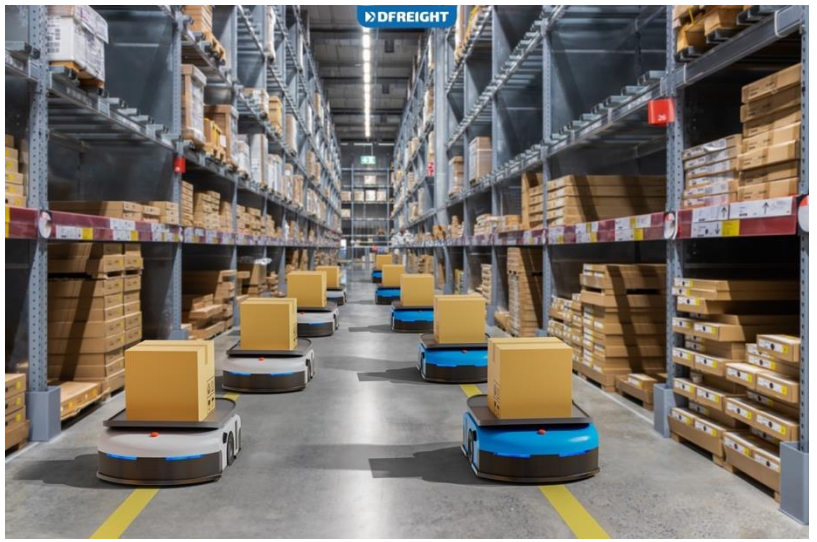
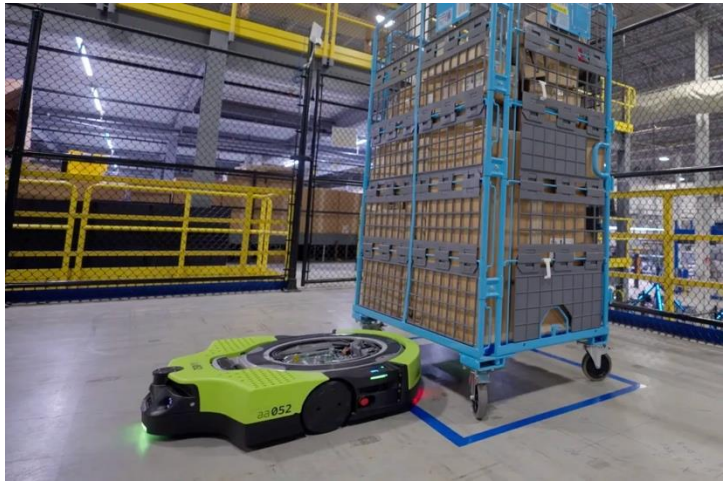
Using Explainable AI and Hierarchical Planning for Outreach with Robots

Rushang Karia*, Jayesh Nagpal*, Daksh Dobhal*, Pulkit Verma,
Rashmeet Kaur Nayyar, Naman Shah, Siddharth Srivastava

Increasing Prevalence of Taskable Robots





What do we want robots to do?

✔ Assist humans with accomplishing tasks

✔ Accomplish tasks without requiring a lot of human hand-holding

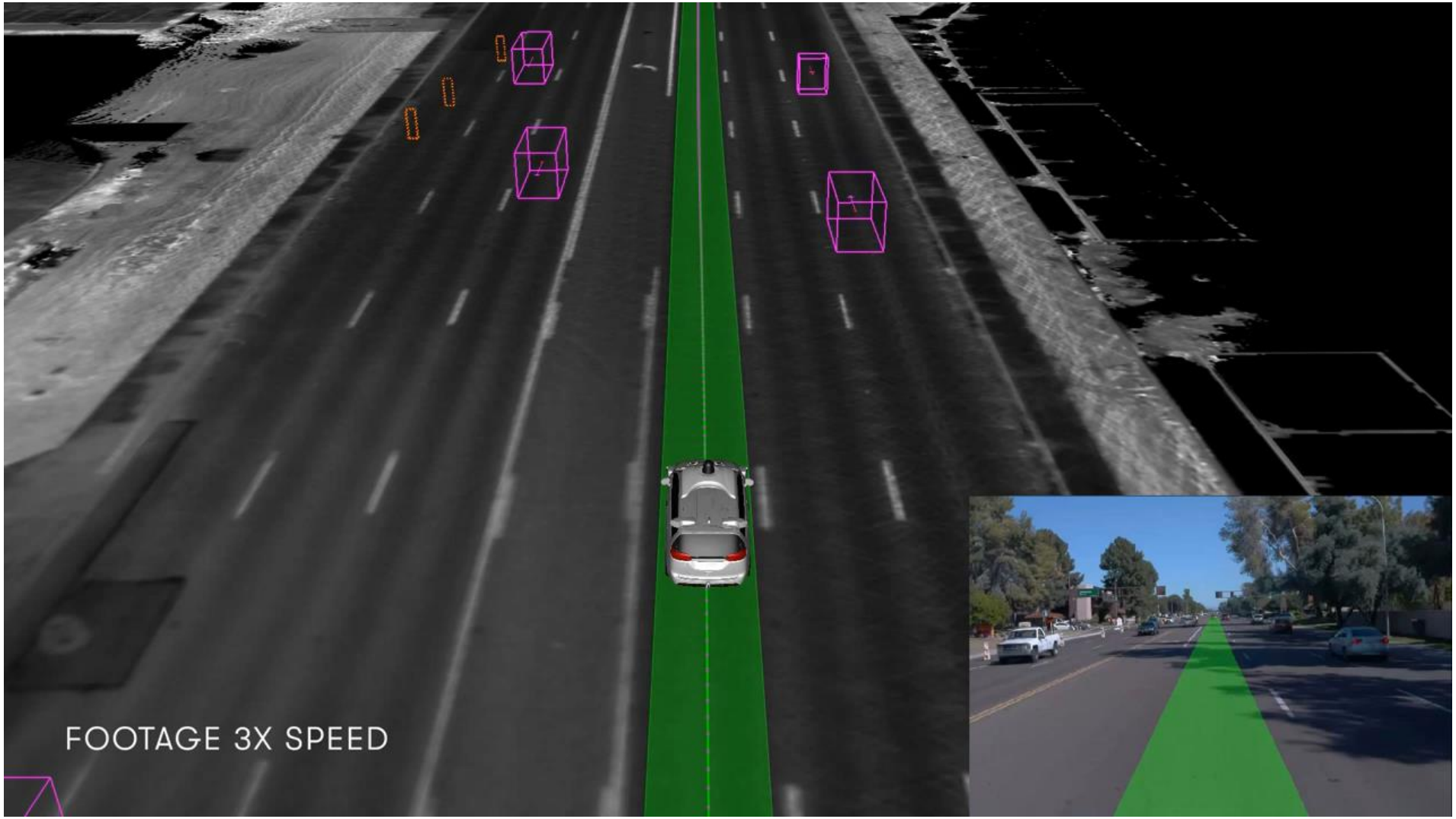
✔ Be versatile

- Do the dishes, prepare the food
- Mow the lawn
- Vacuum the house

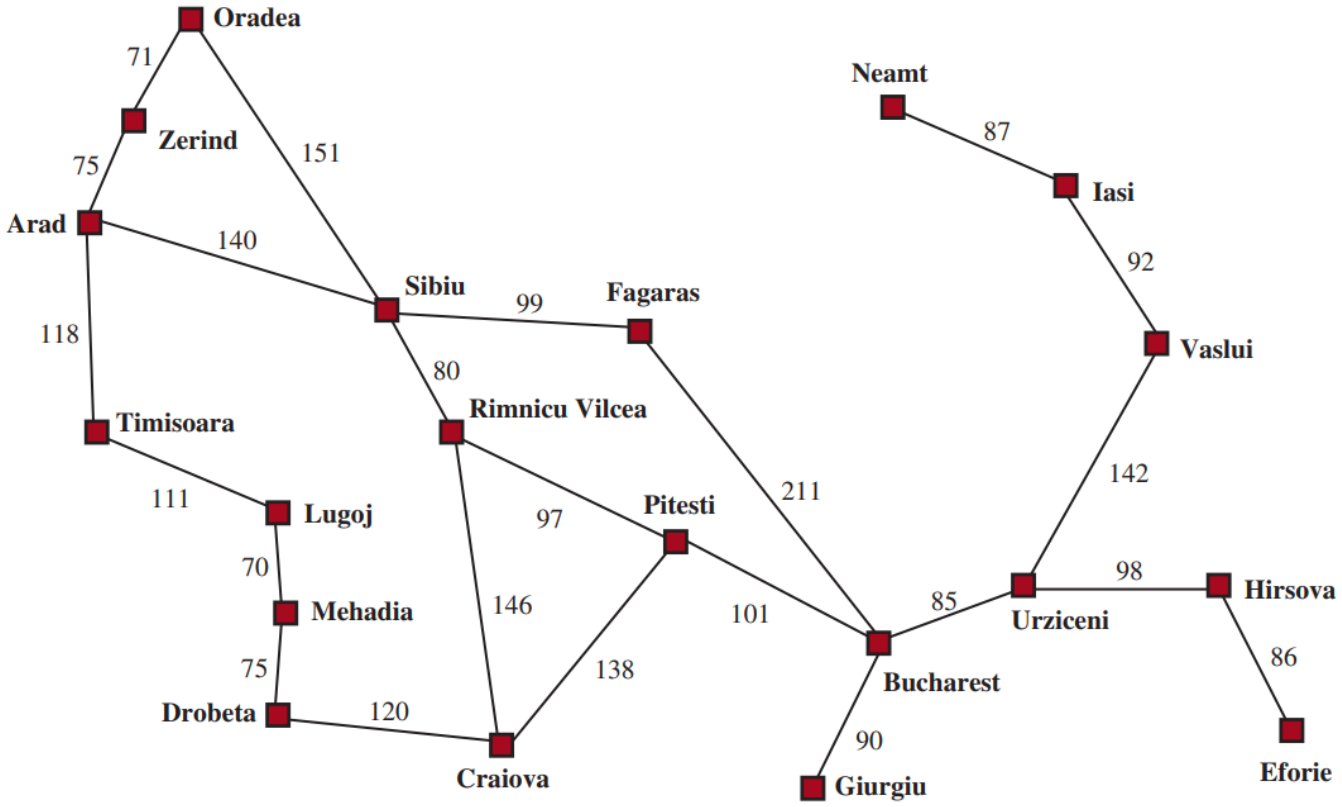
and so on…

What we see robots doing

What goes on under the hood!



