What Can I Do for You?
User-centered design

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Goal & Learning Objectives

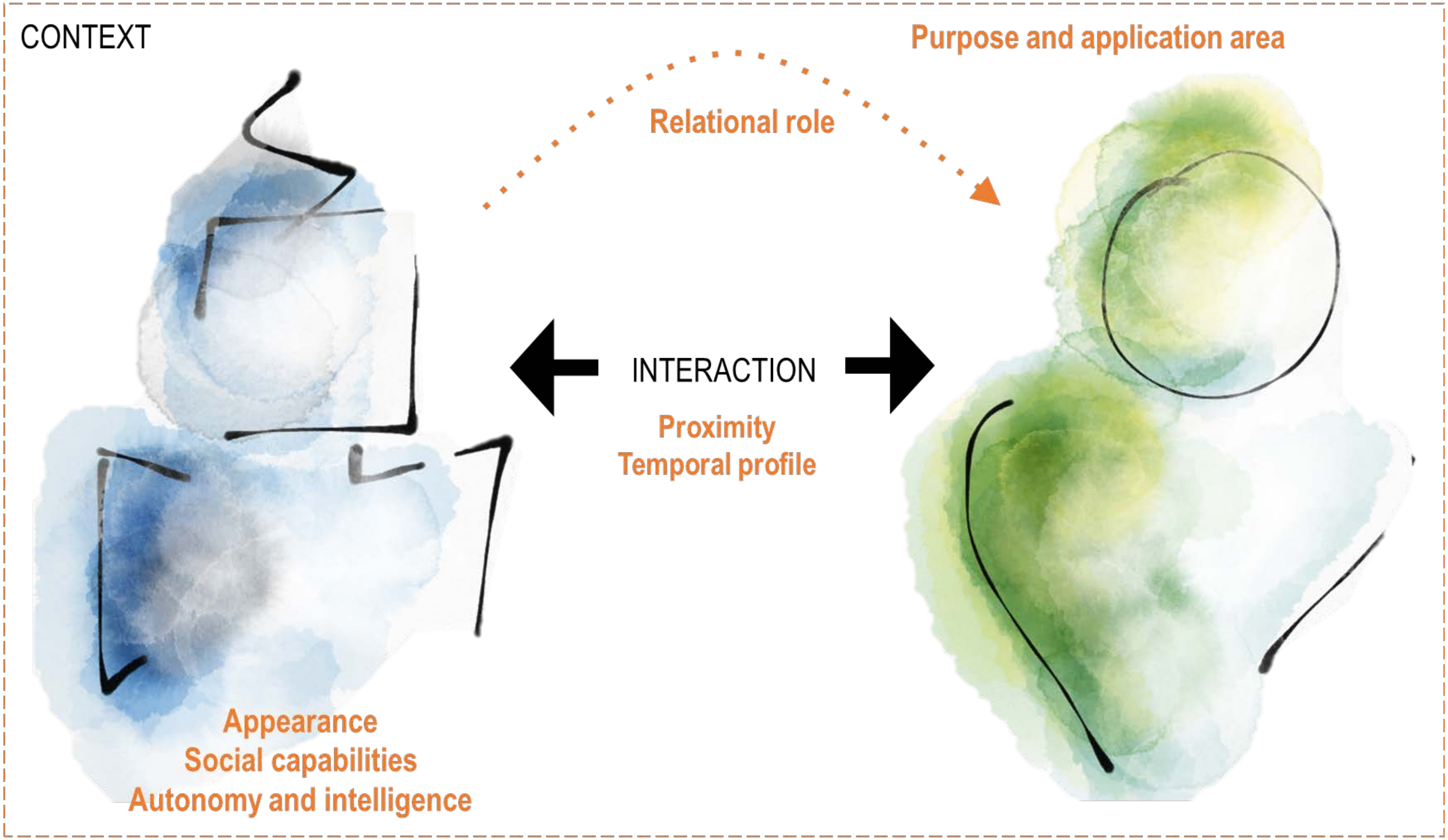
Goal:

- The goal of this lecture is to introduce you to social robot interaction design by means of reflecting on some theory and examples.

Learning Objectives:

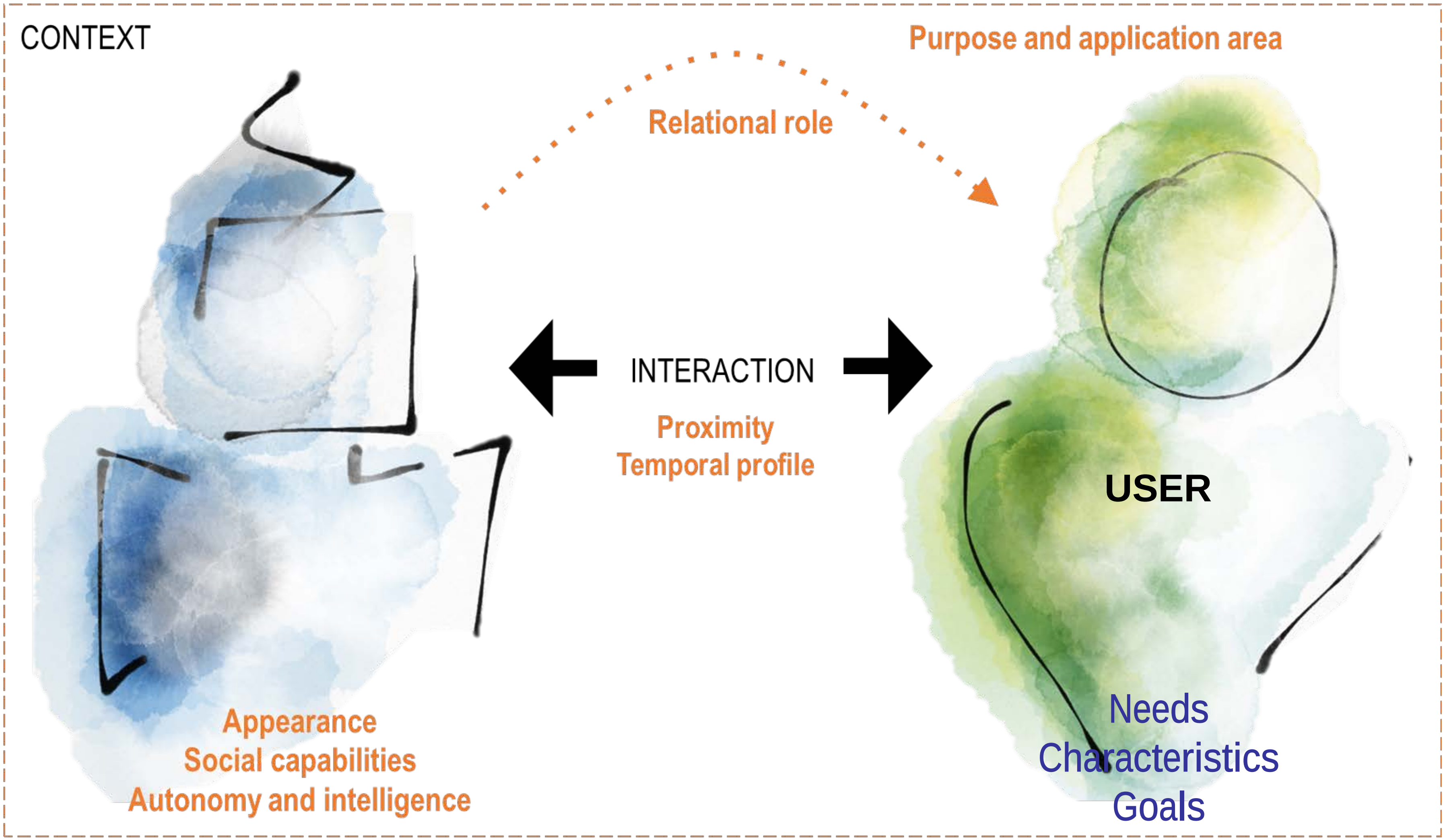
- Able to explain what social robot interaction design is
- Able to explain what robot- vs user-centered design is
- Able to explain what WoZ-based design is

Previous lecture: Social Robot Design Space



Additional dimensions relevant for design?

