

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

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The 28th IEEE International Conference on  
Robot and Human Interactive Communication ,  
RO-MAN 2019

# 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?**

- **ASD:** impaired language and communication
- **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?

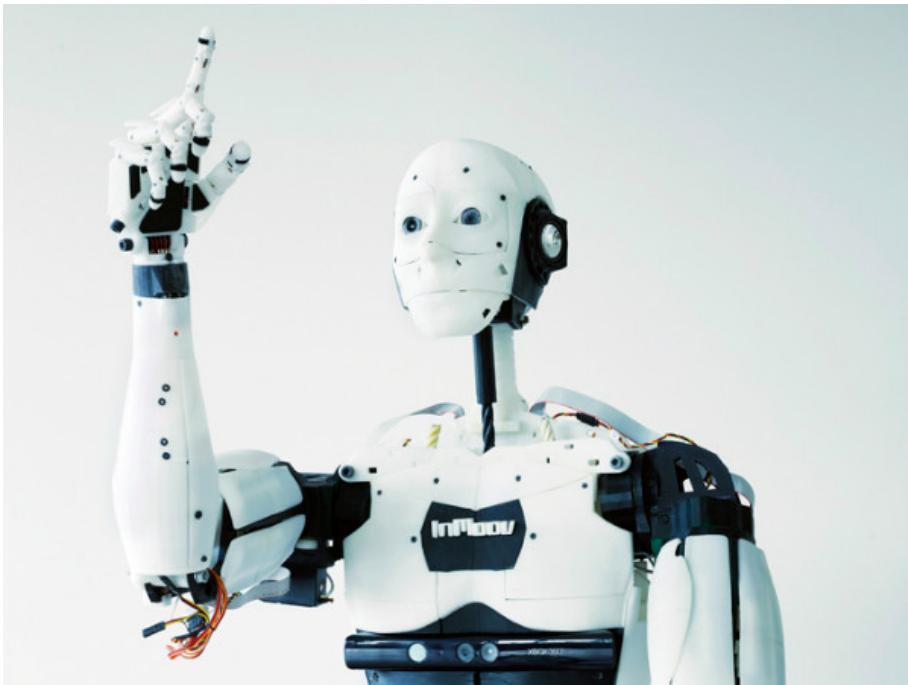
- **ASD:** impaired language and communication
- **Sign language is the most common** form of Alternative and Augmentative Communication (AAC) used by people with ASD



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

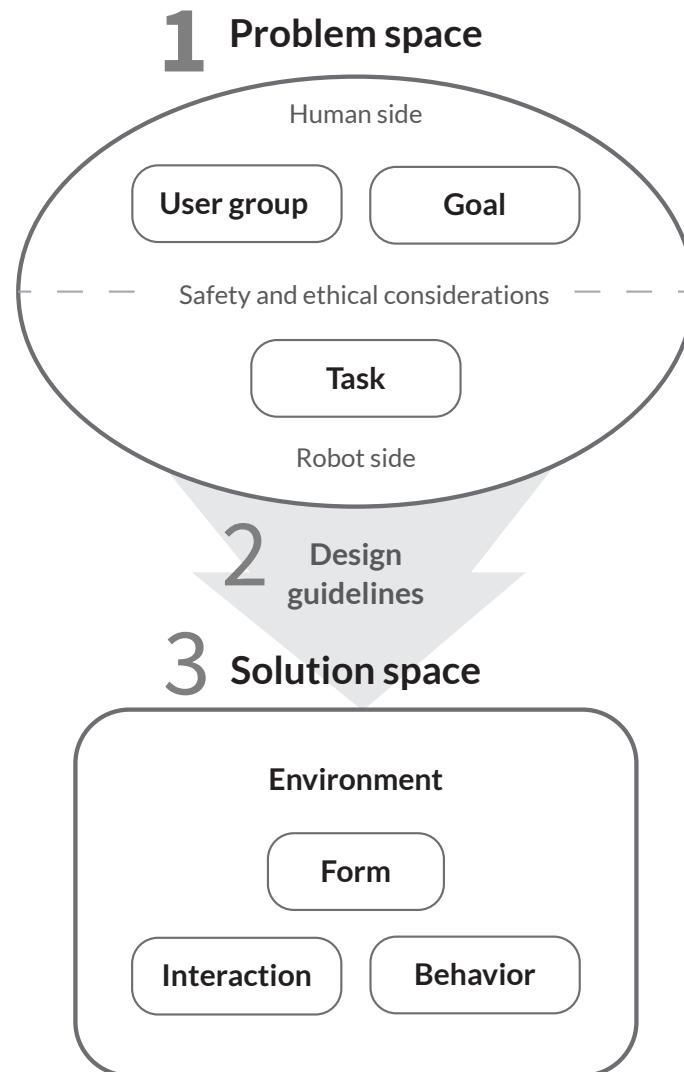
# Design

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

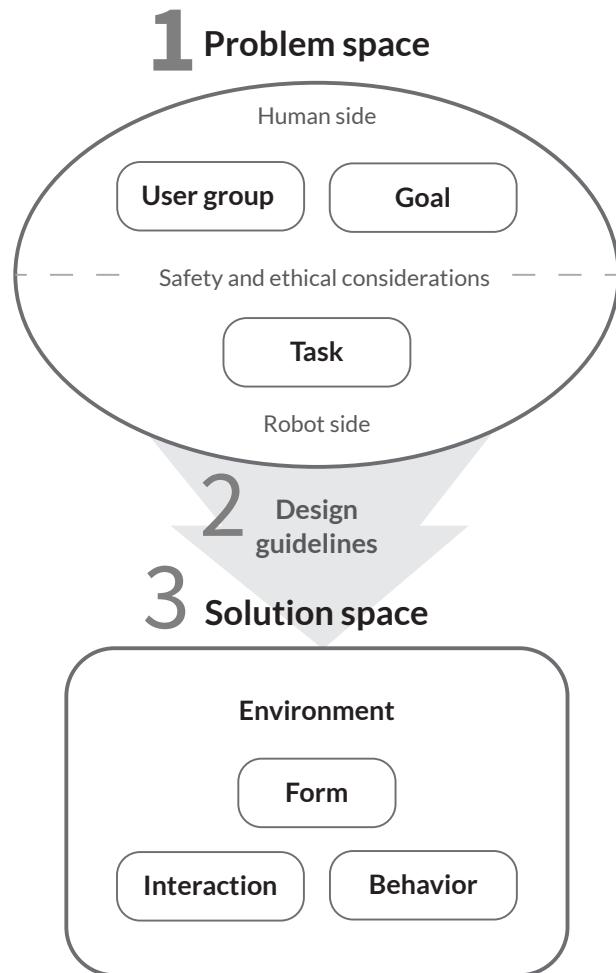


- Participatory design process
- Roboticists and autism therapy specialists

# Design framework

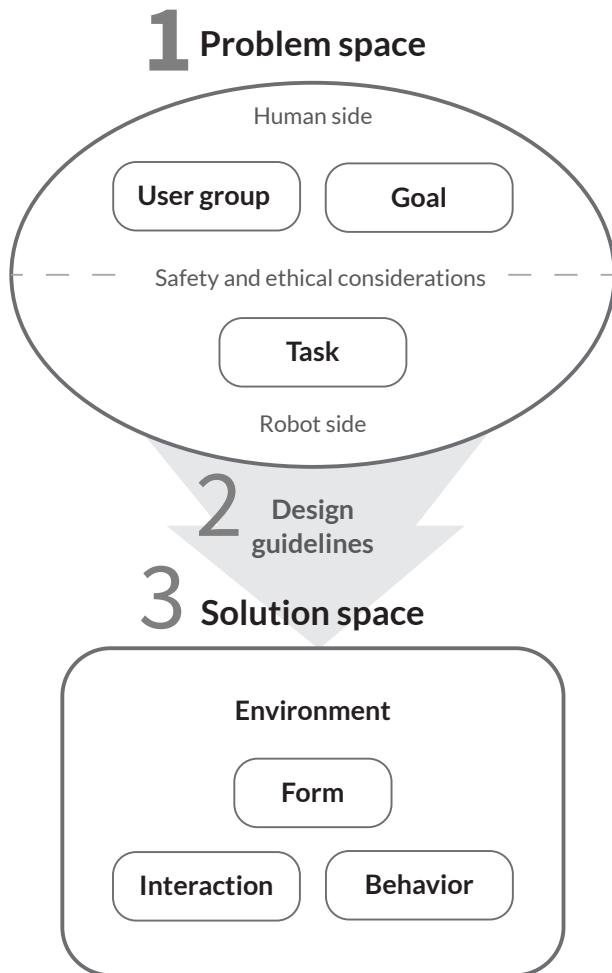


# Problem space



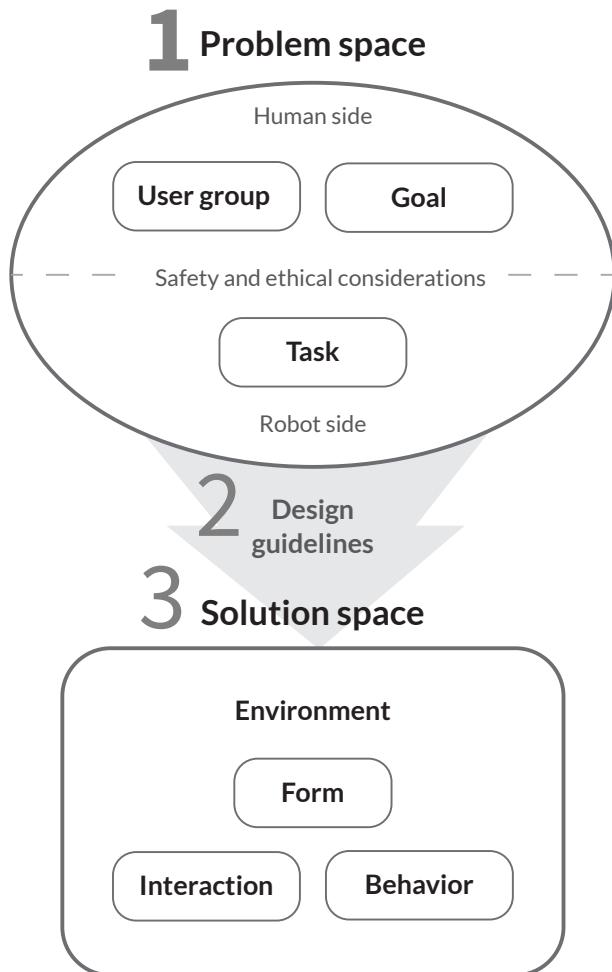
- **The user group's characteristics and needs –**
  - Characteristics: impaired language and communication, impaired social behavior, narrow flexibility
  - Needs: safety, structure.

