A Storytelling Robot for People with Dementia

Designing a simple interface, suitable for People with Dementia

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Abstract

This project investigates the design process of a straightforward, user-friendly interface that enables cooperative storytelling between a person with dementia and a family member, through the mediation of a social robot. Due to ethical constraints, evaluation was conducted only with a medical specialist and HCI students. Low cognitive load, sequential navigation, and multimodal visuals are given top priority in the final prototype. Working without direct user input and striking a balance between functionality and simplicity were two major obstacles. The project contributes to the development of supportive, dementia-friendly human-robot interfaces and provides a basis for future testing with individuals who have dementia.

Keywords: Dementia, Storytelling, Human-Computer Interaction (HCI), User Interface Design, Assistive Technology, Social Robots

1 Introduction

Dementia is a general term for progressive neurological conditions affecting cognitive abilities such as memory, vocabulary, attention, personality, and disposition, to a degree where social functions and daily activities are negatively impacted [1].

Meaningful activities—defined by Harmer & Orrell [2] as those that hold personal importance, promote engagement, and support emotional or social needs—play a critical role in supporting psychosocial well-being and identity for People with Dementia (PwD). Examples include reminiscence-based storytelling, creative expression, and shared social moments. Among these, storytelling—which blends memory, imagination, and interaction—has proven especially effective for enhancing self-expression and engagement across all stages of dementia. Projects like TimeSlips [3] demonstrate how creative storytelling improves communication and quality of life. Basting [4] further highlights how storytelling preserves identity and communication, even when verbal skills decline.

Despite their benefits, these interventions are often difficult to scale due to limited accessibility. Social robots have emerged as promising tools for structuring interactions and supporting storytelling engagement among PwD. Robots like *Pepper* [5] have been used in dementia care for cognitive exercises and companionship [6], yet their potential for creative, co-expressive storytelling remains largely unexplored. Studies such as Inclusive'R'Stories [7] and other storytelling robots [8] show that Artificial Intelligence (AI) and expressive robotic behaviors can enhance user experience and evoke emotion. However, these systems are rarely adapted to the cognitive needs of dementia seniors and often lack key features—such as intuitive interactions, clear cues, and low memory demand—that make interfaces cognitively accessible. Given the cognitive and sensory impairments associated with dementia, poor design can lead to confusion, frustration, or disengagement.

To support People with Dementia, a storytelling robot must go beyond content generation—it should actively guide and include users through an interface designed for cognitive challenges. Compared to other user groups, PwD need interfaces that reduce cognitive load, offer reassurance, and promote participation. They should avoid complex instructions or memory reliance, and include clear feedback to support understanding and engagement. Input methods must be intuitive, not requiring speed or precision, which can be challenging for PwD [9],[10]. Visuals and prompts should gently guide rather than demand, minimizing cognitive load and the risk of confusion [10].

When building such a system, a cognitively accessible and emotionally supportive interface is essential. PwD are particularly vulnerable to frustration and withdrawal when faced with confusing interfaces [9]. Thus, an emotionally supportive design offers needed reassurance, encourages positive interaction, and helps maintain well-being [11],[12]. This design goal is the central focus of this research. A storytelling system cannot meaningfully support engagement, well-being, or identity unless its interface aligns with PwD's cognitive and emotional needs [2],[11]. Accessibility includes accommodating cognitive, motor, and sensory limitations, while intuitive interfaces reduce learning demands through familiar and clearly cued interaction patterns [10].

Although some initial systems have explored storytelling with social robots [7],[8], very few are designed specifically for co-creative storytelling for PwD and their caregivers. Reviews in dementia and Human-Computer Interaction (HCI) design highlight this gap, emphasizing the need for person-centered, accessible interfaces in this space [11],[13]. Collaborative storytelling can be particularly valuable when it involves both the person with dementia and their close social circle, such as family members or carers. Involving family members fosters positive social interactions that reinforce personhood and support emotional well-being [2].

Storytelling is a powerful tool for enhancing emotional well-being among PwD [3],[4], and social robots show promise in enabling structured, supportive interactions in dementia care [6]. The main research question of this thesis is therefore: **"How can we design a simple interface that supports collaborative storytelling between a person with dementia and a family member, using a social robot?"**. This question lays at the intersection of human-robot interactions, accessibility, and co-creative digital tools. To guide the design process, the following sub-questions are explored:

- What can the interface do to promote and facilitate story creation, without overwhelming or confusing the user, while narrating a story?
- How can the interface hint at progress or completion during a storytelling experience in a cognitively supportive manner?
- Which interface components (such as buttons, speech prompts, visual cues) are the simplest for People with Dementia to understand and use in a storytelling environment?
- What input methods (such as touch, speech, gesture) are most accessible and intuitive for People with Dementia to use in a storytelling scenario?
- What type of feedback mechanisms (such as auditory confirmation, visual cues) are the most appropriate to reassure People with Dementia and help maintain their engagement during the storytelling process?
- How can the user interface and the robot's behavior be effectively integrated to support a seamless and supportive storytelling experience for People with Dementia and their caregivers?

This thesis was part of a broader project developing a storytelling robot. Four parallel research projects contributed to the full system [1], and close collaboration ensured the interface aligned with the system's technical and collaborative goals.

[1] The researches that were conducted in parallel targeted:

- keeping the participants engaged in the conversation
- generating an image and a song based on the story's content
- simulating personas using large language models in order to test the system
- evaluating the system for bias and user enjoyment

2 Related Work

2.1 Interfaces for People with Dementia (PwD)

A variety of cognitive, sensory, and physical needs must be taken into account when designing interfaces for people with dementia (PwD). In order to decrease frustration and enhance adoption, the literature frequently highlights the importance of three fundamental usability principles: simplicity, clarity, and personalisation [9],[12],[14]. Clean layouts, simple interactions, and consistent navigation with large fonts, clear labels, and restrained colour schemes are all ways that interfaces should lessen cognitive load [9],[11],[15].

Adjustable text size, contrast settings, and media playback options are crucial personalisation features, as dementia symptoms can vary considerably [9],[15],[16]. For users with sensory or memory impairments in particular, multimodal support—visual, auditory, and tactile—further improves usability [12],[14]. Visual symbols, natural and adjustable audio, and highlighted text synchronised with speech are all effective strategies [10],[14].

Another recurring recommendation is to facilitate collaborative interaction and support co-use with carers, since individuals with dementia frequently require assistance in navigating digital systems [9],[12]. Furthermore, technologies should promote linear workflows, shallow menus, and clear visual hierarchy rather than overwhelming users with blinking elements, deep navigation hierarchies, or excessive graphics [14],[15].

2.2 Self-Expression and Emotional Expression

Beyond utility, interfaces for PwD can facilitate identity preservation, emotional expression, and storytelling. Design strategies that encourage creativity, open-ended communication, and reminiscence help oppose deficit-oriented perspectives of dementia and emphasise the individual's autonomy and strengths [13]. Systems that facilitate non-verbal and open-ended communication—such as soundscapes, visual storytelling, and group projects—allow participation without relying on traditional language or memory [12],[13].

These interfaces frequently allow for self-expression, ambiguity, and emotional connection because they are interpretive rather than directive. By enabling users to construct meaning on their own terms, features like voice recording, word tiles, and art-based interactions foster human connection and dignity [13]. By emphasising the individual's ongoing presence and expression, these tools also help to lessen stigma, increase empathy, and promote social inclusion.

2.3 Broader HCI and Assistive Design

Interface development for dementia is heavily influenced by general principles from the larger fields of cognitive accessibility and assistive design. According to several studies, consistency, predictability, and adaptability are crucial [10],[15],[16]. Interfaces should avoid abrupt changes, behave consistently across screens, and give users clear feedback after each action. The usefulness of adaptive or configurable interfaces, which provide layout modifications, simplified language, and symbolic reinforcement to support comprehension, is demonstrated by systems such as the Easier Web system and the Easy Reading framework [10],[16].

A solid basis of design considerations is provided by accessibility guidelines created for Alzheimer's-specific contexts. These include suggestions for dealing with attention issues (minimalist design, limited options), cognitive impairments (simple text, multimedia support, shallow menu structures), and sensory challenges (large fonts, high contrast, nondistracting audio) [11],[14]. Mobility considerations are also important; users with motor limitations can be accommodated by touchscreens, large interactive zones, minimal typing, and static menus [14].

Significantly, inclusive and equitable design is not only technically sound but also morally right. It entails acknowledging the social and cultural aspects of dementia and making sure that the tools are not only usable but also empowering and affirming [11],[13]. This entails accommodating a range of literacy levels, linguistic backgrounds, and digital proficiency—making technology not only functional but also considerate and human-centered.

3 Methodology

3.1 Research Approach

The focus of this project was to design a simple and cognitively accessible tablet interface to support storytelling sessions moderated by Milo, a Navel social robot [17]. Due to ethical and accessibility constraints, direct involvement of end users in the design phase was unfeasible. Consequently, the project adopted a qualitative, expert-informed, iterative design approach.

By simulating user-driven decision-making through academic and professional proxies, this method enabled a user-centered mindset. The approach was based on literature ([10], [14], [16]), supervisory feedback, and input from domain experts—namely, HCI students and a medical professional familiar with cognitive impairments. Their insights helped shape interface choices, validate design assumptions, and prioritize usability concerns in the absence of direct feedback from PwD.

3.2 Design Process Overview

The design process followed three main stages: (1) requirements gathering, (2) wireframing and prototype design, and (3) expert evaluations and refinements. This structure aligns with established iterative methodologies in dementia-related design, such as the *Exploration, Design, and Evaluation* model proposed by Brankaert [18] and applied in HCI studies involving engagement workshops and prototype feedback [19].

