

A Participatory Design Process of A Robotic Tutor of Sign Language for Children with Autism

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futurice

Background

Why a robotic tutor of sign language for children with autism?

- **ASD:** impaired language and communication

Why a robotic tutor of sign language for children with autism?

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- **Sign language is the most common** form of Alternative and Augmentative Communication (AAC) used by people with ASD

Why a robotic tutor of sign language for children with autism?

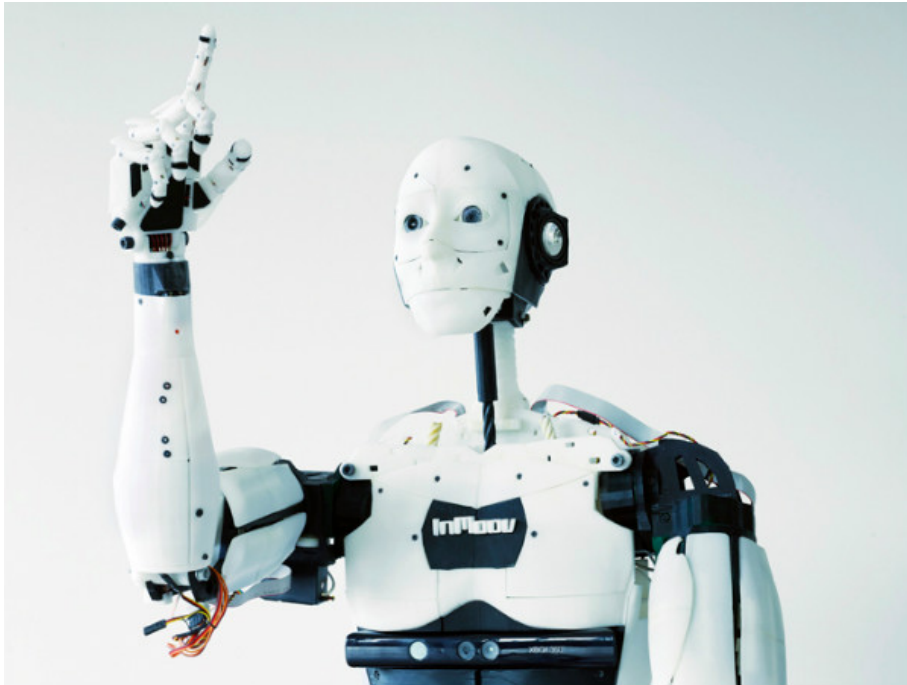
- **ASD:** impaired language and communication
- **Sign language is the most common** form of Alternative and Augmentative Communication (AAC) used by people with ASD



- **No previous research on robotic sign language tutor for children with autism**

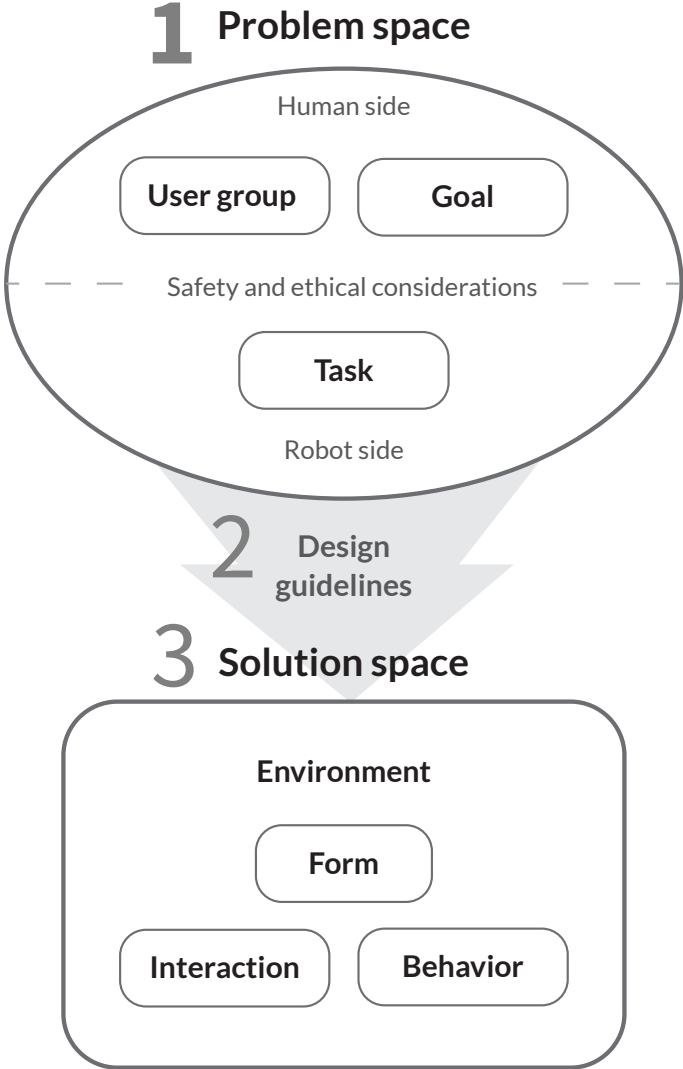
Design

How should we design a robot that teaches sign language to children with ASD?