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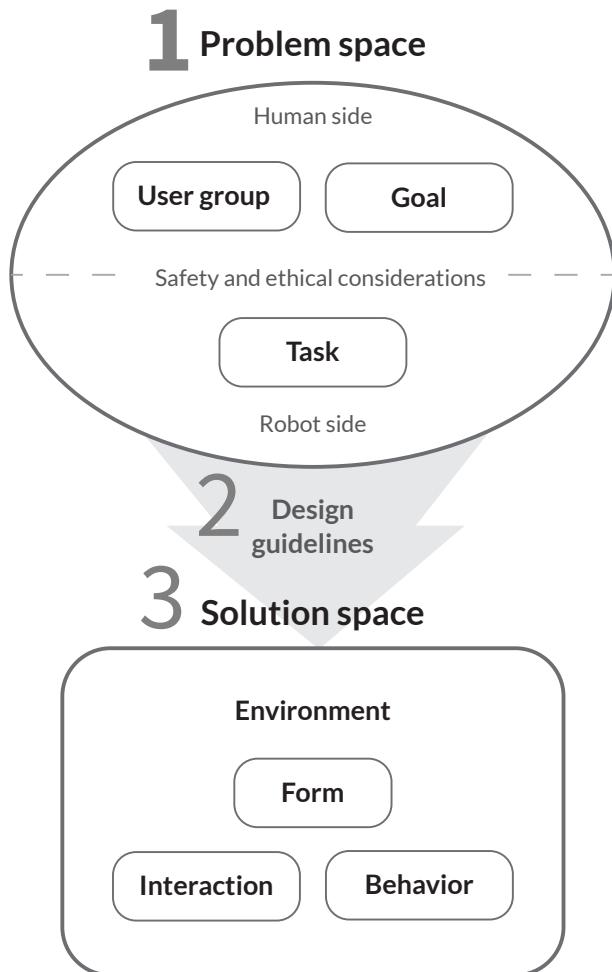
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- **The user's goal –** short-term: imitate signs, long-term, learn and apply signs

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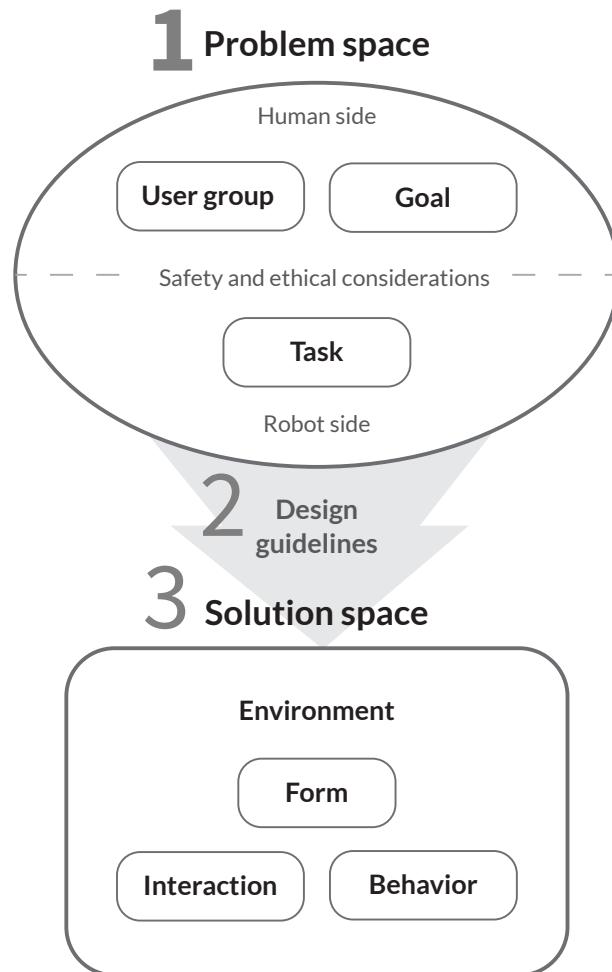
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- **The robot's task** – perform signs, be socially appealing to capture and keep child's attention

# Problem space



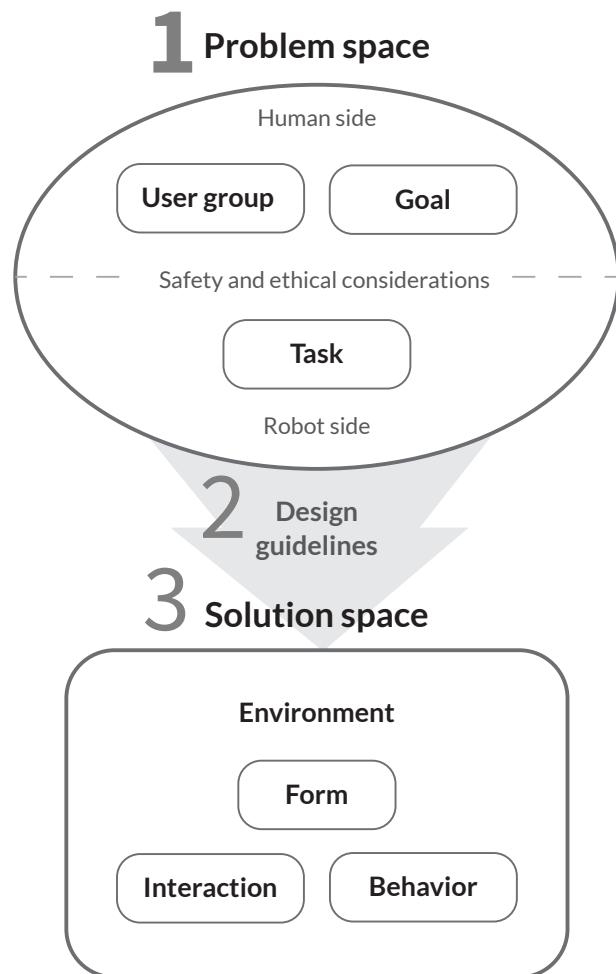
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- **Safety and ethical considerations**

# Problem space – Ethical considerations



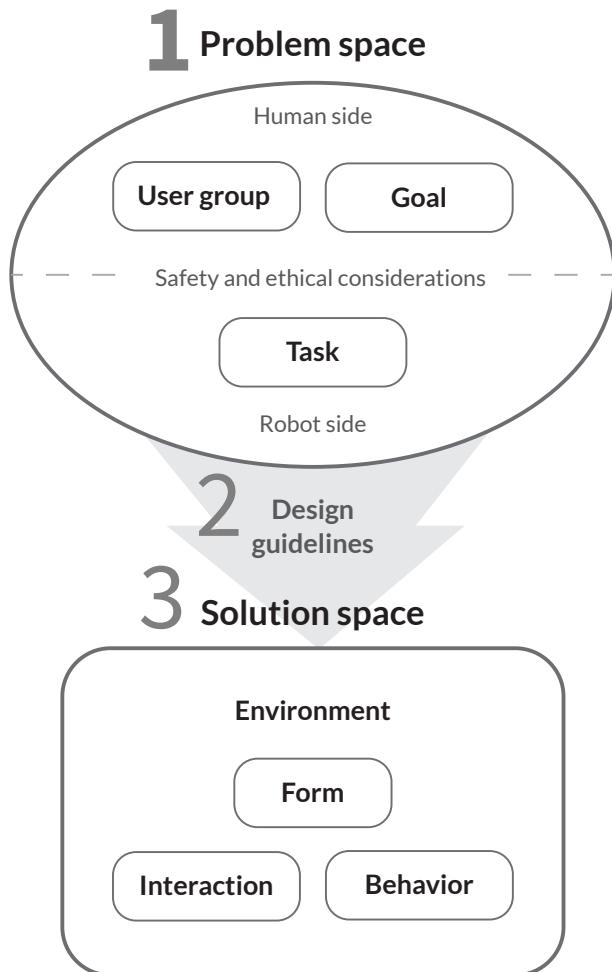
- **Physical safety** – child can't touch robot

