SYSTEMS ENGINEERING RESEARCH CENTER

WRT-1011: Fostering human learning from cognitive assistants for design space exploration

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By

Dr. Daniel Selva and Gabriel Apaza (Texas A&M University)

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1825 Connecticut Avenue NW, 8th Floor

Washington, DC 20009

www.sercuarc.org

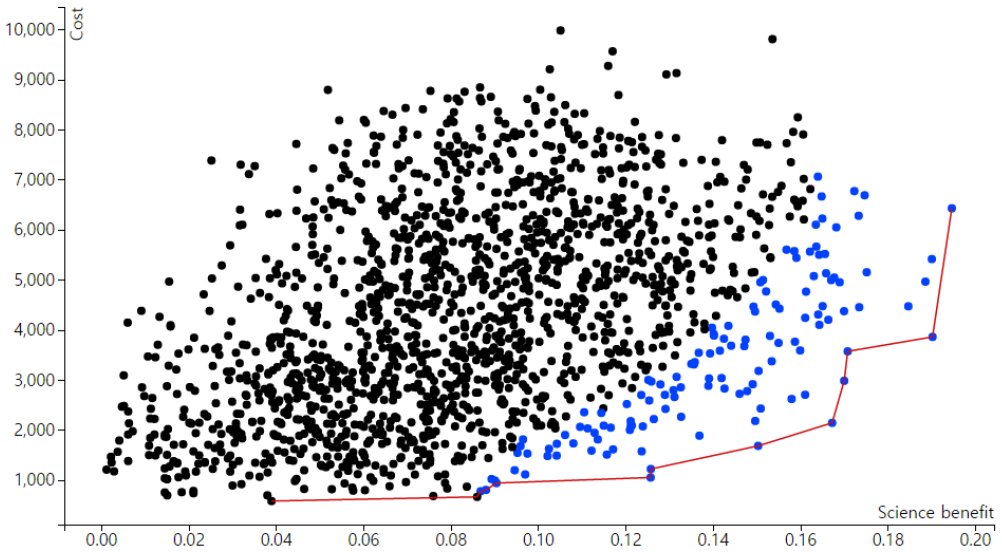
Why cognitive assistants?

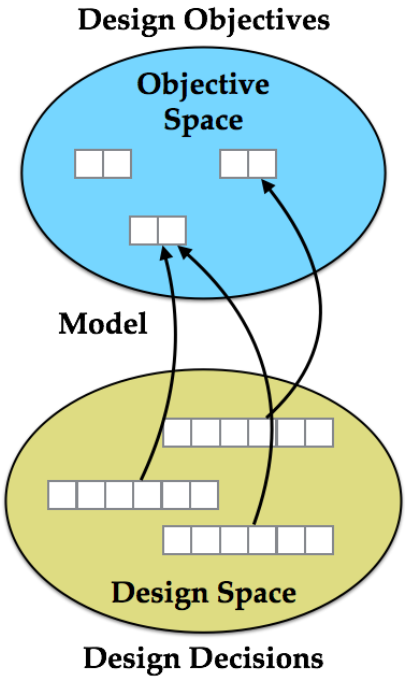
- **The time is ripe for adoption of this technology in the workplace**
- **Technology push**: Advances in Machine Learning (NLP)
- **Societal push**: Digital assistants are ubiquitous in our daily lives
- Still some challenges, need to better understand and improve human-VA interaction in engineering context

Design Space Exploration (DSE)