Although direct involvement of people with dementia was not feasible, the process was adapted to incorporate proxy input. These stages are further detailed in Sections 4 and 5, which describe how heuristic evaluations and expert interviews informed iterative improvements.

This qualitative approach aimed to simulate user-driven design through expert feedback, prioritizing cognitive accessibility while addressing ethical constraints on directly involving vulnerable users.

3.3 Tools and Materials

The following tools and resources were used to facilitate iterative prototyping and documentation during the design and development processes:

- Figma [2]: Used to create the initial wireframes and mid-fidelity prototypes. Chosen for its intuitive interface and asset export capabilities.
- GitHub [3]: The supervisor's version-controlled repository facilitated code management.

[2]Figma, Inc. Figma: Collaborative interface design tool. https://www.figma.com/
[3]GitHub, Inc. Github: Development platform. https://github.com/

- Python & HTML/CSS: In the implementation phase, Python was used for backend scripting and robot integration, while HTML/CSS were used for the tablet interface.
- Evaluation Materials: All participants received consent forms. Expert evaluation used a guided form based on Nielsen's heuristics [20]; the healthcare professional interview followed a semi-structured script. Copies of these materials can be found in Appendices D, E, and F.

3.4 Methodological Limitations

The most significant methodological limitation was the impossibility to include people with dementia in the design and evaluation process. This significantly impacted the study methodology, having to opt for requirements supported by literature and an expert-informed design approach, over experimental user feedback. These ethical and accessibility limitations are discussed in more depth in Section 7.

4 Design Process

The design process followed an iterative approach, integrating feedback from the project supervisor, the responsible lecturer, and members of the project team. With each iteration, invaluable insights from these participants combined with concepts acquired from earlier research, enabling the interface to develop into a functional, user-focused application.

4.1 Requirements Gathering

The interface requirements were compiled through literature reviews ([10],[14],[16]) and discussions with the project supervisor and the responsible lecturer. Since direct involvement of people with dementia was not possible, this stage aimed to combine research insights with expert input from individuals experienced in dementia care.

Design requirements were directly informed by practical recommendations from the Alzheimer's Society's co-creation guide [21], which outlines best practices for creating digital tools tailored to the cognitive needs of people with dementia. The following principles aimed to minimize visual confusion and cognitive overload:

- clear, simple, and positive language
- plain layouts
- large, sans-serif fonts (no italics or all caps)
- consistent navigation and logical information flow
- clear buttons and labels; no drop-down menus
- high contrast visuals and plain backgrounds
- relevant imagery only
- subtitle support
- screen readers compatibility

The Easy Reading Framework [16], though focused on adaptive web support, offered relevant complementary strategies—such as minimizing memory demands, using symbol-based communication, and ensuring interface consistency. It reinforced the importance of multimodal presentation, error tolerance, and avoiding dynamic user interface (UI) changes that may disorient users with cognitive impairments.

Discussions with the supervisor and lecturer helped adapt these features to the narrative context, the robot's facilitative role, and the activity's participatory nature. Requirements were then prioritized using the MoSCoW method [22], as showcased in Table 1, forming the foundation for the prototype and guiding iterative design decisions.

M#	Must Haves
M1	The interface shall include a clearly labeled button to initiate storytelling (e.g., "Start Story").
M2	The interface shall display speaker identifiers for the user, caregiver, and robot.
M3	All robot-generated speech shall be accompanied by a synchronized text transcript.
M4	The interface shall indicate clearly when the storytelling session is complete.
M5	The interface shall display all generated multimedia content (images and songs) at the end of each session.
M6	A clearly accessible "Exit" button shall be provided for ending a session.
M7	The interface shall include confirmation prompts to prevent accidental or irreversible actions.
S#	**Should haves**
S1	The system should provide an option to repeat or rephrase the robot's utterances.
S2	The interface should include a visual progress indicator showing the current stage of the storytelling process.
S3	The user should be able to pause and resume the storytelling interaction.
S4	A "Skip" button should be available to bypass the conversation.
S5	A help or support button should be present to assist users during interaction.
S6	The interface should be able to deliver encouraging prompts to motivate continued participation without applying pressure.
C#	**Could haves**
C1	The system could support a customizable avatar that resembles the user.
C2	The interface could display speech input in real-time as on-screen text.
C3	Speech input could be automatically cleaned and summarized to remove stuttering and irrelevant words.
C4	The user could be offered a choice of story themes at the beginning of the session.
C5	The robot could display emotional feedback through facial expressions.
W#	**Won't haves**
W1	The system will not support saving or resuming partially completed stories.
W2	The system will not provide remote access for viewing completed stories.
W3	Feedback analytics will not be collected or visualized in this version.
N#	**Nonfunctional Requirements**
N1	Navigation shall be simple and intuitive to minimize cognitive load.
N2	The interface shall use consistent design patterns to reinforce user familiarity.
N3	The design shall reduce reliance on memory (e.g., by avoiding tasks that require recall).
N4	A high-contrast color scheme shall be used to enhance readability.
N5	All textual elements shall use large, legible, sans-serif fonts.
N6	Concepts shall be represented using both labels and icons where appropriate.
N7	The interface shall support auditory cues to enhance user engagement.
N8	Button usage shall be minimized to streamline interaction.
N9	The interface shall avoid dropdown menus and scroll panes to reduce complexity.

Table 1: Full List of Design Requirements

4.2 Low-Fidelity Prototype

The initial, low-fidelity prototype, focused on sketching the application's key screens and outlining the main user flow. It's goal was to explore and validate the structural logic of the interface, prioritizing **layout, sequencing, and interaction design**. Consequently, little visual detail was added in the early steps of the design process. Essential features, such as pop-up dialogues, navigation prompts, and key text, were fully represented, while visual elements such as icons and text boxes remained abstract.

The prototype (Figure 1) followed a linear screen sequence simulating the storytelling experience. It began with a *start screen*, allowing users to initiate the conversation, followed by an *introduction screen* supporting the robot's goal to gather the number of participants and their names. A brief *tutorial screen* was introduced to explain the core interface elements.

At the heart of the interface was the *story progress screen*, displaying a live dialogue transcript with turn-taking icons for each participant. At the end of the session, a *finalized story screen* offered users the option to generate multimedia output based on the story—supporting closure and a sense of accomplishment, especially valuable for users with cognitive impairments who benefit from clear transitions. Two final screens followed: a *picture slideshow* with music, and an *end screen* offering the option to begin a new story. These promoted continuity and re-engagement while maintaining a predictable, goal-oriented experience.

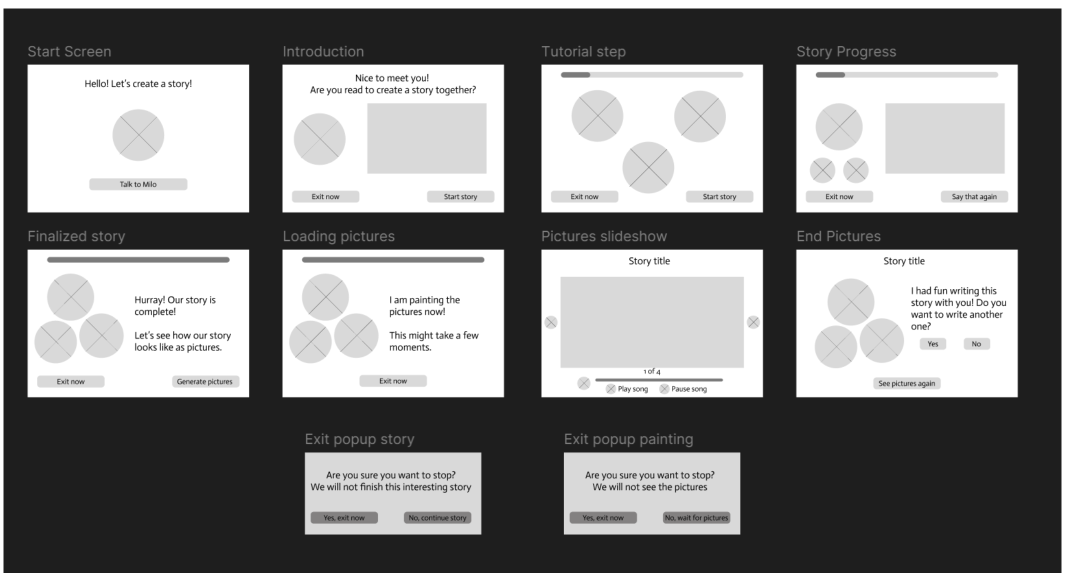

Figure 1: Low-Fidelity Prototype

Several design strategies accessible for PwD were integrated within this first prototype:

- **Error-tolerance**: implemented via confirmation prompts for critical actions like "Exit".
- **Visual overload**: reduced through a plain, uncluttered layout.
- **Legibility**: ensured through large, high-contrast fonts.
- **Linear navigation**: guaranteed by a forward-only flow; only the "Exit" button allowed backward movement, safeguarded by confirmation.

- **No dropdown menus**: replaced by static, clearly labeled choices.
- **Only essential elements** shown: non-essential components were abstracted or omitted.
- **Subtitles**: supported all robot speech for better comprehension.

As the first iteration focused on a low-fidelity prototype, it prioritized structure and accessibility over visual design. Details like iconography and color were deferred to later iterations. A full overview of the low-fidelity illustrations can be found in Appendix B.

4.3 Initial Feedback and Mid-Fidelity Prototype

The low-fidelity prototype was reviewed by supervisors and fellow researchers—stakeholders familiar with the system's scope, infrastructure, and dementia-related accessibility needs. Feedback focused on functional gaps and structural improvements, providing the foundation for targeted refinements and guiding the transition to a mid-fidelity prototype (Figure 2).