# Problem space – Ethical considerations



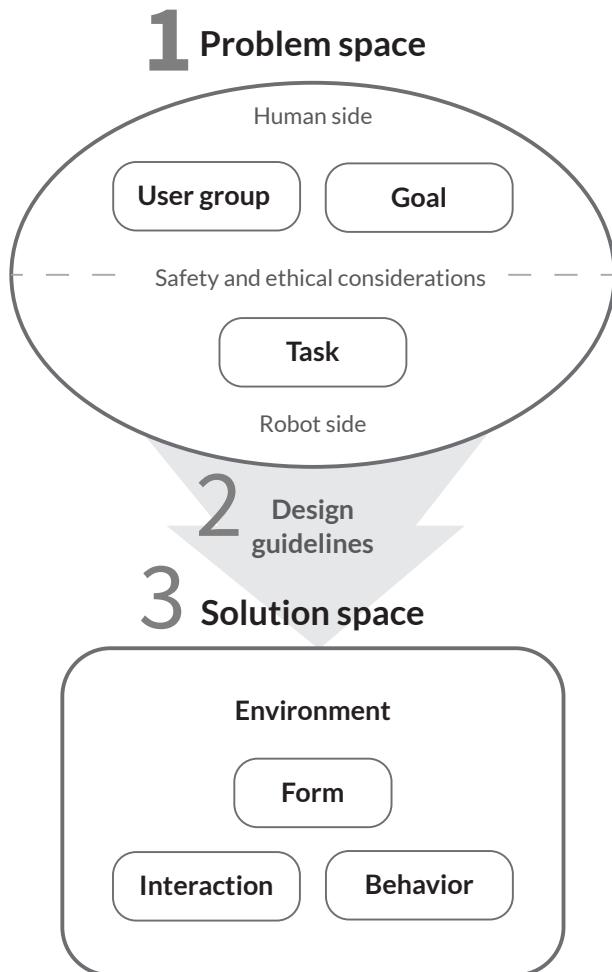
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# Problem space – Ethical considerations



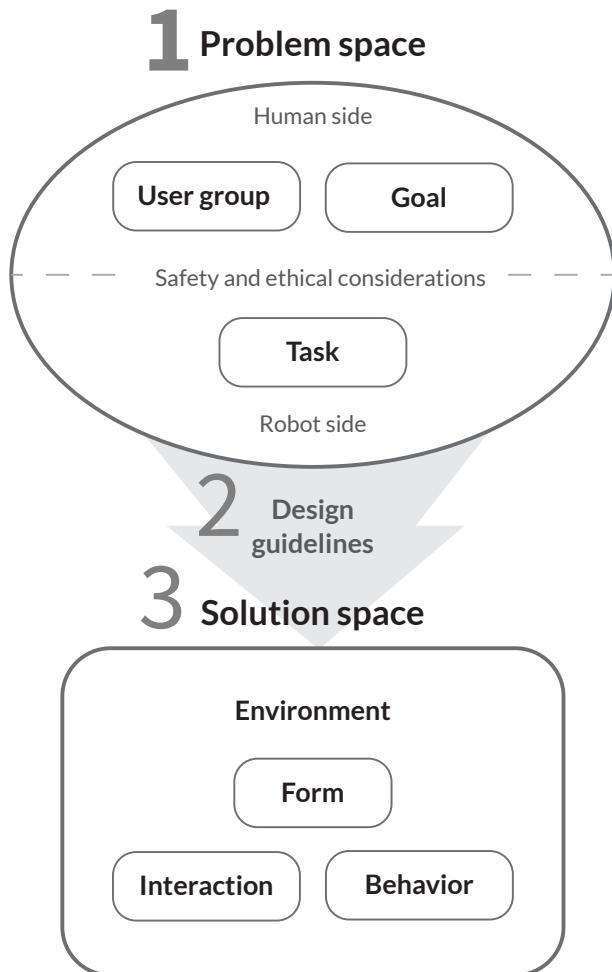
- **Physical safety** – child can't touch robot
- **Safety of data** – kept encrypted
- **Correct behaviour enforcement** – by therapist

# Problem space – Ethical considerations



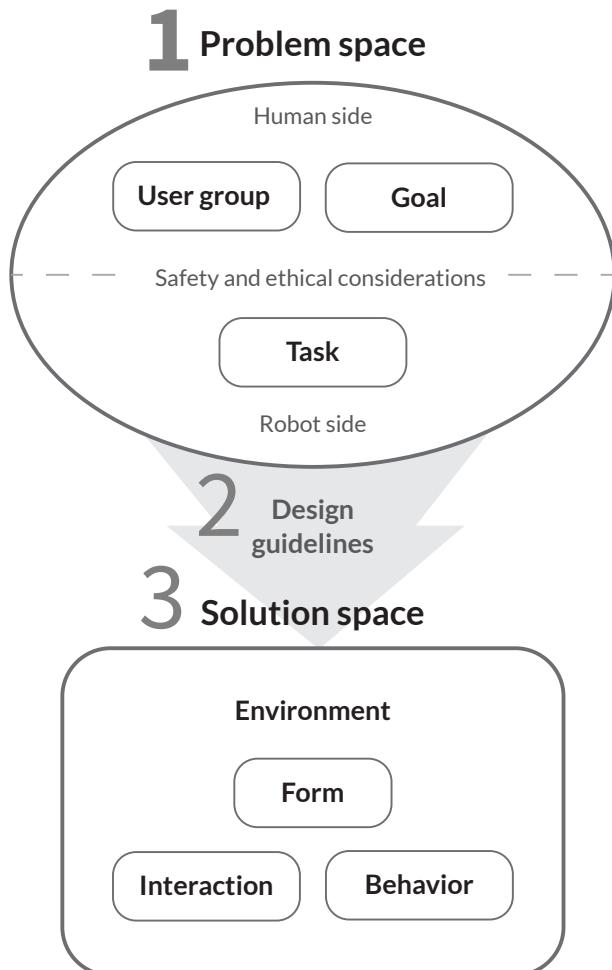
- **Physical safety** – child can't touch robot
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- **Equality across users** – gender neutral robot

# Problem space – Ethical considerations



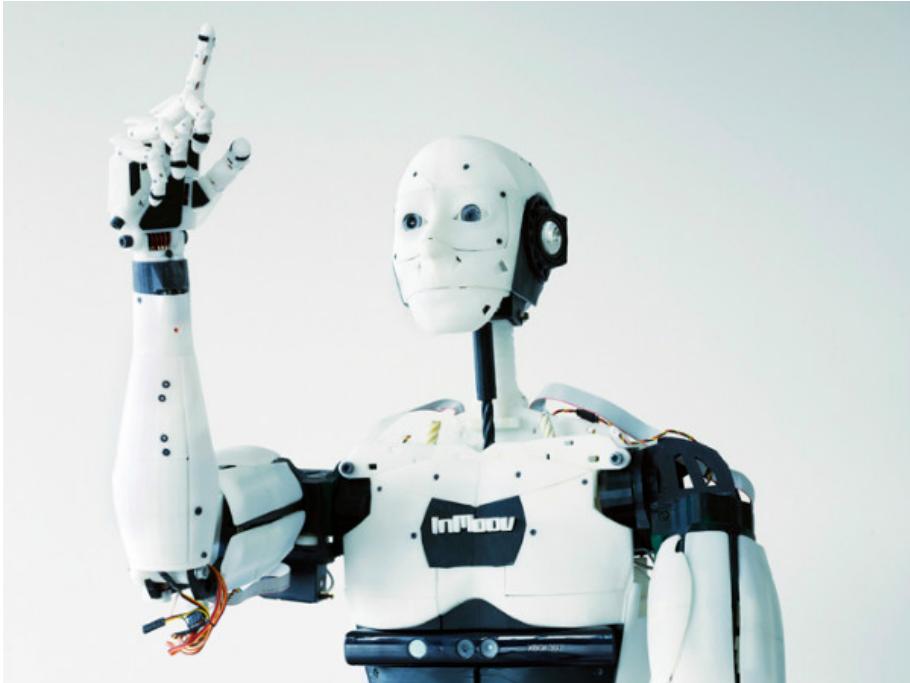
- **Physical safety** – child can't touch robot
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- **Transparency** – informed of teleoperation at end

# Problem space – Ethical considerations



- **Physical safety** – child can't touch robot
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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

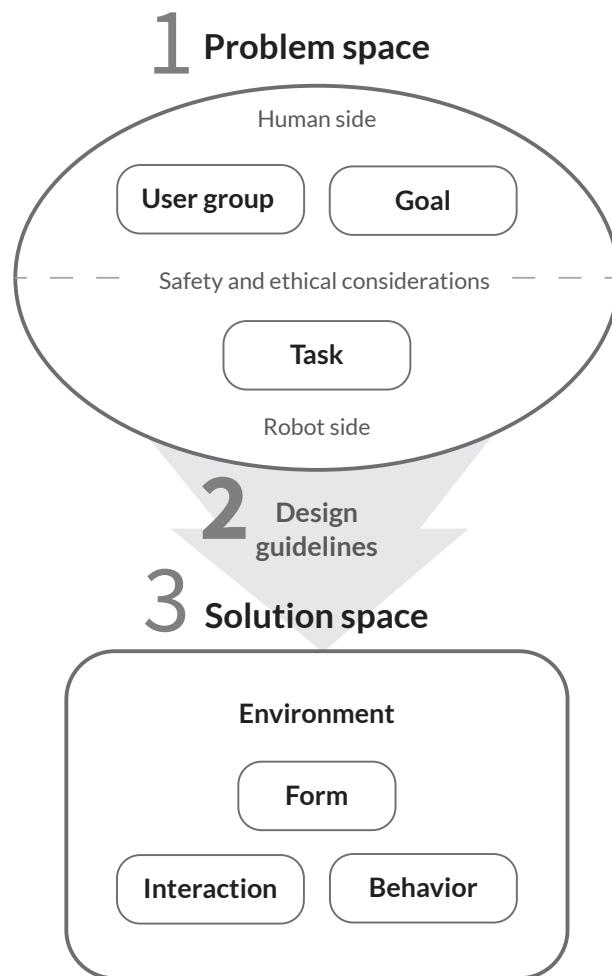
# InMoov



- Designed by Gaël Langevin
- Open source
- 3D-printed
- “MyRobotLab” software
- **5 fingers → signing ability**
- **Modifiable → design modifications**