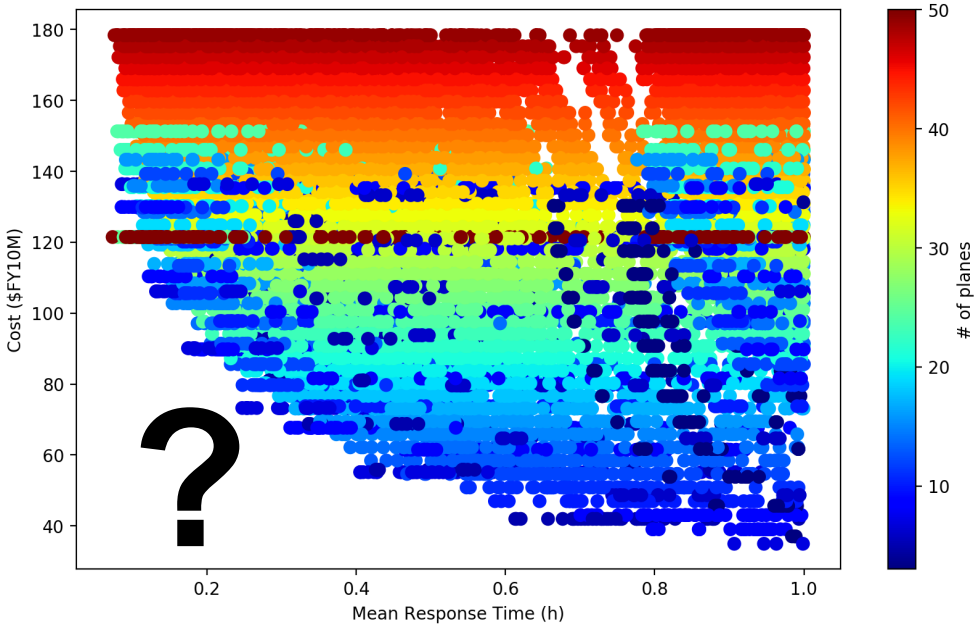
- **Context**: Early system architecture and concept studies

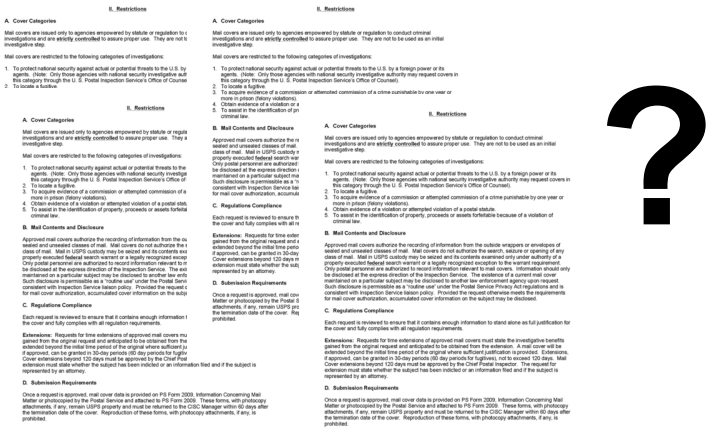
1. Define a solution space (or design space) by means of a set of decisions and allowed values
2. Define an objective space by means of a number of metrics
3. Compose models to map solution space to objective space
4. Use search/optimization to generate large dataset of alternatives
5. Use visual and data analytics to explore dataset and draw conclusions
6. Iterate





