

# Learning Instructor Expectations in ITL Agent Interaction

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Preeti Ramaraj

May 2018



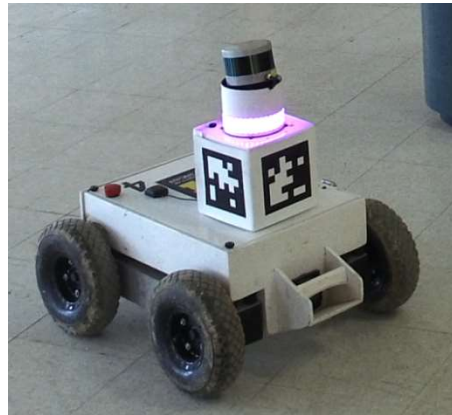
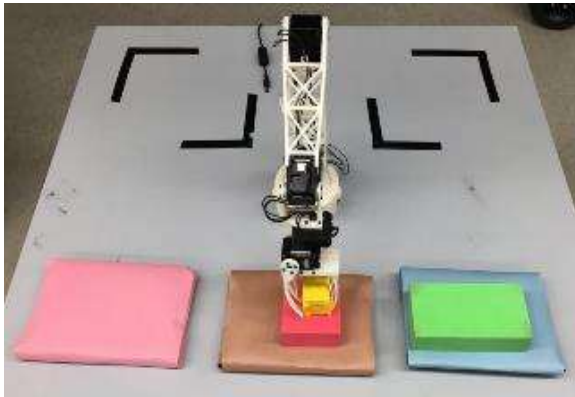
# Interactive Task Learning

- Learns new task through instruction from humans
  - Through language and demonstration
  - Learning is online, one shot, and in real time.



# Interactive Task Learning - Rosie

- Rosie
  - Interactive Task Learning (ITL) agent built on Soar
  - Learn all aspects of tasks: concepts, goals, constraints, failure conditions
  - Knows 30+ games and puzzles, and mobile delivery tasks



Kirk, J., Mininger, A., Laird, J. 2016: Learning task goals interactively with visual demonstrations. Biologically Inspired Cognitive Architectures. New York, New York, 2016.

Mininger, A., & Laird, J. 2016: Interactively Learning Strategies for Handling References to Unseen or Unknown Objects. In Proceedings of the Fourth Annual Conference on Advances in Cognitive Systems.

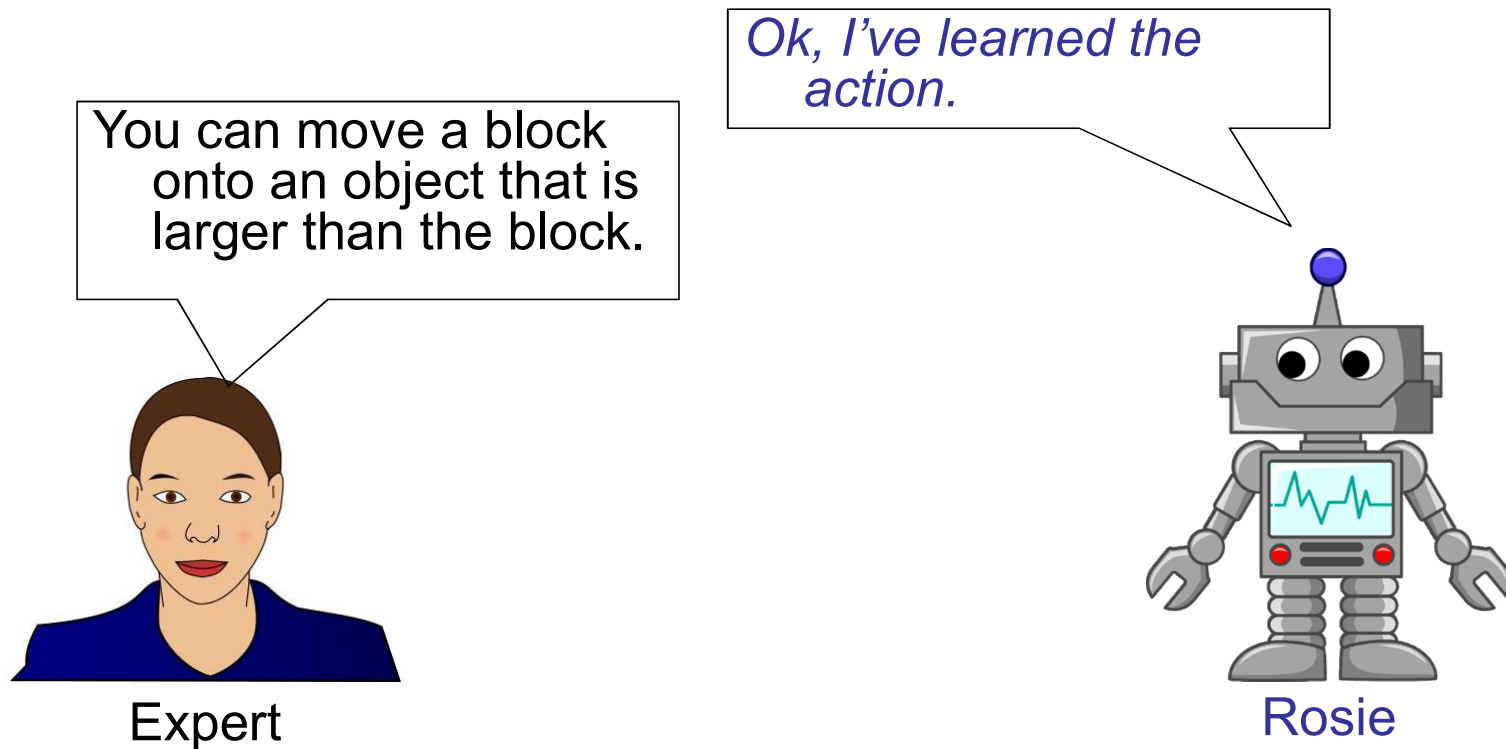


# Outline

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- Current System
- Study design
- Results

- Expert Instructor



# Prototype - Tower of Hanoi

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- Has constraints, actions and goal state



# Existing Expert ITL Interaction

Mentor: The name of the puzzle is Tower-of-Hanoi.  
*Agent: Please setup the puzzle.*  
Mentor: Ok.

**Name**  
**Setup puzzle**





# Existing Expert ITL Interaction

*Agent: Can you describe the actions, goal states and failure conditions?*

Mentor: The goal is that a blue block is on a green block and the green block is on a red block and the red block is on an orange location.

*Agent: Please setup the goal.*

Mentor: Ok.

*Agent: Ok, I've learned the goal.*

**Name**  
**Setup puzzle**

**Learn**  
**Goal**

DR12  
PR13



## Slide 9

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**PR12** change box colors  
Preeti Ramaraj, 5/3/2018

**PR13** start with border.. once it is completed, fill color  
Preeti Ramaraj, 5/3/2018

# Existing Expert ITL Interaction

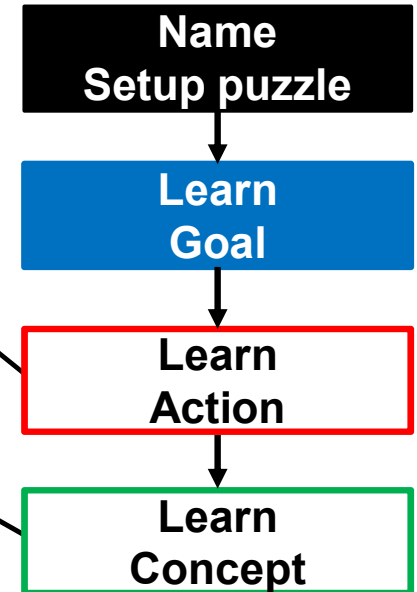
*Agent: Can you describe the actions, goal states and failure conditions?*

Mentor: You can move a clear block onto a clear object that is larger than the block.