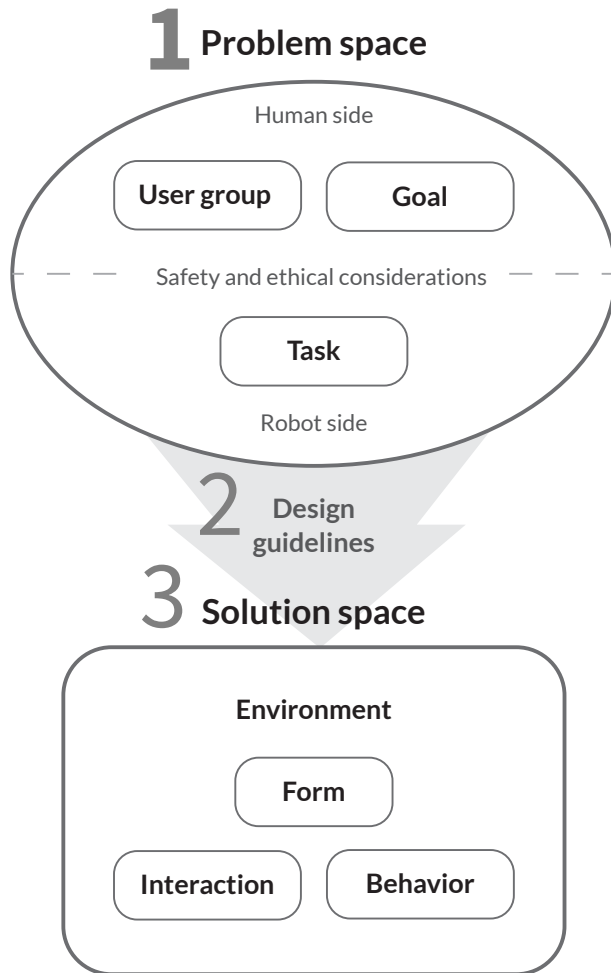


- Participatory design process
- Roboticians and autism therapy specialists

Design framework

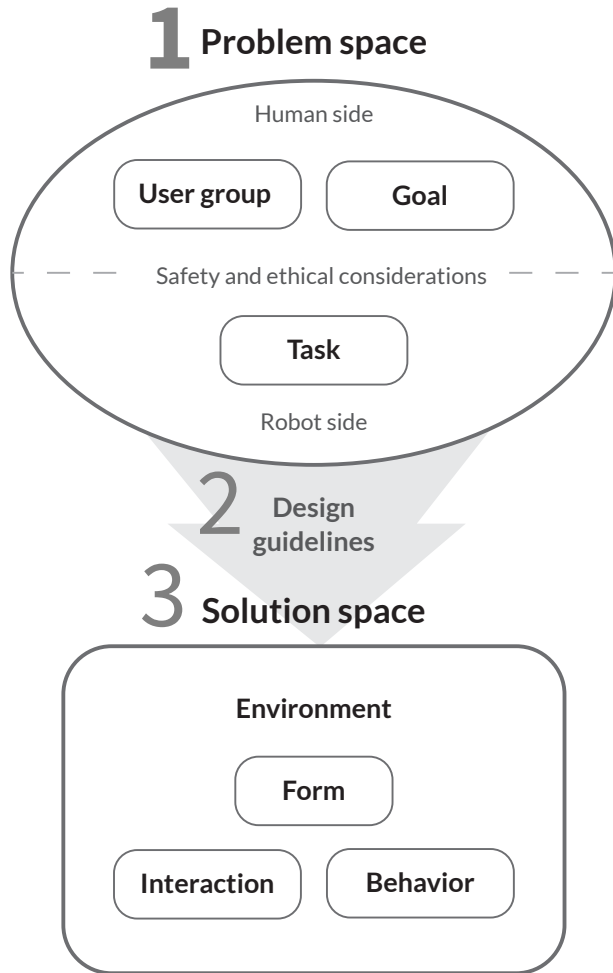


Problem space



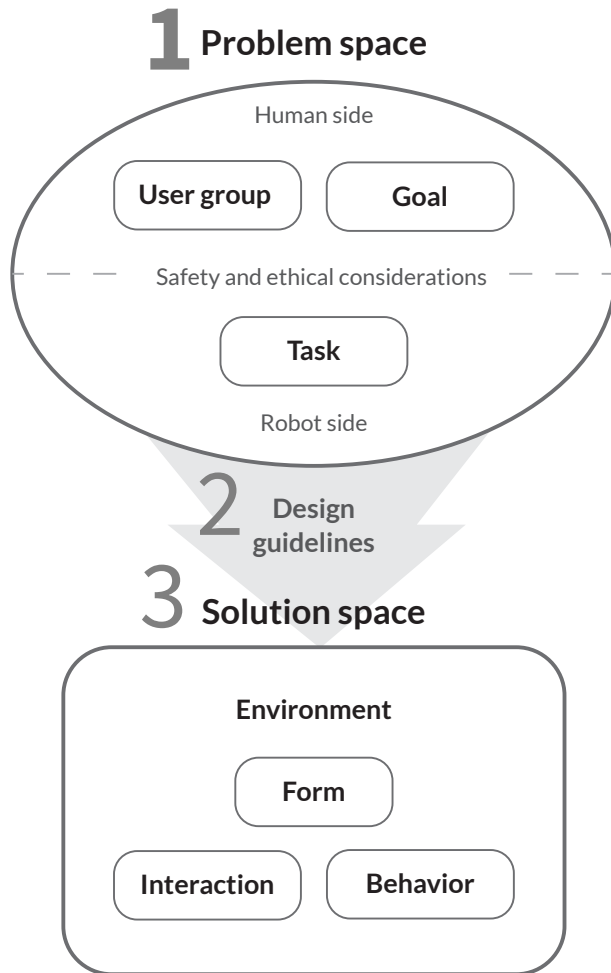
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 - Characteristics: impaired language and communication, impaired social behavior, narrow flexibility
 - Needs: safety, structure.

Problem space



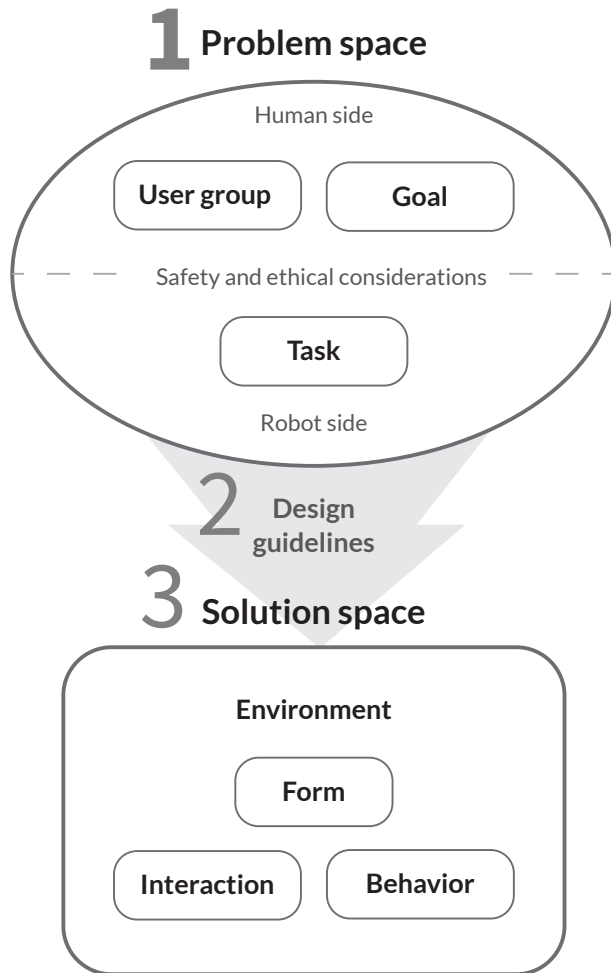
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- **The robot's task –** perform signs, be socially appealing to capture and keep child's attention

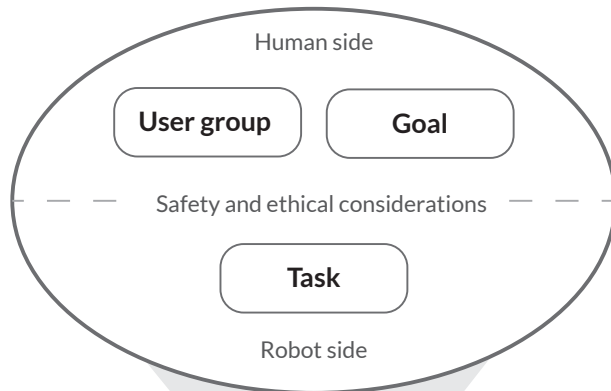
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- **Safety and ethical considerations**

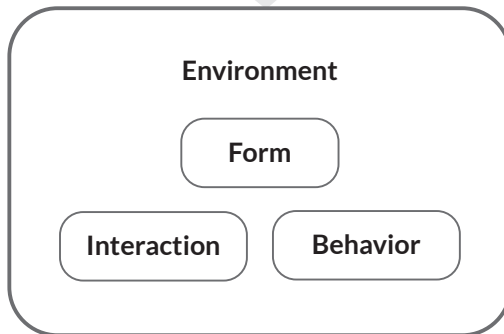
Problem space – Ethical considerations

1 Problem space



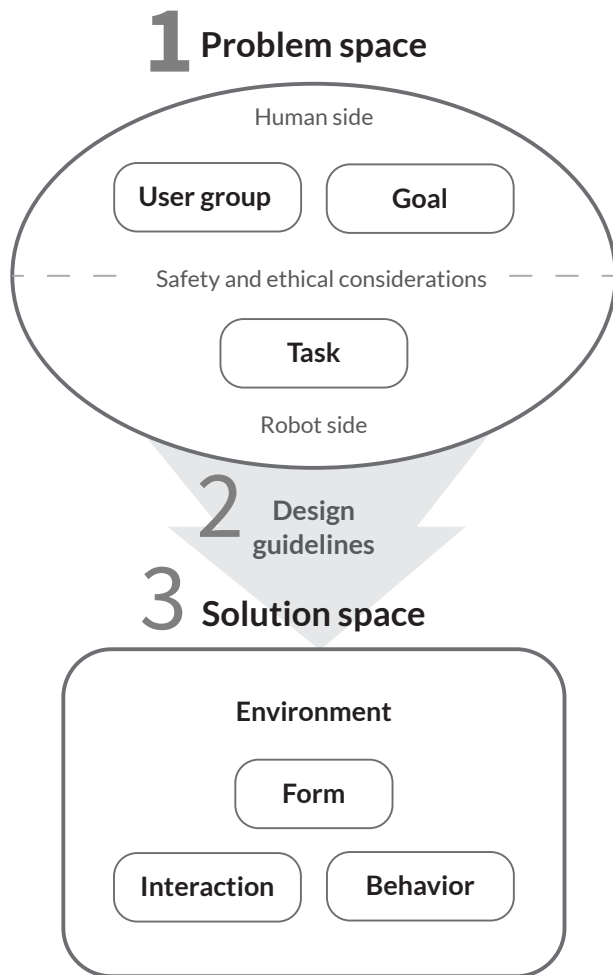
2 Design guidelines

3 Solution space



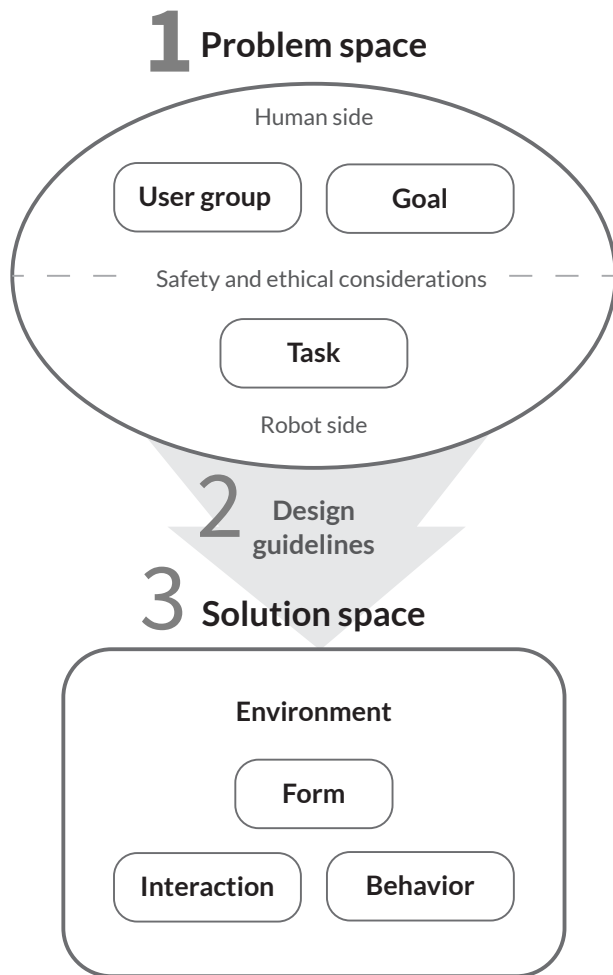
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Problem space – Ethical considerations