DSE is challenging





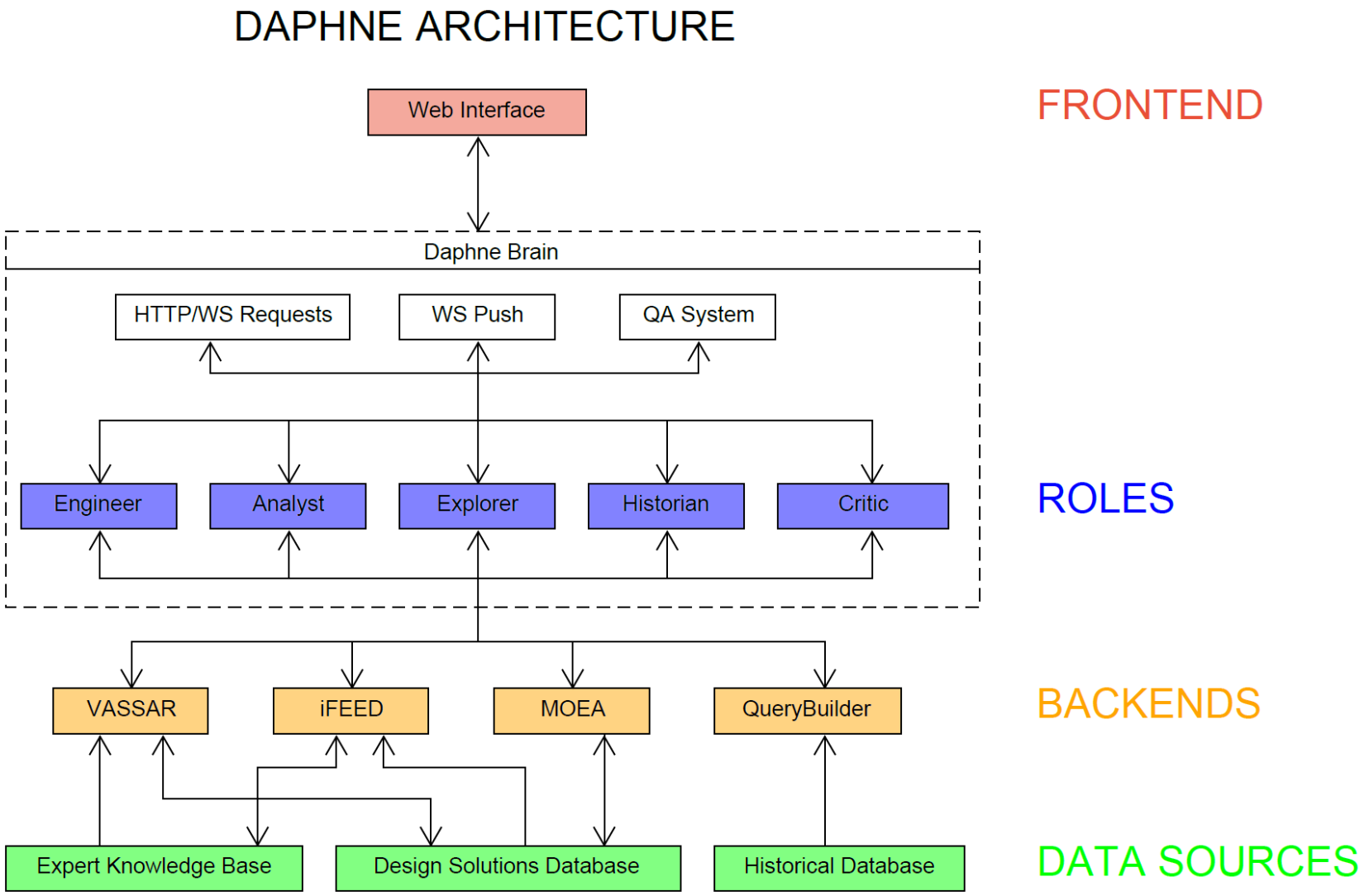
?

- **Information overload**, especially when the solution and/or objective spaces are high-dimensional
- **Information retrieval**: Need information from many different sources (time-consuming)
- **Sense-making**: How do we interpret the results?
- **Garbage-in-garbage-out**: All models are wrong, and optimization tools are good at exploiting unrealistic model assumptions
- Simultaneously doing model validation and tradespace exploration