*Agent: I don't know the concept clear.*

Mentor: If a location is not below an object then it is clear.

*Agent: Ok, I've learned the concept clear*



# Existing Expert ITL Interaction

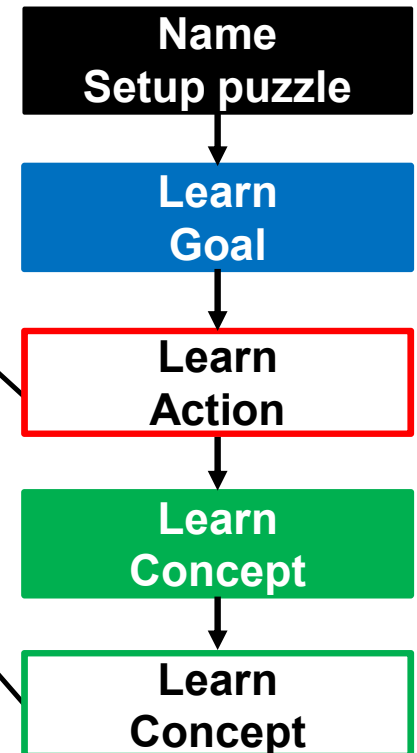
*Agent: Can you describe the actions, goal states and failure conditions?*

Mentor: You can move a clear block onto a clear object that is larger than the block.

*Agent: I don't know the concept larger.*

Mentor: If the volume of a block is more than the volume of an object then the block is larger than the object.

*Agent: Ok, I've learned the concept larger.*

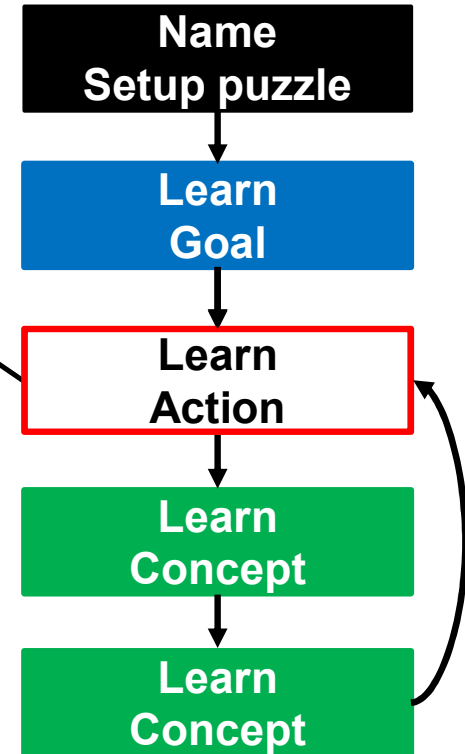


# Existing Expert ITL Interaction

*Agent: Can you describe the actions, goal states and failure conditions?*

Mentor: You can move a clear block onto a clear object that is larger than the block.

*Agent: Ok, I've learned the action.*

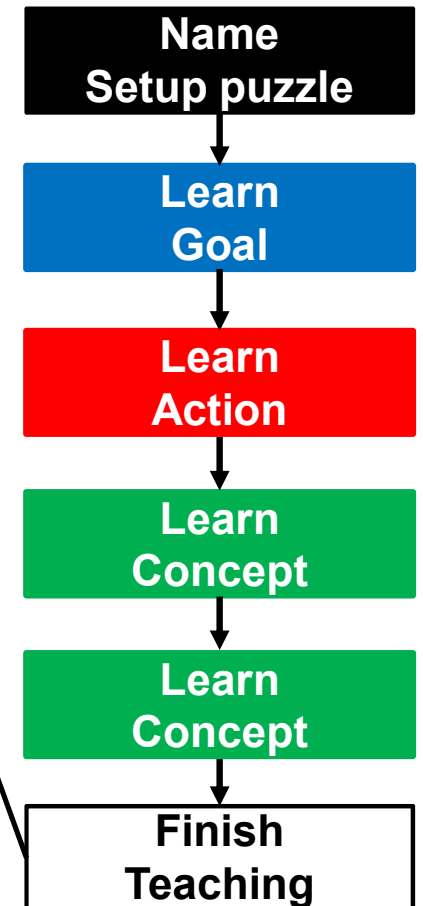


# Existing Expert ITL Interaction

Mentor: Done

*Agent: Ok, I've learned the rules of Tower-of-Hanoi.  
Please setup the initial state so that I can try and solve  
the puzzle.*

Mentor: Ok.



# Existing Expert ITL Interaction

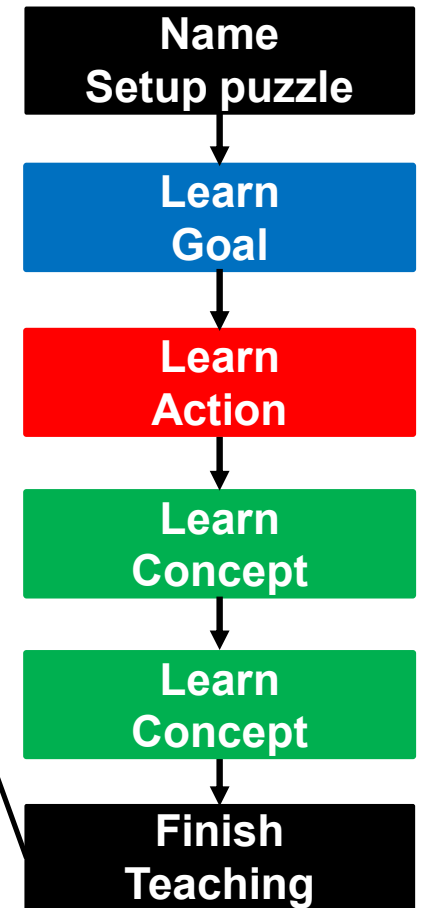
Mentor: Done

*Agent: Ok, I've learned the rules of Tower-of-Hanoi.  
Please setup the initial state so that I can try and solve  
the puzzle.*

Mentor: Ok.

*Agent: (searches for solution)*

*Agent: I have found a solution.*



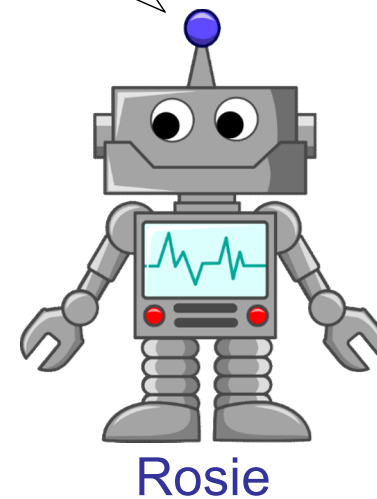
# Problem

- Non-expert Instructor

You can move a fox or a geese to the boat if there are less than 2 blocks on the boat already



*I don't understand.*





**Slide 15**

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**PR56** (maybe show a small snippet of person failing)  
Preeti Ramaraj, 5/7/2018