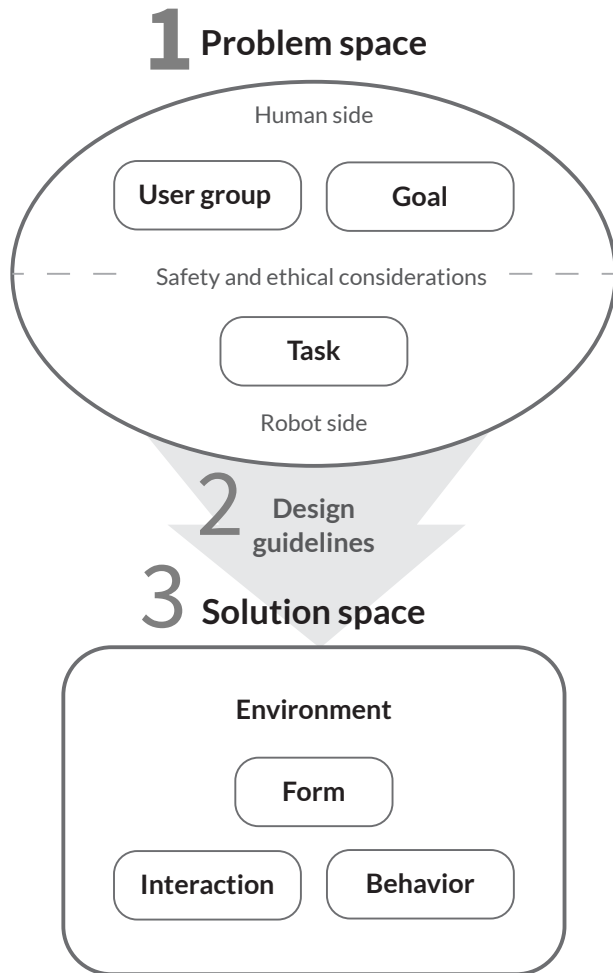
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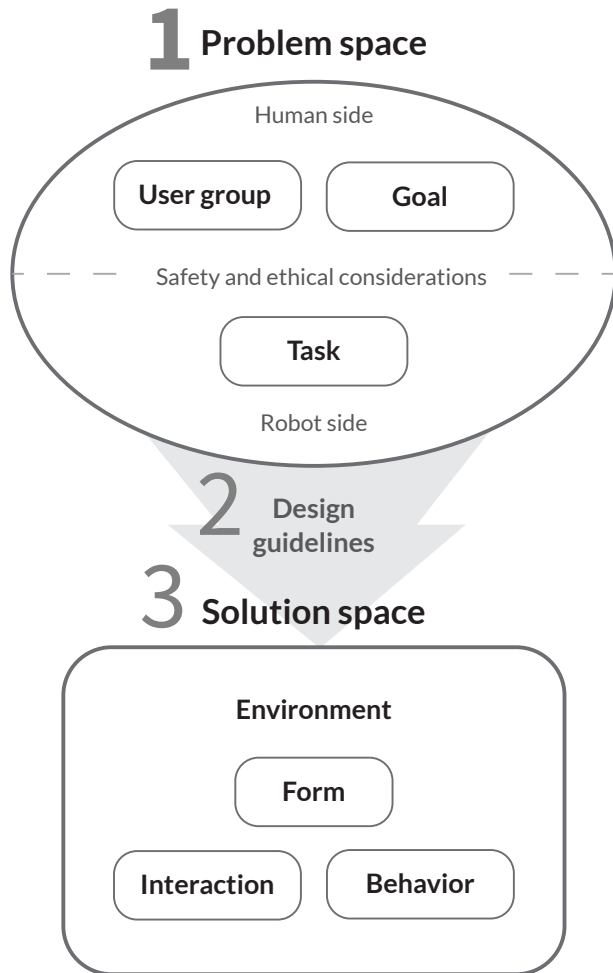
- **Physical safety** – child can't touch robot
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- **Correct behaviour enforcement** – by therapist

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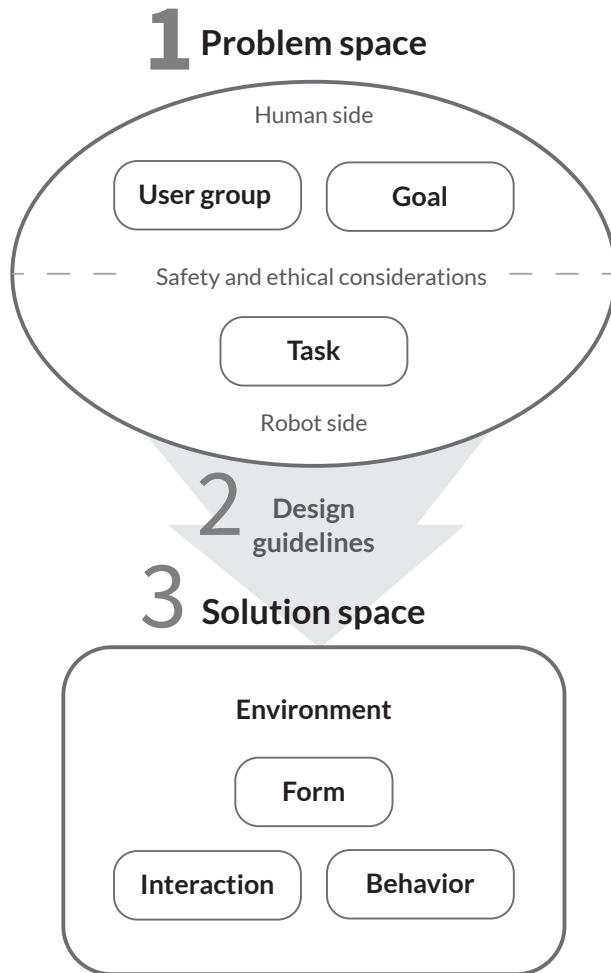
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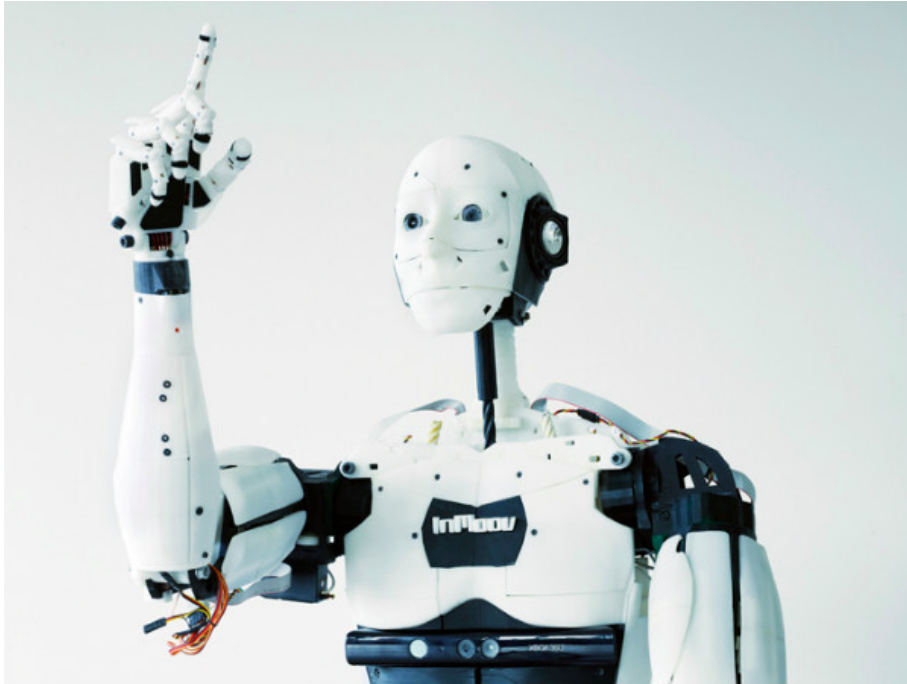
- **Physical safety** – child can't touch robot
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- **Transparency** – informed of teleoperation at end

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- **Correct behaviour enforcement** – by therapist
- **Equality across users** – gender neutral robot
- **Transparency** – informed of teleoperation at end
- **Emotional consideration** – no replacing therapist

InMoov

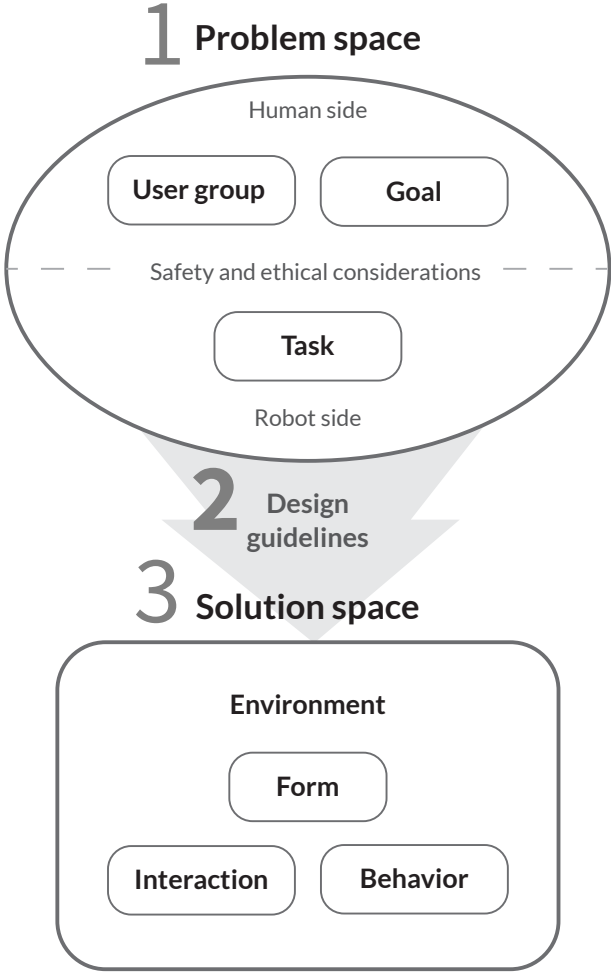


- Designed by Gaël Langevin
- Open source
- 3D-printed
- “MyRobotLab” software

- **5 fingers → signing ability**
- **Modifiable → design modifications**

Image: Gael Langevin, from Wikipedia.