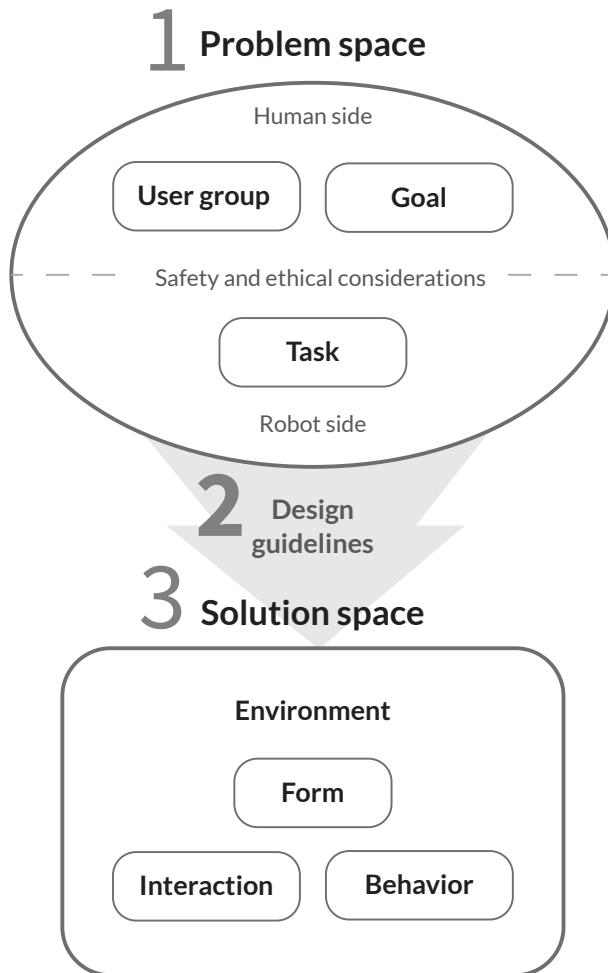
Image: Gael Langevin, from Wikipedia.

# Design guidelines



## 1. Simple form

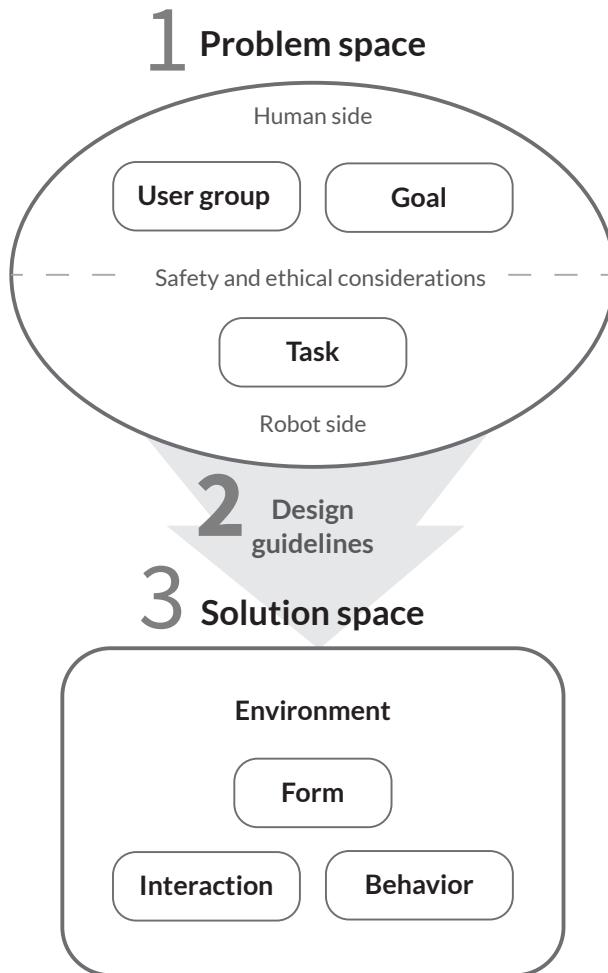
# Design guidelines



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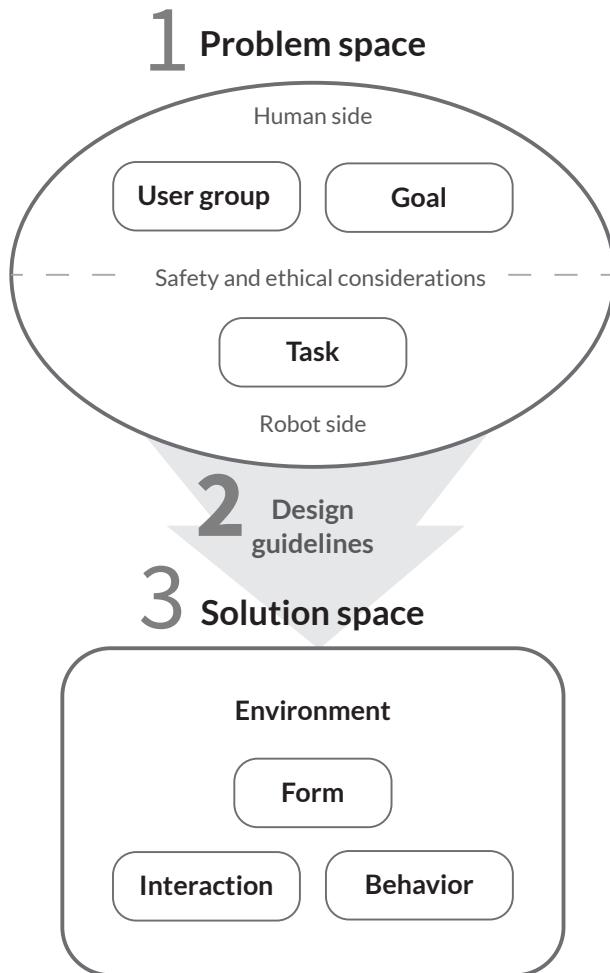
2. Consistent, structured, simple behavior

# Design guidelines



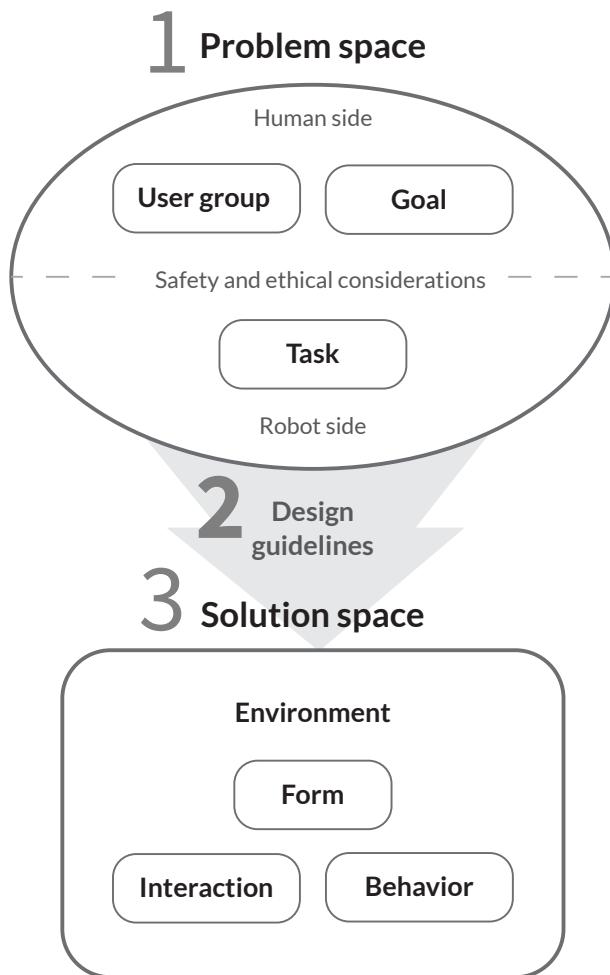
1. Simple form
2. Consistent, structured, simple behavior
3. Positive, supportive, rewarding experience and environment