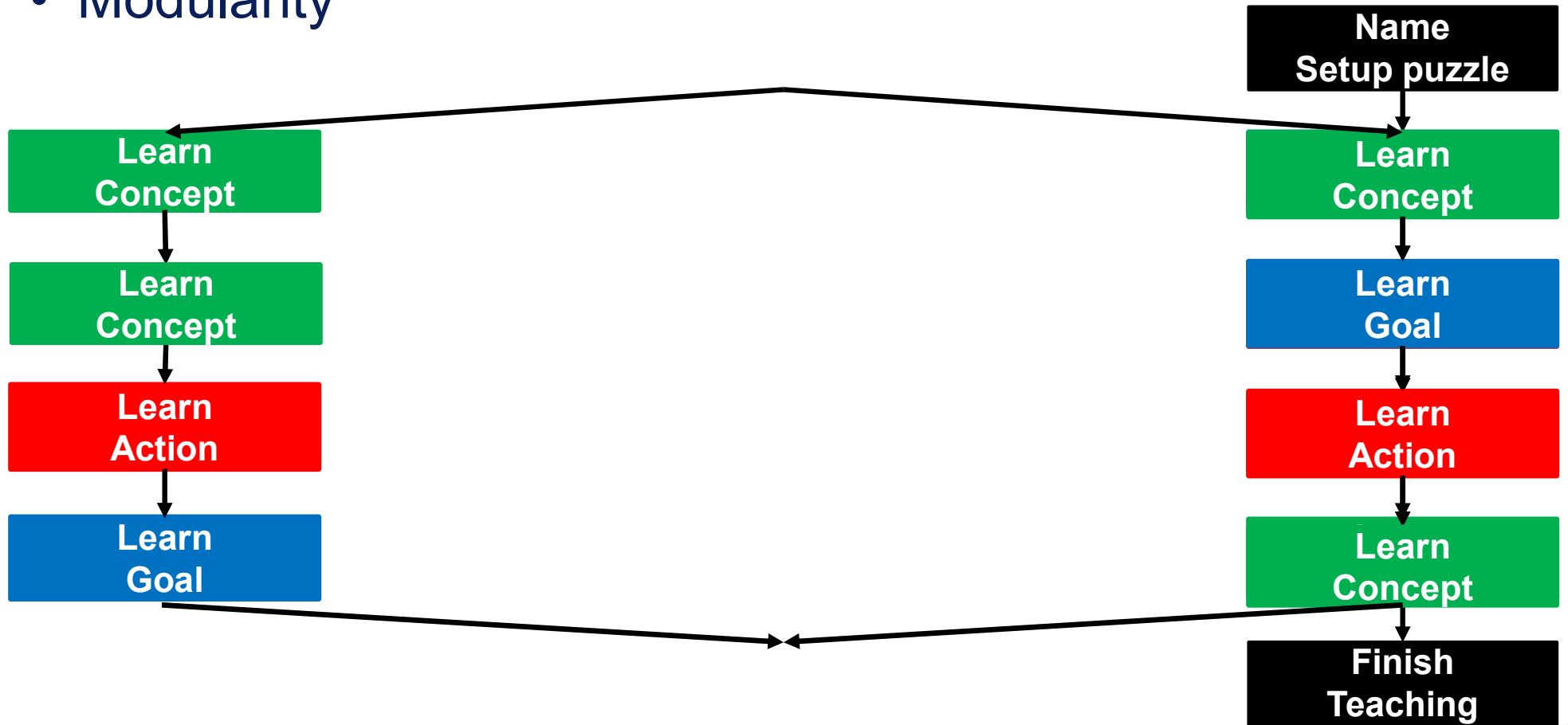
## Question asked in the study

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1. Can a non-expert instructor successfully teach our ITL agent?

# Characteristics of ITL Agent Interaction

- Modularity



# Characteristics of ITL Agent Interaction

- Domain-specific <sup>PR47</sup> Language
- Agent Feedback

Mentor: You can move a clear block onto a clear object that is larger than the block.

Agent: ~~Don't move the clear block.~~

Learn  
Action



## Slide 18

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**PR47** switch agent feedback and local correction  
Preeti Ramaraj, 5/6/2018

- Local Correction

Mentor: The goal is that a blue block is on a green block and the green block is on a red block and the red block is on an orange location.

*Agent: Please setup the goal.*

Mentor: Ok.

*Agent: I cannot satisfy the goal. A blue block is not on a green block.*

Mentor: Ok.

*Agent: Ok, I've learned the goal.*

Learn  
Goal



## Questions asked in the study

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1. Can a non-expert instructor successfully teach our ITL agent?
2. How do the characteristics of modularity, local correction, agent feedback and domain-specific language affect the teaching process?

# Outline

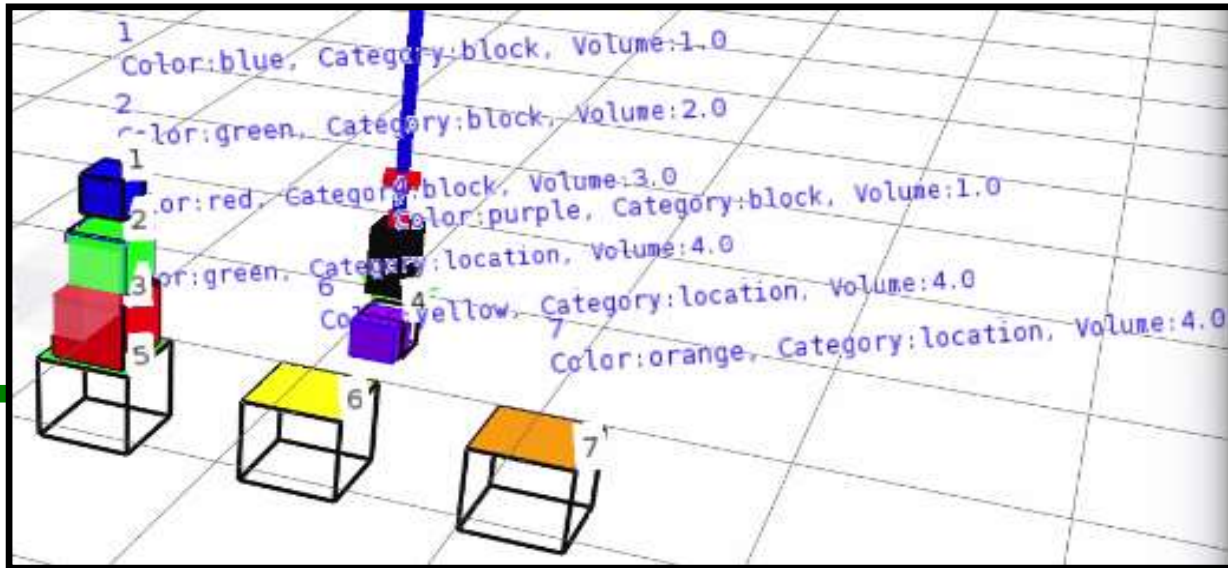
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- Current System
- Study design
- Results




# Study Design

1. 10 participants
  - Ensured they already knew the puzzle Tower of Hanoi
2. Pre-experiment survey
3. Information provided to the instructor

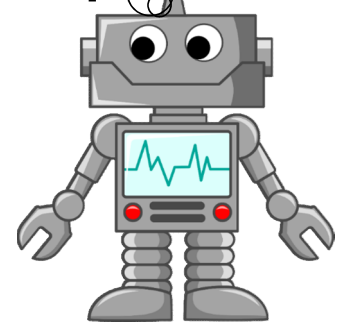


Question?  
“block” =  
Move(block2, loc2)  
red = ...  
ToH actions = ...  
ToH goal =