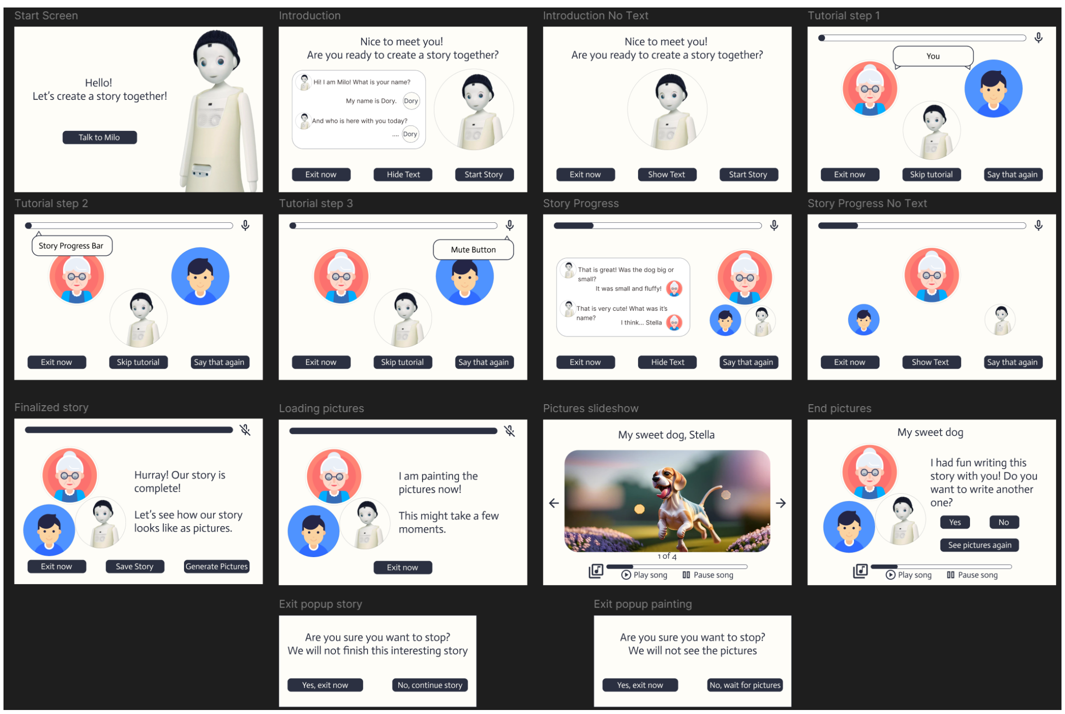

Figure 2: Mid-Fidelity Prototype

Below is a summary of the key issues identified and how they were addressed in the updated prototype:

- **The transcript could potentially distract the user from the robot's presence.** An alternative, simplified screen was introduced for the storytelling stages, showing only the speakers' icons in the center of the screen to reduce visual load.
- **Users may want to speak privately without the robot registering their conversation.** A *mute button* was introduced at the top of the screen, allowing

users to temporarily pause the recorded conversation.

- **There was no way to replay the song after the image slideshow.** The music player was duplicated on the final screen for continued access.
- **There was no option to save generated stories.** A *"Save Story"* button was added to the final stage to support future retrieval and evaluation.
- **The tutorial was unclear and unskippable.** The tutorial was restructured with clearer steps, simplified visuals and a *"Skip Tutorial"* button.

This version introduced refined textual prompts, standardized button designs, and placeholder icons to illustrate intended user interactions. Detailed screenshots from the mid-fidelity prototype are presented in Appendix C.

4.4 Expert Evaluation

Assessing the accessibility and usability of the prototype was a crucial step in the design process. A heuristic usability study was conducted with five expert participants, all of whom were HCI students selected for their interest in interface design, availability, and—in some cases—prior experience with individuals with dementia.

The rationale for selecting specifically five experts was based on established findings in usability research. According to Nielsen [23], a group of five usability experts can identify approximately 77–85% of usability issues in a system, making this number an efficient and well-recognized standard for heuristic evaluation .

The evaluation followed Nielsen's 10 Usability Heuristics [20], a recognized framework for professional interface analysis. Participants received a structured evaluation form and were encouraged to explore the prototype freely rather than follow predefined tasks. The form included detailed instructions on the purpose and process of the evaluation. Full versions of the consent and evaluation forms are included in Appendices D and E.

Evaluation Process

The experts were provided with access to the mid-fidelity prototype, along with an evaluation form outlining:

- **Purpose:** Assessing how effectively the interface supports a storytelling interaction between a person with dementia, a caregiver, and a social robot.
- **Context:** The interface should aid the robot-led storytelling by providing speaker cues, offering visual prompts and generating multimedia output at the end.
- **Instructions:** Participants independently reviewed the prototype and assessed each screen using Nielsen's 10 Usability Heuristics. For each issue, they recorded a severity rating (1–4), summary, anticipated user difficulties, context, and assumed causes.

Key Findings

The expert evaluation revealed the following recurring usability challenges:

1. **Progress bar may increase anxiety:** Initially meant to provide structure, the progress bar was seen as potentially stress-inducing if being interpreted as a time limit or an indicator of needed pacing. Moreover, its accuracy was questioned, as session duration is unpredictable.
2. **Mute button may cause confusion:** Contrary to earlier feedback, experts found the mute button counterintuitive, given the robot's conversational role. Accidental activation could disrupt the interaction without clear recovery cues.

3. **Inconsistent terminology:** Terms like "generate" and "paint" were used interchangeably, creating uncertainty about whether they referred to different actions or outcomes.
4. **Exit message mismatch:** Exit confirmations didn't always reflect system state and were sometimes overly positive, potentially discouraging users from exiting.
5. **Missing volume controls:** One expert noted the lack of audio adjustment, recommending a volume bar for user comfort.
6. **Passive screens lacked feedback:** Screens requiring users to wait (e.g., during image generation) provided no indication of system activity, leading to confusion.
7. **Missing customization:** The absence of adjustable font size or language options was flagged as an accessibility concern.
8. **No content saving:** The lack of a save function for multimedia output was identified as a gap, especially for caregivers or research use.

These findings of the heuristic study directly informed the next iteration. Several design elements were refined, resulting in a more accessible, consistent, and intuitive mid-fidelity prototype. Specific updates are outlined in the following section.

4.5 Design Iteration

Following the heuristic evaluation, several targeted changes were implemented to improve usability, clarity, and alignment with the needs of users with dementia.

1. **Removal of progress bar:** Originally intended to structure the session, its potential to cause anxiety or misinterpretation for PwD outweighed the benefits.
2. **Pause button added:** The mute function was replaced by a more intuitive *pause* button, accompanied by a popup message indicating the conversation can be resumed anytime.
3. **Consistent terminology:** The term *"paint"* was selected instead of "generate", as it was deemed friendlier and more creative, especially in the context of storytelling.
4. **Improved exit messages:** Confirmation popups were redesigned and supplemented to better reflect the system state.Their phrasing remained open to revision by a healthcare professional, to ensure clarity and sensitivity.
5. **Volume control introduced:** A slider was added for both music and robot speech, placed in the upper-left corner, formerly occupied by part of the progress bar.
6. **Passive screen guidance:** Although the confusion stemmed from the prototype's mid-fidelity limitations, a loading animation was proposed to offer reassurance.
7. **Accessibility adjustments:** While dynamic language switching was out of scope for this project, font sizes were increased for better readability. Full customization remains a future recommendation.
8. **Revised story interaction controls:** The original "Save Story" button suggested unsupported functionality and prompted requests to save multimedia output. In consultation with a backend team member, it was renamed and repurposed as a "Replay Story" feature to better match system capabilities and project scope.
9. **Additional feature – Feedback for generated content:** A feedback mechanism was added at a team member's request, allowing users to comment on the generated images or songs.

These adjustments culminated in a refined mid-fidelity prototype, balancing cognitive accessibility, clarity, and technical feasibility. This version would form the foundation for the next evaluation involving one healthcare professional.

5 Evaluation

5.1 Evaluation Setup

The evaluation phase was significantly constrained, as ethical limitations introduced the inability to conduct research with individuals living with dementia (see Section 7). To mitigate this shortcoming, a medical professional with clinical experience in cognitive impairments—though not specialized in dementia care—was invited for a semi-structured interview. A signed consent form was collected prior to the session (Appendix F).

The interview was conducted in a controlled, informal setting, with the researcher acting in a *Wizard of Oz* role [24], simulating the robot's interaction behavior to illustrate the storytelling experience.

5.2 Tasks and Procedure

Instead of giving the participant specific tasks, a live demonstration of the prototype was used to guide them through the interface. The researcher manually simulated the interaction to help the evaluator envision the experience from the perspective of a person with dementia, observing both static screens and dynamic transitions.

The evaluation concentrated on the interface's emotional resonance, cognitive accessibility, intuitiveness, and usability. Verbal observations and reflections were recorded immediately afterward.

5.3 Feedback Collection

The semi-structured interview was based on a set of predefined themes and questions, aiming to assess cognitive clarity, emotional safety, flow, and practical use. The explored themes were:

- **General Impression:** Initial thoughts on the visual structure and usability.
- **Cognitive Load & Clarity:** Assessment of potential confusion or overstimulation.
- **Flow and Intuitiveness:** Navigation, guidance, and clarity of the user journey.
- **Emotional and Behavioral Considerations:** Potential for anxiety or disruption.
- **Use Context:** Appropriateness for therapeutic or casual storytelling use.
- **Suggestions for Improvement:** Concrete design refinements.

To address gaps left by the heuristic evaluation, follow-up questions focused on the mute/pause feature, exit messaging, font size, and screen transitions. Notes were taken during and immediately after the session to capture qualitative insights.