What goes on under the hood!



Human Plan

1. Drive from Arad to Sibiu
2. Drive from Sibiu to Fagaras
3. Drive from Fagaras to Bucharest

Robot Plan for the Human Plan

1. [0.0, 0.0, 0.0, …, 1.2]
2. [1.2, 3.2, 4.x, …, 3.xx]
3. …

174.[200.9, 3.142, 2.1, …, 44.x]

175.…

555.[400.x, 3.2, 3.x, …, 9784.x]

556.[521.x, 5.6, 3.x, …, 10023.x]

Robot's need to search in the space of joint values!

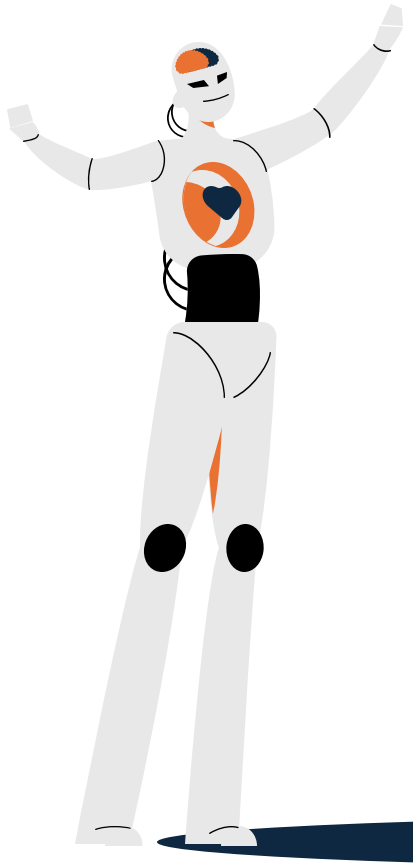
Plans are much longer too and takes a lot of time to compute

Open Questions and Challenges

Humans want to instruct robots at a “high-level”
Robots expect humans to instruct at a “low-level”

Open Questions and Challenges

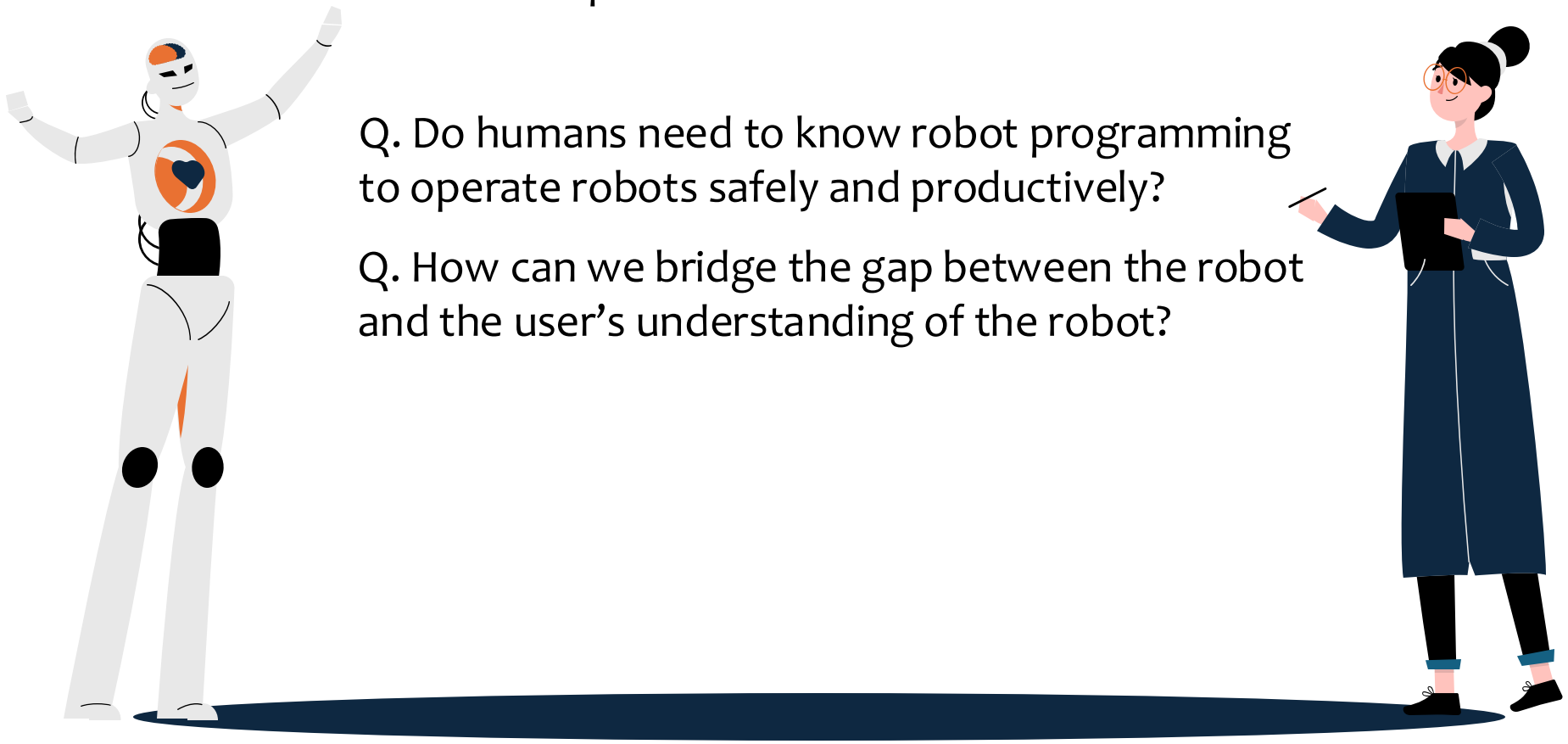
Humans want to instruct robots at a “high-level”
Robots expect humans to instruct at a “low-level”



Q. Do humans need to know robot programming to operate robots safely and productively?

Open Questions and Challenges

Humans want to instruct robots at a “high-level”
Robots expect humans to instruct at a “low-level”

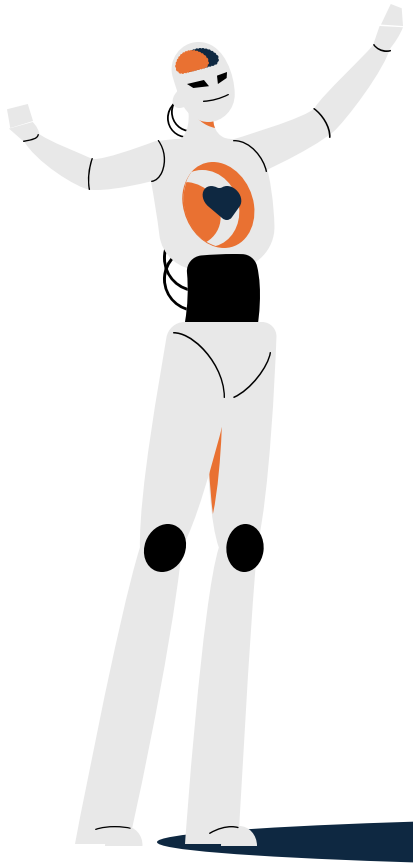


Q. Do humans need to know robot programming to operate robots safely and productively?

Q. How can we bridge the gap between the robot and the user’s understanding of the robot?

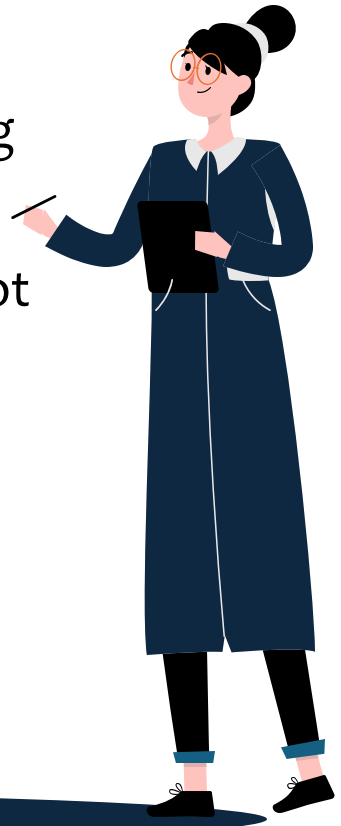
What we need

Humans want to instruct robots at a “high-level”
Robots expect humans to instruct at a “low-level”



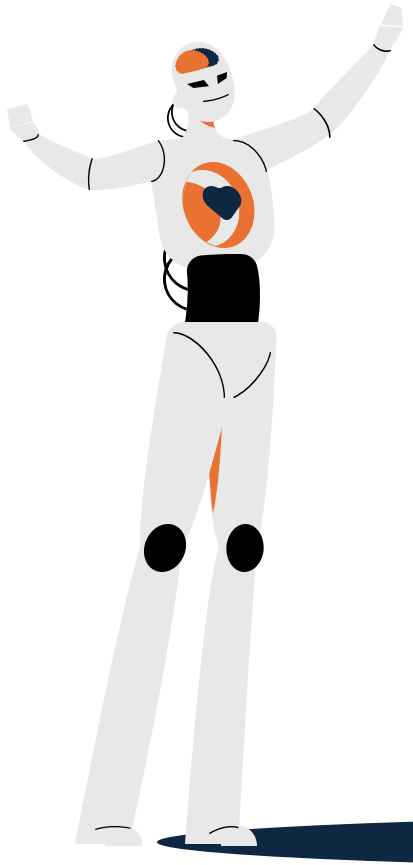
Q. Do humans need to know robot programming to operate robots safely and productively?

