvels & Tales, 32*(1), 182–185. https://doi.org/10.13110/marvelstales.32.1.0182

Jones, L., & Nabil, S. (2022). Goldwork embroidery: Interviews with practitioners on working with metal threads and opportunities for e-textile hybrid crafts. *Creativity and Cognition,* 364–379. https://doi.org/10.1145/3527927.3532809

Kérchy, A. (2016). Alice in transmedia wonderland: Curiouser and curiouser new forms of a children's classic. McFarland.

Lam, N. Y. K., Tan, J., Toomey, A., & Cheuk, K. C. J. (2022). Washability and abrasion resistance of illuminative knitted e-textiles with POFs and silver-coated conductive yarns. *Fashion and Textiles, 9*(1), 39. https://doi.org/10.1186/s40691-022-00313-9

Ge, L., & Tan, J. (2024). Design and development of lightweight and sheer interactive textile with illumination. *Journal of Donghua University (English Edition), 41*(3), 282-288. https://doi.org/10.19884/j.1672-5220.202310005

Lo, J., Torres, C., Yang, I., O'Leary, J., Kaufman, D., Li, W., Dontcheva, M., & Paulos, E. (2016). Aesthetic electronics: Designing, sketching, and fabricating circuits through digital exploration. *Proceedings of the 29th Annual Symposium on User Interface Software and Technology,* 665–676. https://doi.org/10.1145/2984511.2984579

Mecnika, V., Hoerr, M., Krievins, I., Jockenhoevel, S., & Gries, T. (2014). Technical embroidery for smart textiles: Review. *Materials Science. Textile and Clothing Technology, 9*, 56-63. https://doi.org/10.7250/mstct.2014.009

Nam, T.-J., & Kim, C. (2011). Design by tangible stories: Enriching interactive everyday products with ludic value. *International Journal of Design, 5*(1), 85-98. http://hdl.handle.net/10203/96091

Post, E. R., Orth, M., Russo, P. R., & Gershenfeld, N. (2000). E-broidery: Design and fabrication of textile-based computing. *IBM Systems Journal, 39*(3.4), 840–860. https://doi.org/10.1147/sj.393.0840

Pouta, E., Mikkonen, J. V., & Salovaara, A. (2024). Opportunities with multi-layer weave structures in woven e-textile design. *ACM Transactions on Computer-Human Interaction, 31*(5), 1-38. https://doi.org/10.1145/3689039

Rosner, D. K., Shorey, S., Craft, B. R., & Remick, H. (2018). Making core memory: Design inquiry into gendered legacies of engineering and craftwork. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems,* 1–13. https://doi.org/10.1145/3173574.3174105

Segalo, P., & Fine, M. (2017). Threading life stories: Embroidery as an engaged method. *Emancipatory and Participatory Methodologies in Peace, Critical, and Community Psychology,* 107–117. Springer, Cham. https://doi.org/10.1007/978-3-319-63489-0_9

Shashwat, S., Padmagirwar, A., Arora, S., & Srivastava, A. (2024). KaavadBits: Exploring tangible interactive storytelling of branching narratives through a Kaavad-inspired installation. *Proceedings of the*

*Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction,* 1–6. https://doi.org/10.1145/3623509.3635251
Sullivan, A., McCoy, J. A., Hendricks, S., & Williams, B. (2018). Loominary: Crafting tangible artifacts from player narrative. *Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction,* 443–450. https://doi.org/10.1145/3173225.3173249

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