5.4 Results

The clinician's feedback was largely positive, confirming the interface's simplicity. The prototype was deemed as neither overwhelming, nor overly complex. The participant noted that users would likely be somewhat familiar with modern technologies and, with multimodal cues, the interface should be manageable for users with cognitive impairments. Key insights and recommendations included:

1. **Transcript screens should be a secondary visualization:** Text-based transcript of the story could distract from the robot. Icon-centered displays were thus made default, with the transcript shown only as a user-activated option.

2. **Multimodal Representation:** It was strongly recommended that all icons be accompanied by corresponding text labels to ensure clarity.
3. **Volume Controls:** In addition to the slider, +/- buttons were strongly recommended for more accessible volume adjustments.
4. **Help Button:** A dedicated help button was proposed to allow users to revisit tutorial guidance at any time, especially if they forget the interaction steps.
5. **Color-coded Popups:** Confirmation popups should include green (confirm) and red (cancel) color cues to reduce ambiguity.
6. **Improved Transition Flow:** The transition from the picture slideshow to the final screen lacked clarity. A "Finish Session" button was added to mark the final phase.
7. **Consistent Exit Options:** An exit button was added to the sideshow for consistency and user control.

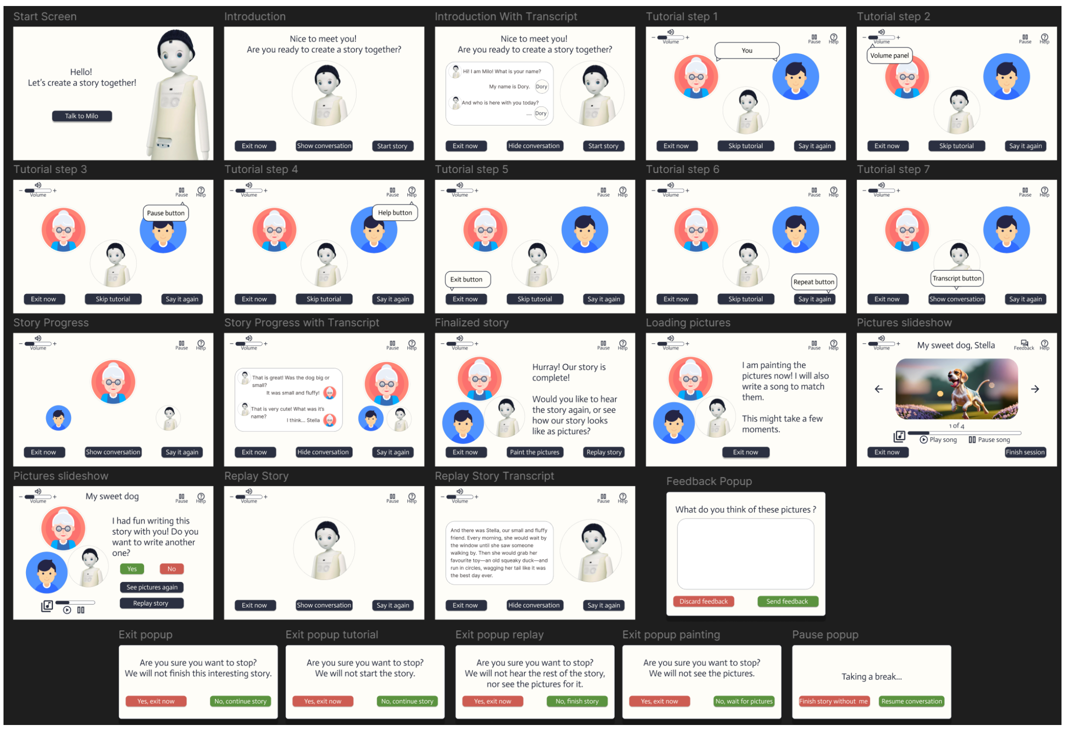

Figure 3: Final Prototype

The layout was found clear, the flow intuitive, and the visuals non-overstimulating. The interface was deemed appropriate for one-on-one sessions with minimal guidance required. All proposed changes were integrated into the final prototype (Figure 3), which informed the development of the high-fidelity minimum viable product. Detailed screenshots can be found in Appendix G.

6 Discussion

6.1 Interpretation of Key Findings

Thorough evaluation confirmed the interface as generally intuitive, emotionally safe, and overall accessible. Its use of multimodal representation, iconography, clear cues, and guided progression was well received. Nevertheless, early elements like the progress bar and mute button showed that even well-intended features can cause unintended cognitive or emotional strain for PwD. Prioritizing robot presence over text and reinforcing non-verbal cues with iconography emerged as key insights.

6.2 Challenges and Design Trade-Offs

The main challenge was balancing simplicity with functional completeness—designing an interface accessible to PwD without sacrificing meaningful features. Since direct testing with the target group was not feasible, expert and proxy feedback guided design decisions. While helpful, this may have influenced feature prioritization in ways that don't fully reflect the needs of actual users.

To prevent distress, we developed a fully functional prototype based on indirect input, enabling immediate, hands-on testing once access to the target group becomes possible, thus reducing the reliance on imagination or instruction. While further refinement may be needed, this approach offers a strong foundation for future inclusive evaluations.

6.3 Implications for Future Design and Testing

A key priority for future work is conducting evaluations for usability and emotional impact with individuals living with dementia. Their direct feedback is crucial to verify whether the current design truly promotes cognitive accessibility and engagement.

A parallel project developed AI-generated personas simulating individuals with dementia to test storytelling flows and media generation. However, they could not be used for interface evaluation due to technical and conceptual mismatches. The personas were not designed to process visual input and dynamic interaction—both essential for assessing layout clarity, navigation, and emotional response. Future iterations could be adapted for such interactions, offering a valuable intermediate testing step before involving real users with dementia.

Beyond user testing, future design iterations should expand system capabilities to better assist caregivers. Features like interaction statistics, emotional feedback summaries, and post-session insights could help relatives or staff better understand and assist the user.

A login system could further personalize the experience, allowing users to revisit previously generated stories and media. Over time, this may foster a stronger emotional bond with the application, promoting continued engagement and storytelling.

7 Responsible Research

7.1 Ethical Considerations

The goal of this research project was to design a basic interface for storytelling sessions involving a social robot, a person with dementia, and a family member. Direct testing with PwD was not feasible due to their cognitive vulnerabilities. Involving such participants would require strict ethical protocols—including specialized consent procedures, safety measures, and partnerships with medical institutions—which were beyond the project's time frame. This created an ethical dilemma: although real user insight is essential, proceeding without sufficient safeguards could cause confusion or distress to participants.

To address this, proxy evaluations were used. Five HCI students and one medical professional—selected for their relevant knowledge—participated in the evaluations. All gave informed consent and understood that no personally identifiable data would be collected.

We acknowledge that using proxies introduces limitations. Their insights cannot fully represent the emotional or cognitive responses of PwD. Challenges such as measuring emotional well-being, understanding potential distress, or interpreting verbal feedback reliably in this population remain unresolved. This constraint and its implications are discussed in the thesis.

7.2 Reproducibility and Replicability

All evaluation materials—including heuristic forms, interview guides, anonymized feedback, and Figma prototypes—are included to support transparency. The interface codebase is available upon request to support replication or further development.

Although the study is qualitative and interpretive, it followed a structured heuristic framework [20] to enhance consistency. Interview data was analyzed by a single researcher; future studies could improve reproducibility through collaborative coding.

7.3 Alignment with TU Delft Core Values

The project aligns with TU Delft's core values of Diversity, Integrity, Respect, Engagement, Courage, and Trust (DIRECT):

- **Diversity:** Although engaging with PwD wasn't possible, the design was centered on cognitive diversity and inclusive interface practices, stemming from literature, caregiver insight, and clinical expertise.
- **Integrity:** By avoiding experiments that might cause participants distress, getting informed consent, and being transparent about its limitations and methodology, the project complied with ethical standards.
- **Respect:** Proxy evaluators were chosen based on their relevant experience, and their opinions were fully taken into account and openly recorded.
- **Engagement:** With a focus on empowerment, well-being, and communication, the interface aims to promote meaningful storytelling between PwD, family, and robot.
- **Courage:** By embracing design innovation and acknowledging ethical boundaries, the project faced challenging questions about working with a vulnerable population.
- **Trust:** By not gathering identifying information, data privacy was protected, and all procedures, information, and authorizations are recorded and verifiable.

By adhering to these principles, the research demonstrates responsible innovation and technical integrity within the TU Delft ethos.

8 Conclusions and Future Work

This project addressed the research question: *"How can we design a simple interface that supports collaborative storytelling between a person with dementia and a family member,* *using a social robot?”*. Through iterative design, expert input, and accessibility-focused decisions, a working prototype balancing clarity, structure, and emotional sensitivity emerged.

The interface proposed solutions for all research subquestions:

- **Story facilitation:** A linear flow and robot narration should reduce effort and reliance on support for user engagement.
- **Progress and pacing:** Progress bars were tested and removed due to stress risks, indicating the need for adaptive pacing cues.
- **Interface components:** Clear and consistent buttons, speech-synced subtitles, and icon–text pairs should enhance understanding and clarity.
- **Input methods:** Touch was chosen for simplicity; voice was simulated for future use.
- **Feedback mechanisms:** Popups and subtle visual cues should provide reassurance without overstimulation.
- **Robot and interface integration:** The interface should align with the robot’s narration and gestures. Clear cues, synchronized prompts, and shared feedback between the robot and screen help maintain user orientation and engagement.

The absence of direct testing with people with dementia remains the primary limitation. While proxy evaluations offered insight, they cannot fully predict real user responses. Additionally, the prototype lacks full backend functionality—robot integration is still pending.