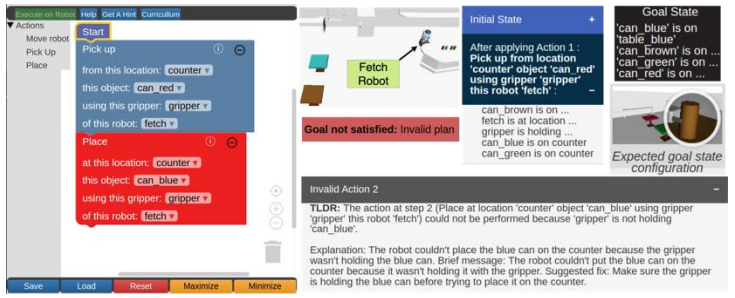
Q. How can we bridge the gap between the robot and the user’s understanding of the robot?



Need a tool that enables non-experts to learn and use robots

Introducing JEDAI.Ed – JEDAI Explains Decision-making AI





JEDAI.Ed:
An easy-to-use GUI tool that allows programming robots via human plans

Our Contributions

JEDAI.Ed, an online platform that:

- **Teaches users to understand reasoning** and quickly provide high-level instructions to robots to perform tasks.

Our Contributions

JEDAI.Ed, an online platform that:

- **Teaches users to understand reasoning** and quickly provide high-level instructions to robots to perform tasks.

- **Identifies and explains bugs in user instructions** so that users learn more about the capabilities of the robot and update the instructions.

Our Contributions

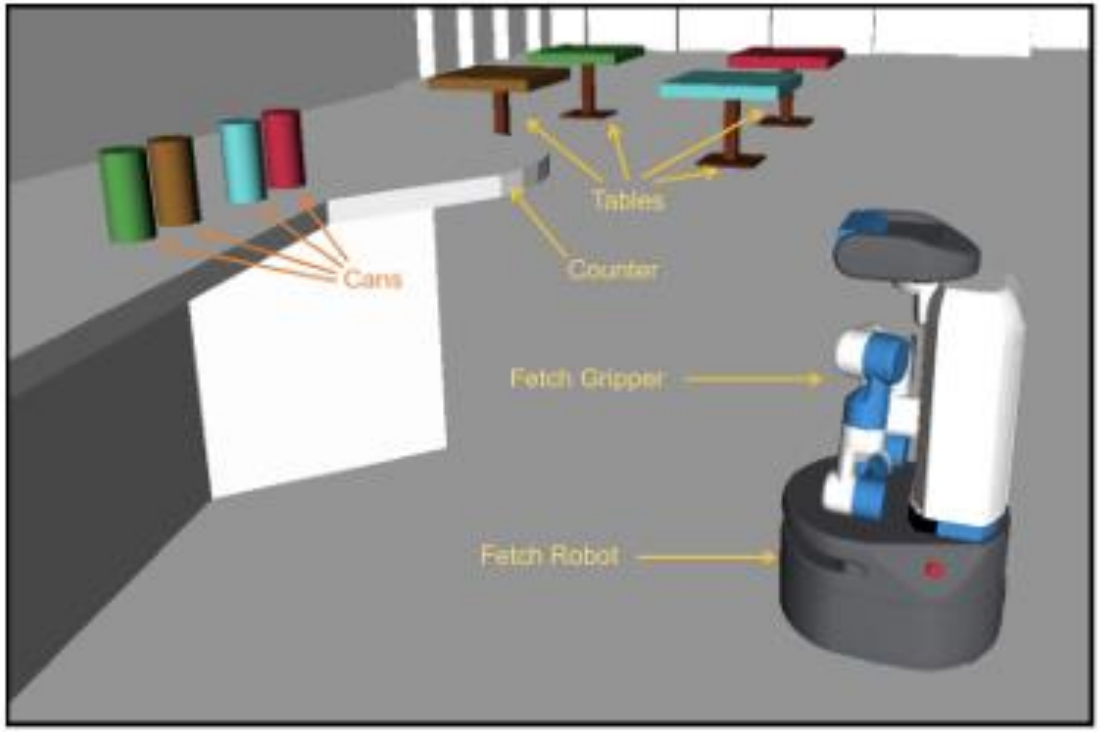
JEDAI.Ed, an online platform that:

- **Teaches users to understand reasoning** and quickly provide high-level instructions to robots to perform tasks.

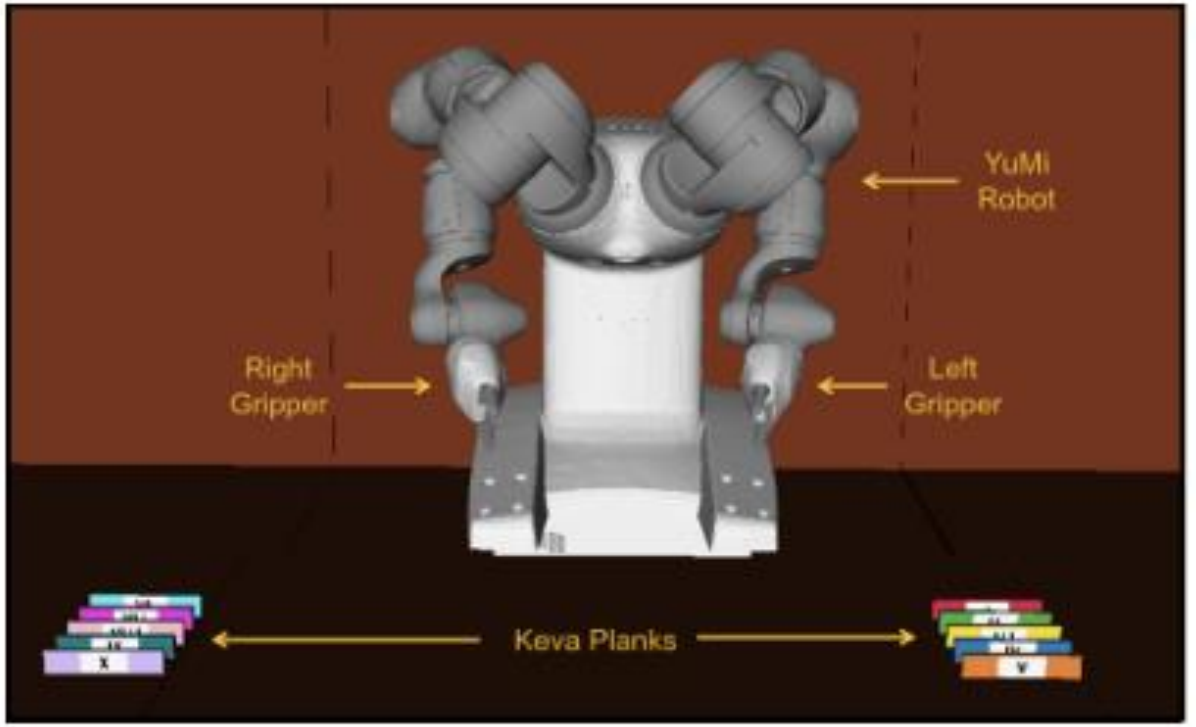
- **Identifies and explains bugs in user instructions** so that users learn more about the capabilities of the robot and update the instructions.

- Adaptively **generates problems tailored to the user's understanding**.