Previous lecture: Social Robot Design Space



Relevant ASPECTS OF USERS for design

Go to menti.com and use code **1516 7473**

Robot- vs User-Centered Design

Key issue in design: **Should technology adapt to user or vice versa?**

Robot-centered design

How can we make a robot do X?

Technology-driven frameworks for:

- processing sensor data
- decision making
- controlling actuators

User-centered design

What does a user need?

Methodologies and tools for:

- identifying user needs, characteristics, and goals
- interaction design

NB: we do not discuss mechanical engineering and the design of a robot platform itself.

Social Robot Interaction Design

Social robot interaction design is a type of interaction design where the choice of interaction technology is: a **social robot**.

– This does not mean there is no need for a **rationale** for this choice!!

- **PACT** (People, Activities, Context, Technologies) principle(*):
  – People → in Design Doc: Target Audience, Personas
  – Activities → in Design Doc: Scenarios, Interaction Design
  – Context → in Design Doc: Application Context
  – Technologies → in Design Doc: Social Robot subsection

(*)Benyon, David (2019). Designing User Experience: A Guide to HCI, UX and Interaction Design. Pearson UK. pp. 2–17. ISBN 9781292155531.

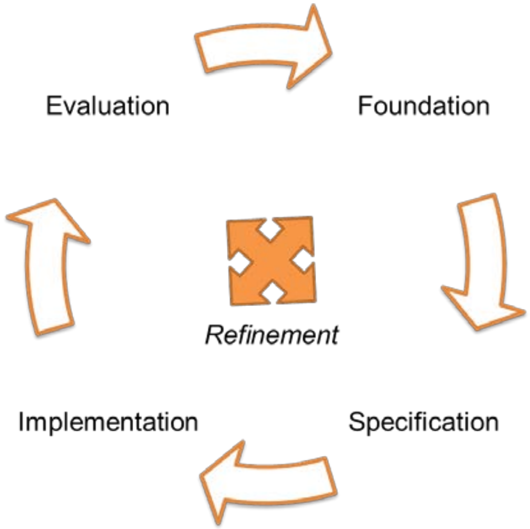
“Paradox” of HRI design methodologies

Is a (social) robot the right interface in the first place?

User Centered Research

Definition

A set of methods to gain powerful insights into the ‘actual’ practices, habits, needs and values of the users you are designing technology for, rather than purely having to rely on your own perceptions, assumptions and preconceptions.



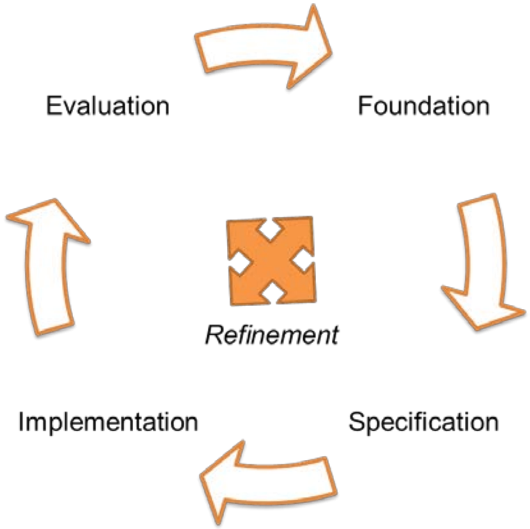
Lofthouse, V. A., & Lilley, D. (2006). What they really, really want: user centered research methods for design. In *DS 36: Proceedings DESIGN 2006, the 9th International Design Conference, Dubrovnik, Croatia*.

Why User-Centered Design?

Go to menti.com and use code **2157 4095**

Why User Centered Research?

- Reduce risk for poorly designed or misused technology.
- Provide insight into the complex relationship between people and technology.
- A persuasive tool for communicating user wants and needs to the whole team.



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Designing for transparency

Transparency of communicability of a robot design ensures that it is transparent to a user what the capabilities and/or roles of the robot are.

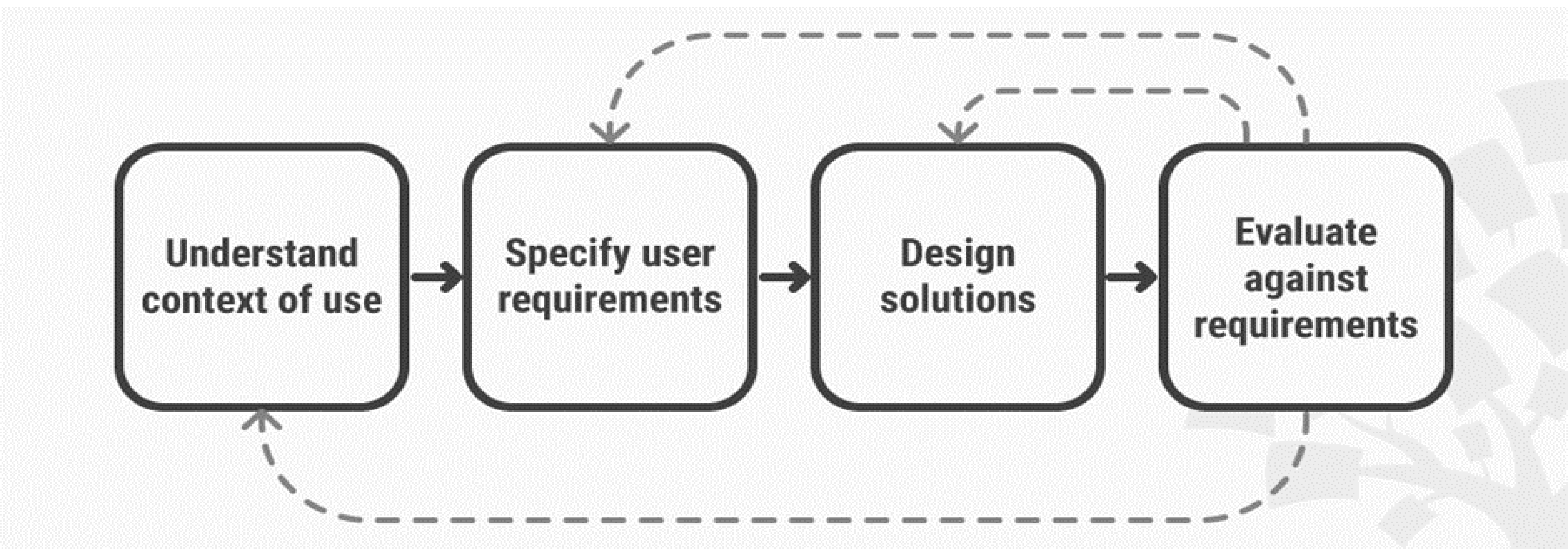
Go to menti.com and use code **5792 4020**

What is this robot doing here?

