

Ashtekar Frontiers of Science



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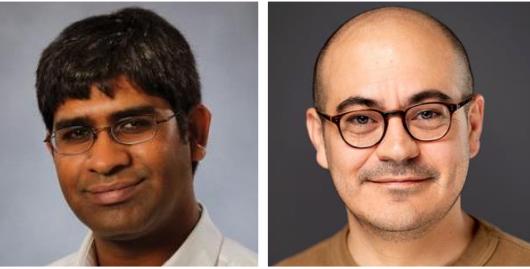


The lecture series was founded by Abhay Ashtekar, founding director of the Institute for Gravitation and the Cosmos and a member of the National Academy of Sciences. It owes its success to Barbara Kennedy, who presided over the series during its first 25 years, making it one of the most successful science outreach events in central Pennsylvania.

The 2026 Ashtekar Frontiers of Science lecture series will explore how researchers in the Eberly College of Science approach some of today's biggest societal questions using different approaches. The 2026 lecture series brings together researchers from disparate disciplines to showcase how faculty from across the college's seven departments leverage wide-ranging methodologies and theoretical approaches to tackle pressing scientific issues and help shape the future of science, health, and humanity.

001 Chemical and Biomedical Engineering Building

"Origins"
January 24, 2026



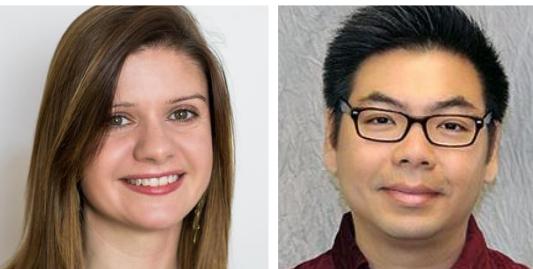
Suvrath
Mahadevan Tom Stewart

"Medicine"
January 31, 2026



Santhosh
Girirajan Wenrui Hao

"Climate"
February 7, 2026



Helen
Greatrex John Harlim

"Materials"
February 14, 2026



Bryce
Gadway Danielle
Hickey

"Resources"
February 21, 2026



Charlie
Anderson Joey Cotruvo

"Education"
February 28, 2026



Jennelle
Malcos Matthew
Beckman



AI Support for Teaching and Learning (at scale)

Matthew D. Beckman
Department of Statistics

Resource Page



February 28, 2026



The learning environment *matters*





Welcome

Eliz
The
This

ELIZA:
YOU:
ELIZA:
YOU:
ELIZA:
YOU:
ELIZA:
YOU:
ELIZA:
YOU:
ELIZA:
YOU:

A horizontal timeline diagram illustrating the evolution of the LIGO detector. The timeline is represented by a black line with vertical tick marks at regular intervals. Seven circular markers are placed along the line, each connected to a label representing a specific year or state:

- 1966
- 1991
- 2011
- 2022
- 2023
- 2026
- Today

The labels are positioned above the timeline, rotated diagonally for better readability.

Unexpected Pairings Addressing Big Questions



OFFICE OF
Education

Artificial and the Teachin

Insights and Recom

May 2023

Recommendations

- Insight: Aligning AI to Policy Objectives
- Calling Education Leaders to Action
- Recommendation #1: Emphasize Ethical AI
- Recommendation #2: Align AI with Learning Objectives
- Recommendation #3: Design for Accessibility
- Recommendation #4: Prioritize Data Privacy
- Recommendation #5: Inform AI Development
- Recommendation #6: Focus on Equity
- Recommendation #7: Develop Ethical Guidelines
- Next Steps.....

Next Step

Announcement

Claude's new constitution

Jan 22, 202

Read the constitution



How AI Impacts Skill Formation

Judy Hanwen Shen* Alex Tamkin†

February 3, 2026

Abstract

AI assistance produces significant productivity gains across professional domains, particularly for novice workers. Yet how this assistance affects the development of skills required to effectively supervise AI remains unclear. Novice workers who rely heavily on AI to complete unfamiliar tasks may compromise their own skill acquisition in the process. We conduct randomized experiments to study how developers gained mastery of a new asynchronous programming library with and without the assistance of AI. We find that AI use impairs conceptual understanding, code reading, and debugging abilities, without delivering significant efficiency gains on average. Participants who fully delegated coding tasks showed some productivity improvements, but at the cost of learning the library. We identify six distinct AI interaction patterns, three of which involve cognitive engagement and preserve learning outcomes even when participants receive AI assistance. Our findings suggest that AI-enhanced productivity is not a shortcut to competence and AI assistance should be carefully adopted into workflows to preserve skill formation – particularly in safety-critical domains.