Example Environments

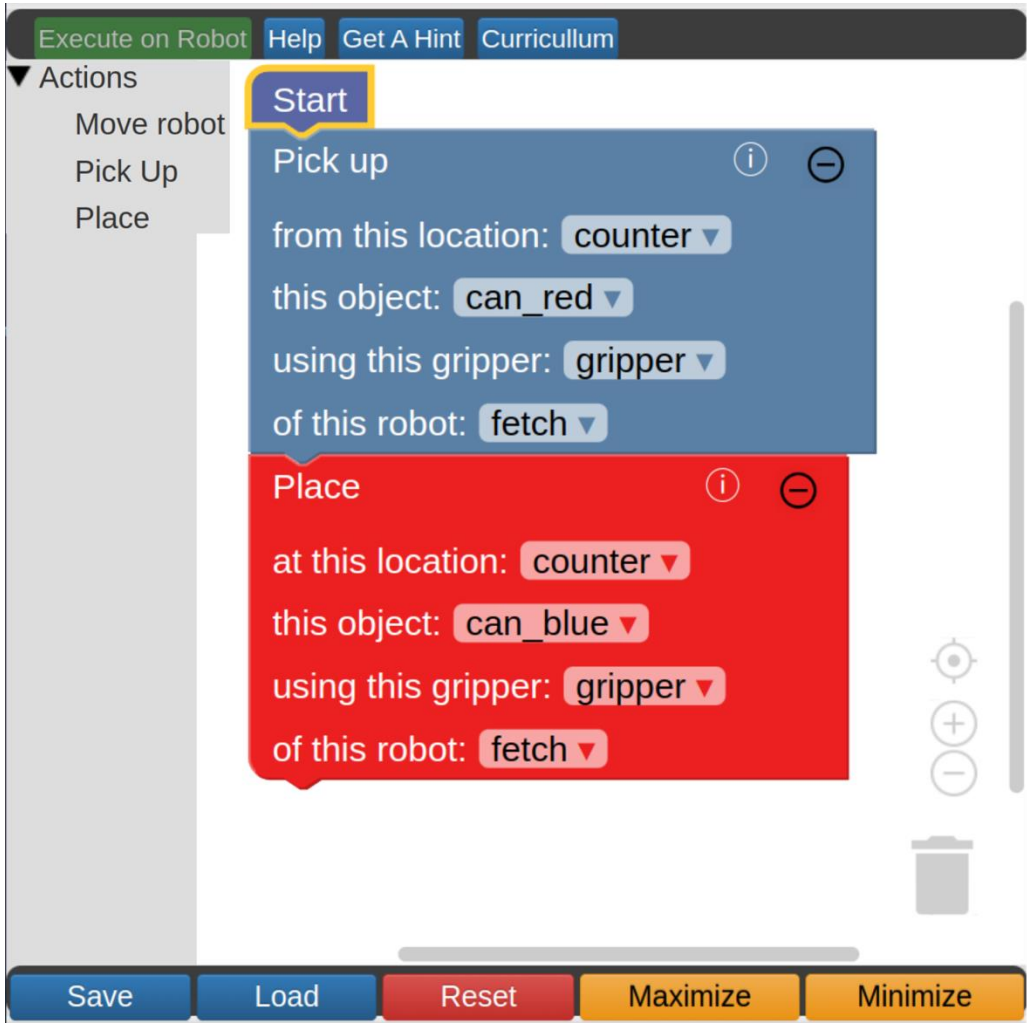


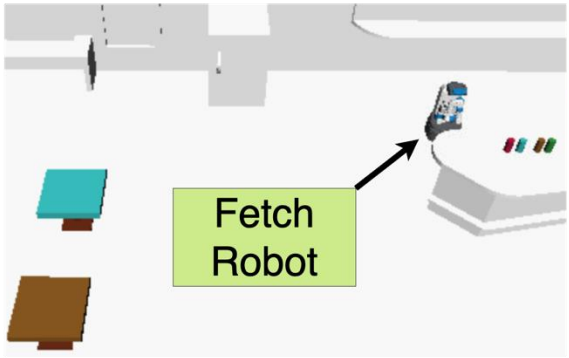
Coffee Shop



Keva

JEDAI.Ed Interface





Goal not satisfied: Invalid plan

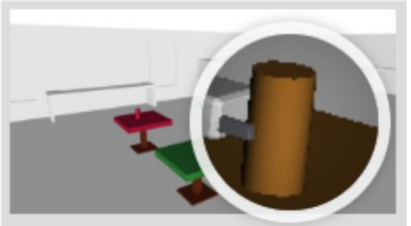
Initial State +

After applying Action 1 : **Pick up from location 'counter' object 'can_red' using gripper 'gripper' this robot 'fetch'** : –

can_brown is on ...
fetch is at location ...
gripper is holding ...
can_blue is on counter
can_green is on counter

Goal State

'can_blue' is on 'table_blue'
'can_brown' is on ...
'can_green' is on ...
'can_red' is on ...



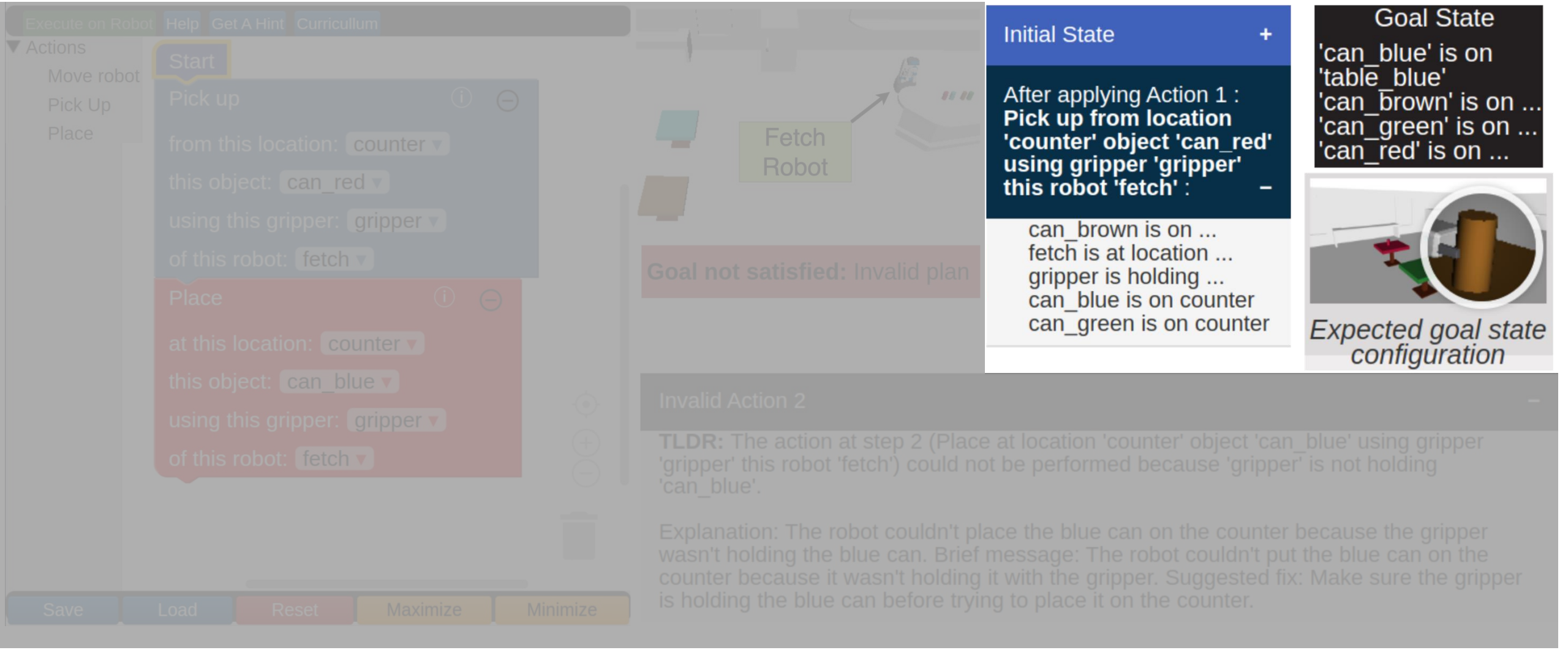
Expected goal state configuration

Invalid Action 2 –

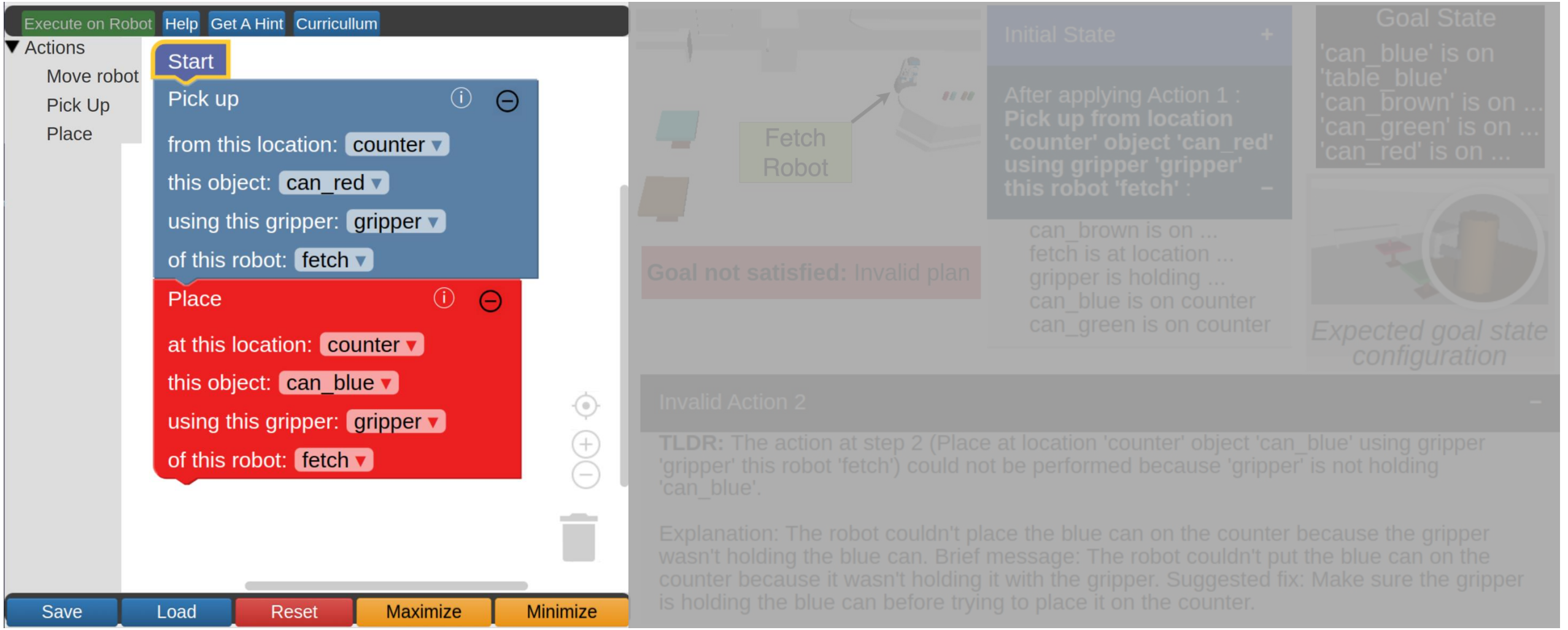
TLDR: The action at step 2 (Place at location 'counter' object 'can_blue' using gripper 'gripper' this robot 'fetch') could not be performed because 'gripper' is not holding 'can_blue'.