Ideas for creating transparency for users:

- Have the robot explain itself using speech at the start of the interaction with a user.
- Have a secondary user introduce the robot to a primary user, e.g. a teacher introduces a math tutor robot to a student.
- Change the appearance of the robot to more clearly signal the main function or role of the robot (using, e.g., clothing, displays).
- Design and modify the context the robot is placed in to signal what service the robot is offering (using, e.g., signs or banners next to the robot).
- …

User Centered Design

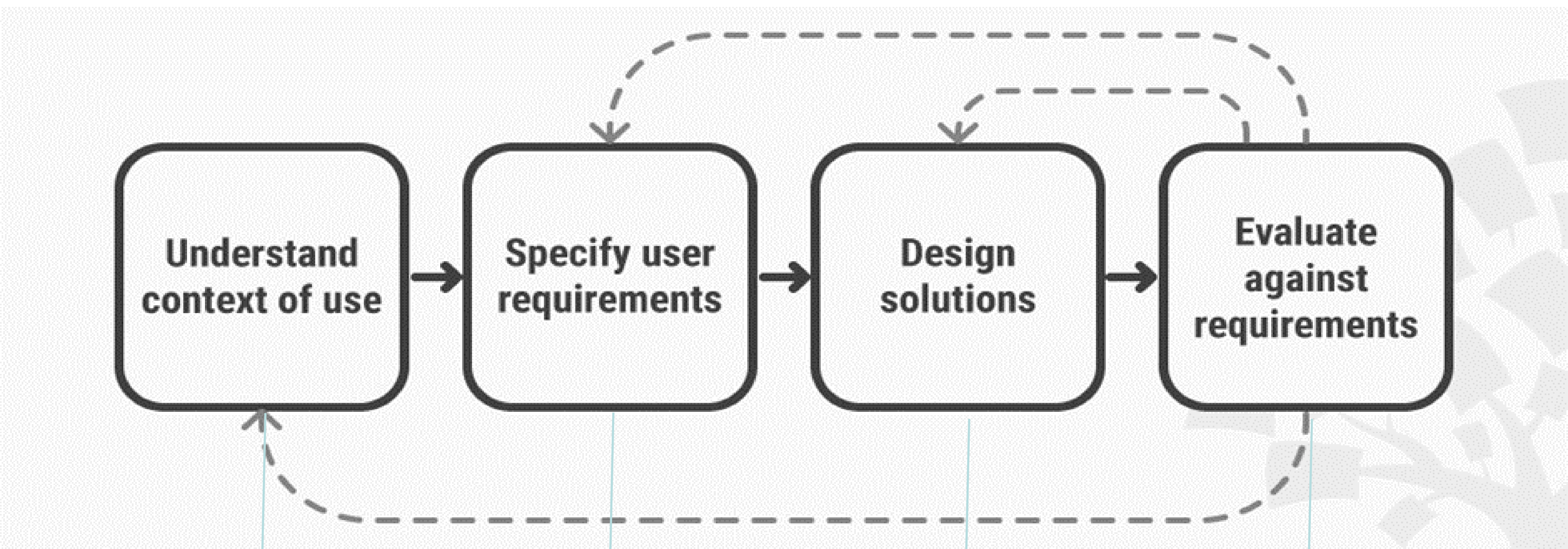


An approach to system development by focusing on the **end user**

Four principles:

- Early user involvement
- Empirical assessment
- Iterative design
- Multidisciplinary teams

User Centered Design: Methods



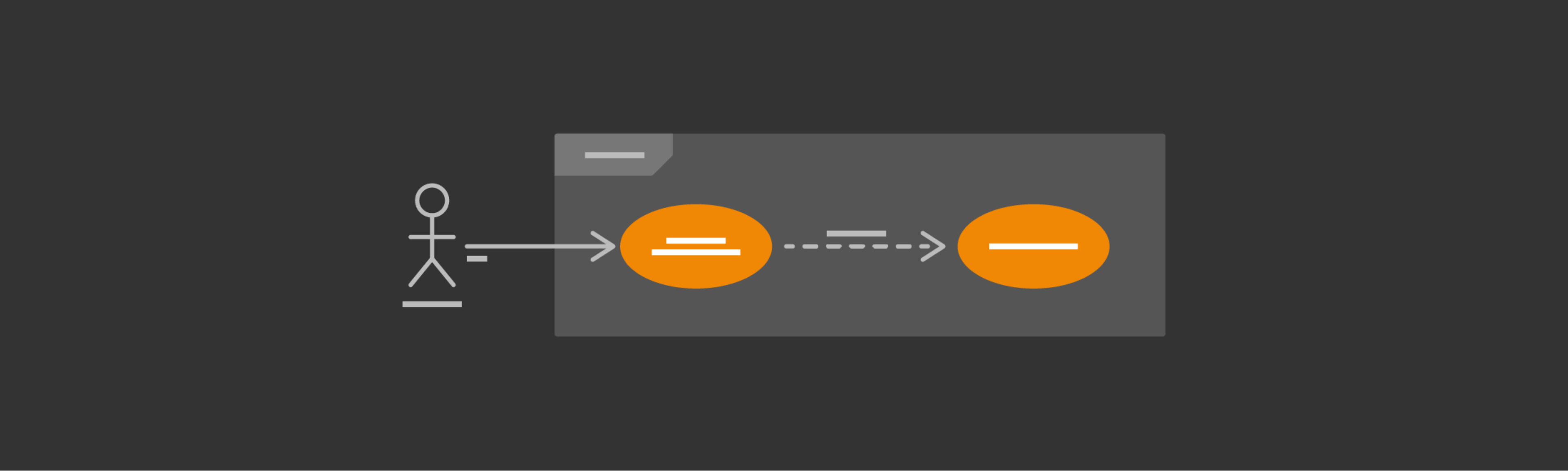
Contextual inquiry Focus groups Interviews **Human factors knowledge**	**Personas Scenarios Requirements & Claims**	**Design ideas Use case Interaction diagram Implementation**	**User study (Field/Lab)**

Assignment: Human Factors Knowledge

- One or more insights obtained from a paper that you reference that can serve to guide your design.

- The insight(s) should be concrete and be useful to further develop the design.

- **One or more specific human characteristics** of the problem target group should be specified and discussed, which clarify the problem that is addressed. These characteristics should be taken into account later in the design specification.



INTERACTION DESIGN – USE CASE

Use Case –Detailed Interaction Specification

- A **use case** is a detailed specification of:
  - the **objectives**, the **actors**, and interaction **steps** between actors;
  - the **conditions** assumed by the use case, and any **requirements** and **claims** to its effectiveness.

How detailed should a use case be?