# Design guidelines



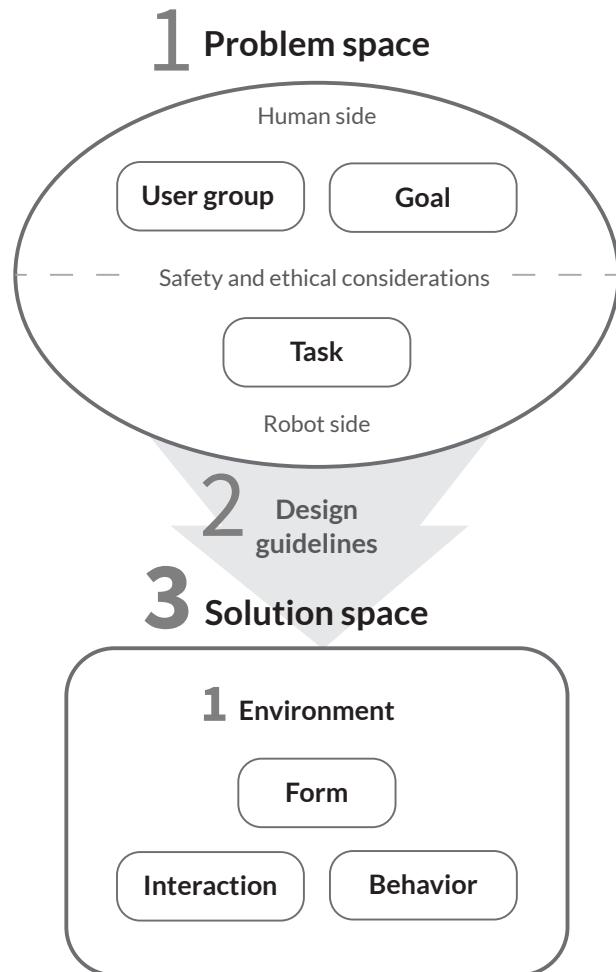
1. Simple form
2. Consistent, structured, simple behavior
3. Positive, supportive, rewarding experience and environment
4. Modular complexity

# 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

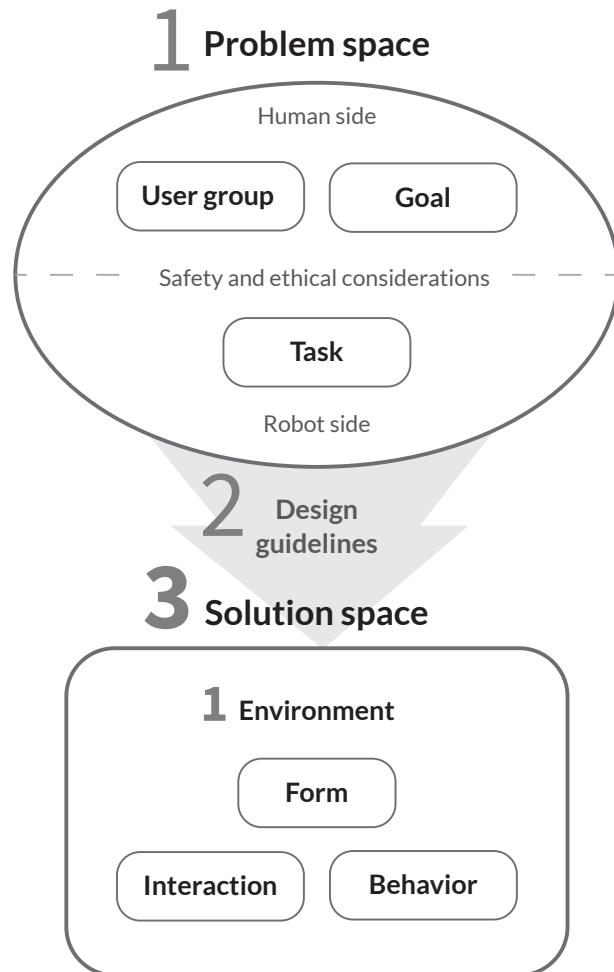
# Solution Space – Environment



Factors surrounding the robot's operation:

- **Experiment flow** – predefined

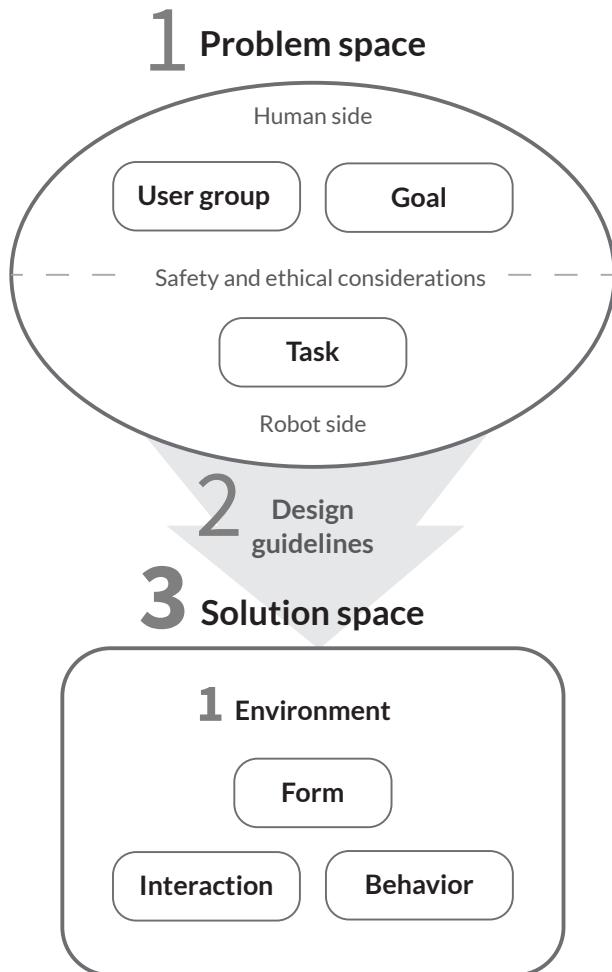
# Solution Space – Environment



Factors surrounding the robot's operation:

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

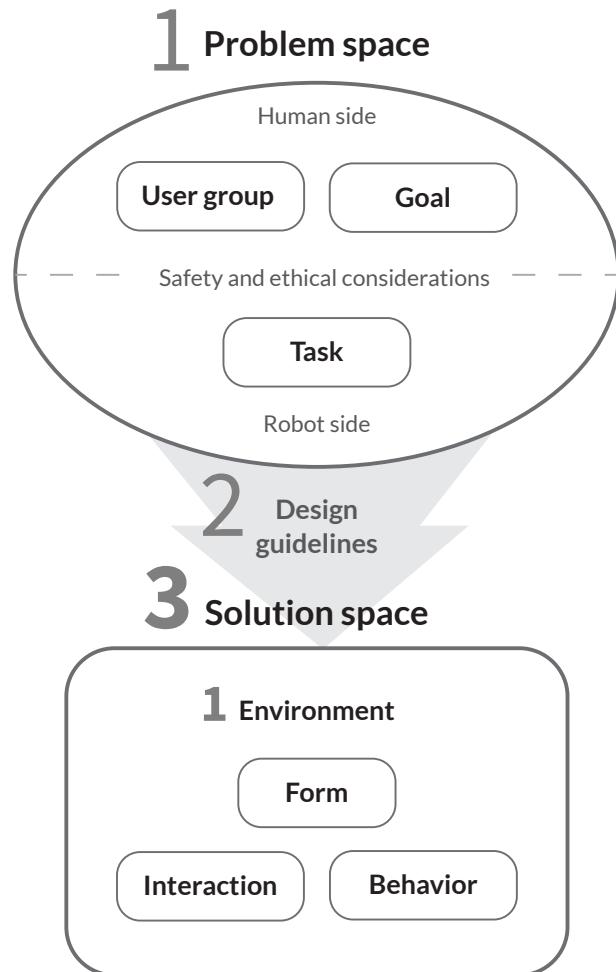
# Solution Space – Environment



Factors surrounding the robot's operation:

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

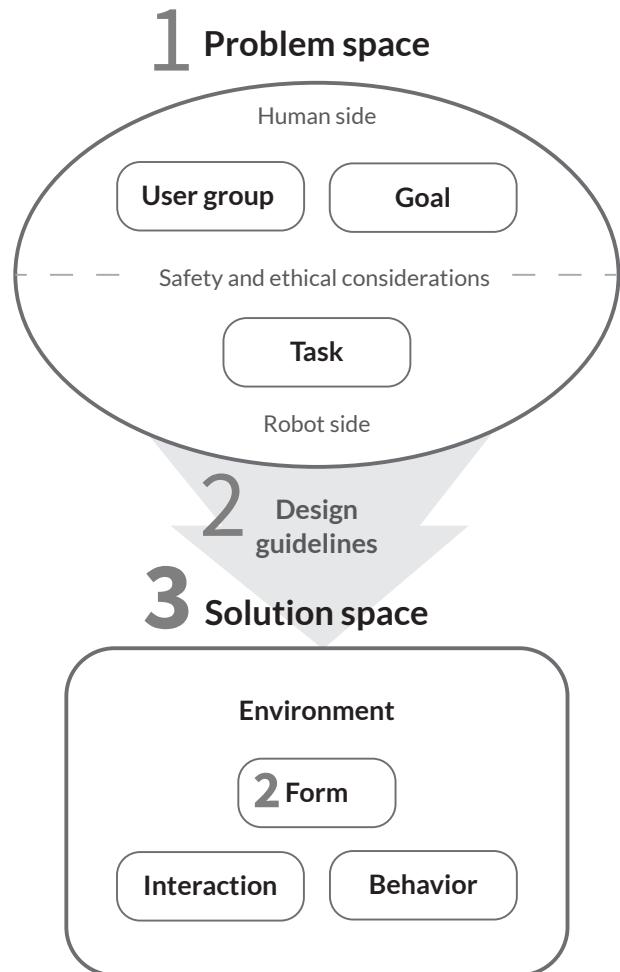
# Solution Space – Environment



Factors surrounding the robot's operation:

- **Experiment flow** – predefined
- **Simultaneous users** – one child at a time
- **Human facilitation** – therapist facilitator
- **Role of the robot** – authority, co-operator