Explanation: The robot couldn't place the blue can on the counter because the gripper wasn't holding the blue can. Brief message: The robot couldn't put the blue can on the counter because it wasn't holding it with the gripper. Suggested fix: Make sure the gripper is holding the blue can before trying to place it on the counter.

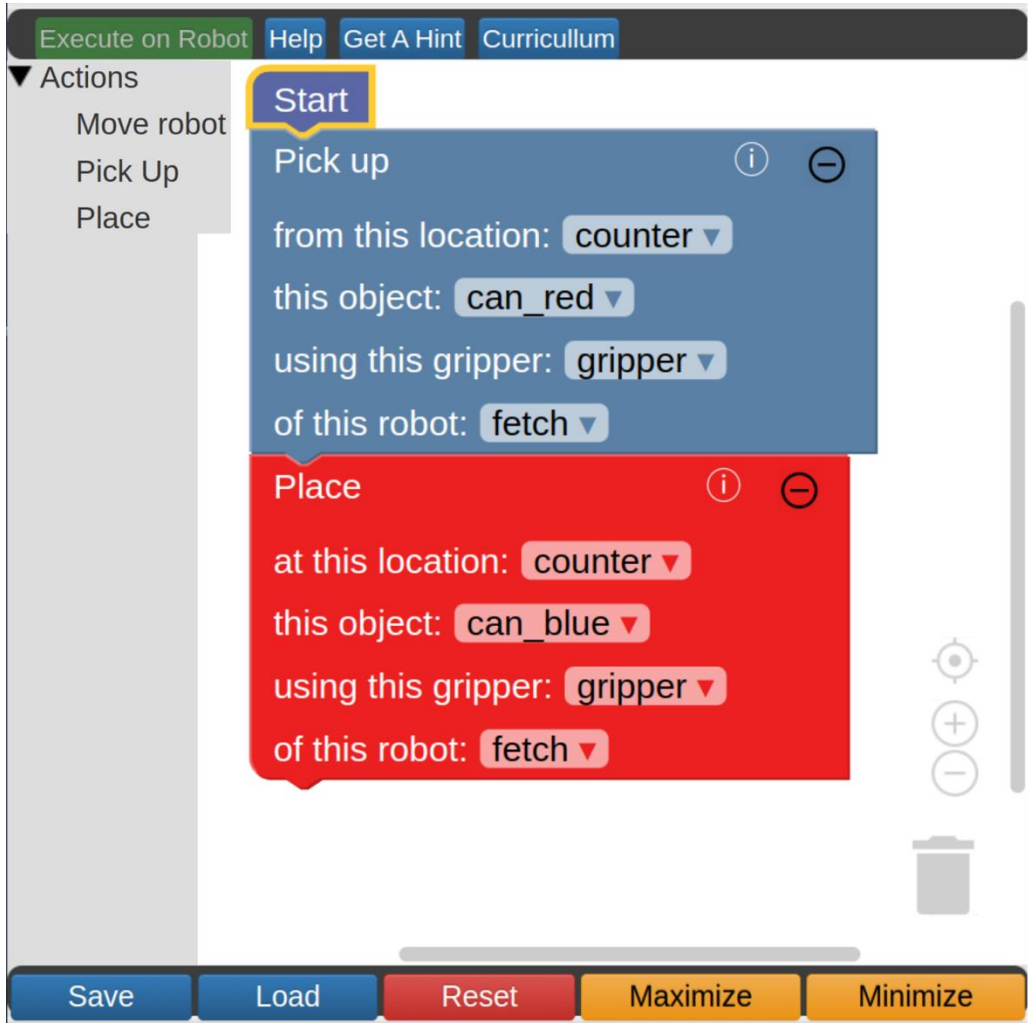
JEDAI.Ed Interface: Domain and Task

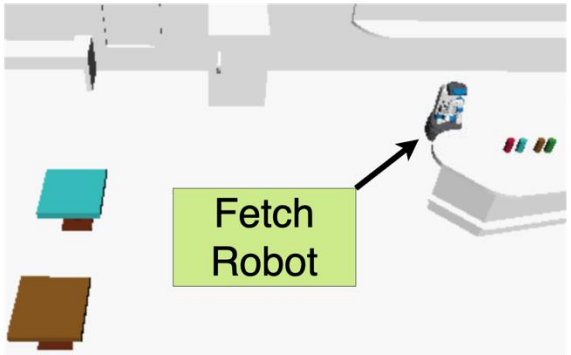


JEDAI.Ed Interface: Generating a Plan



JEDAI.Ed Interface: Plan Execution





Goal not satisfied: Invalid plan

Initial State

After applying Action 1 :
Pick up from location 'counter' object 'can_red' using gripper 'gripper' this robot 'fetch' :

can_brown is on ...
fetch is at location ...
gripper is holding ...
can_blue is on counter
can_green is on counter

Goal State

'can_blue' is on 'table_blue'
'can_brown' is on ...
'can_green' is on ...
'can_red' is on ...

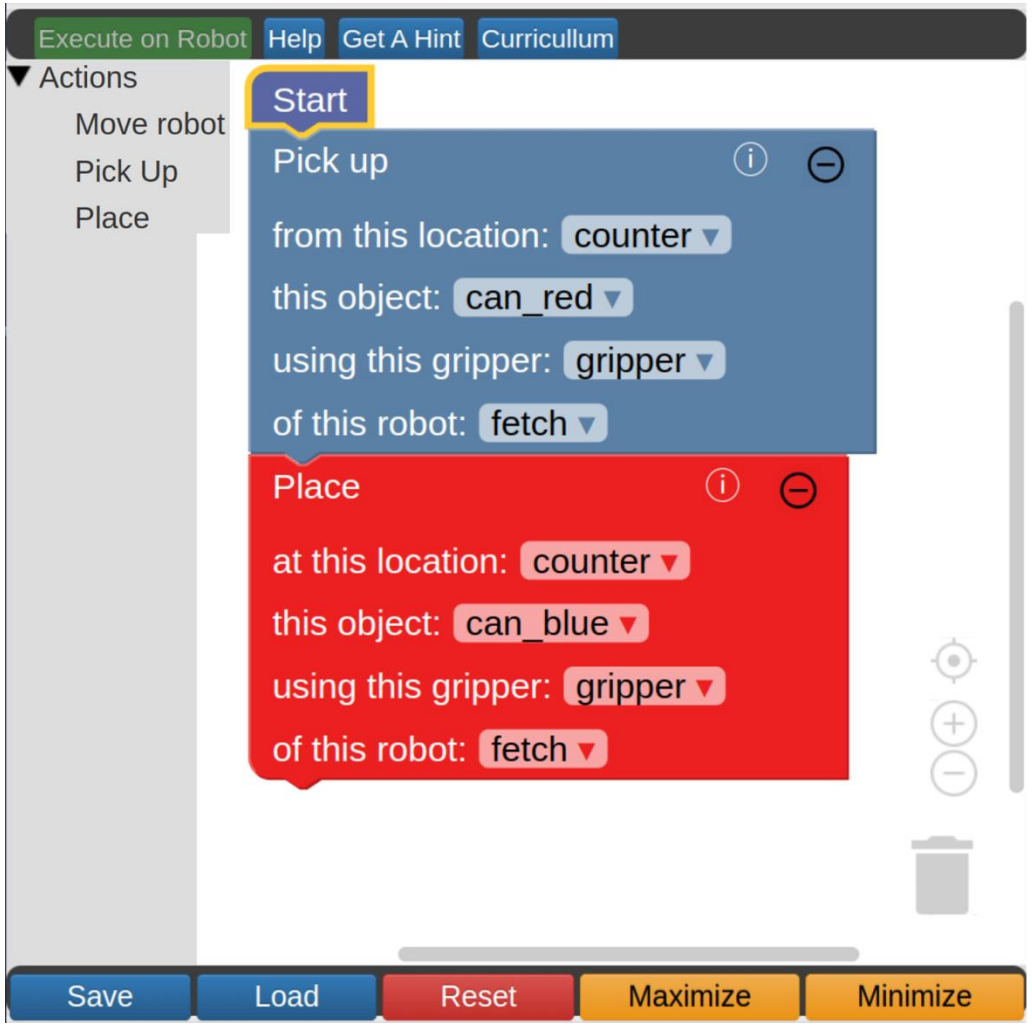
Expected goal state configuration

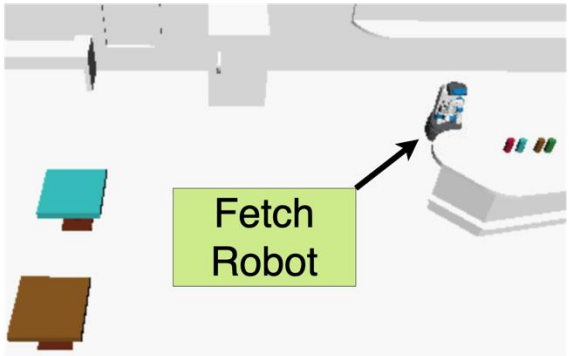
Invalid Action 2

TLDR: The action at step 2 (Place at location 'counter' object 'can_blue' using gripper 'gripper' this robot 'fetch') could not be performed because 'gripper' is not holding 'can_blue'.