The main points of action are:

1. **Project integration:** All the projects that were conducted in parallel should be fully integrated in order for the robot to perform as intended.
2. **Testing with PwD:** Future studies should involve real users through medical partnerships to validate the design.
3. **Caregiver and personalization features:** Adding statistics, session histories, and user accounts would support long-term use.

In conclusion, this project demonstrates how structured, accessible design enables meaningful storytelling for people with dementia. Such interfaces can promote connection, joy, and memory sharing when paired with user feedback and further technical improvements.

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A Use of Large Language Models (LLMs)

Throughout the development process of this project, OpenAI's ChatGPT (GPT-4o, June 2025 version) was used as a support tool in both the research and writing processes. The LLM had strictly an assistive role that included:

- Summarizing the papers that were reviewed
- Assisting with front-end code styling when transitioning from a Figma prototype to a live, working interface (HTML/CSS formatting issues)
- Rephrasing and shortening sections to improve clarity and reduce redundancy
- Restructuring and reformatting sections to improve coherence and meet page count requirements
- Help resolve LaTeX formatting issues (arranging images and tables, formatting bullet lists)

All intellectual contributions—including research directions and decisions, system design, and written content—originated from the author. All AI-assisted outputs were thoroughly reviewed and edited to ensure they aligned with the project's scope and academic integrity.

The use of AI tools followed the university's policies on the responsible and ethical use of artificial intelligence in academic work.

Example of prompts that were used:

- (Paper provided) Summarize the following paper.
- (HTML/CSS code provided) The bottom buttons fill up the entire screen. Please add some spacing between them, and give all buttons the same width.
- Help me shorten these sections without loosing any important content. I want to avoid duplicate information. As much as possible, don't change the text, but just shorten it. Don't change the writing style.
- Please reduce the spacing between the items of the bullet list.
- Add a thin black border to all pictures.

B Low-Fidelity Prototype

This low-fidelity prototype showcases the initial design through sequential screens of the storytelling interface. Screen transitions occur through user actions, such as button presses, or system-driven events like story finalization or image generation.

Figure 4: Start Screen

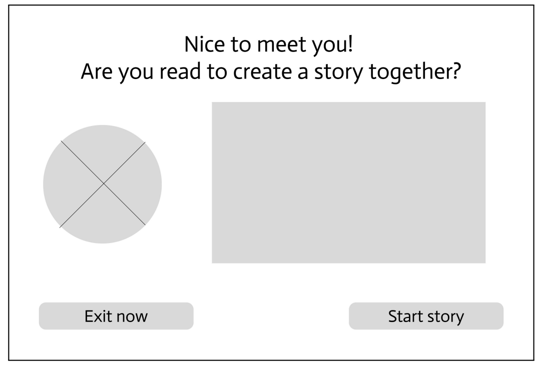

Figure 5: Introduction

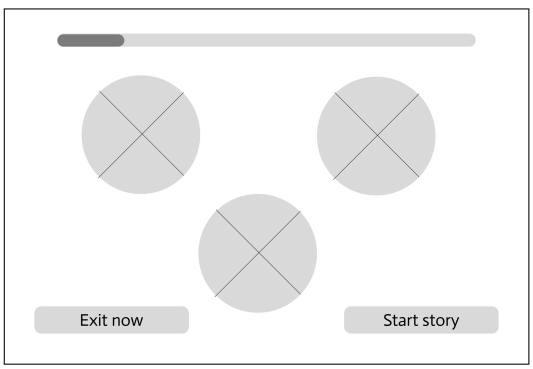

Figure 6: Tutorial Step

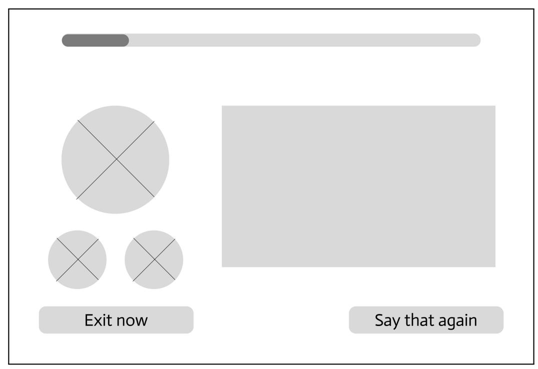

Figure 7: Story Progress

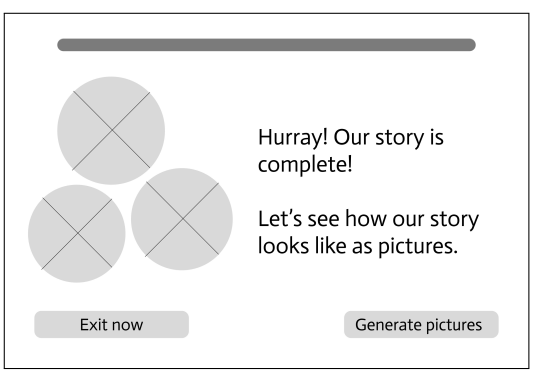

Figure 8: Finalized Story

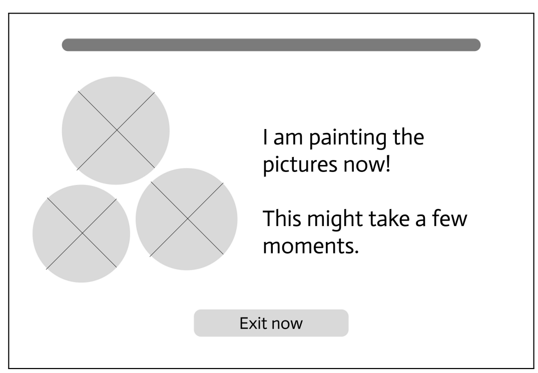

Figure 9: Painting Pictures

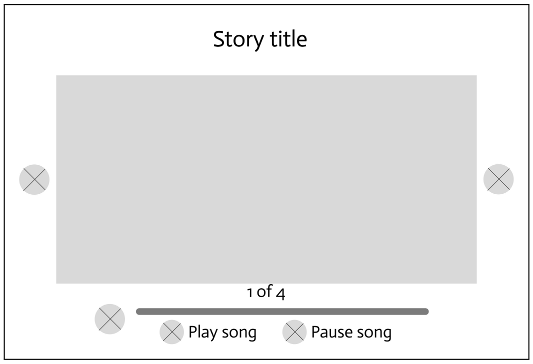

Figure 10: Pictures Slideshow

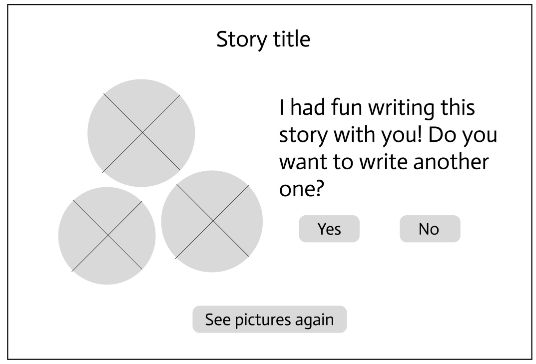

Figure 11: End Pictures

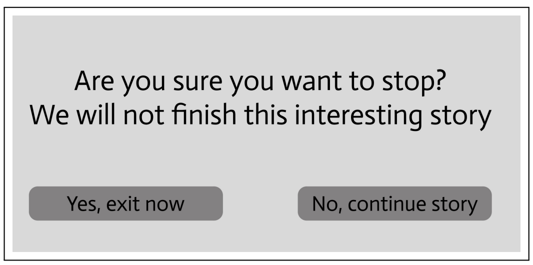

Figure 12: Exit Popup - Story

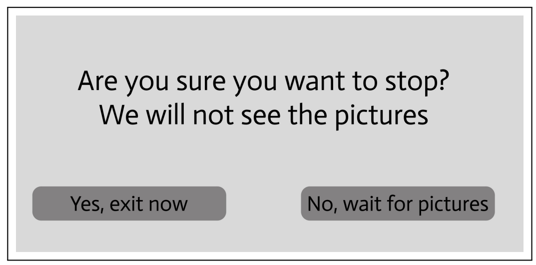

Figure 13: Exit Popup - Painting

C Mid-Fidelity Prototype

This mid-fidelity prototype showcases the design constructed during the second iteration. It incorporated improvements including simplified transcript views, mute functionality and enhanced tutorial flow. This prototype served as the foundation for expert evaluation.