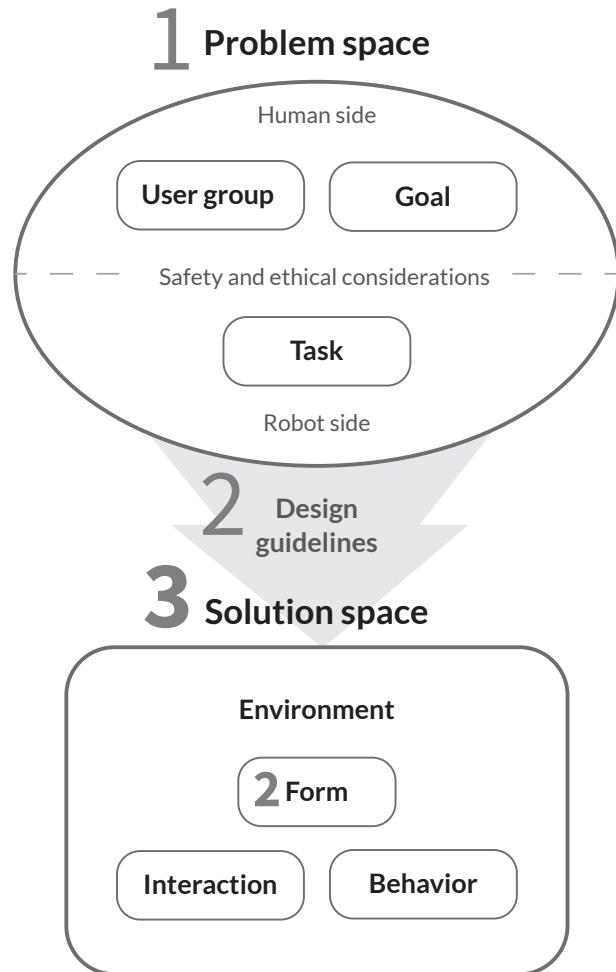
# Solution Space – Form



Externally perceptible qualities:

- **Appearance** – anthropomorphic, mechanical

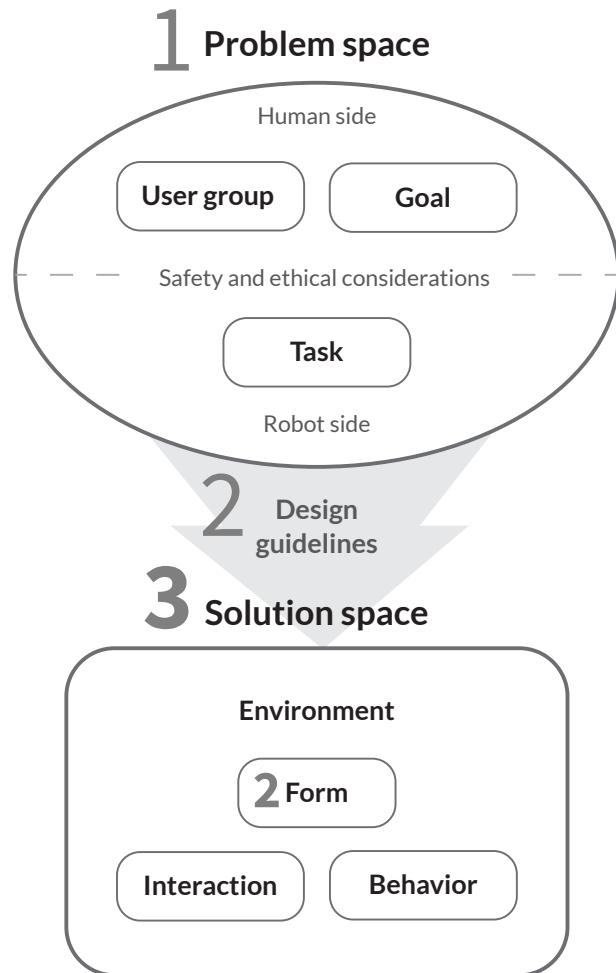
# Solution Space – Form



Externally perceptible qualities:

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

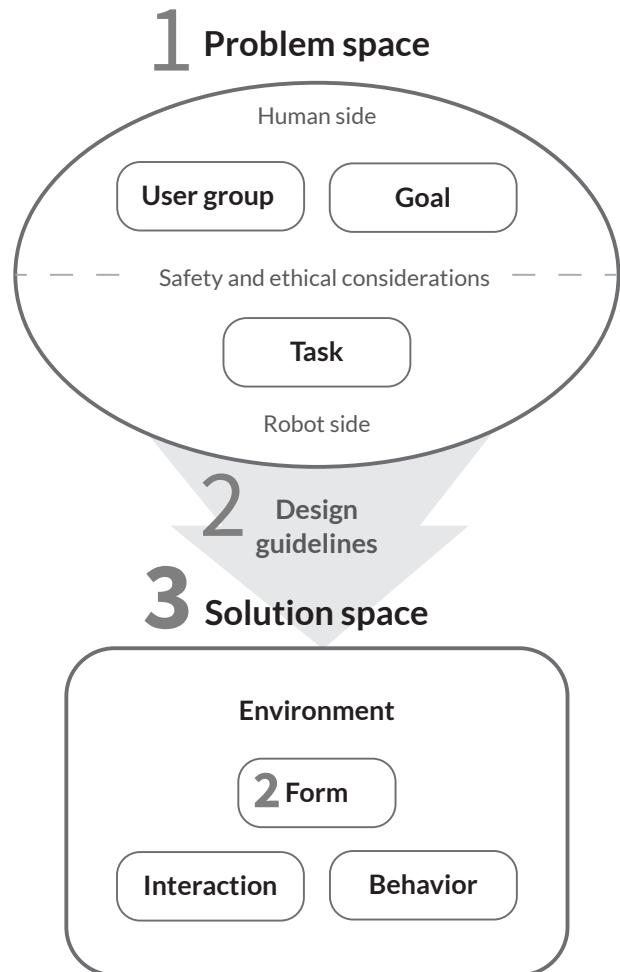
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Externally perceptible qualities:

- **Appearance** – anthropomorphic, mechanical
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- **Voice** – machine-like, gender-neutral

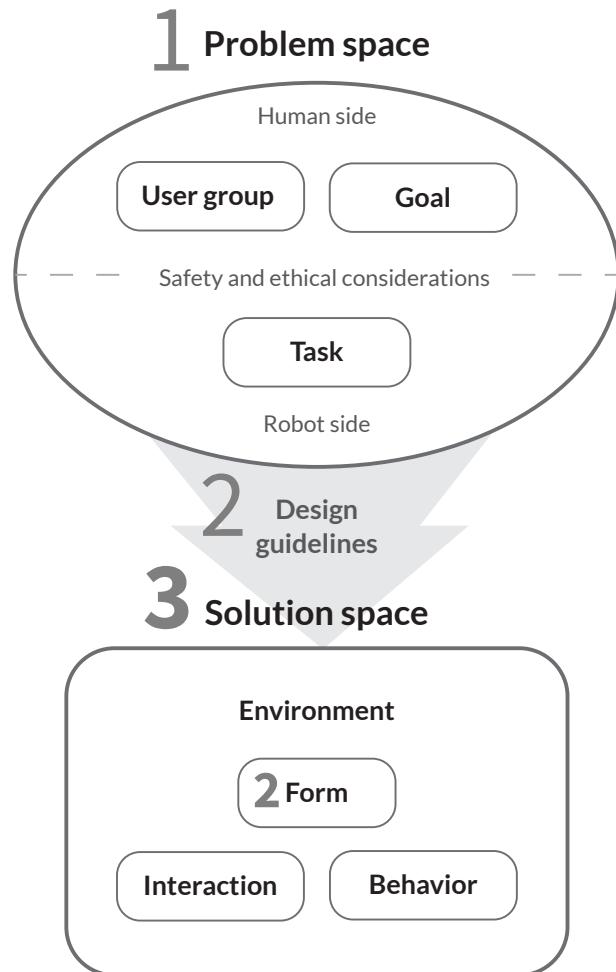
# Solution Space – Form



Externally perceptible qualities:

- **Appearance** – anthropomorphic, mechanical
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- **Sounds** – congratulatory music on success

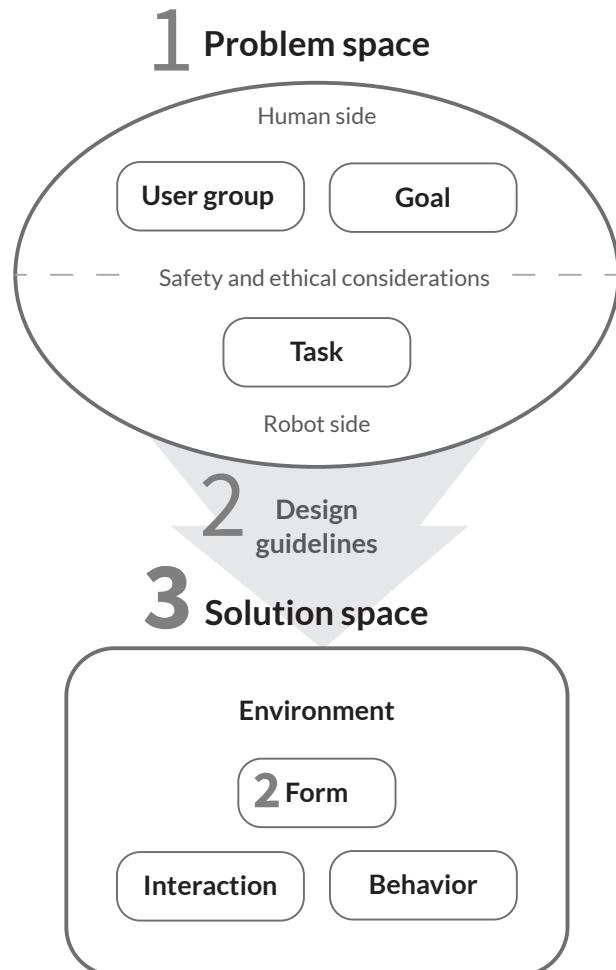
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- **Tactile sensations** – not relevant in this application