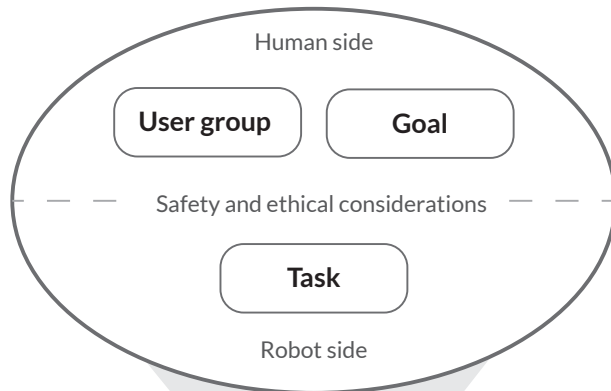
Design guidelines



1. Simple form

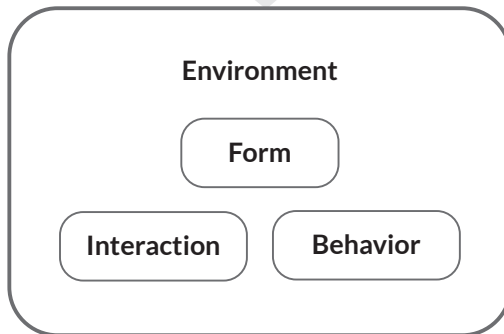
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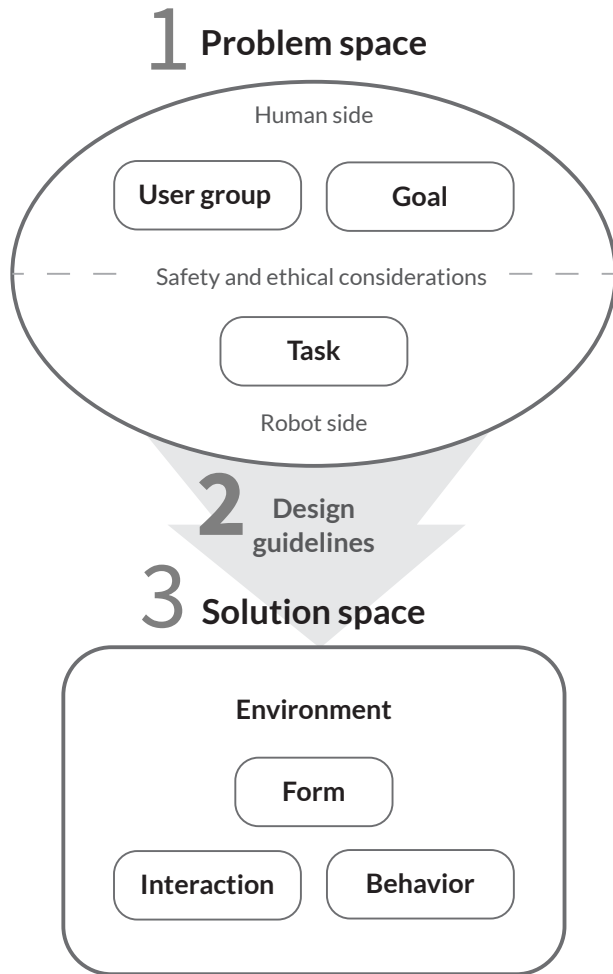
3 Solution space



1. Simple form

2. Consistent, structured, simple behavior

Design guidelines

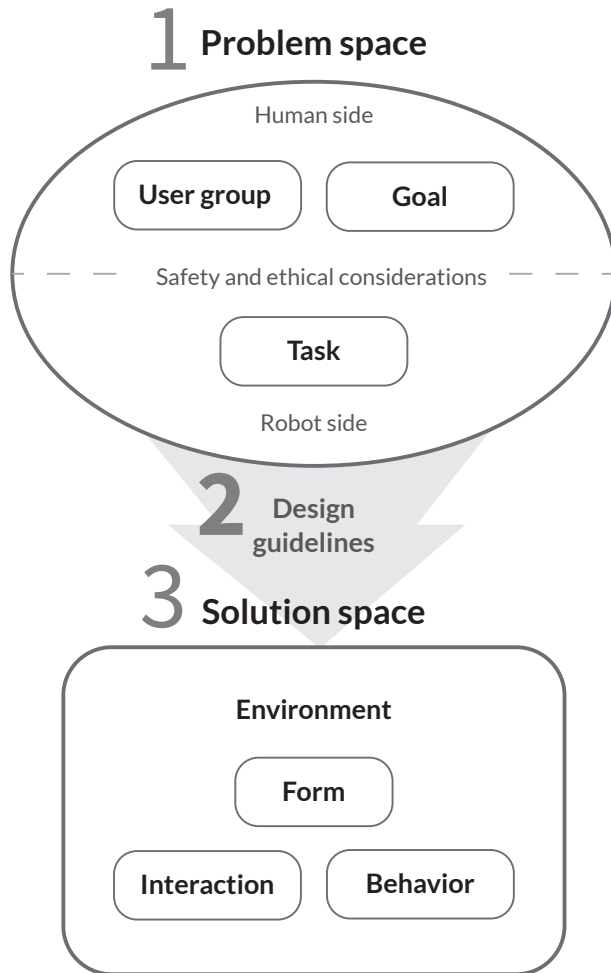


1. Simple form

2. Consistent, structured, simple behavior

3. Positive, supportive, rewarding experience and environment

Design guidelines



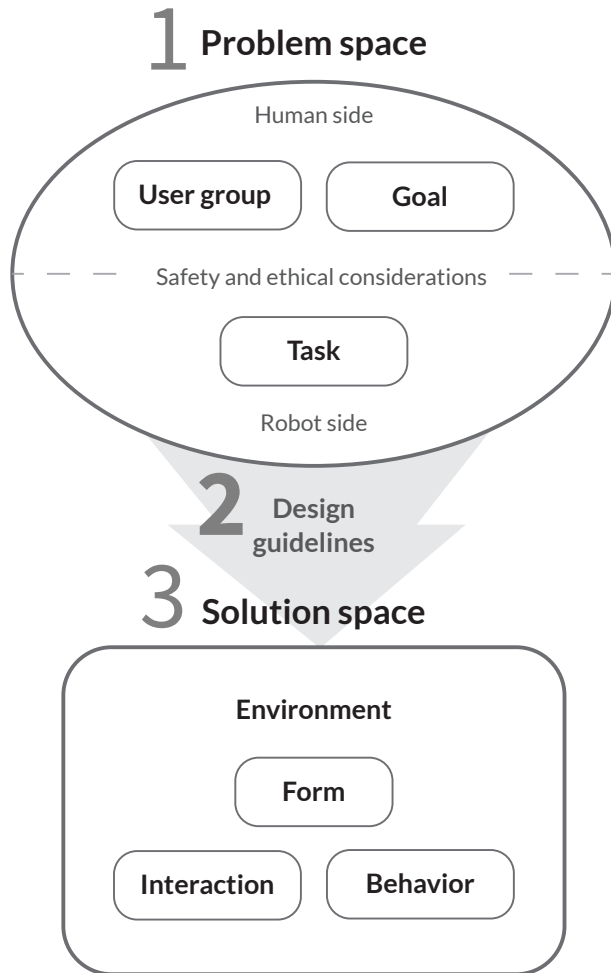
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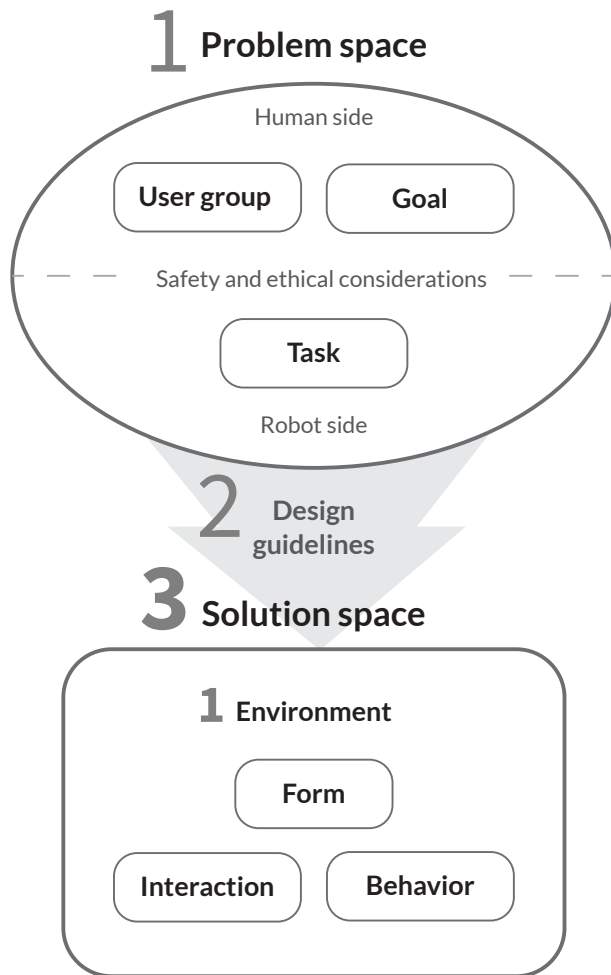
4. Modular complexity