ANTHROPIC

Lessons for Education

- Not an “end of homework”
- Teaching shifts emphasis
- Access and Scale Improve
- Caution: “ELIZA Effect”

```
Welcome to
EEEEE LL     IIII    ZZZZZZ  AAAAA
EE      LL     II     ZZ  AA  AA
EEEEE LL     II     ZZZ  AAAAAAA
EE      LL     II     ZZ  AA  AA
EEEEE LLLLLL IIII ZZZZZZ  AA  AA

Eliza is a mock Rogerian psychotherapist.
The original program was described by Joseph Weizenbaum in 1966.
This implementation by Norbert Landsteiner 2005.

ELIZA: Is something troubling you ?
YOU: Men are all alike.
ELIZA: What is the connection, do you suppose ?
YOU: They're always bugging us about something or other.
ELIZA: Can you think of a specific example ?
YOU: Well, my boyfriend made me come here.
ELIZA: Is it important to you that your boyfriend made you come here ?
YOU: He says I'm depressed much of the time.
ELIZA: I am sorry to hear that you are depressed.
YOU: It's true. I am unhappy.
ELIZA: Can you explain what made you unhappy ?
YOU:
```



Ashtekar
Frontiers of Science

Personalized Practice / Tutoring

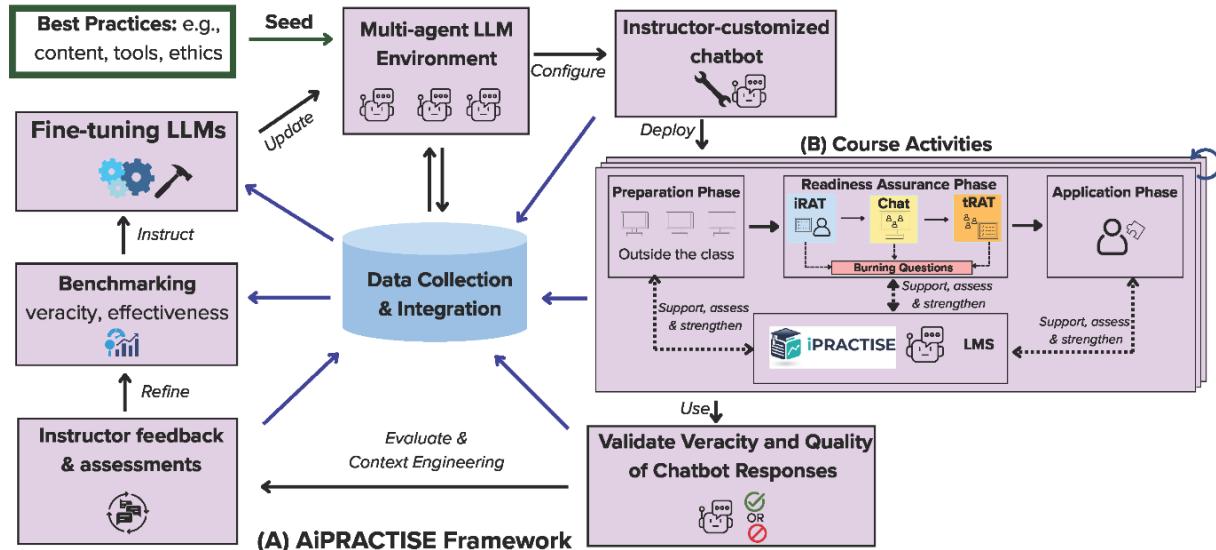


Fig. Schematic representation of Ai-Practise Project related technologies.