Explanation: The robot couldn't place the blue can on the counter because the gripper wasn't holding the blue can. Brief message: The robot couldn't put the blue can on the counter because it wasn't holding it with the gripper. Suggested fix: Make sure the gripper is holding the blue can before trying to place it on the counter.

JEDAI.Ed Interface: Explanation for Errors





Goal not satisfied: Invalid plan

Initial State +

After applying Action 1 :
Pick up from location 'counter' object 'can_red' using gripper 'gripper' this robot 'fetch' : –

can_brown is on ...
fetch is at location ...
gripper is holding ...
can_blue is on counter
can_green is on counter

Goal State

'can_blue' is on 'table_blue'
'can_brown' is on ...
'can_green' is on ...
'can_red' is on ...

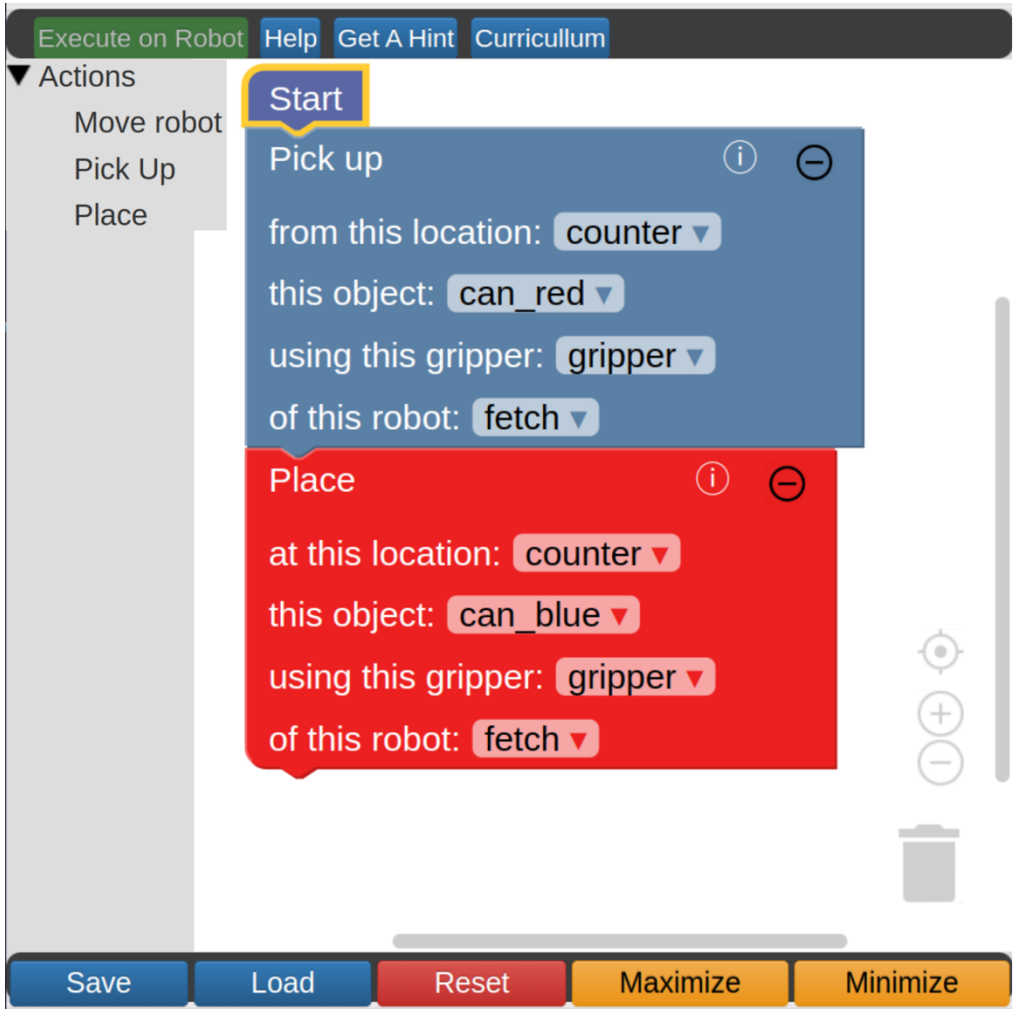
Expected goal state configuration

Invalid Action 2 –

TLDR: The action at step 2 (Place at location 'counter' object 'can_blue' using gripper 'gripper' this robot 'fetch') could not be performed because 'gripper' is not holding 'can_blue'.

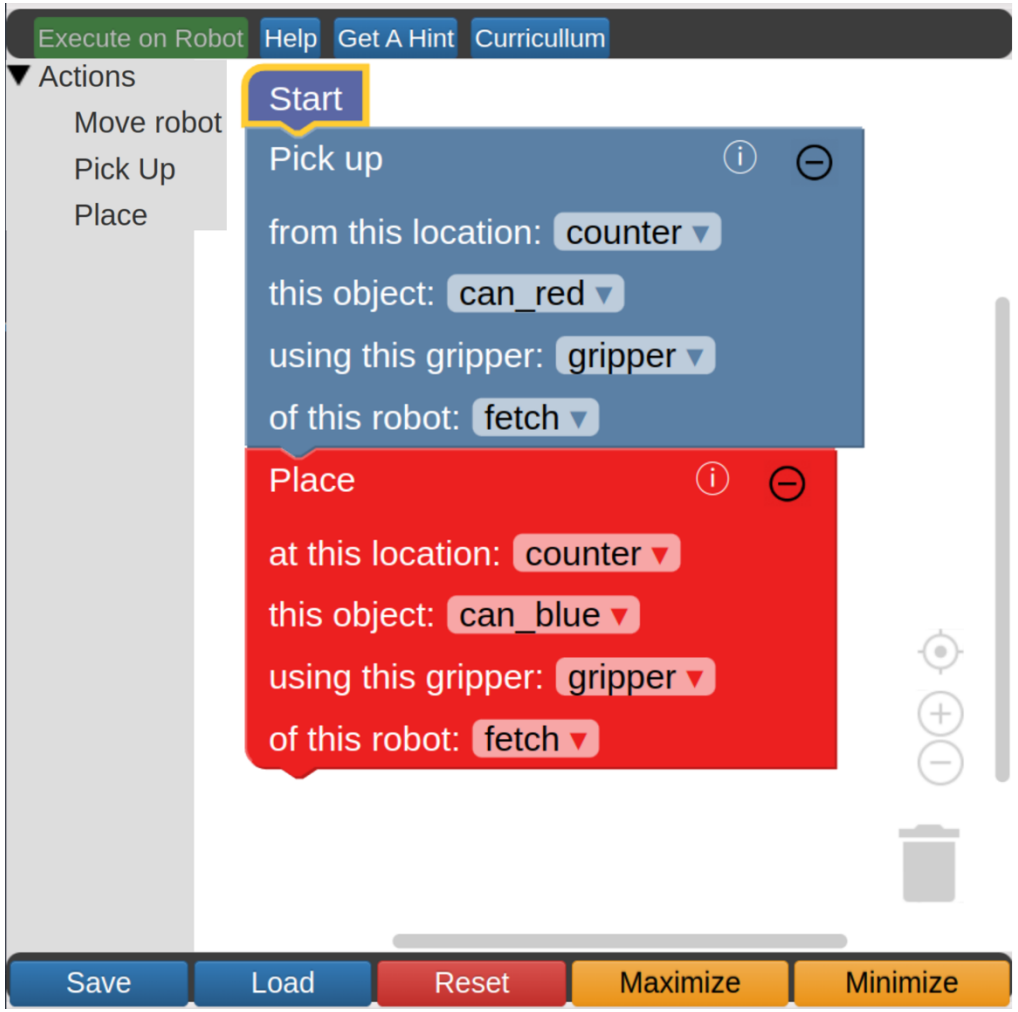
Explanation: The robot couldn't place the blue can on the counter because the gripper wasn't holding the blue can. Brief message: The robot couldn't put the blue can on the counter because it wasn't holding it with the gripper. Suggested fix: Make sure the gripper is holding the blue can before trying to place it on the counter.