Design guidelines



1. Simple form
2. Consistent, structured, simple behavior
3. Positive, supportive, rewarding experience and environment
4. Modular complexity
5. Modular specific to child's preferences

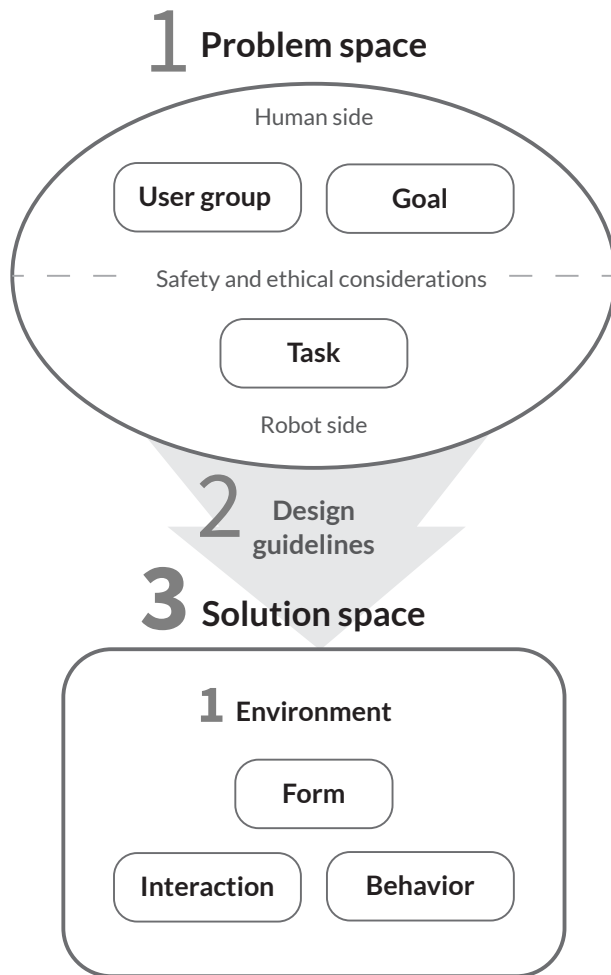
Solution Space – Environment



Factors surrounding the robot's operation:

- **Experiment flow** – predefined

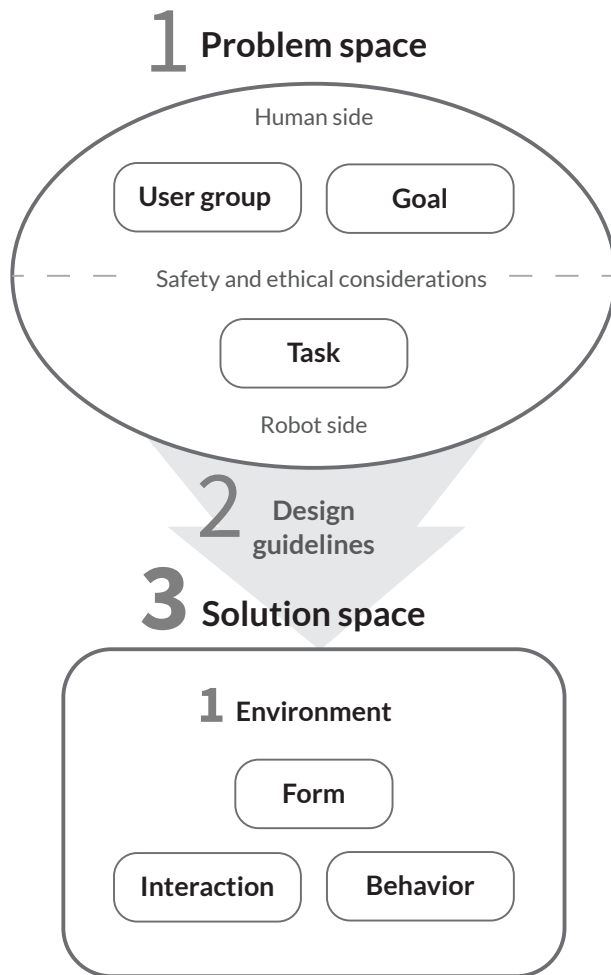
Solution Space – Environment



Factors surrounding the robot's operation:

- **Experiment flow** – predefined
- **Simultaneous users** – one child at a time

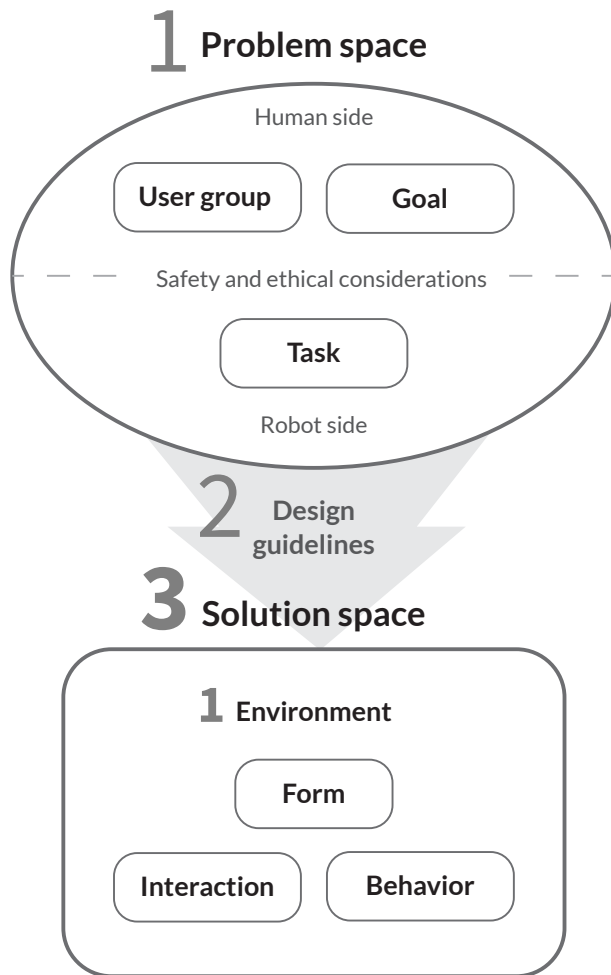
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Factors surrounding the robot's operation:

- **Experiment flow** – predefined
- **Simultaneous users** – one child at a time
- **Human facilitation** – therapist facilitator

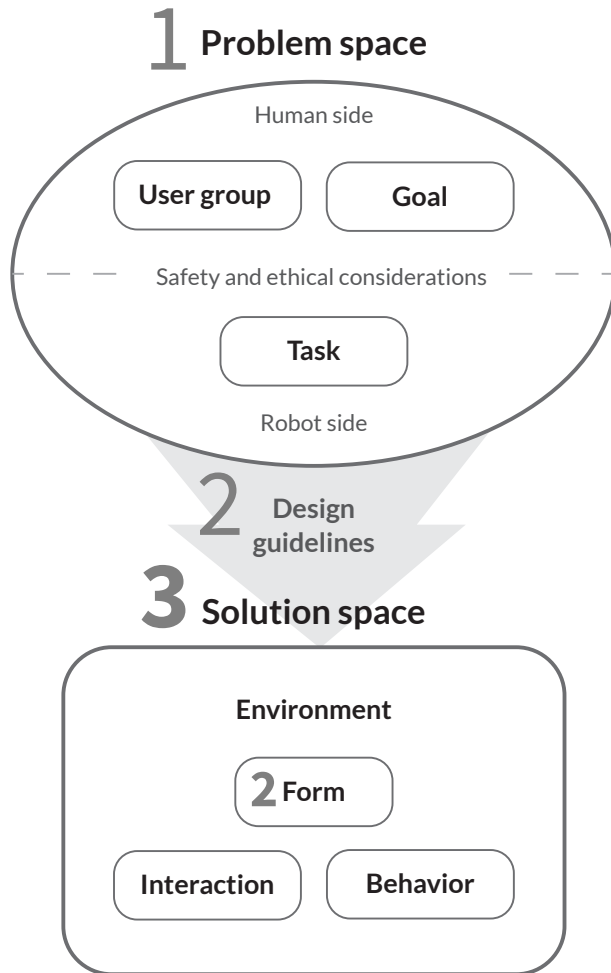
Solution Space – Environment



Factors surrounding the robot's operation:

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- **Human facilitation** – therapist facilitator
- **Role of the robot** – authority, co-operator