- A use case should be so specific that another group is able to re-implement the same steps. *Provide enough detail to reproduce the use case design.*
- Steps should be elementary (as simple as possible) and should not consist of two very different actions (e.g., “The parent turns on the robot and sends the child to its bedroom”). *Split steps into simpler steps whenever possible.*

Your ideas for a use case

Go to menti.com and use code **4232 9491**

HERO Use Case – Title & Objectives

Title:

- UC01 - Meeting the robot for the first time

Objectives:

- Objective 1: initiate the bonding process between the pediatric oncology patient and the robot

- Objective 2: the robot learns about the child's preferences and hobbies

Use Case – Conditions

Pre-condition:

- The child is in a room waiting for the child-life specialist.

Post-condition:

- A first step in developing a bond between the child and the robot has been made.
- The child likes the robot.
- The robot has learned about the child's preferences and hobbies.

Use Case – Actors

- Pediatric oncology patient (primary user and active participant of bonding process)

- Robot (initiates bonding process)

- Child-life specialist (introduces the robot)

Use Case – Happy Flow

1. The **child-life specialist** enters the room with the robot.
2. The **child-life specialist** places the robot on the floor and asks the child to sit directly in front of the robot.
3. The **robot** introduces itself by telling its name and its role in the hospital.
4. The **robot** asks the name and age of the child.
5. The **robot** asks if the child wants to see it dance.
6. The c**hild** answers: if yes → the robots performs the dance; if no → the robot will tell a joke instead.
7. The **robot** asks which sport is the child's favorite.
8. The **child** names it's favorite sport.
9. The **robot** asks the child why that sports is their favorite.
10. The **child** explains why this sport is its favorite sport.
11. The **robot** responds enthusiastically to the story.
12. The **robot** shares a story about its own favorite sport.

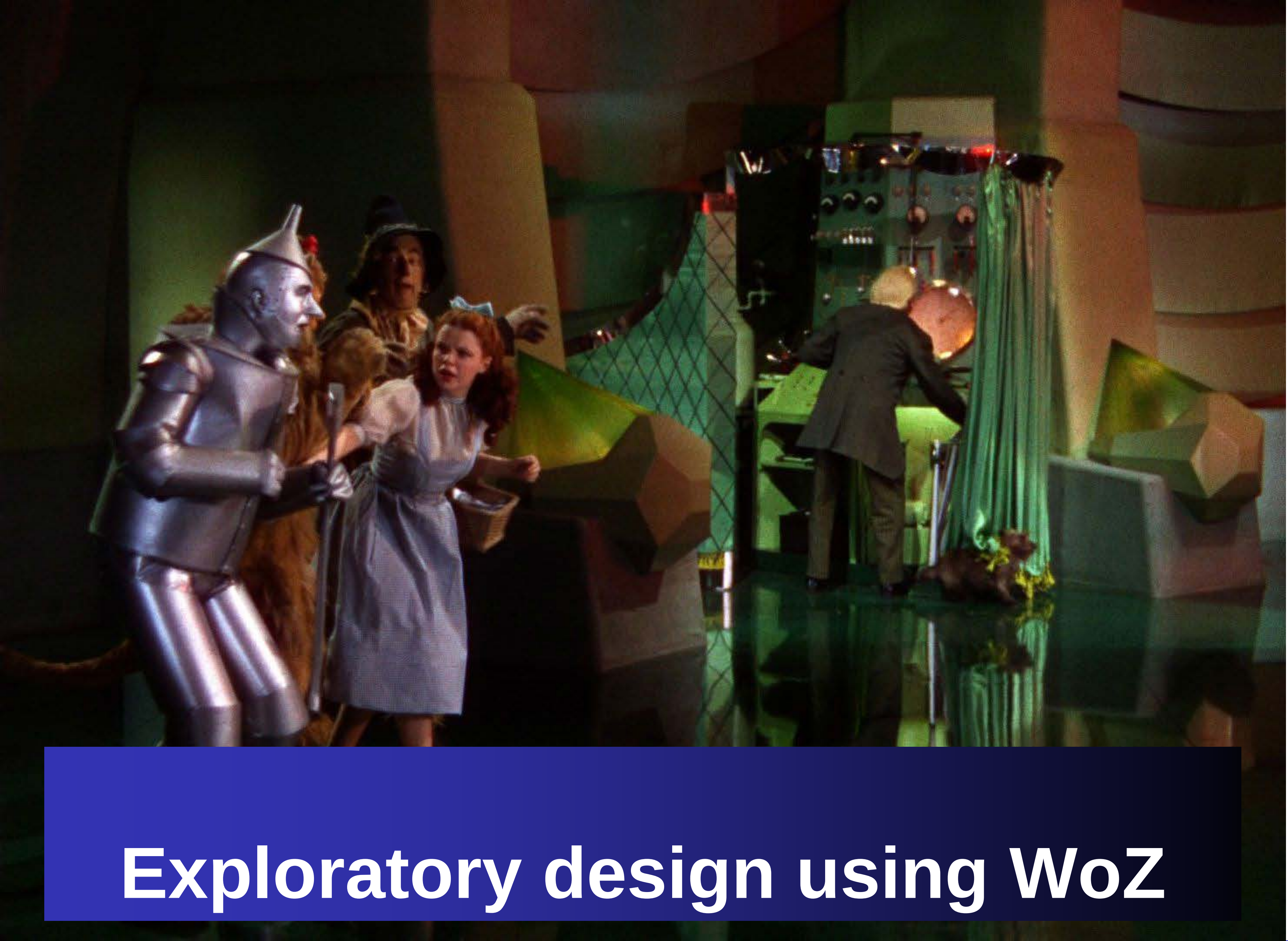
Alternative Flow

Alternative flows specify flows that the system also supports that are different from the happy flow.

For example:

- The child indicates it has no favorite sport (does not name favorite sport in step 8 in the happy flow.
- Instead of naming a favorite sport the child asks the robot what its favorite sport is.

Technical issues do not give rise to alternative flows, e.g. speech recognition failures, robot falls, etc. are implementation issues, not interaction design specification issues.



Exploratory design using WoZ

Wizard of Oz (WoZ)

WoZ interface is an interface that provides buttons for classifying and recording user behavior and for generating robot responses.

WoZ does interpretation of what human users do and say;

and/or

WoZ controls the robot's responses.