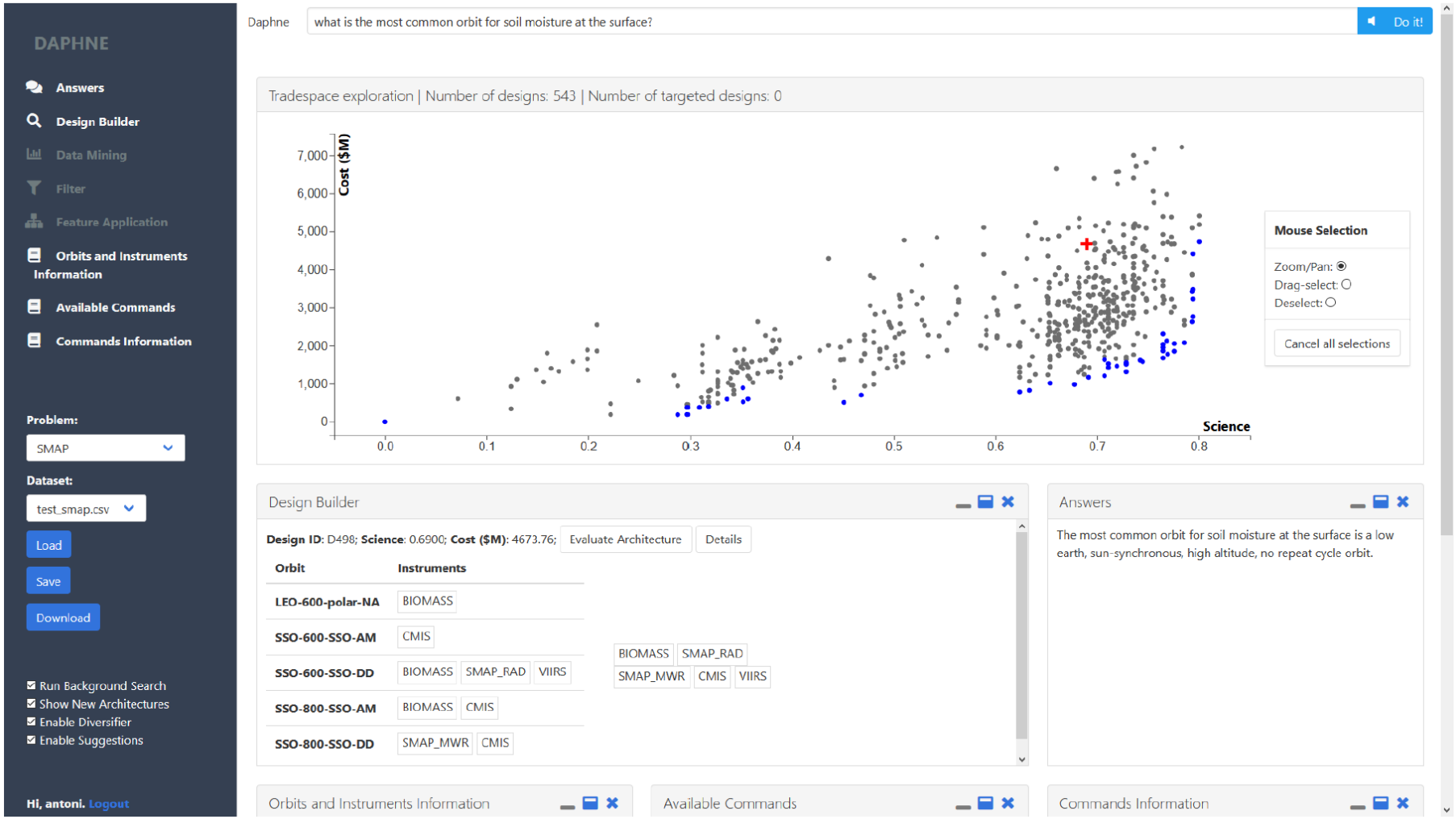
Cognitive assistants can help

- **Cognitive assistant**: An AI agent that augments human cognition for a specific task
- Usually has a Question Answering (QA) system with a natural language interface
- 5 main components
  - **Front-end**: GUI, robot
  - **QA system**: ML for NLP (query intent classification)
  - **Skills/roles**: Specialized QA agents (e.g., weather)
  - **Back-ends**: Functions needed to help skills answer requests
  - **Data/knowledge sources**: relational databases, ontologies, knowledge graphs.