Figure 14: Start Screen

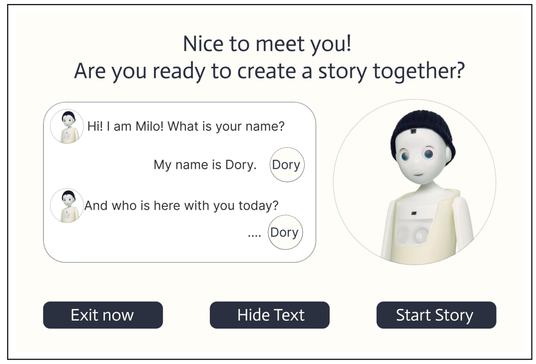

Figure 15: Introduction

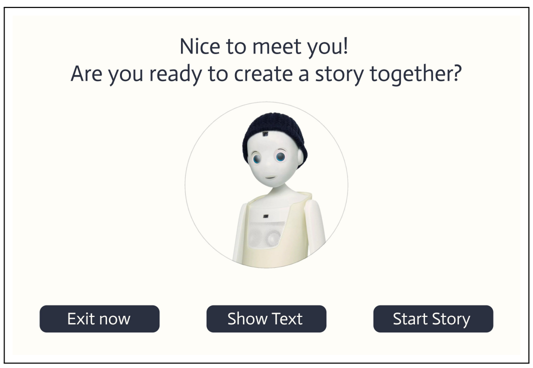

Figure 16: Introduction No Text

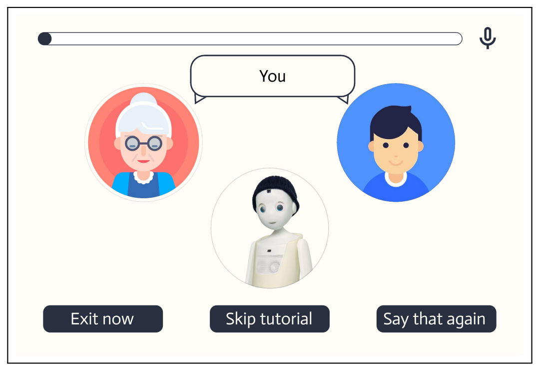

Figure 17: Tutorial Step 1

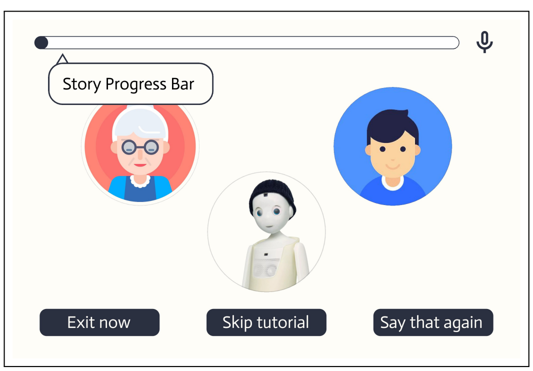

Figure 18: Tutorial Step 2

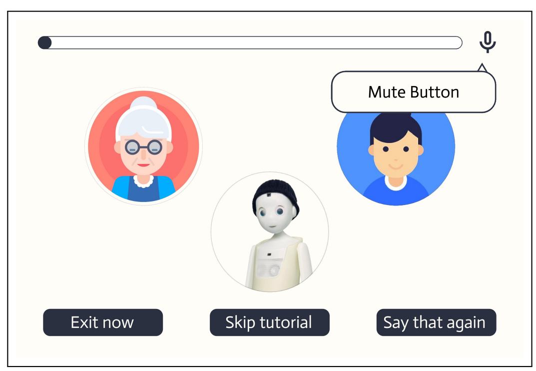

Figure 19: Tutorial Step 3

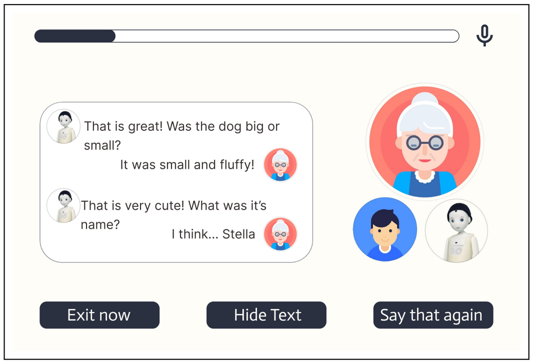

Figure 20: Story Progress

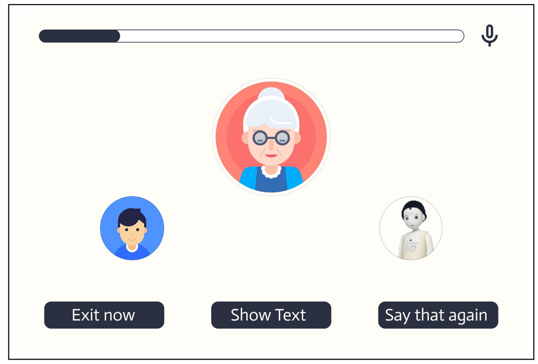

Figure 21: Story Progress No Text

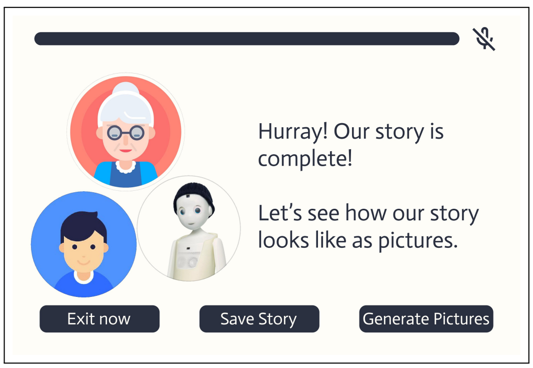

Figure 22: Finalized Story

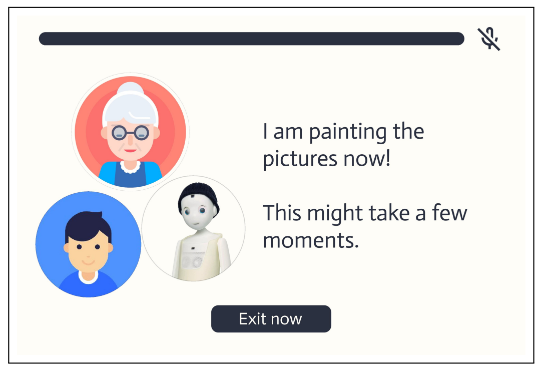

Figure 23: Painting Pictures

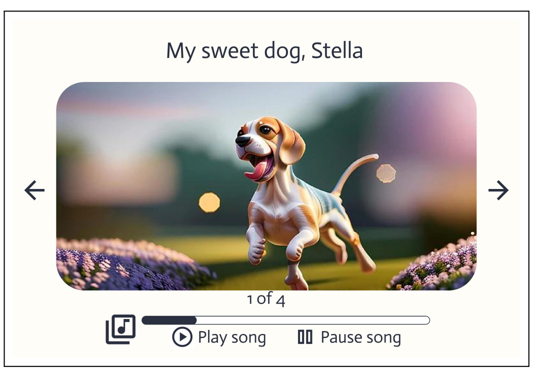

Figure 24: Pictures Slideshow

Figure 25: End Pictures

Figure 26: Exit Popup - Story

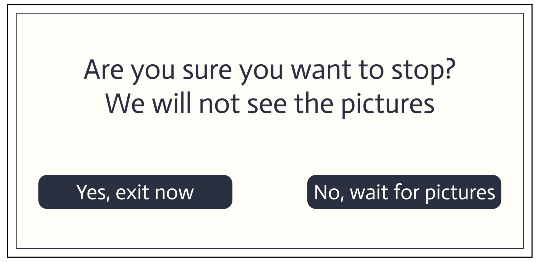

Figure 27: Exit Popup - Painting

D Consent Form - Heuristic Evaluation

Consent Form – Heuristic Evaluation

Please read the following information carefully before agreeing to participate.

Purpose of the Study

This research is conducted as part of the CSE3000 Research Project course at Delft University of Technology. In collaboration with our supervisor, our research team is designing and implementing a storytelling robot tailored to the needs of People with Dementia. The purpose of this survey is to gather feedback on the design, usability, and functionality of the interface that will provide physical and visual support during the conversation with the robot. This aims to ensure the application meets the needs of our target users. By participating, you are helping improve the application's accessibility and user experience.

Participation Details

The researcher will provide all volunteers with a Medium-Fidelity Prototype that mimics the general functionality that the final application will perform. Participants will be asked to utilize the prototype and assess it based on Nielsen's Usability Heuristics.

The researcher may ask follow-up questions to understand the user's expectations and experiences. Afterward, the participants will be asked to provide structured feedback for the design and usability of the application.

All personal data will be anonymized. The anonymized data will be used in a final report submitted to course instructors and may be used in future research or development iterations.

Withdrawal and Data Usage

Participation is entirely voluntary. You can withdraw from the study at any time without any consequences. Any personal information that could identify you will not be shared beyond the study team. Additionally, the collected data will be stored securely for the duration of this study and anonymized. Only the research team will have access to the raw data. However, both course staff (teachers and teaching assistants), as well as select TU Delft staff, such as the Board of Examiners, will be able to view the report, which will contain a summary of your responses.

Finally, members of the research team reserve the right to use the findings based on your data for personal and professional use, such as a showcase project within their portfolio, which may be published online.

Risks and Benefits of Participation

There are minimal risks involved in participating in this study. However, participants may choose to skip any question or leave the session at any time without providing a reason. You may also request access to or rectification or erasure of personal data at any time.

There is no compensation for participating in this study. Nevertheless, your insights will contribute to designing an application that enhances accessibility and usability for older adults.

Consent Form

Please tick the appropriate boxes:

Statement	**Yes**	**No**
I have read and understood the study information dated 24.05.2025. I have had the opportunity to ask questions, and my questions have been answered to my satisfaction.	☐	☐
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw at any time, without having to give a reason.	☐	☐
I agree that my information can be quoted in research outputs.	☐	☐
I give permission for my anonymized data to be archived for future research and learning purposes.	☐	☐
I understand that identifying personal information collected about me, such as my name, will not be shared beyond the research team.	☐	☐
I am over the age of 18.	☐	☐

If you have answered 'No' to any of these questions, you may not be able to participate in this study. Thank you for your time.

Signatures

Participant:

________________________ ________________ ________

Participant name **Signature** **Date**

Researcher:

I have presented the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands what they are freely consenting to.

_______________ ________________ _______________

Researcher name **Signature** **Date**

E Evaluation Form

Expert Evaluation

Thank you for agreeing to participate in the expert evaluation of storytelling robot tailored to the needs of People with Dementia. The goal of this evaluation is to gain insight into the usability and suitability of our system.

Purpose

Our goal is creating a user-interface that will provide physical and visual support during a conversation with the social robot, focused on creating a short story, in order to encourage communication, shared experiences, and moments of joy.

A person in early- or middle stages of dementia, their caregiver and the robot will be participating in such a conversation, the end goal being to create a small story. The application, through the recording capabilities of the robot, will listen and prompt back what is discussed, will highlight whose turn it is to speak, and at the end of the story will generate a set of pictures and a song, based on the contents of the discussion.