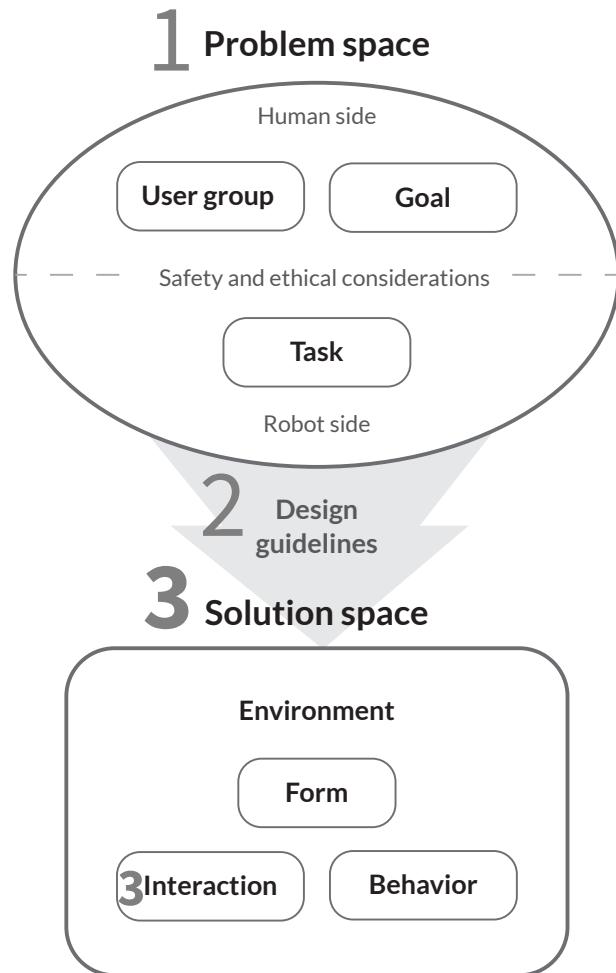
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- **Olfactory sensations** – not relevant in this application

# Solution Space – Interaction

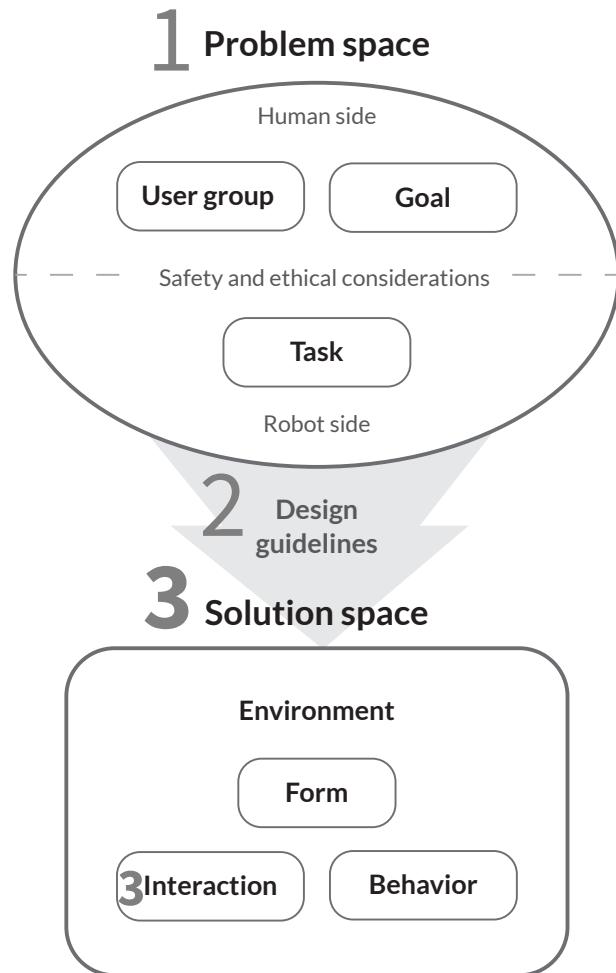


The manner in which a user interacts with a robot:

- **Modalities –**

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

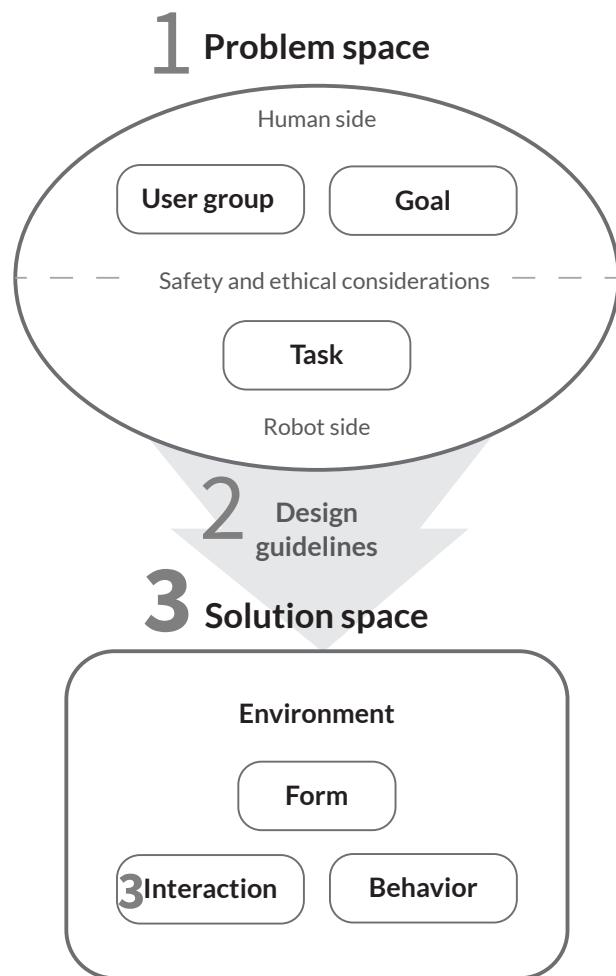
# Solution Space – Interaction



The manner in which a user interacts with a robot:

- **Modalities** –
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- **Leadership** – robot-led

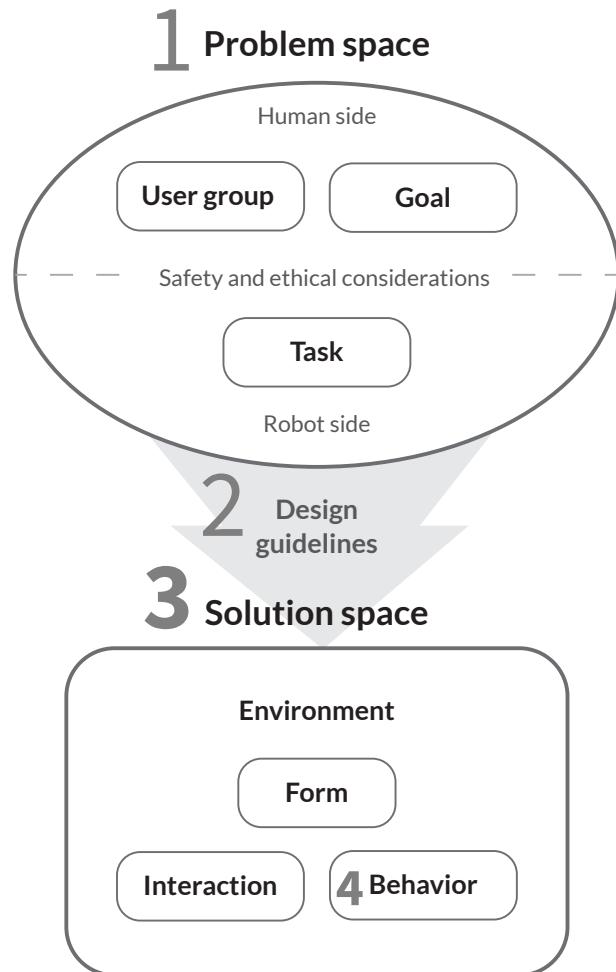
# Solution Space – Interaction



The manner in which a user interacts with a robot:

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- **Leadership** – robot-led
- **Goal** – task accomplishment