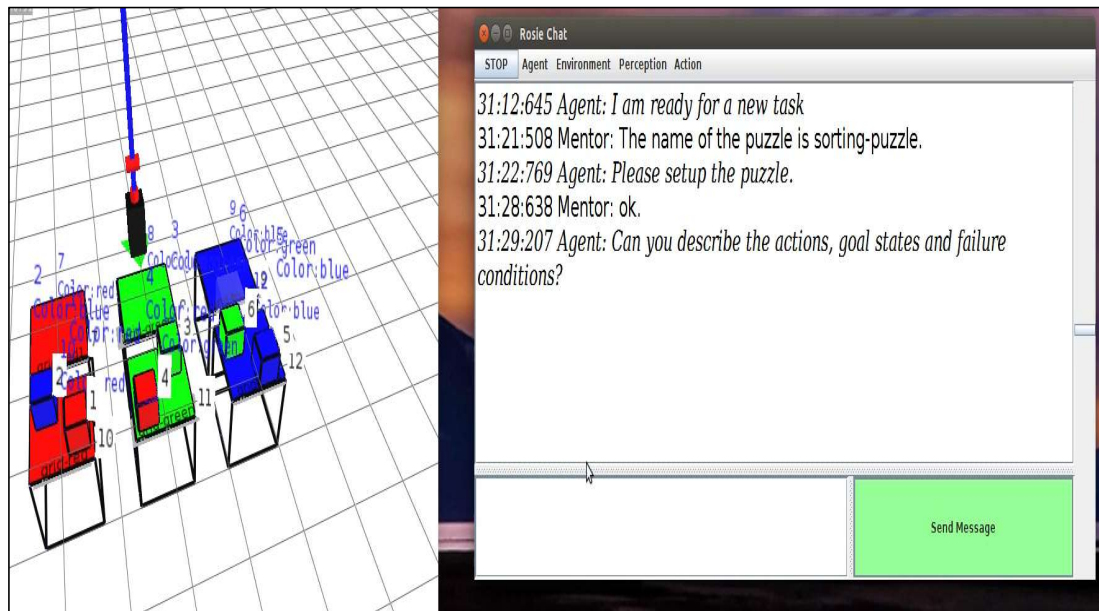


than, = is-equal-to

(block)



## Condition 1



## Condition 2

- Name: The name of the puzzle is sorting-puzzle.
- Failure state: **If** a red block is on a blue location **then you lose**.
- Goal state: **The goal is that** all the red blocks are on the red locations and all the blue blocks are on the blue locations and all the green blocks are on the green locations.
- Action: **You can move** a block onto a clear location.
- Concept: **If** a location is not below an object **then** it is clear.

## 5. Post-Experiment Survey

- Rate ease of teaching
- Rate helpfulness of
  - condition information (video/sample instructions)
  - agent knowledge
  - being able to ask questions of the agent

## Slide 24

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**PR28** add images for condition info, agent knowledge, ??? for interaction better or worse, maybe thumbs up and thumbs down... and ease of teaching

Preeti Ramaraj, 5/5/2018

## Study Design

- Wizard of Oz Design
- To accommodate free-form language
- Created a codebook

Move block from location 1 to location 2  
You can move block onto a location.  
.....

“on top of” = “above” = “on”  
“place” = “move”  
.....

I have learned the goal  
I cannot satisfy the  
goal state .....

- Agent says “I don’t understand”

# Outline

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- Current System
- Study design
- **Results**

## Results: Question asked in the study

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Can a non-expert instructor successfully teach our ITL agent?

9 out of 10 instructors successfully taught the puzzle of Tower of Hanoi.

## Qualitative results from the study - Outline

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- Failures in instruction
- Instructor responses to survey questions
- Effect of characteristics of ITL agent interaction

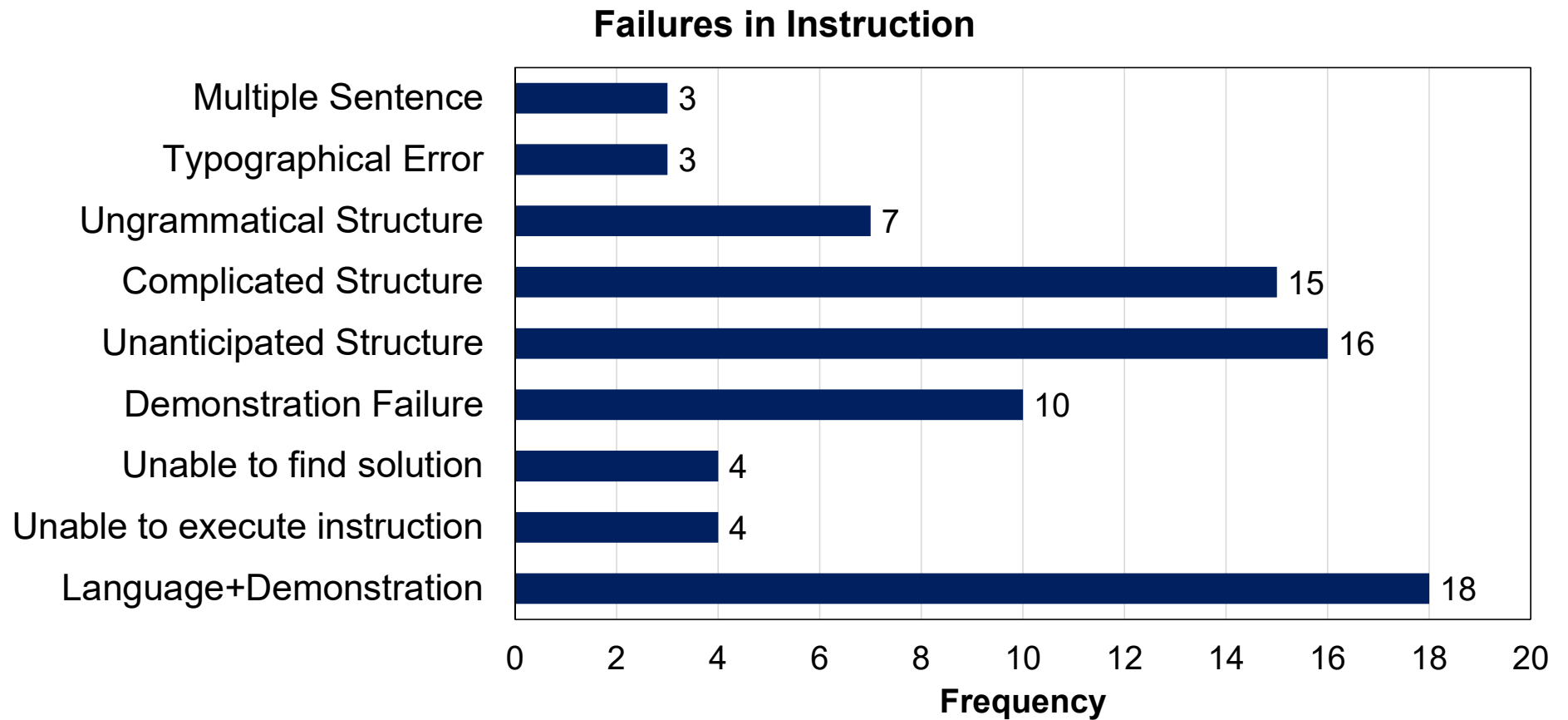


## Failures in Instruction

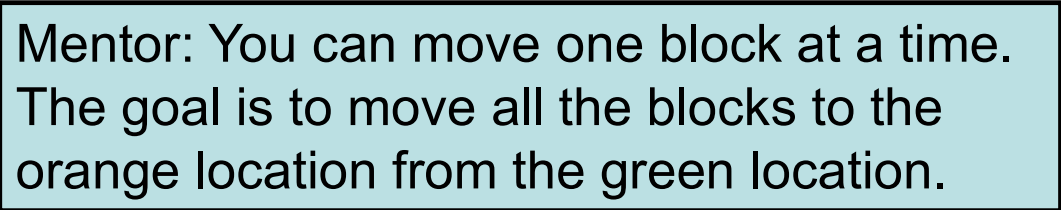
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- Instruction is not understood by agent
- Task Component is not successfully learned
- 80 total failures

# Failures in Instruction



- Multiple sentences
- Typographical Error
- Ungrammatical Structure
- Complicated Structure
- Unanticipated Structure
- Unable to find solution
- Unable to execute instruction
- Demonstration Failure
- Language + Demonstration Failure



Mentor: You can move one block at a time.  
The goal is to move all the blocks to the  
orange location from the green location.