Process

You will be conducting an **Heuristic Evaluation.** Please provide your feedback in the form attached to this document. Feel free to include any screenshots that might help us understand the problems you faced or the points you are making.

Please access this link for the prototype and follow the instructions below for the evaluation.

Instructions

Explore the application on your own and evaluate it based on Nielsen's Usability Heuristics:

1. **Visibility of system status -** Keep users informed with timely and clear feedback
2. **Match between system and the real world** - Use language and concepts familiar to the users and follow real-world logic
3. **User control and freedom** - Provide easy ways to undo or exit unintended actions
4. **Consistency and standards** - Stick to common terms and platform conventions
5. **Error prevention -** Design to avoid errors before they happen
6. **Recognition rather than recall** - Make options and info visible—don't rely on memory
7. **Flexibility and efficiency of use** - Support shortcuts and customization for expert users
8. **Aesthetic and minimalist design** - Show only relevant information—avoid clutter
9. **Help users recognize, diagnose, and recover from errors** - Use clear, helpful error messages with solutions
10. **Help and documentation** - Offer simple help if needed, even if ideally unnecessary

Please write any usability issues you encounter and provide suggestions for improvement.

Heuristic Evaluation

Problem description: a brief description of the problem

Likely/actual difficulties: the anticipated difficulties that the user will encounter because of the problem

Specific contexts: the specific context in which the problem may occur

Assumed causes: description of the cause(s) of the problem

Severity: for each issue using the following scale:
- 1 = Minor issue
- 2 = Moderate issue
- 3 = Major issue
- 4 = Critical issue

Problem description	
Likely/actual difficulties	
Specific contexts	
Assumed causes	
Severity	

Problem description	
Likely/actual difficulties	
Specific contexts	
Assumed causes	
Severity	

Feel free to copy-paste the table for reporting more problems. It is much appreciated.

Additional notes:

This is the end of the evaluation.

Thank you for participating!

F Consent Form - Expert Interview

Consent Form – Expert Interview

Please read the following information carefully before agreeing to participate.

Purpose of the Study

This research is conducted as part of the CSE3000 Research Project course at Delft University of Technology. In collaboration with our supervisor, our research team is designing and implementing a storytelling robot tailored to the needs of People with Dementia. The purpose of this survey is to gather feedback on the design, usability, and functionality of the interface that will provide physical and visual support during the conversation with the robot. This aims to ensure the application meets the needs of our target users. By participating, you are helping improve the application's accessibility and user experience.

Participation Details

The researcher will provide all volunteers with a Medium-Fidelity Prototype that mimics the general functionality that the final application will perform. Participants will be asked to utilize the prototype and later asked a series of questions about the overall experience with the application, with respect to how a Person with Dementia might interact with it. The researcher may ask follow-up questions to understand the user's expectations and experiences.

All personal data will be anonymized. The anonymized data will be used in a final report submitted to course instructors and may be used in future research or development iterations.

Withdrawal and Data Usage

Participation is entirely voluntary. You can withdraw from the study at any time without any consequences. Any personal information that could identify you will not be shared beyond the study team. Additionally, the collected data will be stored securely for the duration of this study and anonymized. Only the research team will have access to the raw data. However, both course staff (teachers and teaching assistants), as well as select TU Delft staff, such as the Board of Examiners, will be able to view the report, which will contain a summary of your responses.

Finally, members of the research team reserve the right to use the findings based on your data for personal and professional use, such as a showcase project within their portfolio, which may be published online.

Risks and Benefits of Participation

There are minimal risks involved in participating in this study. However, participants may choose to skip any question or leave the session at any time without providing a reason. You may also request access to or rectification or erasure of personal data at any time.

There is no compensation for participating in this study. Nevertheless, your insights will contribute to designing an application that enhances accessibility and usability for older adults.

For any questions or requests, please reach out to *l.nitescu@student.tudelft.nl*.

Consent Form

Please tick the appropriate boxes:

Statement	**Yes**	**No**
I have read and understood the study information dated 24.05.2025. I have had the opportunity to ask questions, and my questions have been answered to my satisfaction.	☐	☐
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw at any time, without having to give a reason.	☐	☐
I agree that my information can be quoted in research outputs.	☐	☐
I give permission for my anonymized data to be archived for future research and learning purposes.	☐	☐
I understand that identifying personal information collected about me, such as my name, will not be shared beyond the research team.	☐	☐
I am over the age of 18.	☐	☐

If you have answered 'No' to any of these questions, you may not be able to participate in this study. Thank you for your time.

Signatures

Participant:

________________________ ________________ ________

Participant name **Signature** **Date**

Researcher:

I have presented the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands what they are freely consenting to.

____________ ________________ ______________

Researcher name **Signature** **Date**

G Final Prototype

This final prototype illustrates the fully refined interface following the last design iteration. It integrates all usability improvements gathered through expert and professional evaluation.