The Daphne-EO cognitive assistant

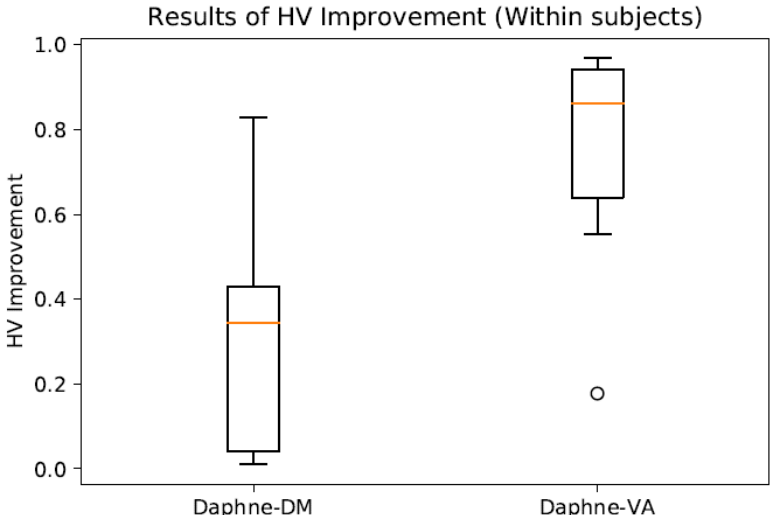


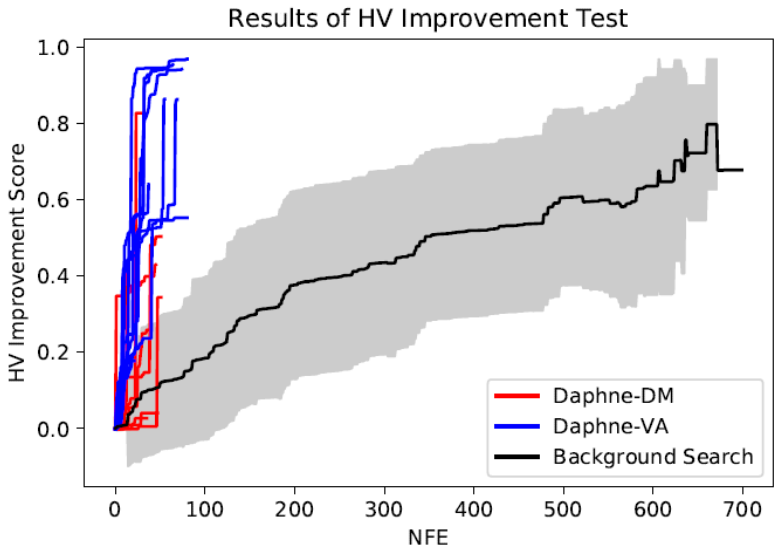
Daphne-EO front end



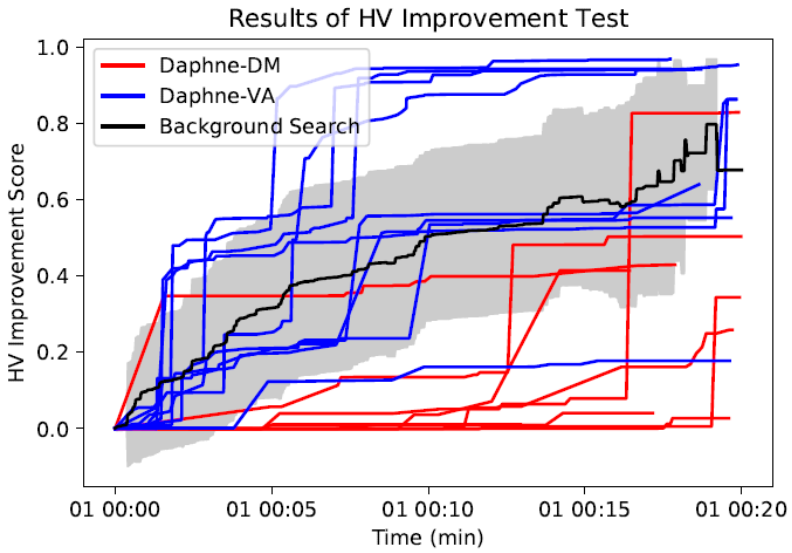
CA do increase performance in DSE tasks

- Conducted a study at JPL with N=9 system engineers
- 2 conditions (Daphne-VA vs no VA)
- Measured design quality, diversity, human learning, and usability
- Within-subjects, counter-balanced design