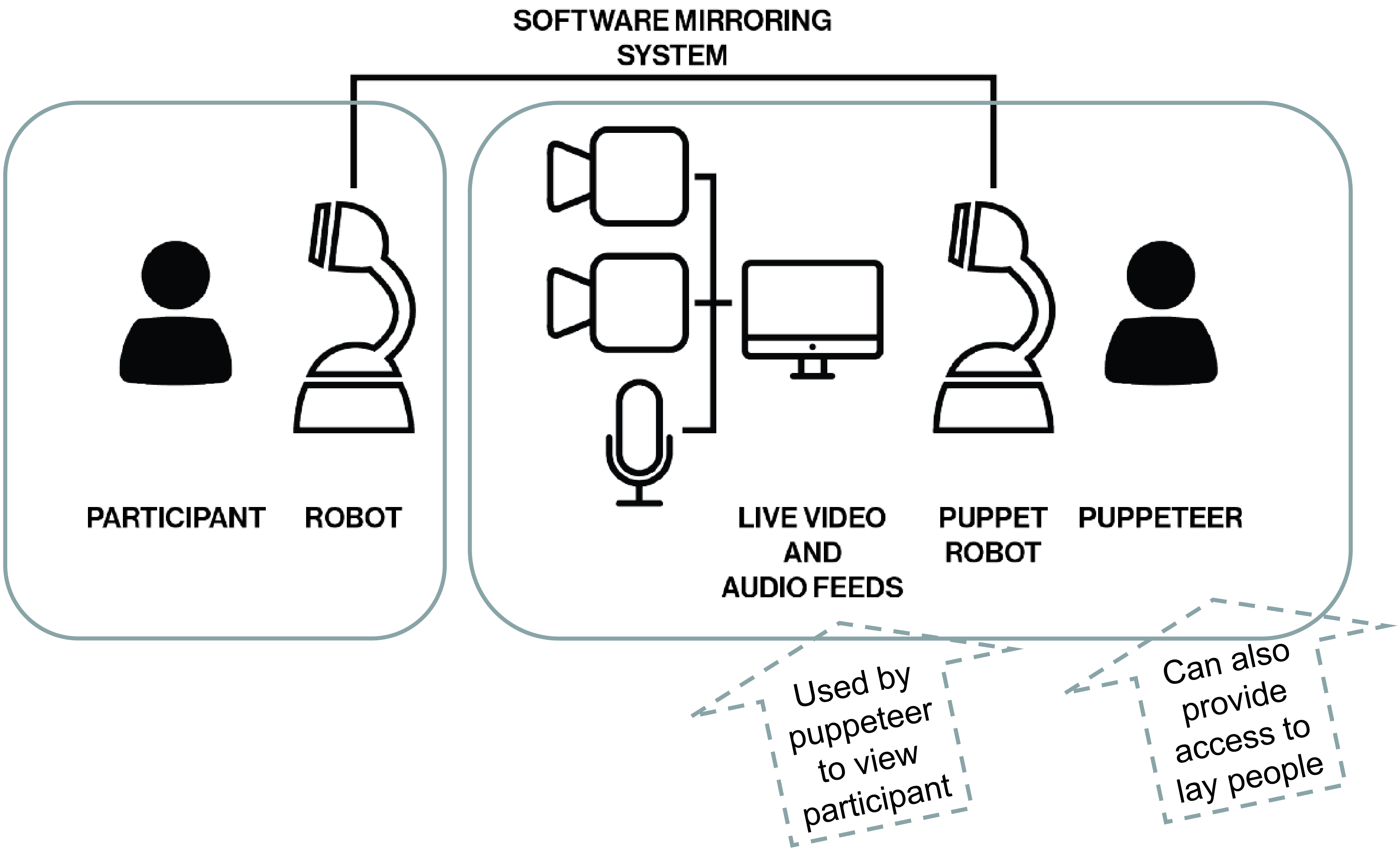
Use of WoZ for design vs evaluation

- WoZ interface available as part of SIC: https://socialrobotics.atlassian.net/l/c/corNdmJR
- Design *vs evaluation*: Use WoZ as a generative design technique *instead of an experimental one*
- In this course, your prototype should be automated (no use of WoZ for evaluation)

Reasons for using WoZ for design

Go to menti.com and use code **4204 3964**

WoZ Puppeteering Approach

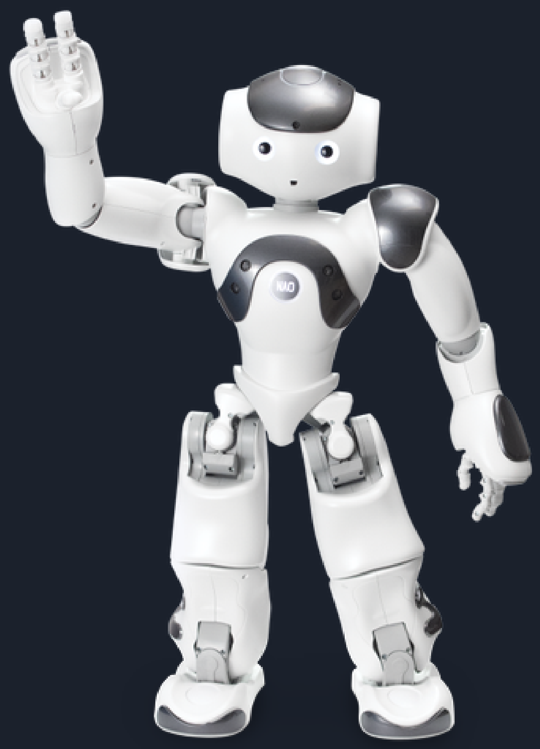


See for more details the PAPERINO paper: https://doi.org/10.1145/3272973.3272994

Co-creation as a Facilitator for Co-regulation in Child-Robot Interaction

Mike E.U. Ligthart, Mark A. Neerincx, and Koen V. Hindriks

Problem



Hero

Supporting children with cancer with a social robot companion.

Previous work: Narrative dialogue

Through conversation, the robot tells about itself and its adventures. It offers an engaging distraction and supports the development of a supportive relationship.

However

To keep the interaction manageable the robot takes a lot of control, undermining children’s ability to co-regulate the interaction.

How can we address Hero’s problem?

Go to menti.com and use code **2846 6405**

Add more co-regulation opportunities

USER CHARACTERISTIC: Children have different preferences for how to co-create with the robot

- Create expressive content all day, every day
- Not comfortable to create expressive content
- First want to see how it goes and try it out later in the conversation
- ...

DESIGN DECISION: To accommodate for these varying levels of desired involvement (user preferences), we included a step in the co-creation process that allows children to indicate their level of involvement.

Co-creation

Creating expressive content for the robot to use during the conversation.