Figure 28: Start Screen

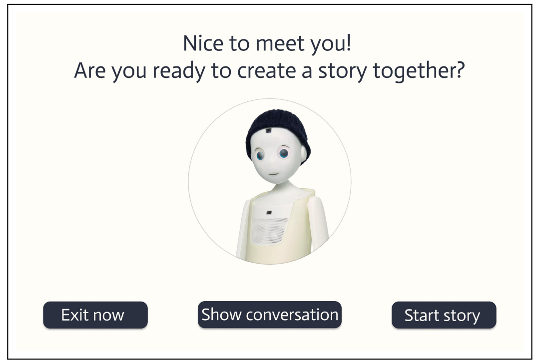

Figure 29: Introduction No Text

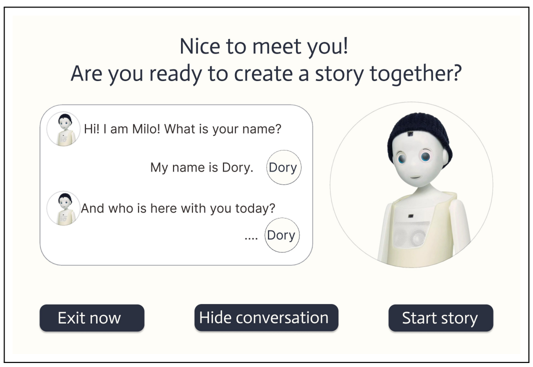

Figure 30: Introduction

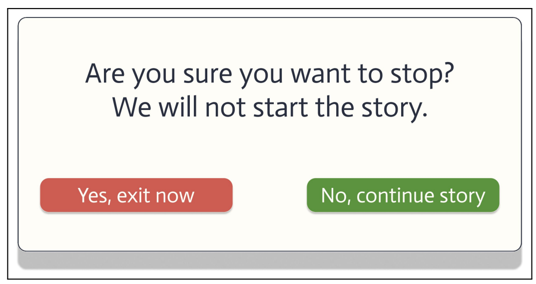

Figure 31: Exit Popup - Introduction

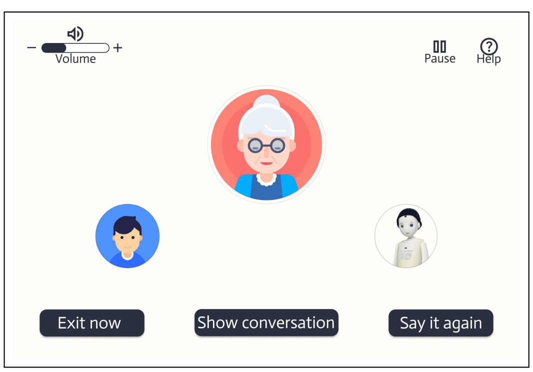

Figure 32: Story Progress No Text

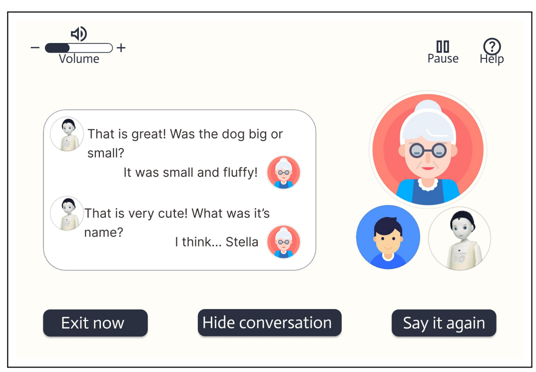

Figure 33: Story Progress

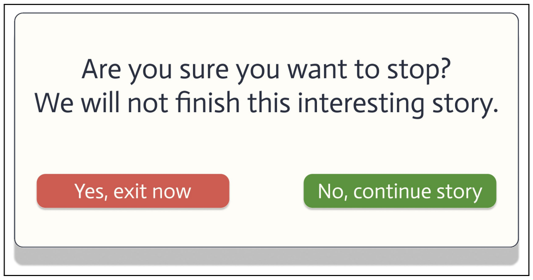

Figure 34: Exit Popup - Story

Figure 35: Finalized Story

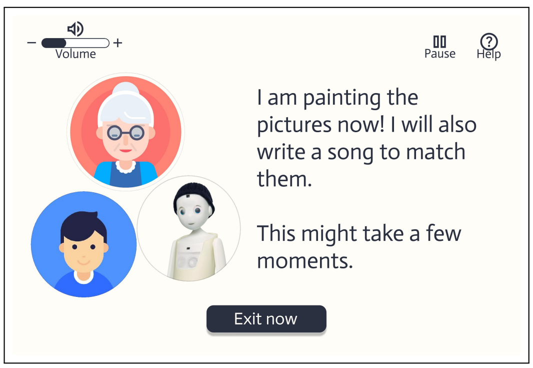

Figure 36: Painting Pictures

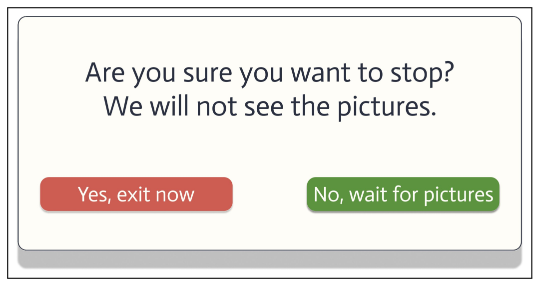

Figure 37: Exit Popup - Painting Pictures

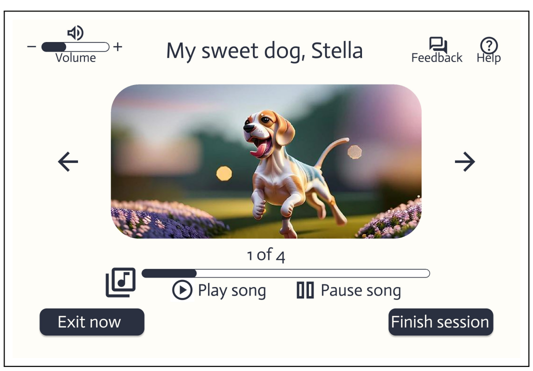

Figure 38: Pictures Slideshow

Figure 39: End Pictures

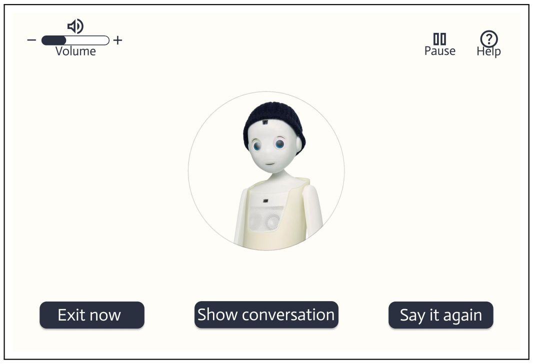

Figure 40: Replay Story No Text

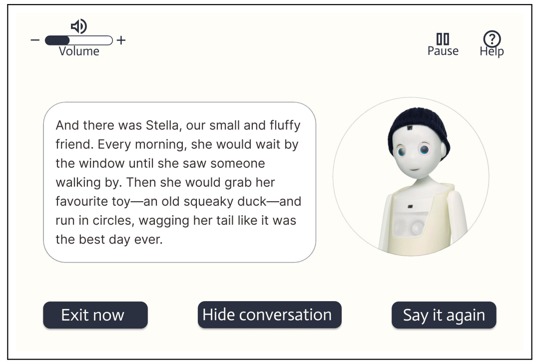

Figure 41: Replay Story

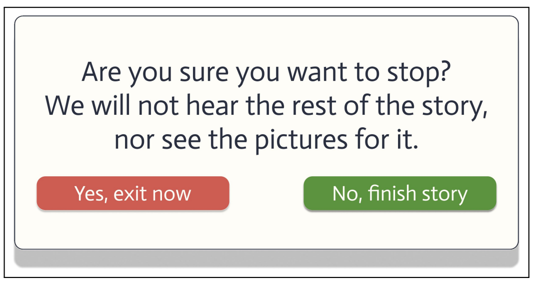

Figure 42: Popup Exit - Replay

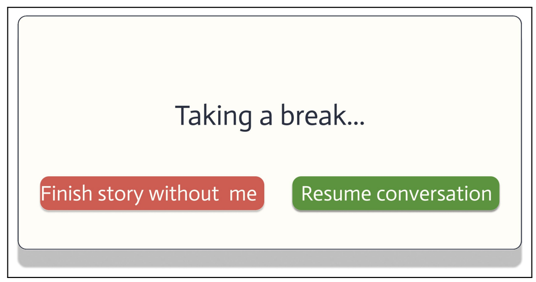

Figure 43: Pause Popup

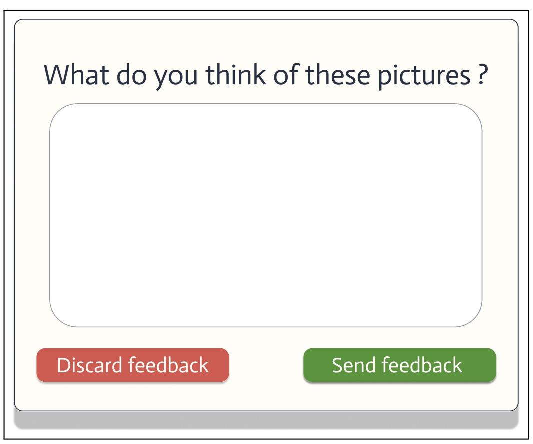

Figure 44: Feedback Popup

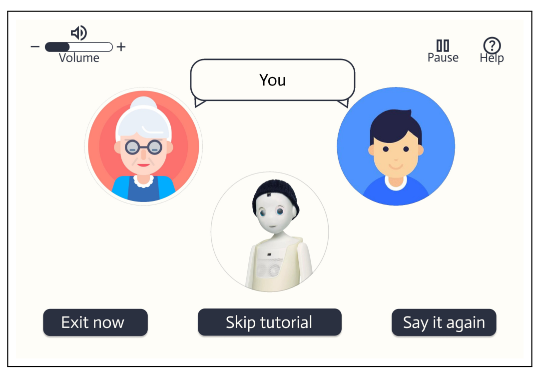

Figure 45: Tutorial Step 1

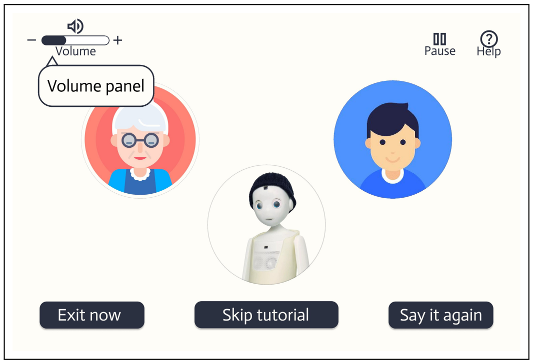

Figure 46: Tutorial Step 2

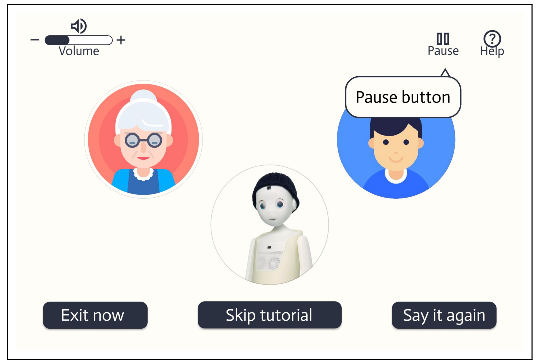

Figure 47: Tutorial Step 3

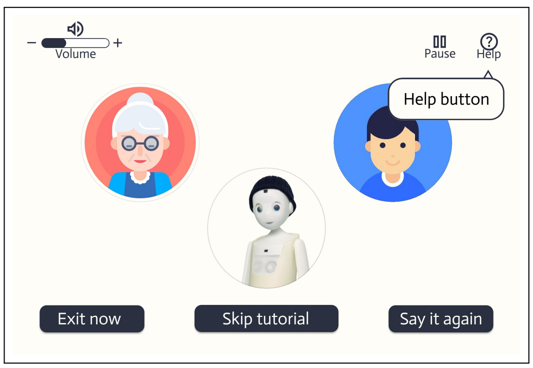

Figure 48: Tutorial Step 4

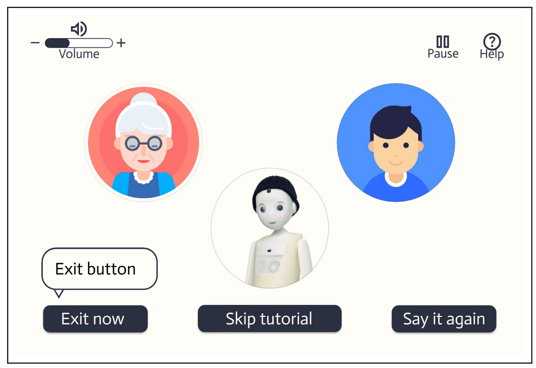

Figure 49: Tutorial Step 5

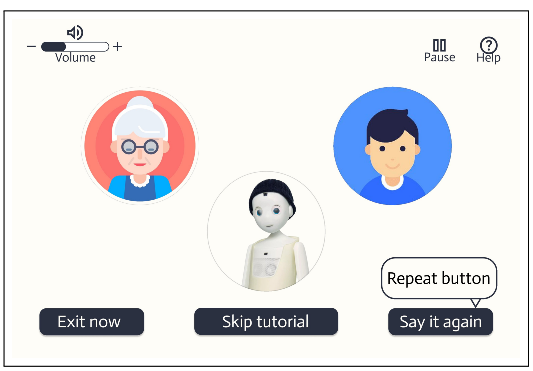

Figure 50: Tutorial Step 6

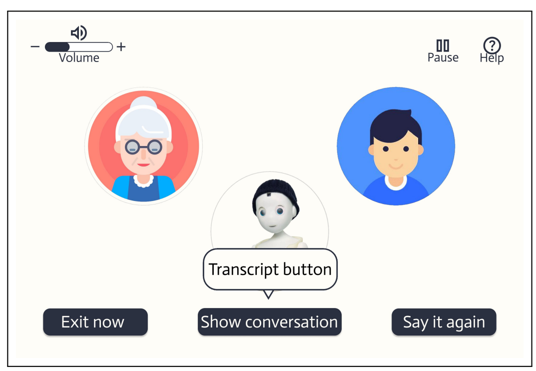

Figure 51: Tutorial Step 7