JEDAI.Ed Interface: Hints



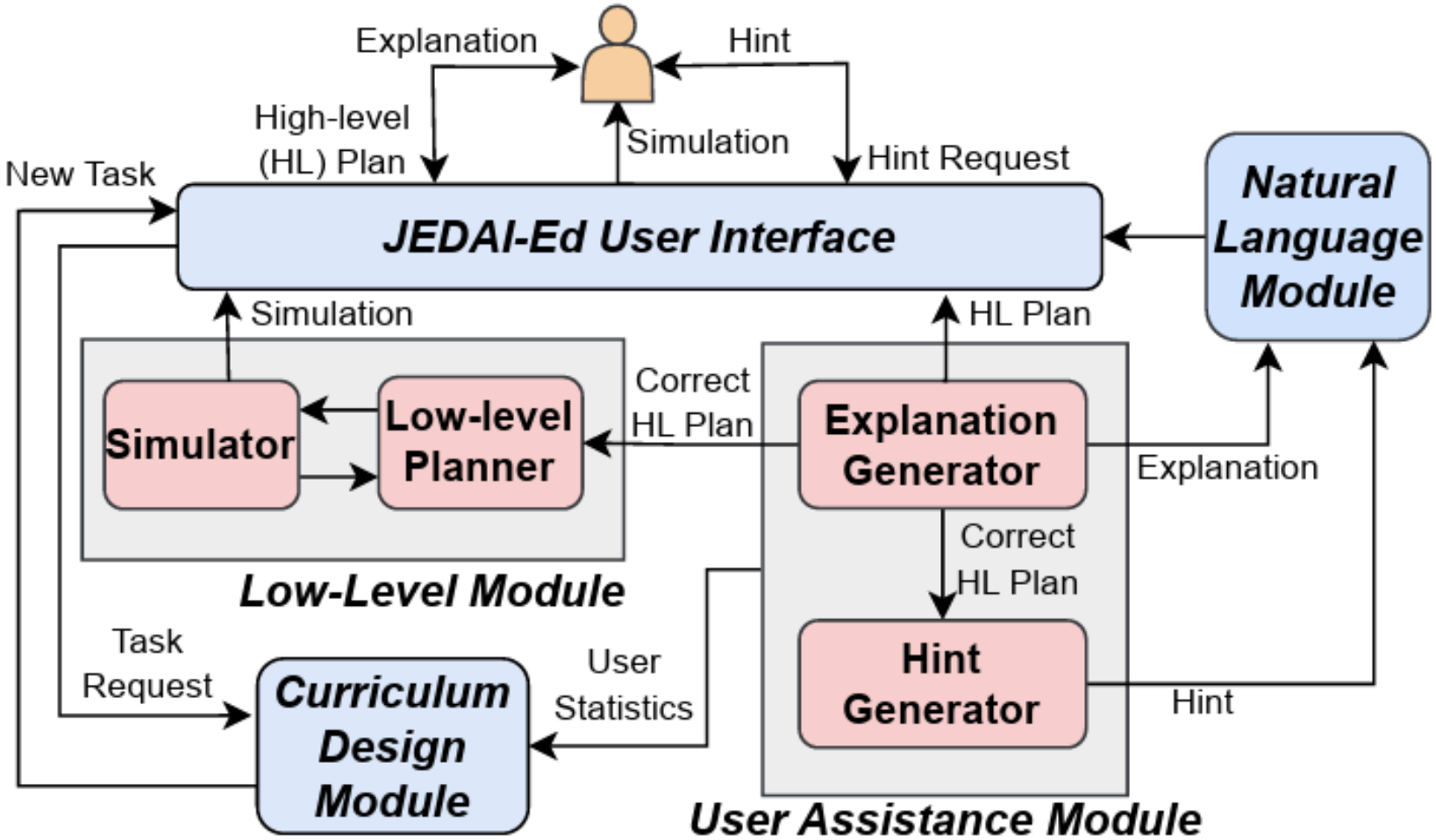
Users can take help from a hint!

JEDAI.Ed Interface: Curriculum Design



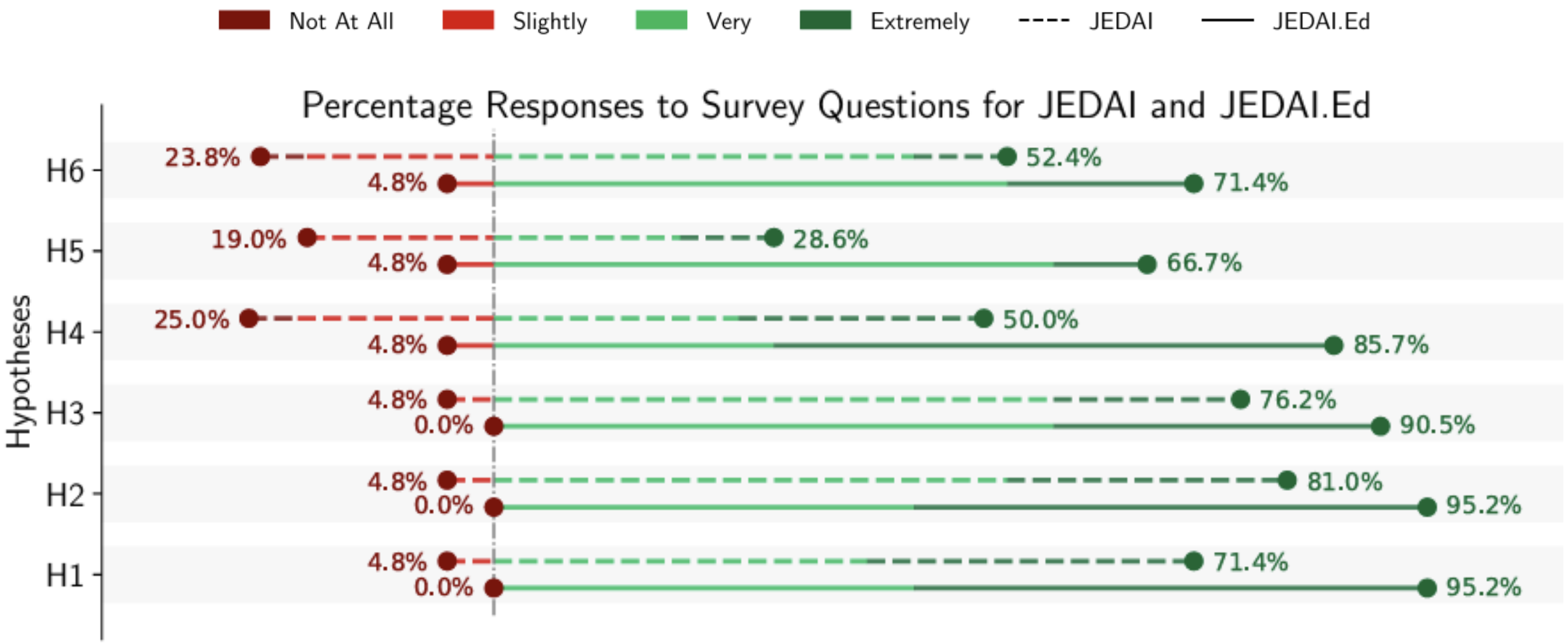
Curriculum design adjusts problem complexity based on user understanding!