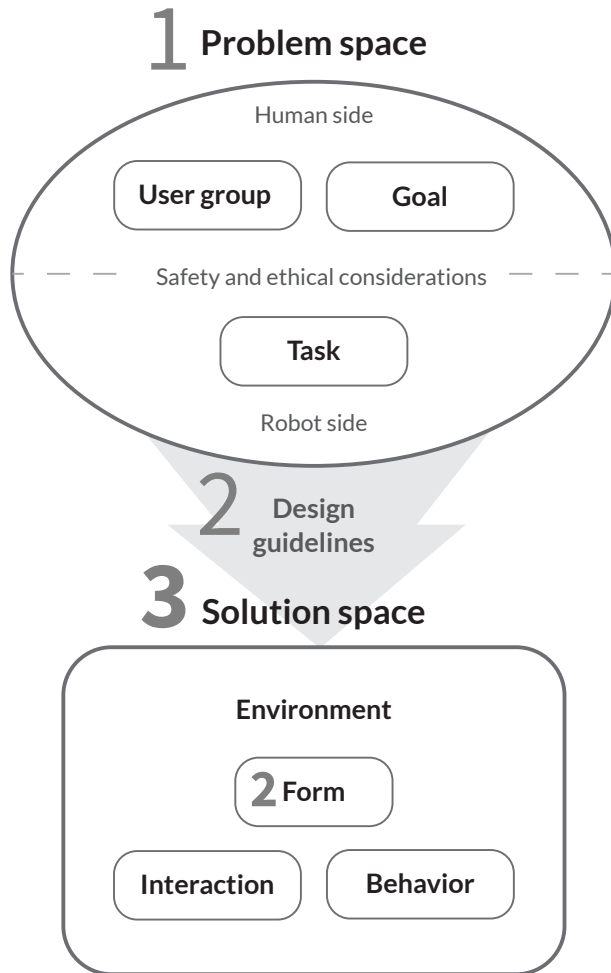
Solution Space – Form



Externally perceptible qualities:

- **Appearance** – anthropomorphic, mechanical

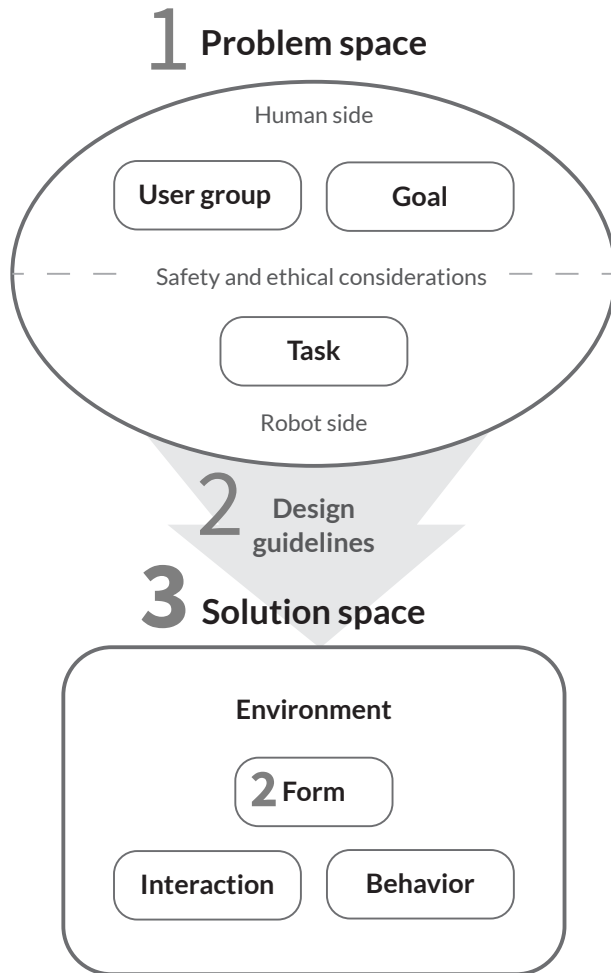
Solution Space – Form



Externally perceptible qualities:

- **Appearance** – anthropomorphic, mechanical
- **Movement** – machine-like

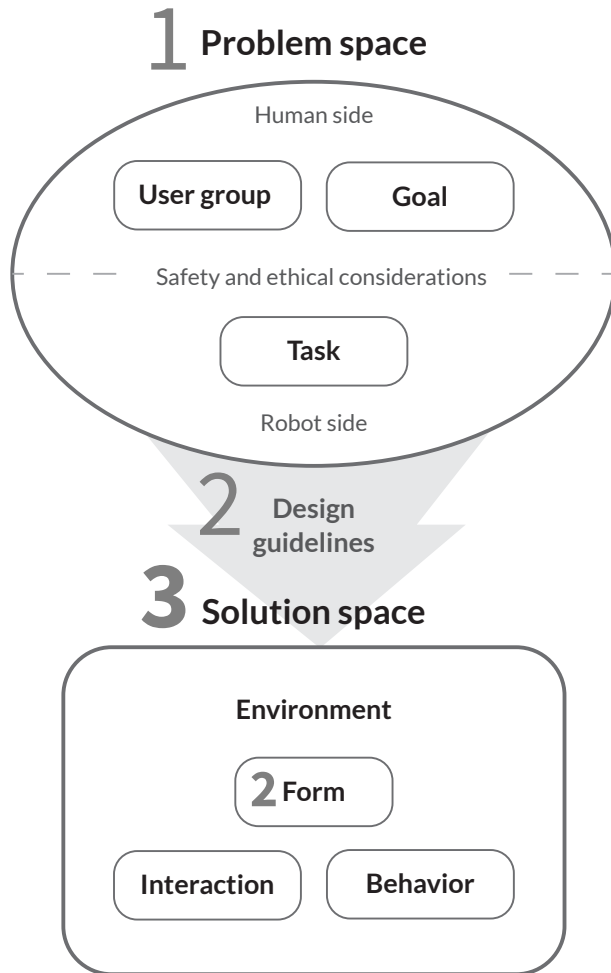
Solution Space – Form



Externally perceptible qualities:

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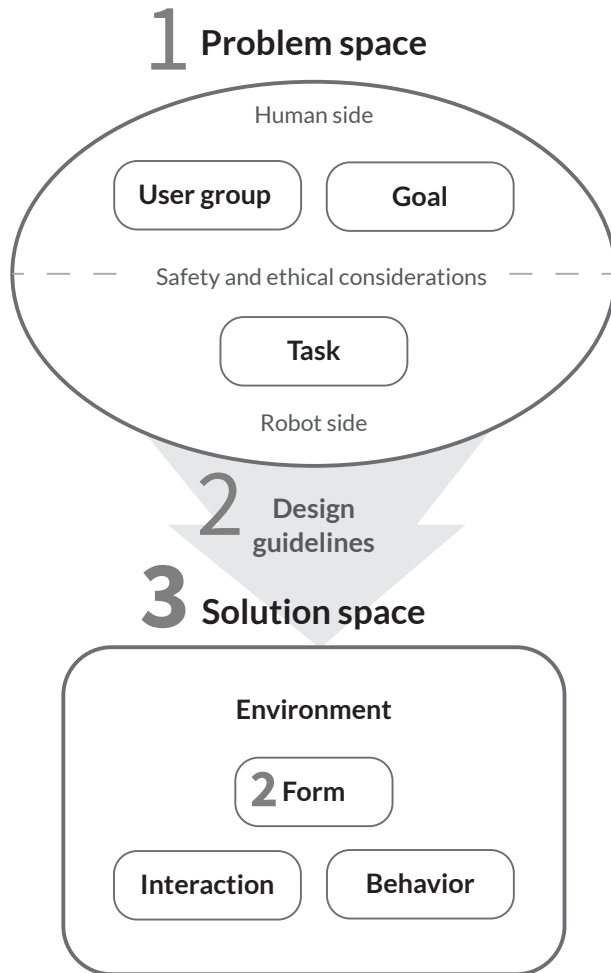
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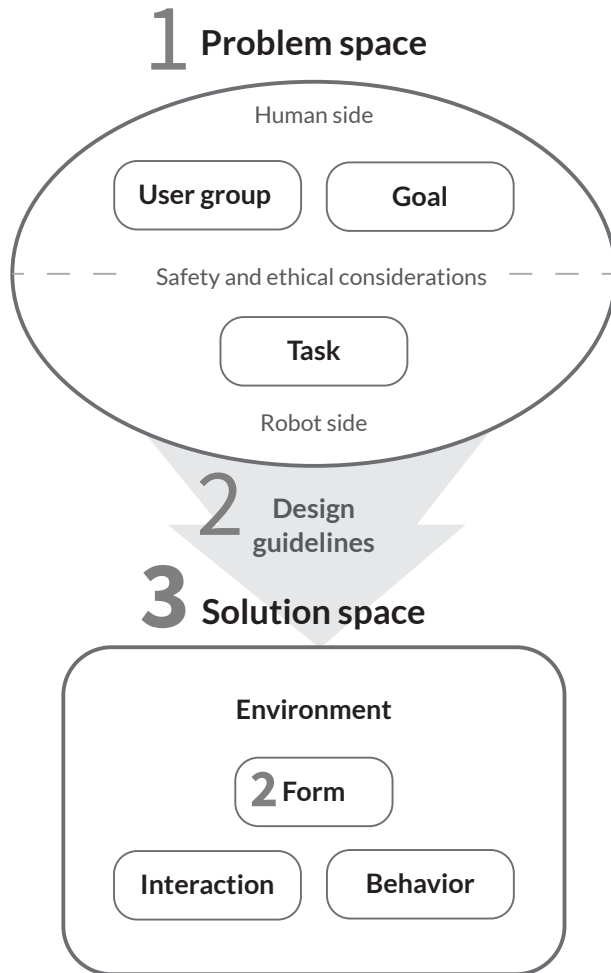
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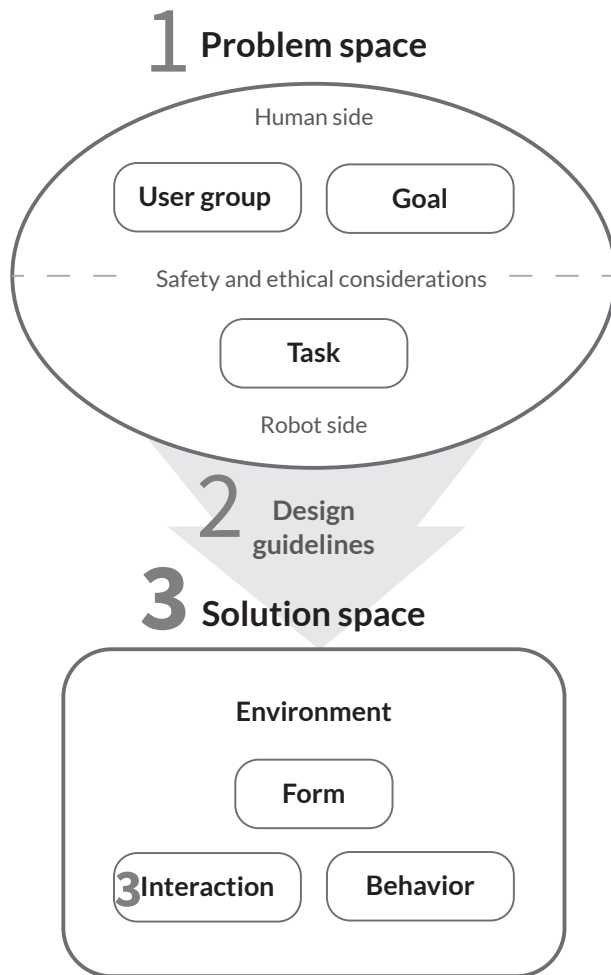
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- **Olfactory sensations** – not relevant in this application