Sound effects

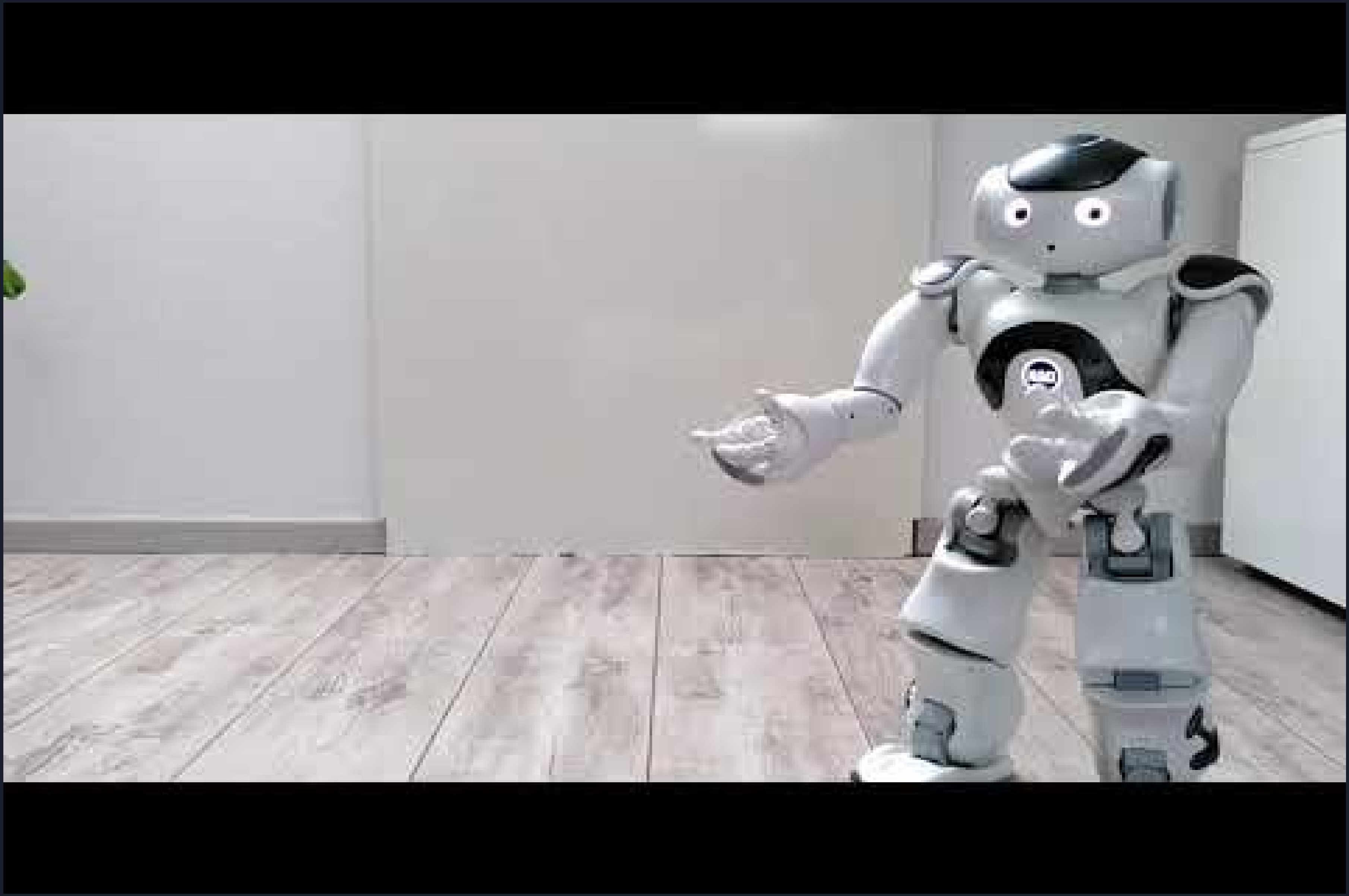
Gestures

Light show

Rationale: the act of co-creation strengthens children’s sense of agency

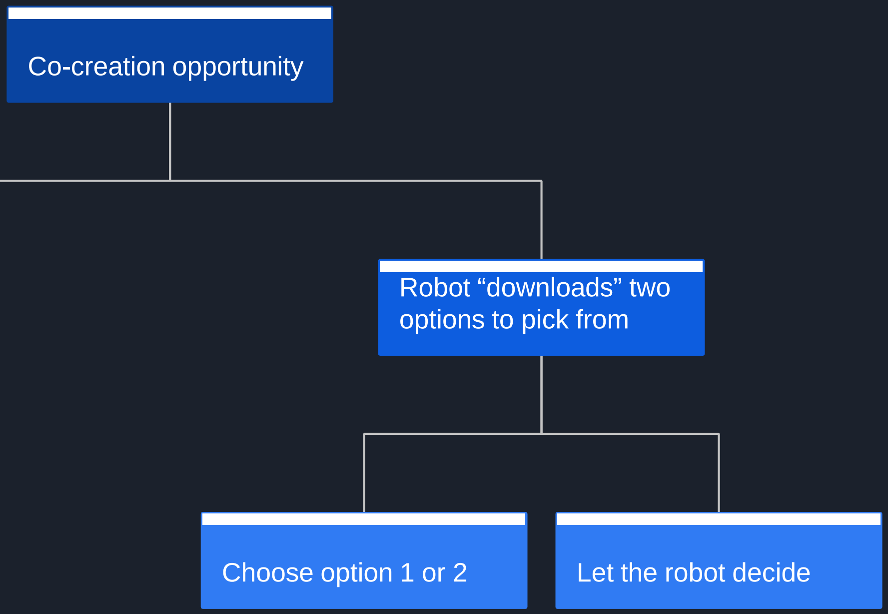
Co-creation of
sounds

Co-creation of
gestures

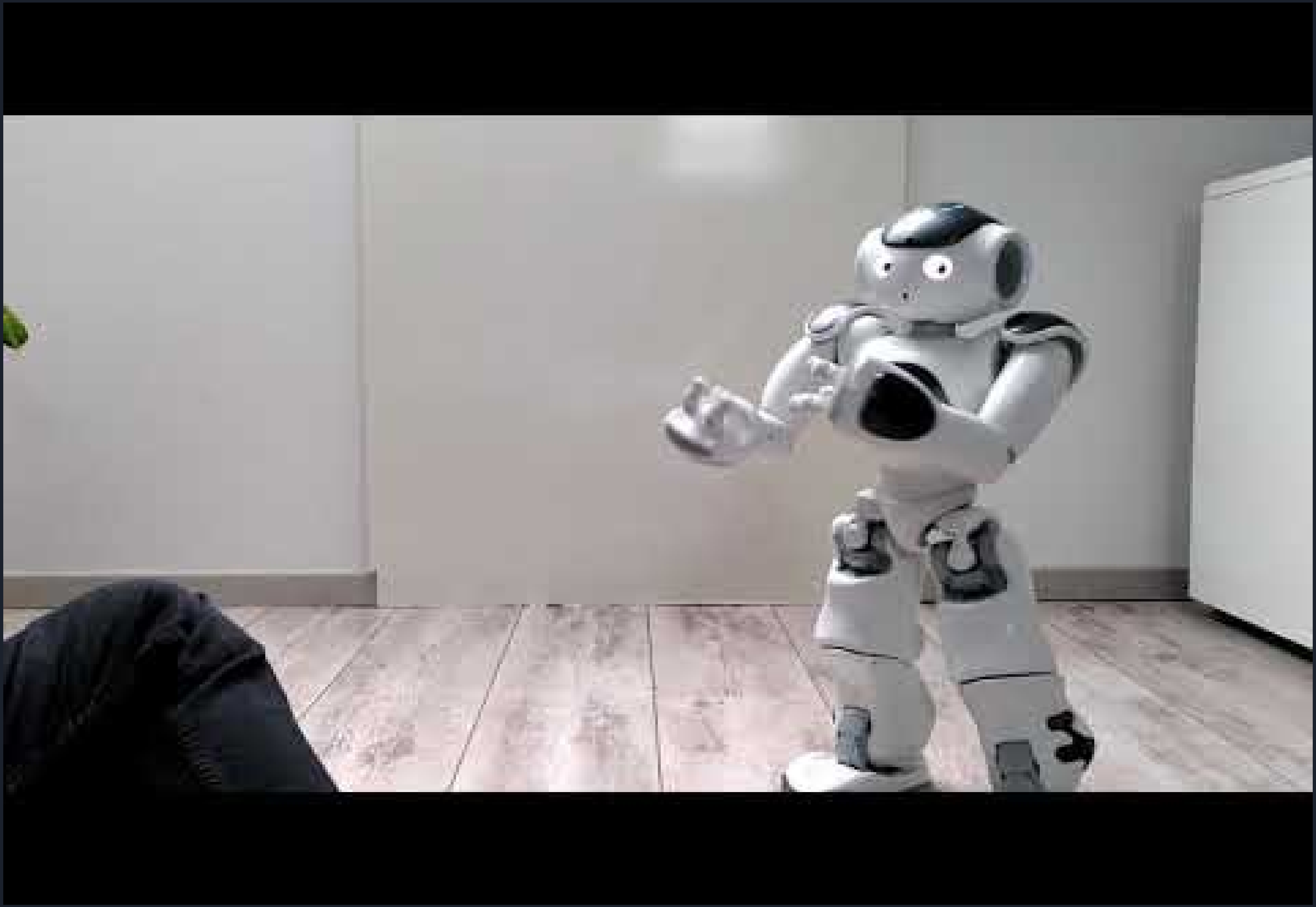


Co-creation of
light shows

Coordination of involvement



Rationale: when the robot offers children the opportunity to coordinate their involvement they accept the robot more and are more satisfyed with the interaction.



Coordination
of involvement

User study

59 participants (school children; 28 girls and 31 boys; 7-11 y.o.)

Hypotheses | when enabled to co-create

H1: children experience more agency.
H2: children are more satisfied with the interaction.
H3: children accept the robot more.

Between-subject | two conditions

Co-creation

- With coordination of involvement
- All co-creation possibilities

Control

- No coordination of involvement
- Forced choice between two “downloaded” options.

Procedure

20 min one-by-one narrative conversation with robot
- incl. how-to tutorial
- incl. 2 co-creation opportunities for each modality

10 min questionnaire
- 5-point likert scales: sense of agency, satisfaction with interaction, robot acceptance

Results

Procedure
Scores: median [quartiles]
Test: Mann-Whitney U (significant level: $\alpha_{\text{bonforoni}}$=0.016)

Sense of agency
Co-creation (4.7 [3.7, 5.0]) | control (3.7 [3.3, 4.3])
U(59)=639, p=.001, d_{cohen}=.89.

Satisfaction with the interaction
Co-creation (4.7 [4.7 5.0]) | control (4.7 [4.3 5.0])
U(59)=445.5, p=.829, d_{cohen}=.053.

Robot acceptance