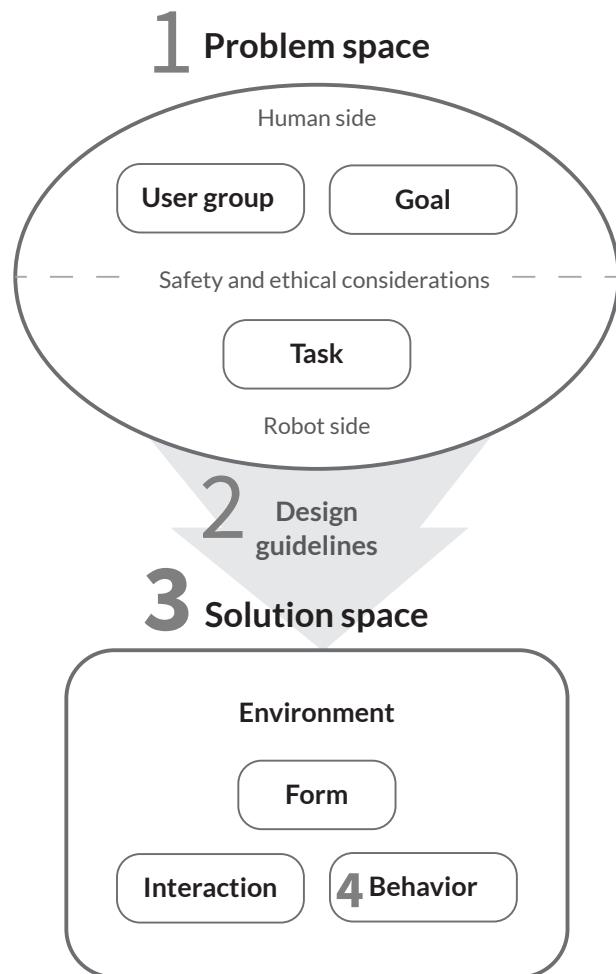
# Solution Space – Behaviour



How and why the robot acts:

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

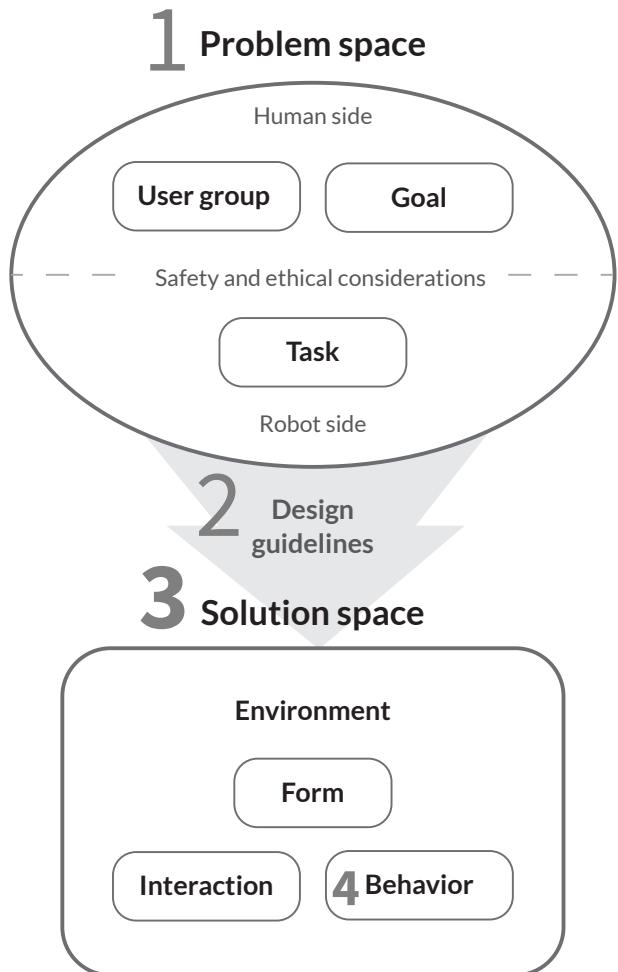
# Solution Space – Behaviour



How and why the robot acts:

- **Contextual adaptation** – no adaptation, structured behaviour
- **Motivation** – externally motivated, responds to childrens' behaviour

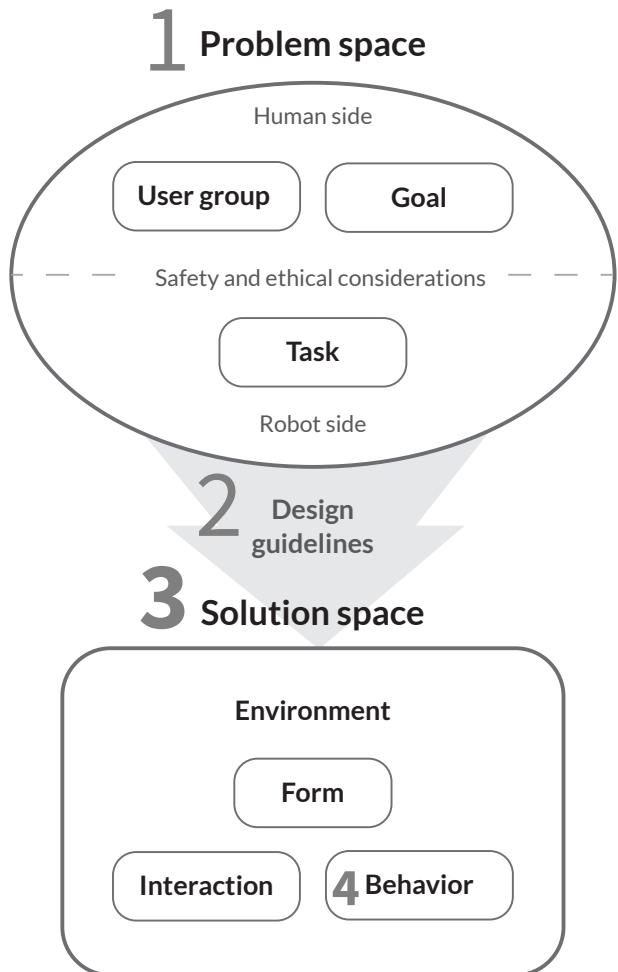
# Solution Space – Behaviour



How and why the robot acts:

- **Contextual adaptation** – no adaptation, structured behaviour
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- **Social awareness** – rudimentary, greeting and saying goodbye

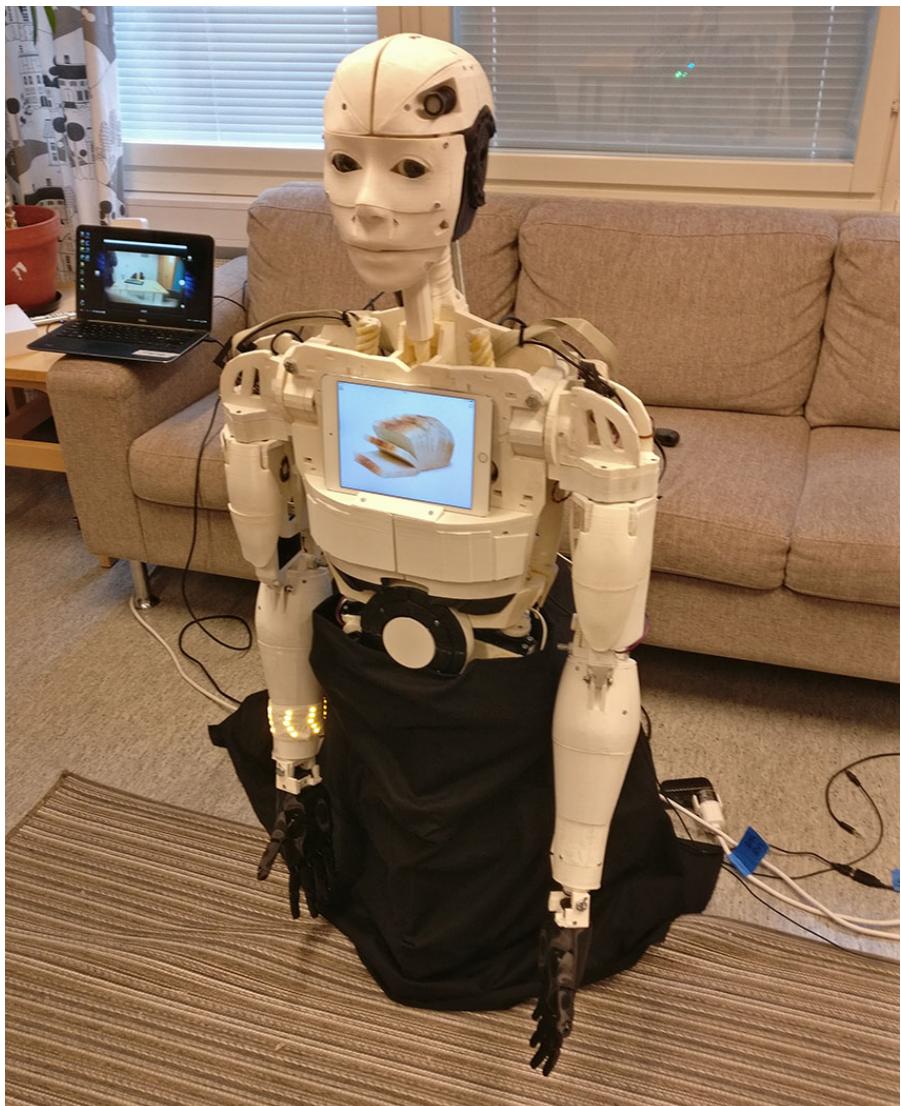
# Solution Space – Behaviour



How and why the robot acts:

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

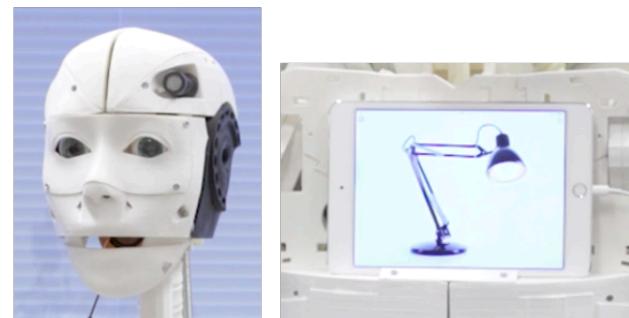
# User study

**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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