Solution Space – Interaction

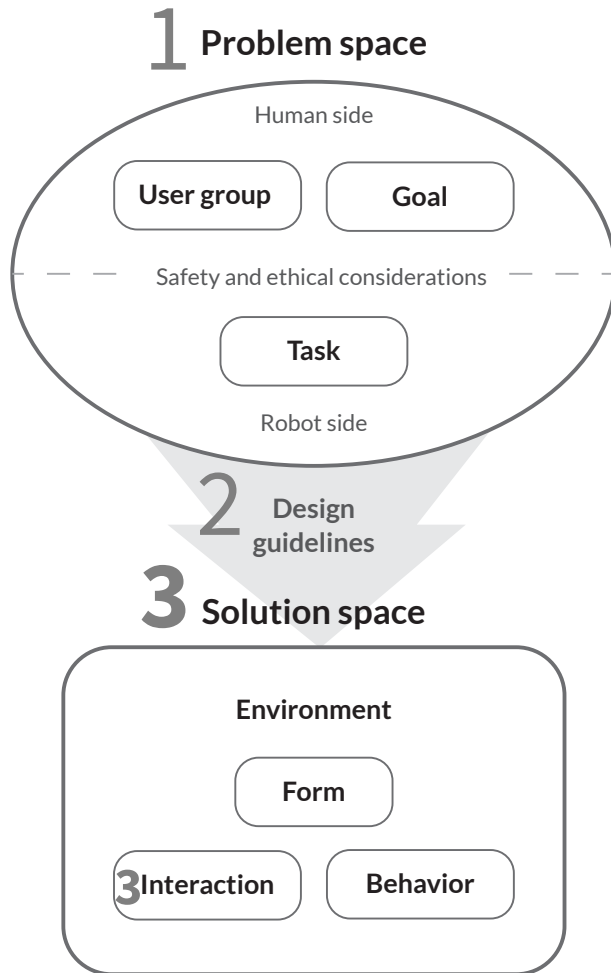


The manner in which a user interacts with a robot:

- **Modalities –**

- Input: speech, signs
- Output: speech, signs, sounds, lights, images

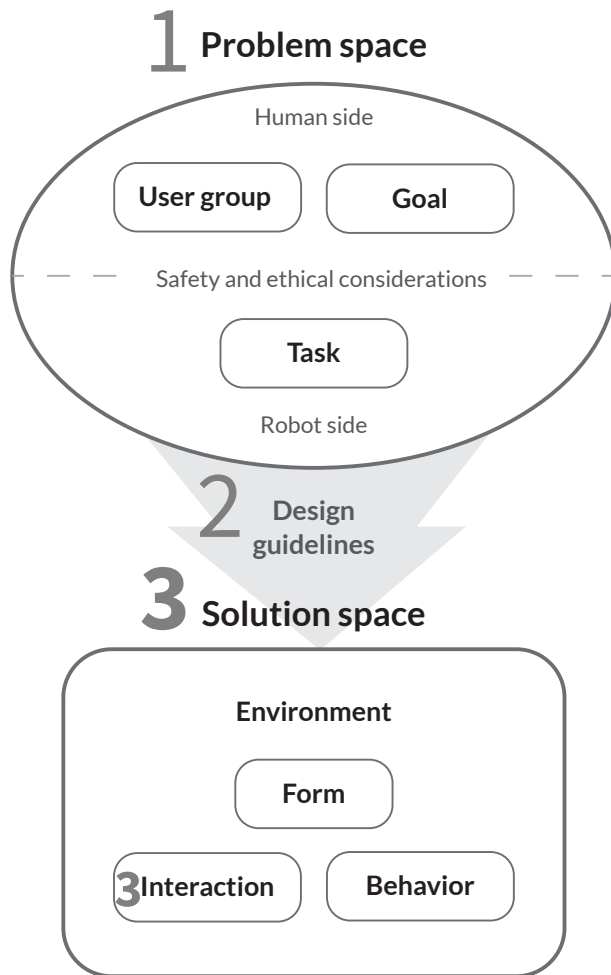
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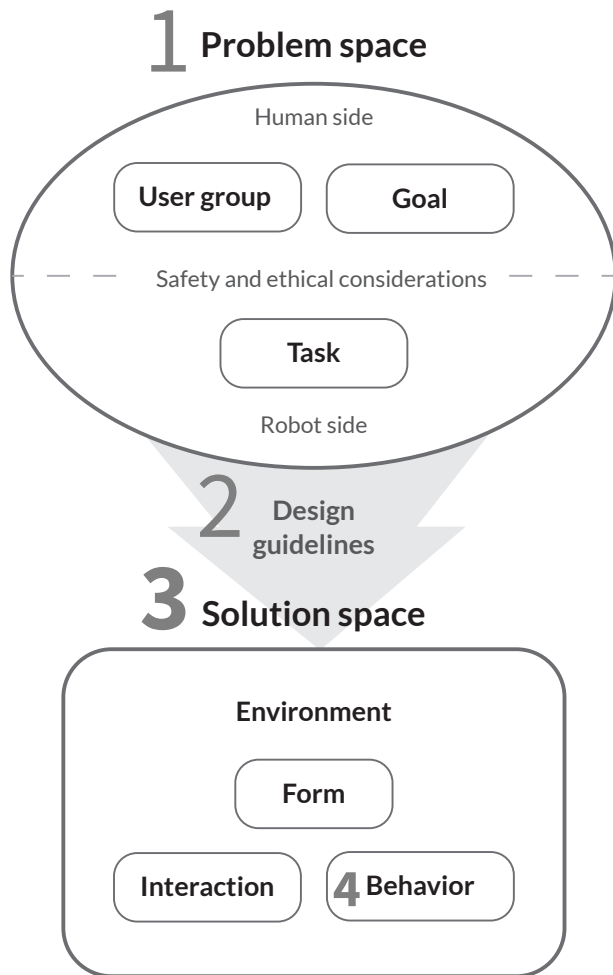
Solution Space – Interaction



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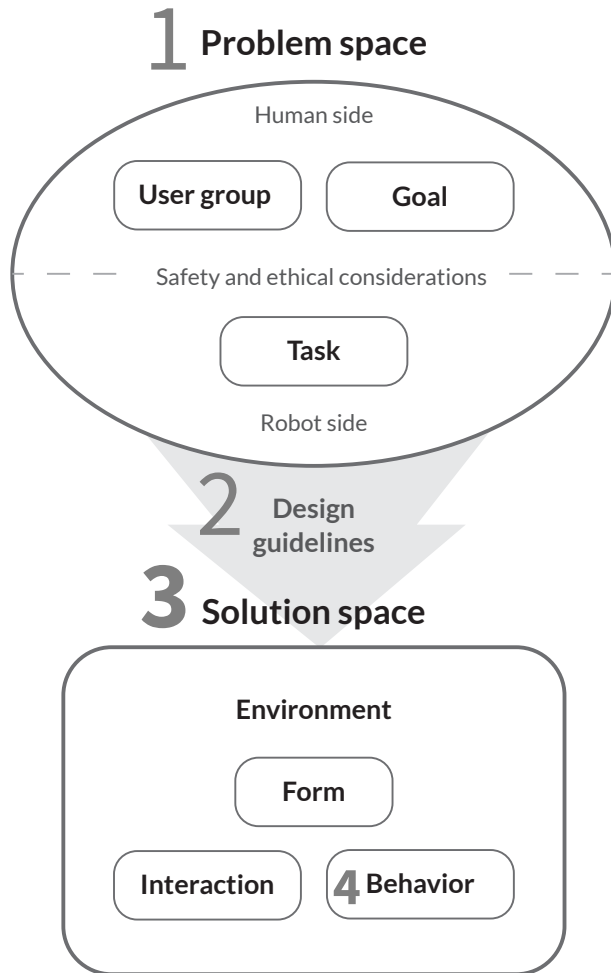
Solution Space – Behaviour