- Multiple sentences
- **Typographical Error**
- Ungrammatical Structure
- Complicated Structure
- Unanticipated Structure
- Unable to find solution
- Unable to execute instruction
- Demonstration Failure
- Language + Demonstration Failure

Mentor: **AA** valid location is when category is location or category is block with volume greater-than object.

- Multiple sentences
- Typographical Error
- **Ungrammatical Structure** →
- Complicated Structure
- Unanticipated Structure
- Unable to find solution
- Unable to execute instruction
- Demonstration Failure
- Language + Demonstration Failure

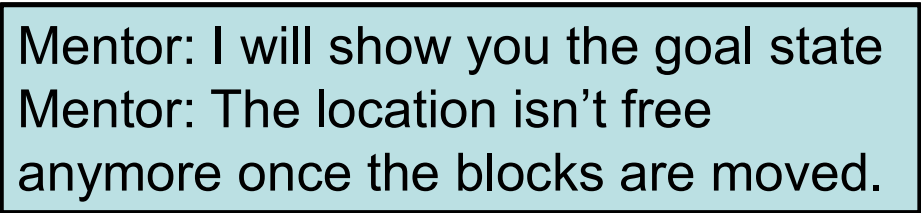
Mentor: **Blocks that are greater-than** other blocks cannot be on top of lesser-than blocks.

- Multiple sentences
- Typographical Error
- Ungrammatical Structure
- **Complicated Structure**
- Unanticipated Structure
- Unable to find solution
- Unable to execute instruction
- Demonstration Failure
- Language + Demonstration Failure



Mentor: The goal of the game is to have the red, green, and blue blocks on top of each other with the same order as the initial state at a location different than the initial location.

- Multiple sentences
- Typographical Error
- Ungrammatical Structure
- Complicated Structure
- **Unanticipated Structure**
- Unable to find solution
- Unable to execute instruction
- Demonstration Failure
- Language + Demonstration Failure



Mentor: I will show you the goal state  
Mentor: The location isn't free  
anymore once the blocks are moved.

- Multiple sentences
- Typographical Error
- Ungrammatical Structure
- Complicated Structure
- Unanticipated Structure
- Unable to find solution
- Unable to execute instruction
- Demonstration Failure
- Language + Demonstration Failure



*Agent: "I don't understand"*



# Failures in instruction

- Multiple sentences
- Typographical Error
- Ungrammatical Structure
- Complicated Structure
- Unanticipated Structure
- **Unable to find solution**
- Unable to execute instruction
- Demonstration Failure
- Language + Demonstration Failure



Mentor: Done.  
*Agent: Setup initial state*  
Mentor: Ok.  
*Agent: I am unable to find a solution. I do not see any actions in the state.*

# Failures in instruction

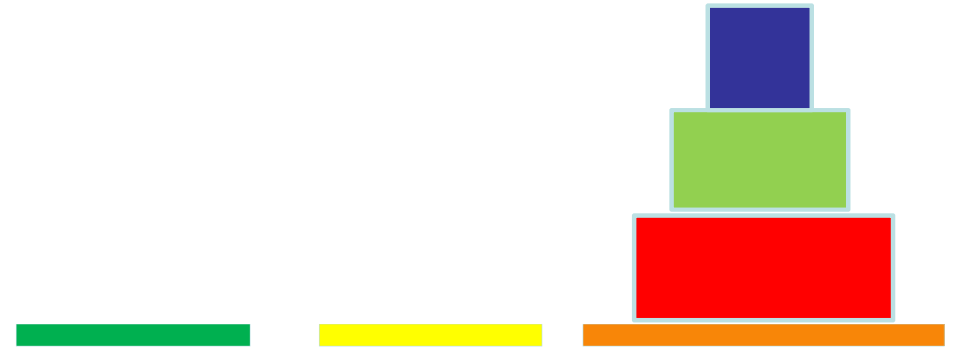
- Multiple sentences
- Typographical Error
- Ungrammatical Structure
- Complicated Structure
- Unanticipated Structure
- Unable to find solution
- **Unable to execute instruction**
- Demonstration Failure
- Language + Demonstration Failure



Mentor: Please move the red block to the orange location  
*Agent: I cannot do this action.*

# Failures in instruction

- Multiple sentences
- Typographical Error
- Ungrammatical Structure
- Complicated Structure
- Unanticipated Structure
- Unable to find solution
- Unable to execute instruction
- **Demonstration Failure**
- Language + Demonstration



Mentor: The goal state is that the red block is on the orange location, the green block is on the red block, and the blue block is on the green location.

*Agent: Please setup the goal state*

Mentor: Ok

*Agent: I cannot satisfy the goal. The blue block is not on the green location.*

## Language and Demonstration Failure

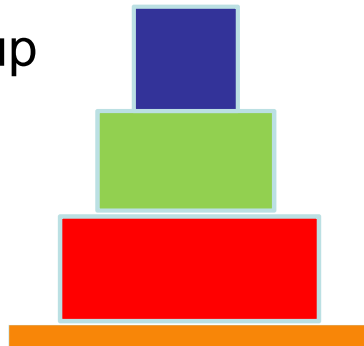
Mentor: The goal is that all the blocks are on the orange location.

*Agent: Please setup the goal state.*

Mentor: Ok.

*Agent: I cannot satisfy the goal. All the blocks are not on the orange location.*

Person setup



What agent expected



# Failures in Instruction

- Multiple sentences
  - Typographical Error
  - Ungrammatical Structure
  - **Complicated Structure** ★
  - **Unanticipated Structure** ★
  - Unable to find solution
  - Unable to execute instruction
  - Demonstration Failure
  - **Language + Demonstration Failure** ★
- Cannot anticipate all possible instructions
  - Agent could provide example instruction
  - More explicit feedback than “I don’t understand”
- Feedback completely dependent on instruction
  - Transparency mechanisms to get access to agent’s view