Co-creation (4.6 [4.3 5.0]) | control (4.0 [3.5 4.5])
U(59)=661.5, p=.0004, d_{cohen}=1.02

Conclusion

Co-creation facilitates CO-REGULATION

It provides a novel way for children to add something to the interaction.

new robot SOCIAL ABILITY enabling children to coordinate involvement

One that is recognized and greatly appreciated by the children, reflected by their improved sense of agency and acceptance of the robot.

Robot PERSONALIZES interaction with children.

It is a step towards a more inclusive robot. Catering to children with different needs and preferences for their interaction with the robot.

A Robot Math Tutor that Gives Feedback

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Sander Liebens
Technical University Delft

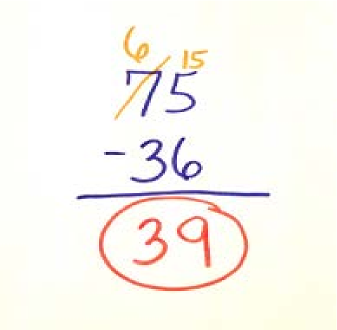
Teaching Math

Frontal teaching instruction

One-on-one teaching instruction

Our focus

Math Problems



Domain of addition and subtraction, for sums and differences up to 100. (2-digit addition and subtraction)

Categories:
- Passing tens: 7 + 6
- Adding tens and units: 37+31
- Adding tens and units, passing tens: 67+14
- Through tens: 12-5
- Remove tens and add later: 53 – 2
- Tens minus tens and units: 38-17
- Tens and units, through tens: 46-18

Calculation strategies:
- Jump: 34 + 27 = 34 + 20 + 7 = 61
- Split: 34 + 27 = 30 + 20 + 4 + 7
- …

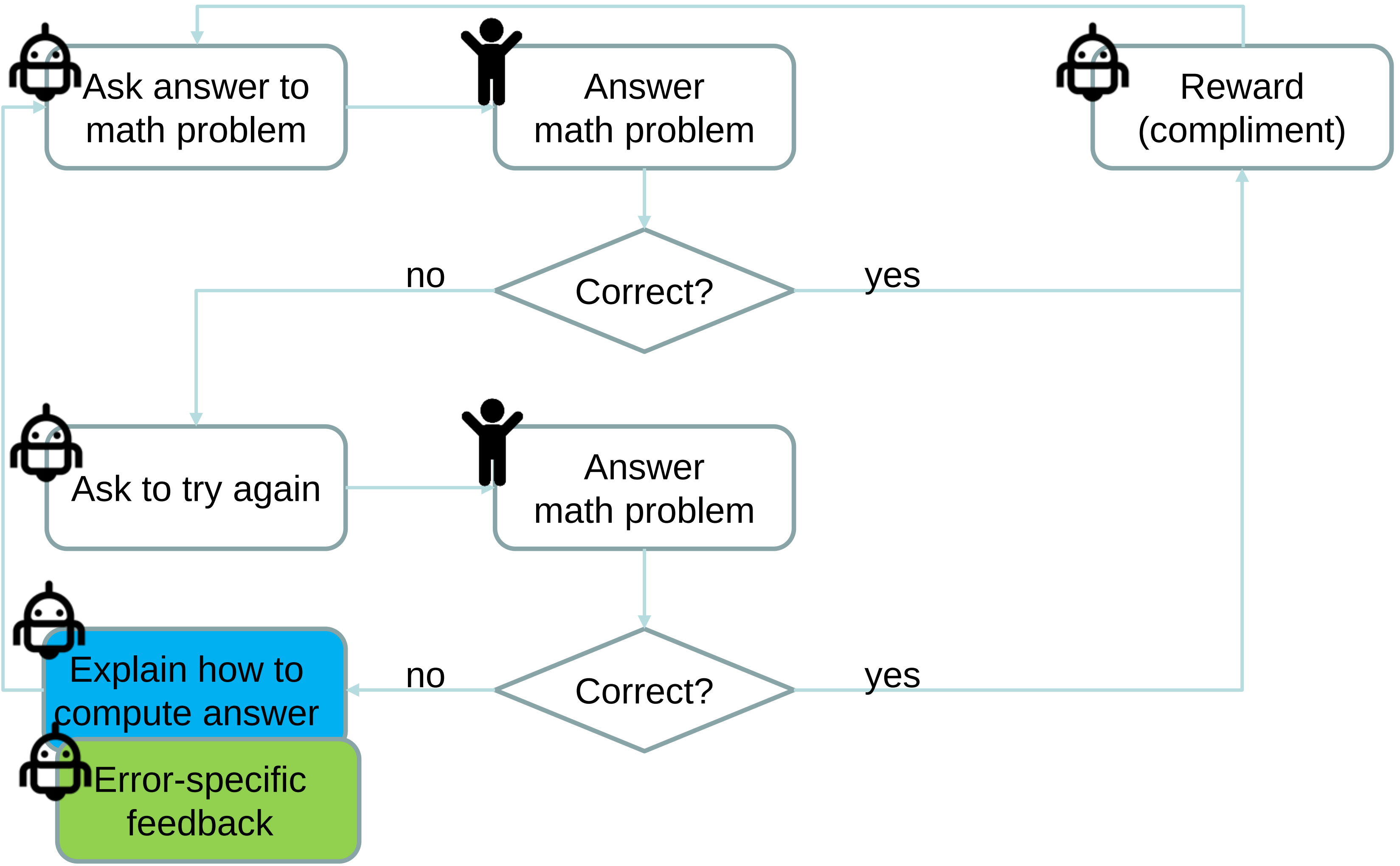
Provide additional training to children aged 8-9 (third grade)

Error-Specific Feedback

One of the most powerful influences on learning and achievement

How to design a social robot that can provide **error-specific** feedback on answers to math problems?