How and why the robot acts:

- **Contextual adaptation** – no adaptation, structured behaviour

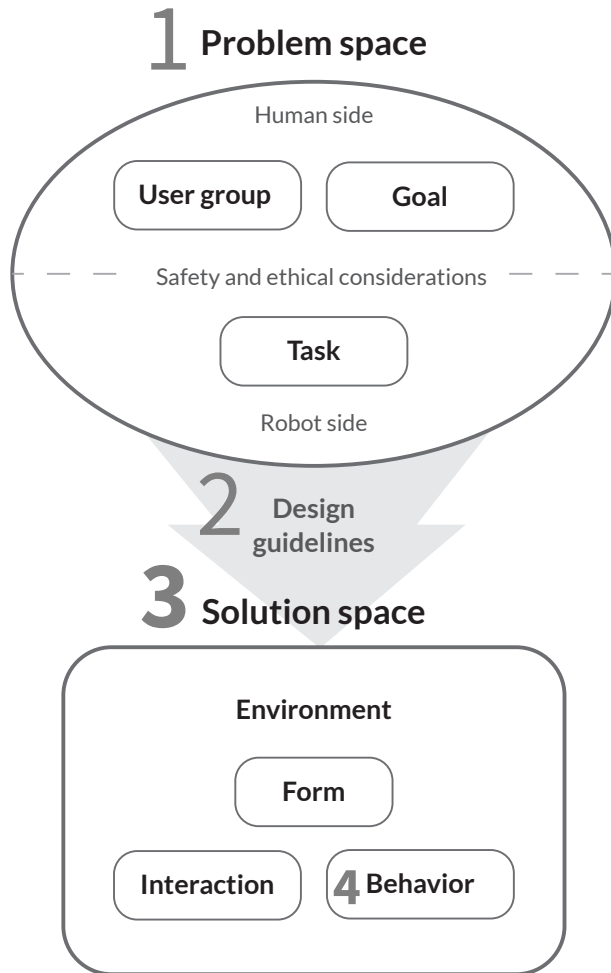
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How and why the robot acts:

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- **Motivation** – externally motivated, responds to childrens' behaviour

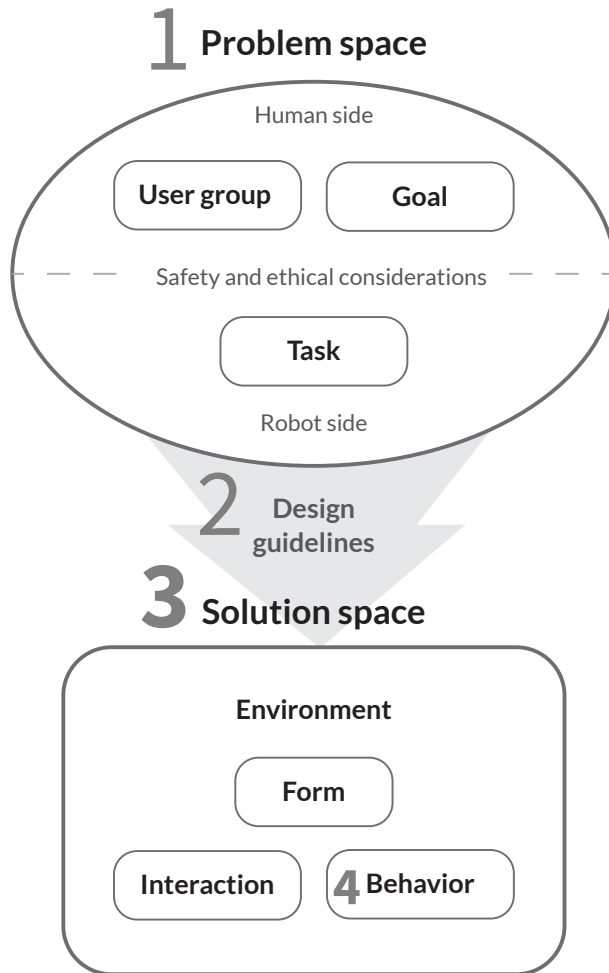
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How and why the robot acts:

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- **Social awareness** – rudimentary, greeting and saying goodbye

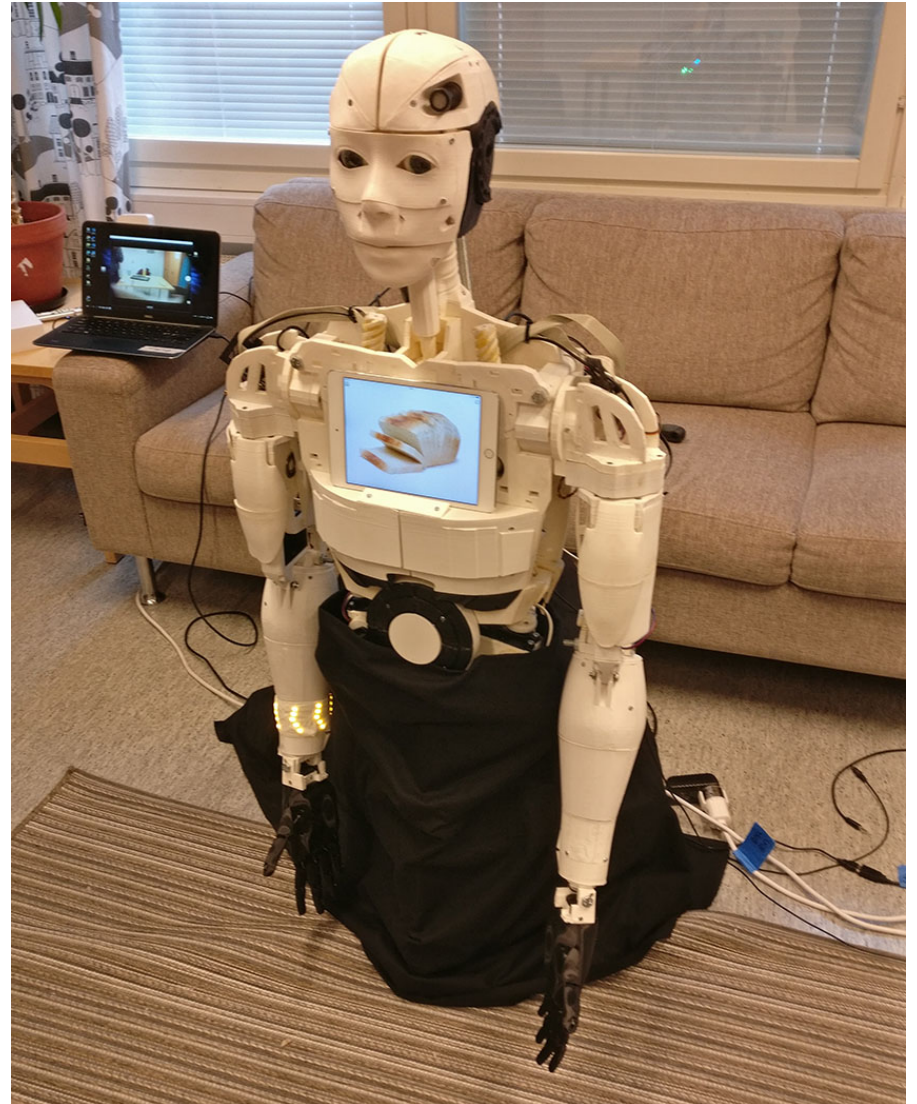
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- **Motivation** – externally motivated, responds to childrens’ behaviour
- **Social awareness** – rudimentary, greeting and saying goodbye
- **Autonomy** – teleoperated robot

Modifications



User Study

User study

- 9 signs to learn
- Robot asks children to imitate signs
- Wizard of Oz

User study

Comparative design study, explored one design dimension (interaction)

1. Speech + signs



2. Speech + signs
+ images



3. Speech + signs
+ lights



User study



Analysis of robot's effectiveness

- **Eye gaze** – indicates attention focus
- **Imitation success rate** – success defined as independent imitation of robot, without help from therapist
- **Surveys with children** – experience with the robot
- **Surveys with children's companions** – how they evaluate the child's experience with the robot

Results & Discussion

Main results

- **Robot successful in prompting imitations**
 - 7/10 children imitated the robot at least once
 - 6/8 companions said the child could benefit from use of the robot
- **Robot successful in capturing and keeping attention**
 - Children focused their eye gaze on the robot for the majority of the duration of the study
 - 8/8 companions thought the child had a connection with the robot
 - 5/6 children said the robot was fun
 - 7/8 companions reported that the robot seemed to feel fun to the child

Future design and research suggestions

- **”Image” design condition should be developed further:**
 - No statistically significant results on design conditions
 - 5/6 children regarded the robot’s design conditions as ”good”
 - 7/8 companions had preference for ”Image” condition
- **Robot’s scariness should be reduced:**
 - 2/6 children said the robot was scary, their companions agreed

Future design and research suggestions

- **Performance of signs needs to be improved**
- **Understanding of signs needs to be verified**
- **Understand who best benefits from the robot**
 - 3/10 children did not imitate at all
- **Examine methods for speech therapist's control of the robot**
- **Examine guidelines (4) and (5):**
 - Modular complexity
 - Modular specific to child's interests

Conclusion

We proposed a Participatory Design Framework and utilized it for the challenging task of designing a robotic tutor of sign language for children with ASD.

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