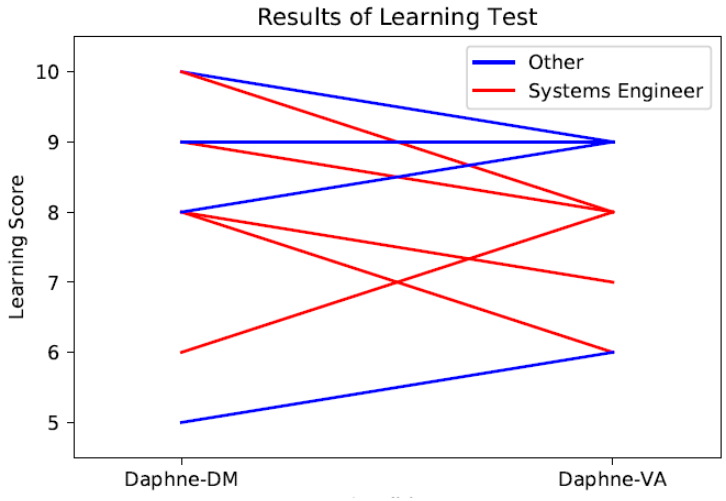


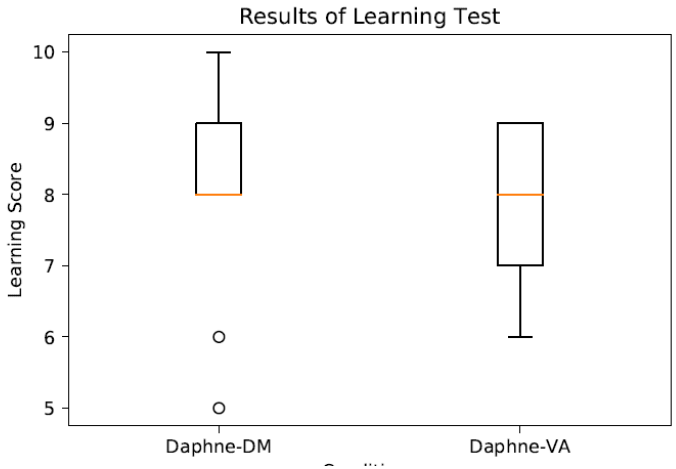
(a) Comparison in NFE



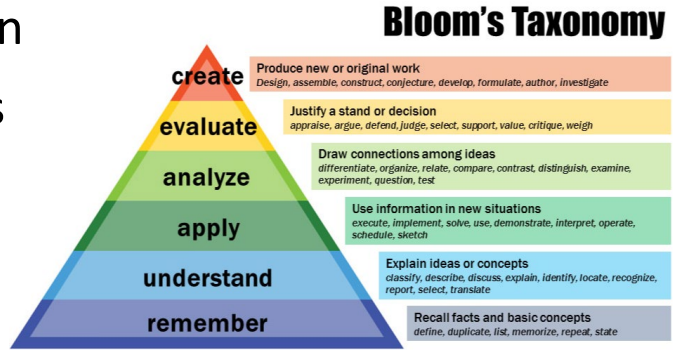
(b) Comparison in time

But they may decrease human learning





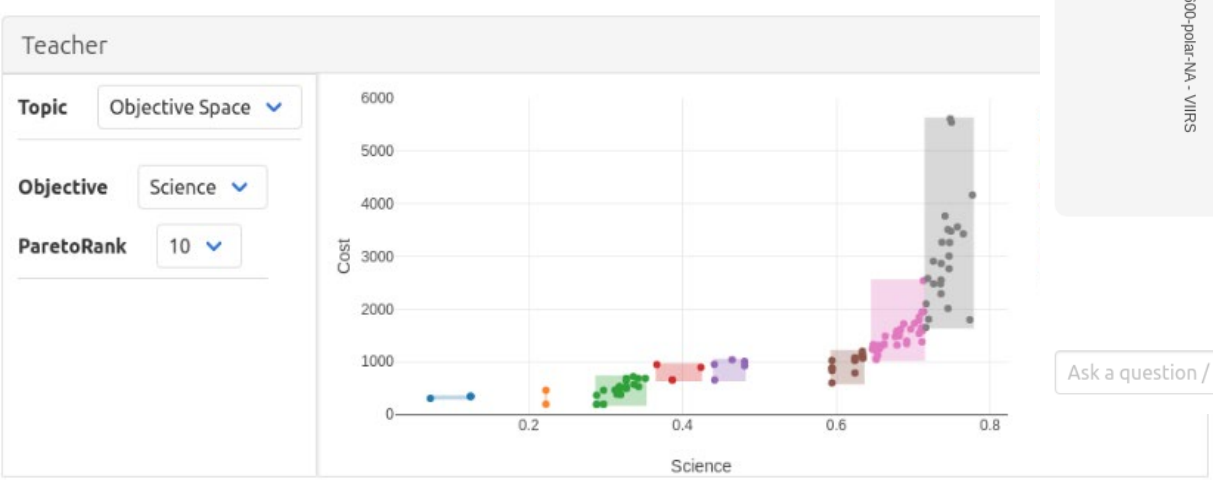
- What is it that people are learning with DSE tools?
  - Sensitivities, couplings between parameters, driving features, what-if questions
- How do we actually measure human learning in DSE?
  - Tests
- What types of questions?
  - Bloom's taxonomy
  - Factual information
  - Prediction
  - Synthesis