Basic Interaction Flow



Identify Kind of Mistake (1/2)

- Children typically and naturally engage in thinking aloud behavior when trying to solve a math problem with a robot.
- However, complicated to identify kind of mistake made from children's speech.
- We tried to identify kind of mistake from (final) answer given.

Interaction Design Pattern 1: Focus Speech Recognition on Answer

Problem	When asked to answer a question by a robot, children may engage in thinking aloud while trying to compute the answer to the question. Children's speech while thinking aloud is harder to recognise as speech volume, for example, is varied more. Both the longer and more complicated speech produced (instead of providing only the answer) and the variation in speech parameters complicates the natural language understanding, in particular the identification of the answer.
Principle	We do not want to restrict children in the way they compute an answer, and allow them to engage in thinking aloud and other interaction (e.g. asking another child sitting next to them). Instead, to provide an answer, a child is asked to indicate it is ready and focused to provide an answer.
Solution	A child is asked to indicate that it thinks it knows the answer to a question by means of a touch sensor. Touching the sensor will activate speech recognition and the robot will then listen for an answer for a specified period of time.

Table 1. Interaction Design Pattern: Touch-Based Speech Activation

Identify Kind of Mistake (2/2)

Four commonly made errors:

- missing the last step: 7 + 5 = 7 + 3 = 10
- visualizing number incorrectly: 83 instead of 38
- split and add error: 32 - 14 = 22
- using the wrong operator: 7 + 5 = 7 - 5 = 2

→ Designed error-specific feedback for these errors.

Interaction Design Pattern 2: Error-Specific Feedback

Problem	Children make a variety of errors when answering math problems, in e.g., the addition and subtraction domain. Feedback is more effective if it can target the error made more specifically.
Principle	We want to provide feedback that specifically focuses on the type of error a child makes. The robot should be able to explain *what* went wrong to help the child understand its mistake but also allow a child to correct the error to learn from it.
Solution	An algorithm is used to classify the type of error a child makes when answering math problems. Feedback is designed to specifically explain what the child did wrong to help the child understand how to fix the error in a step-by-step fashion. If the type of error cannot be classified, simply provide feedback that the answer is incorrect. In any case, allow the child to retry and provide an answer to the same problem again. If an incorrect answer is provided for the second time, indicate this and have the robot explain how the correct answer can be computed.

Table 2. Interaction Design Pattern: Feedback Targeting Specific Error

Evaluation

Measures:

- task performance (repeated math tests),
- affection (PANAS), and
- interaction (observation, logs)

Hypotheses:

- Feedback increases scores on math problems
- Children like robot that gives feedback more

User Study: Setup

- Feedback, control group:
  - both groups received correct/incorrect feedback, only feedback group got error-specific feedback.
- Week 1:
  - Hour long frontal instruction
  - Math pre-test
- Week 2:
  - brief explanation of robot interaction, PANAS form
  - 20 minute session of math problems.
  - PANAS form, survey.
- Week 3:
  - 20 minute session of math problems.
  - PANAS form, survey, math post-test
- Week 5:
  - Second post-test

Results

	Feedback group (error-specific feedback)	**Control group (only right/wrong feedback)**
	13 boys, 7 girls	10 boys, 11 girls
Session 1	477 math problems (all children)	635 math problems (all children)
	30.0% (143) problems incorrect	25.7% (164) problems incorrect
	algorithm recognized 15 errors	-
Session 2	420 math problems	515 math problems
	33.1% (139) problems incorrect	30.5% (157) problems incorrect
	algorithm recognized 12 errors	-

- We did <u>not</u> find learning effects (ceiling effect)
- We did <u>not</u> find a motivational effect (affect)

Lessons Learnt

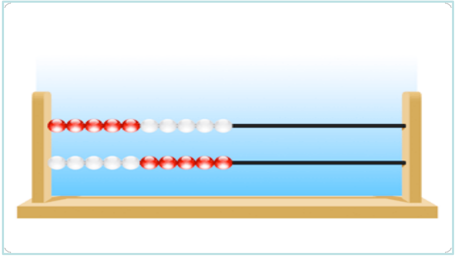
- robot can execute our interaction design patterns autonomously and pattern is robust.
- advanced algorithms for error classification and adaptation to performance levels are needed.
- children appreciate more time for answering (no timer as in math apps on tablets).
- differentiate between children that have / have not difficulty with math problems.

Robot- or user-centered design?

Go to menti.com and use code **36 71 44 2**

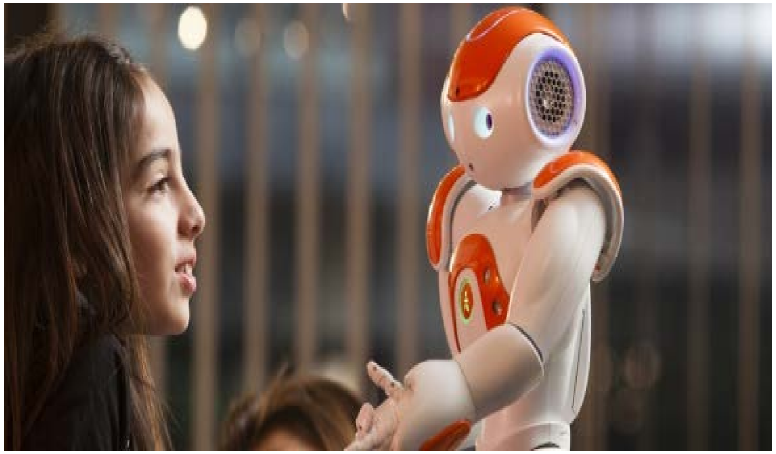
Future Work

1



Add visuals (tablet), digital counting frame, and touch to simplify detection problem

2



Conversational design for an instructional model that is able to adapt to child's performance

Summary

- **Social robot interaction design** is a type of interaction design where the choice of interaction technology is: a social robot.

- **Robot- vs user-centered design:**
  - **Robot-centered design** focuses on robot capabilities
  - **User centered design** is an approach to system development by focusing on the end user

- A **use case** is a detailed specification of:
  - **objectives**, **actors**, and interaction **steps** between actors;
  - the **conditions** assumed by the use case, and any **requirements** and **claims** to its effectiveness.