JEDAI.Ed Architecture



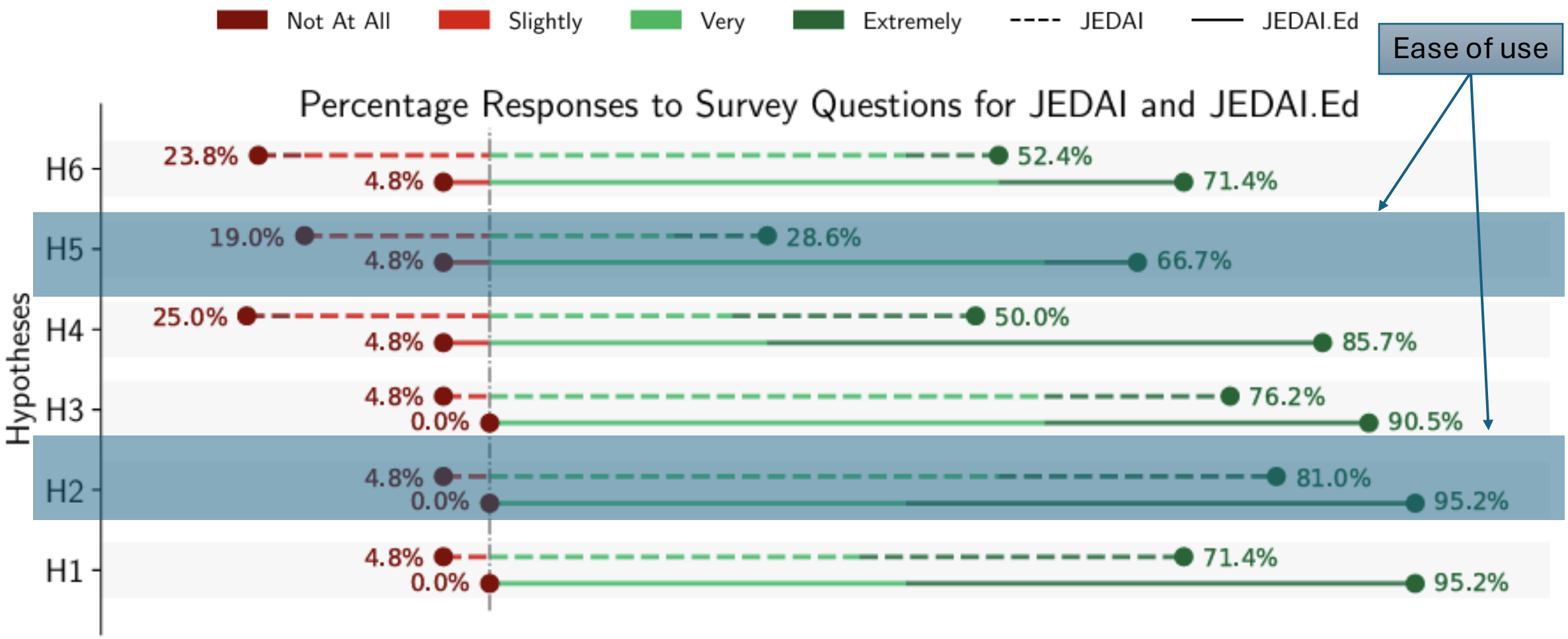
Empirical Evaluation

Responses from User Study with 42 participants



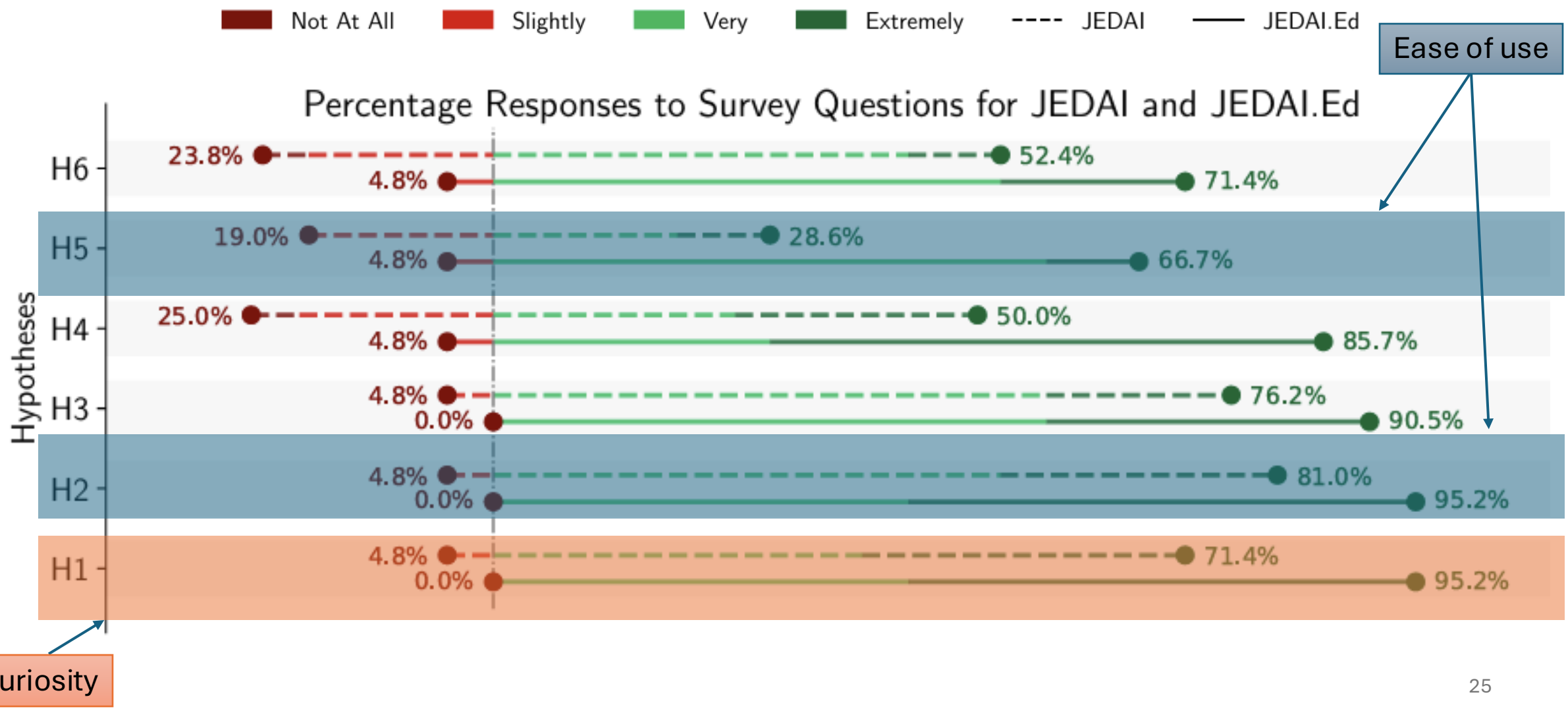
Empirical Evaluation

Responses from User Study with 42 participants



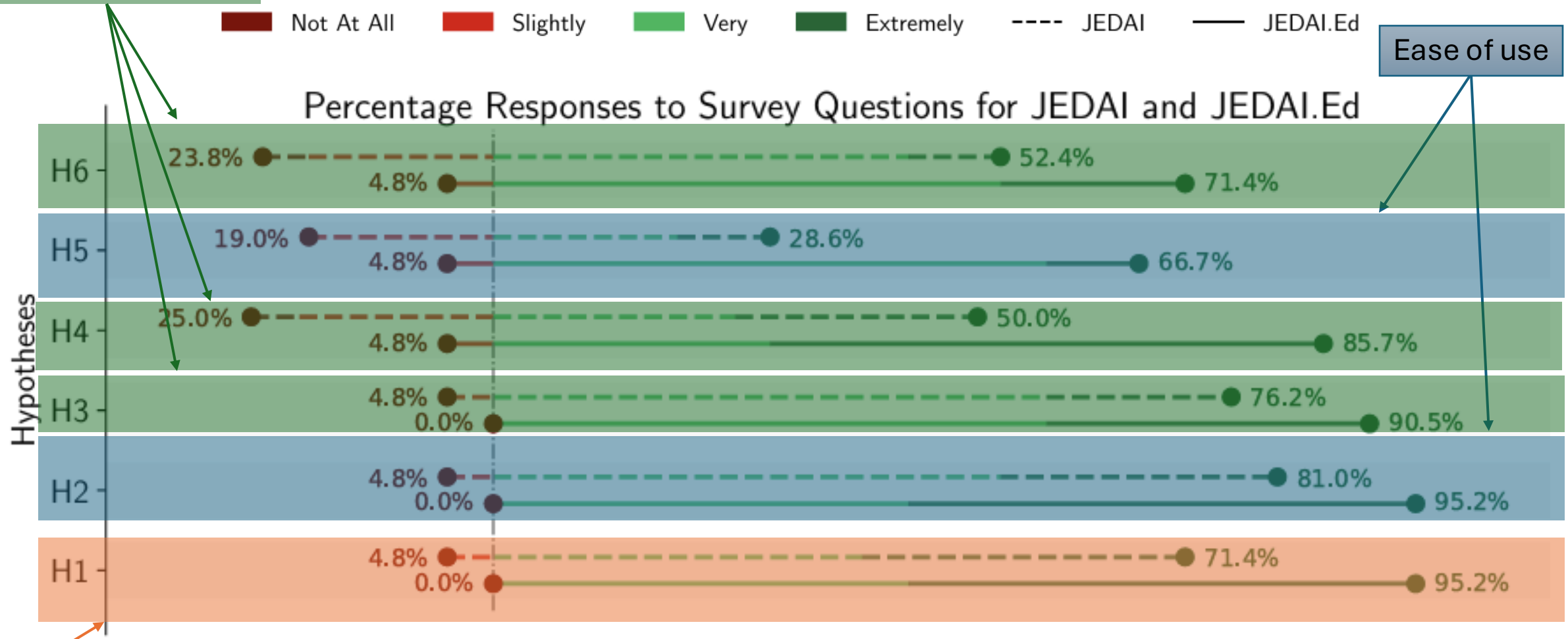
Empirical Evaluation

Responses from User Study with 42 participants



Usefulness (understanding, helpfulness, confidence)

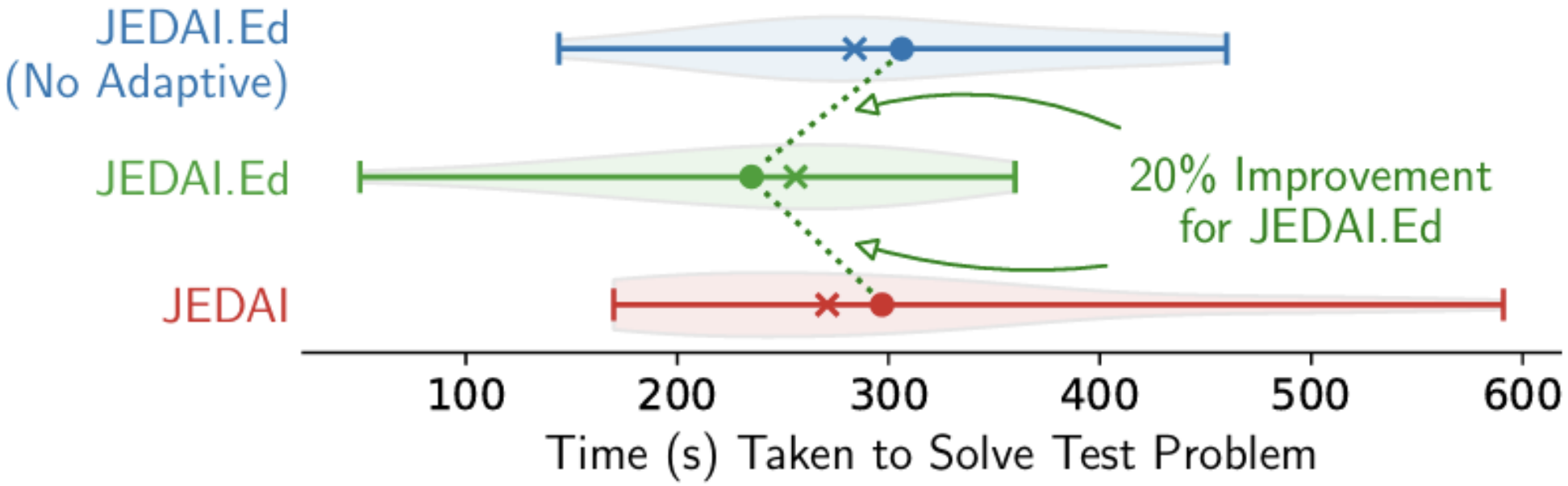
Responses from User Study with 42 participants



Ease of use

Curiosity

Empirical Evaluation: Test Times



20% improvement in test times!!

Engagement in JEDAI.Ed's pilot program on 2 high schools (90 students)

Open-Source Code for JEDAI.Ed

Source code is available at: https://github.com/AAIR-lab/jedai