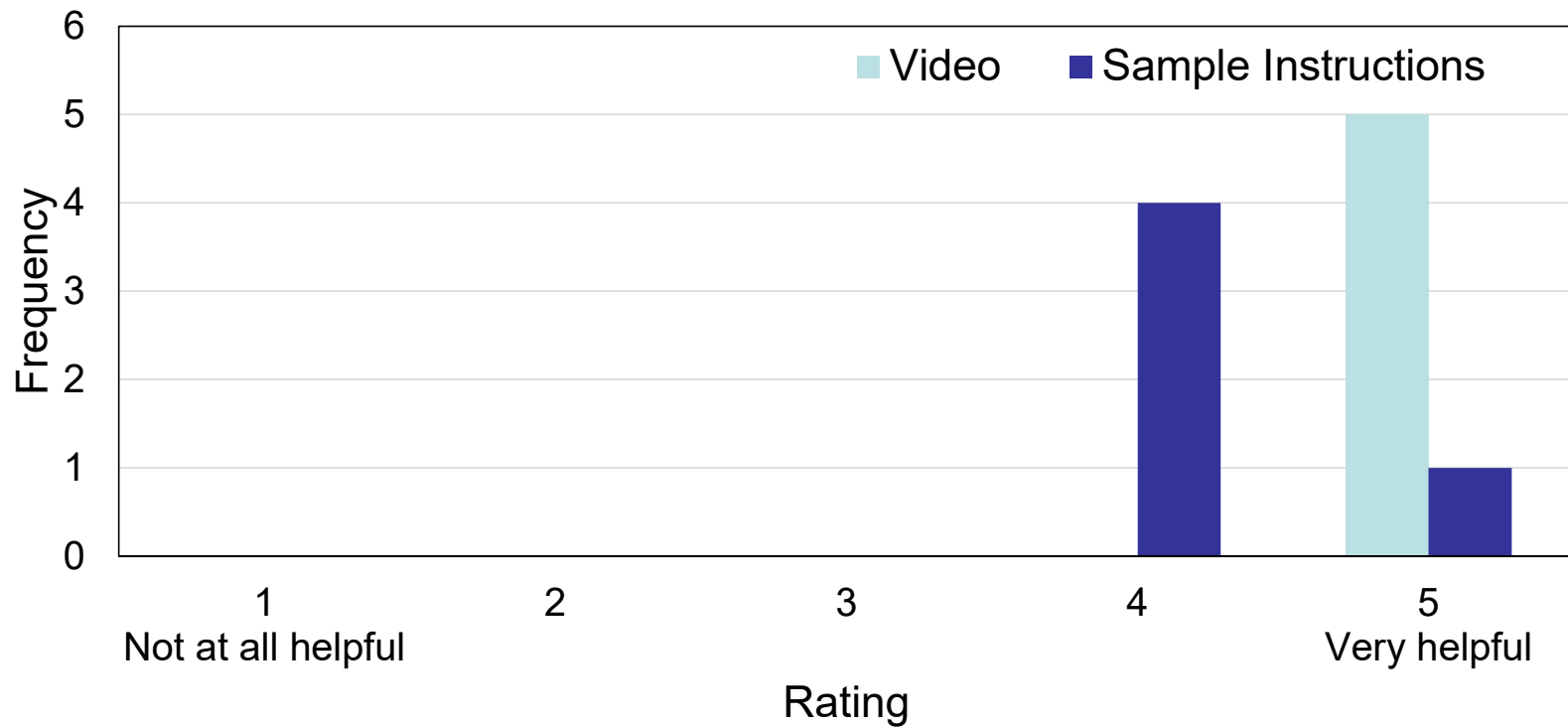
## Qualitative results from the study - Outline

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- Failures in instruction
- Instructor responses to survey questions
- Effect of characteristics of ITL agent interaction

# Instructor Responses to Survey Questions

## Helpfulness of Video/Sample Instructions



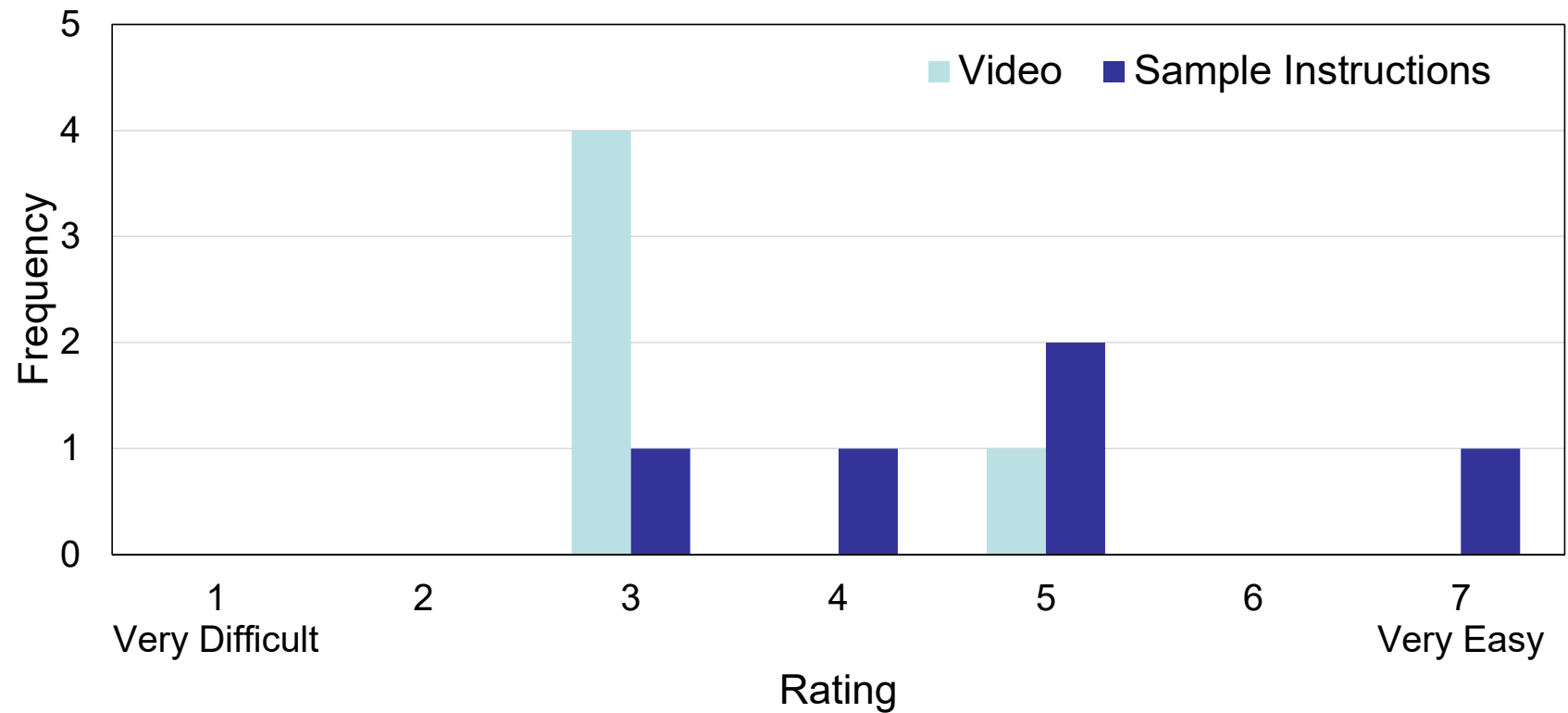
## Helpfulness of Video/Sample Instructions

- Video
  - P63: *“It helped clarify the type of language needed to teach her and what information was necessary before she could solve the puzzle.”* (Rating: 5)
- Sample Instructions
  - P13: *“Provided some base terms to work with along with the framework that Rosie was building to solve the puzzle.”* (Rating: 4)