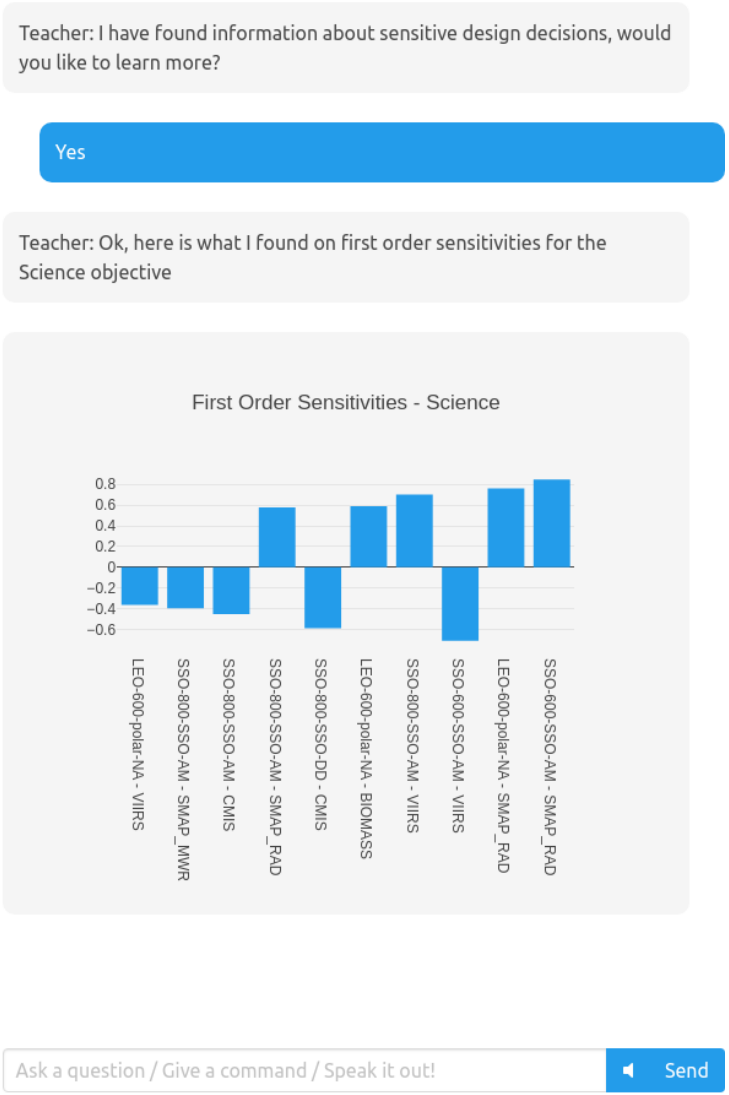


How can we foster human learning in CA?

- Add a *Teacher* role that:

1. Helps the user explore underexplored areas of the design/objective space
2. Points out relevant information to the user (e.g., sensitivities)
3. Asks questions to the user (e.g., about driving features) focusing on areas where the user shows less understanding





Current and future work

- Studying different ways of measuring learning in DSE
- Conducting pilot study to see if *Teacher* role actually fosters learning
- How do we take into account the fact that we are simultaneously exploring the design space and estimating user learning?
  - —Borrow from intelligent tutoring systems literature

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