# Instructor Responses to Survey Questions

## Ease of Teaching

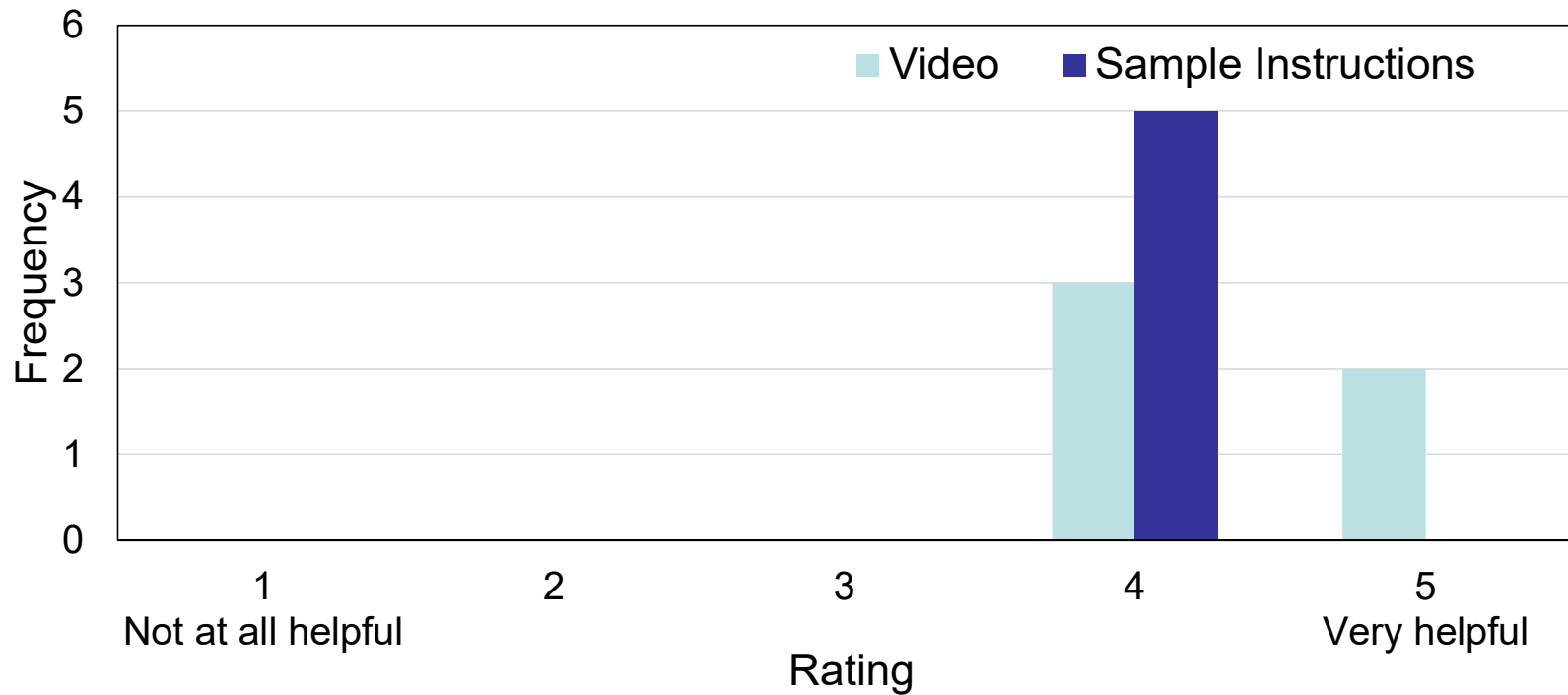


## Ease of Teaching

- Video
  - P63: “I was unsure about some of the words and phrases I used and whether Rosie would understand them. However, after a few interactions with her it became more clear what kind of teaching style was necessary.” (Rating:5)
- Sample Instructions
  - P91: “The language processing abilities of the agent were very intuitive, but the feedback was very minimal.” (Rating:5)

# Instructor Responses to Survey Questions

## Helpfulness of knowing agent knowledge



## Slide 47

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**PR49**    ake this one graph dont separate by condition  
Preeti Ramaraj, 5/6/2018

**PR50**    knowledge was same for both conditions  
Preeti Ramaraj, 5/6/2018

## Helpfulness of knowing agent knowledge

P13: “*It was very helpful to know whether or not she understood the instructions.*” (Rating: 4)

## Qualitative results from the study - Outline

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- Failures in instruction
- Instructor responses to survey questions
- **Effect of characteristics of ITL agent interaction**

- Modularity
  - Instructors taught component in non-specific order
  - Agent response valuable
  - Can adapt to teaching style

- Agent Feedback
    - Confirming its knowledge
    - Indicating it is ready for a new instruction
    - Reassuring to get general and component-level feedback
    - Clearer feedback required
- } Valuable



# Effect of characteristics of ITL agent interaction

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- Local Correction
  - Used agent feedback to
    - Rephrase instruction
    - Verify demonstration
  - Unsure how to get out of instruction failure
  - Explicit instruction to reverse knowledge helpful

## Slide 52

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**PR53** consider adding a video snippet of instructor constantly failing

Preeti Ramaraj, 5/7/2018

**PR54** maybe in accompanying slide

Preeti Ramaraj, 5/7/2018

- Domain-specific Language
  - Instructor adapted to expected instruction set
  - Instructor used interchangeable words and synonyms
  - Top 3 failures were result of language
  - Expand language processing capabilities

## Nuggets

- First step into understanding what an instructor's expectations are
- Instructors were able to successfully teach the task

## Coal

- Preliminary results
- Too specific to Rosie, need to generalize further
- Improvements are not implemented yet



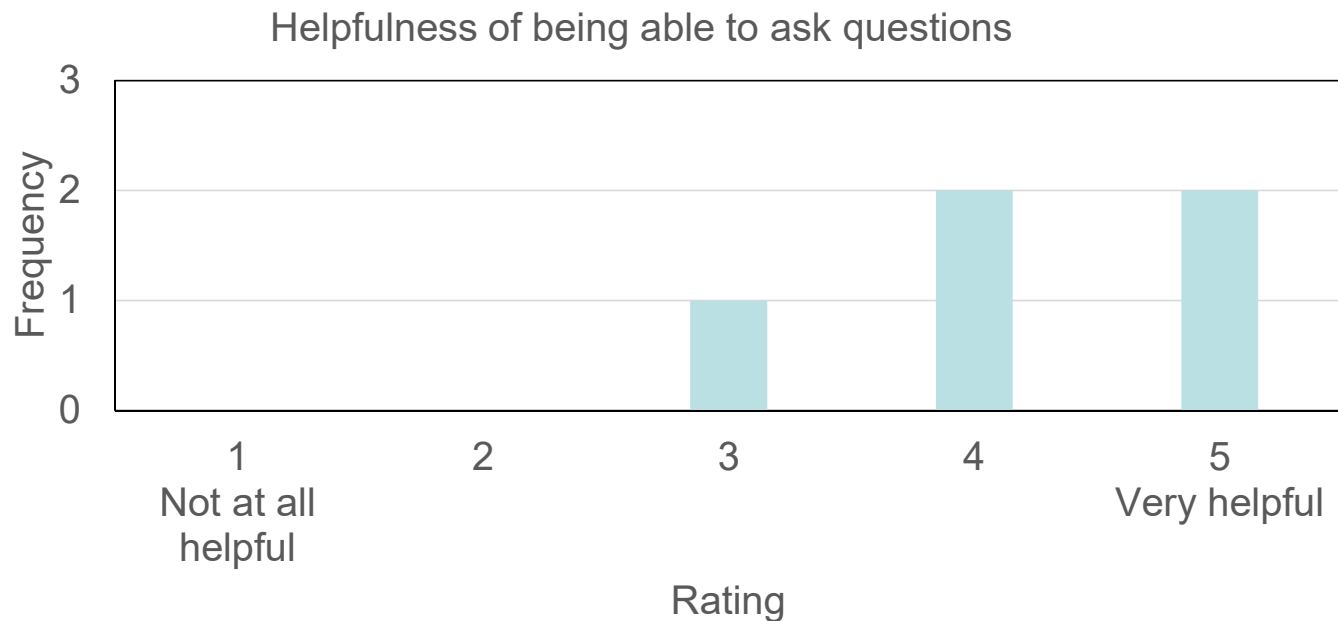
# Questions

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1. Chao, C., Cakmak, M., & Thomaz, A. L. (2010, March). Transparent active learning for robots. In Human-Robot Interaction (HRI), 2010 5th ACM/IEEE International Conference on (pp. 317-324). IEEE.
2. Rosenthal, S., Veloso, M., & Dey, A. K. (2012). Acquiring Accurate Human Responses to Robots' Questions. *International Journal of Social Robotics*, 4(2), 117–129.
3. Thomaz, A. L., & Breazeal, C. (2008). Teachable robots: Understanding human teaching behavior to build more effective robot learners. *Artificial Intelligence*, 172(6–7), 716–737.
4. Laird, J. E., Gluck, K., Anderson, J., Forbus, K., Jenkins, O., Lebiere, C., Salvucci, D., Scheutz, M., Thomaz, A., Trafton, G., Wray, R. E., Mohan, S., Kirk, J. R. (2017). Interactive Task Learning, *IEEE Intelligent Systems*,
5. Clark, H. H., & Brennan, S. E. (1991). Grounding in communication. *Perspectives on socially shared cognition*, 13(1991), 127-149.
6. Clark, Herbert H., and Deanna Wilkes-Gibbs. "Referring as a collaborative process." *Cognition* 22.1 (1986): 1-39.
7. Chai, J. Y.; Fang, R.; Liu, C.; and She, L. 2016. Collaborative language grounding toward situated human-robot dialogue. *AI Magazine* 37(4).
8. Kirk, J. R., and Laird, J. E. 2016. Learning general and efficient representations of novel games through interactive instruction. *Advances in Cognitive Systems* 4.
9. Mininger, A., and Laird, J. 2016. Interactively learning strategies for handling references to unseen or unknown objects. *Adv. Cogn. Syst* 5.
10. Wu, E.; Gopalan, N.; MacGlashan, J.; Tellex, S.; and Wong, L. L. 2016. Social feedback for robotic collaboration.

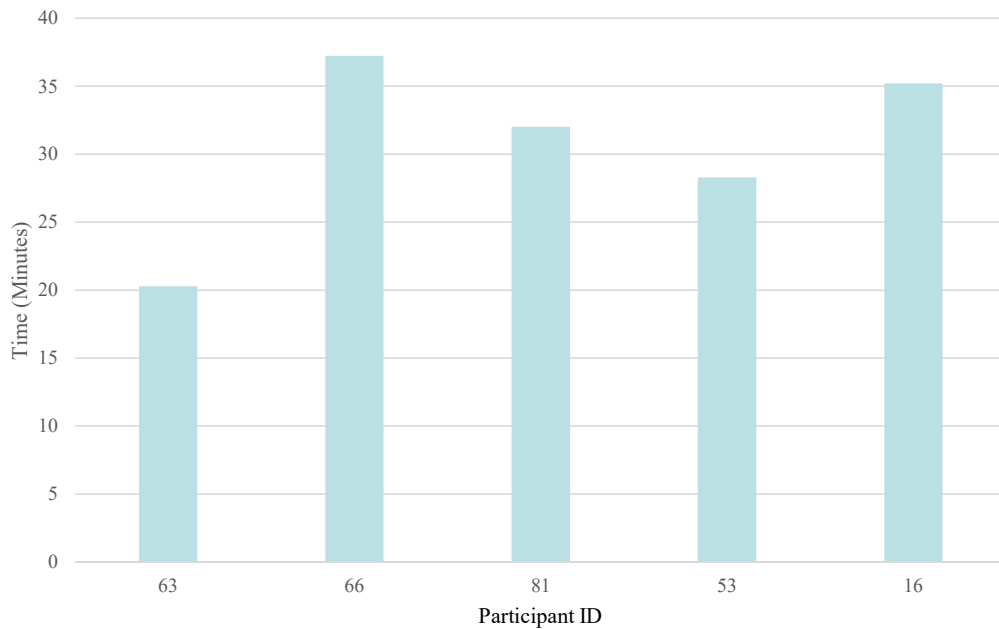
## Questions asked by instructors

- 6 out of 10 instructors asked questions
- about perception, long-term knowledge and what actions can it do at any given point of time

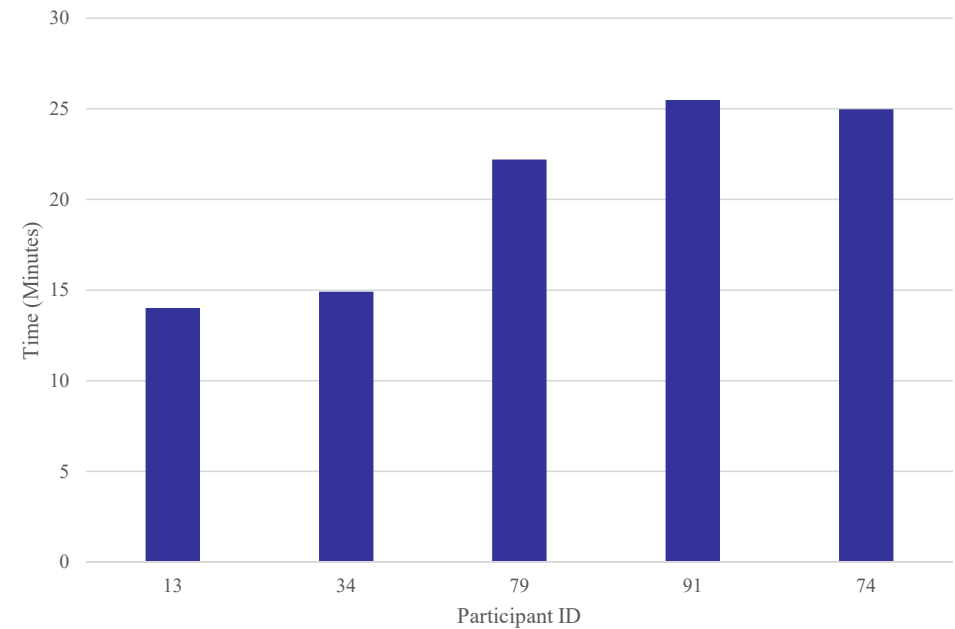


# Time taken across participants

Video (Total Teaching Duration)



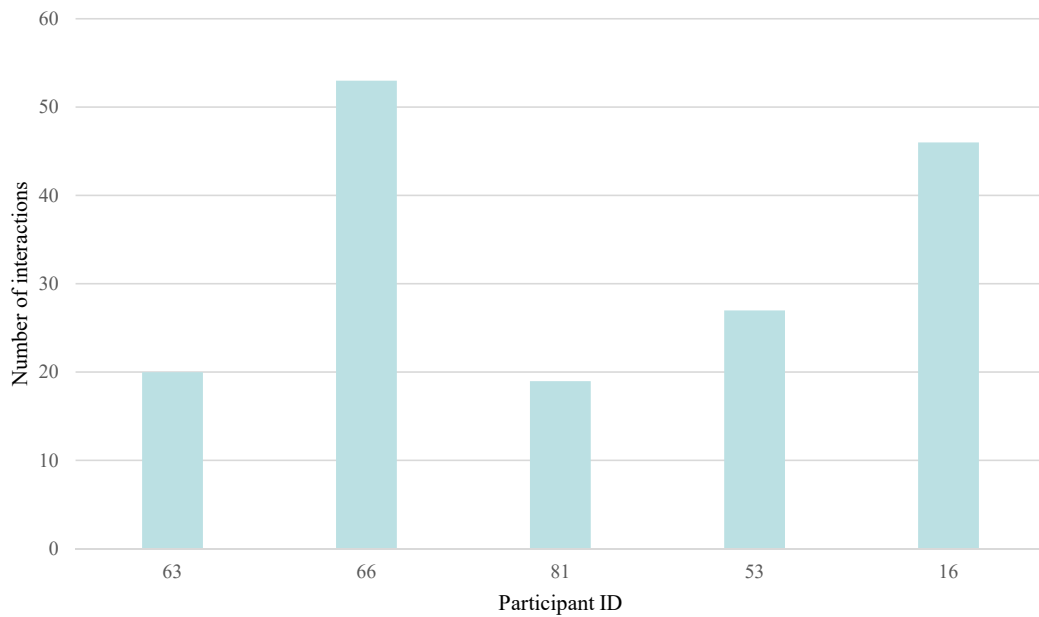
Sample Instructions (Total Teaching Duration)





# Variation across instructors

Instructor Initiated Interactions (Video)



Instructor Initiated Instructions (Sample Instruction)