- **Ai-Practise** PennState
 - SSRI AI Seed Grant; Sy-Miin Chow, PI
 - Extends iPractise & T-Practise NSF Grants
- **SPARK Self-Regulated Learning** PennState
 - Rayne Sperling, PI
- **Context-aware Chatbots for Education**
 - Khan Academy's Khanmigo
 - Pearson's AI-Powered Chat Bot
 - NSF-Funded HaLLMos Tool (<https://hallmos.com>)

Initial Schematic of LLM support for formative assessment at scale



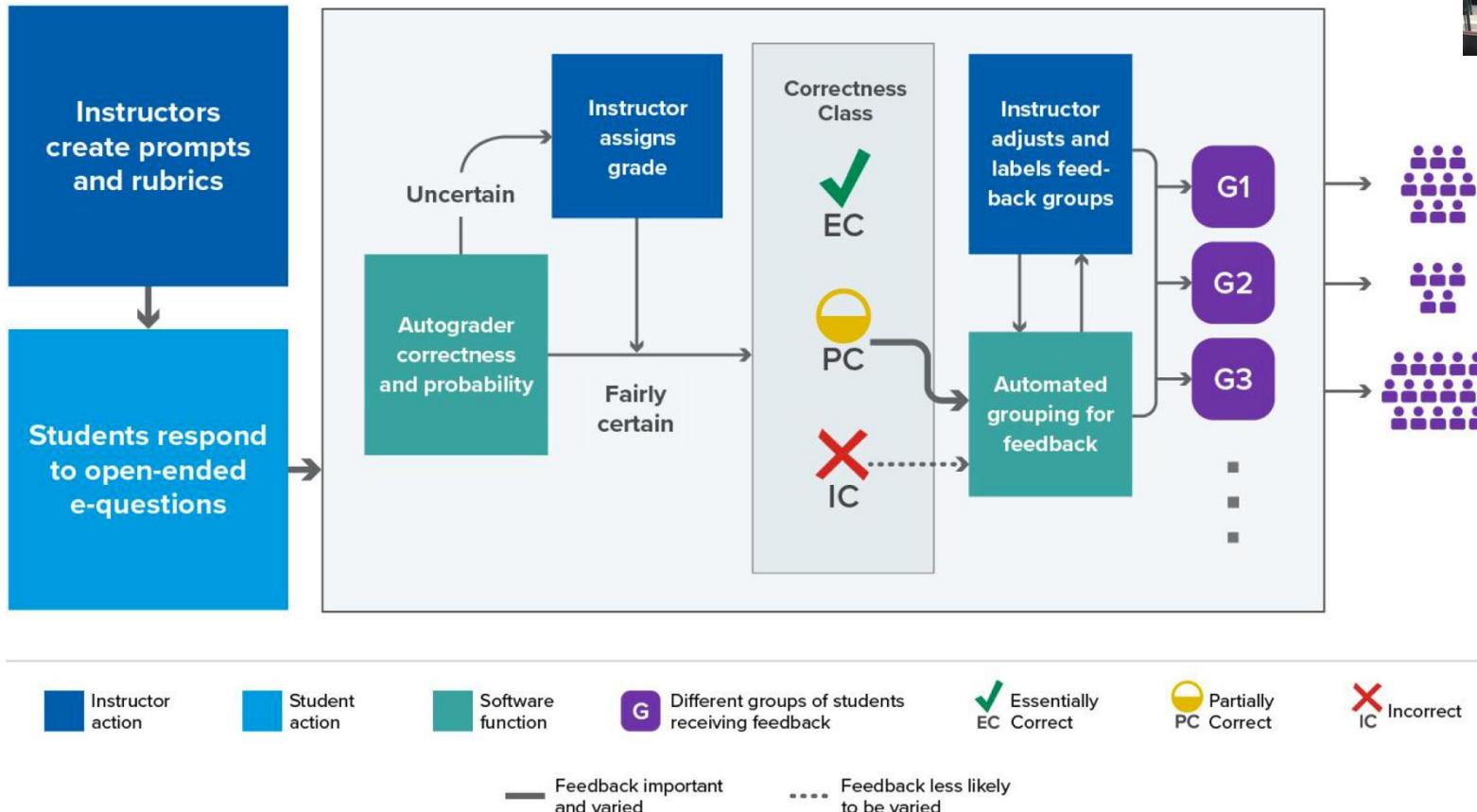
Matt Beckman
(Statistics)



Becky Passonneau
(Computer Science)



Dennis Pearl
(Statistics)



Anna Fergusson



Liza Bolton



Anne Patel



Lars Thompson



Emma Lehrke



Matt Beckman

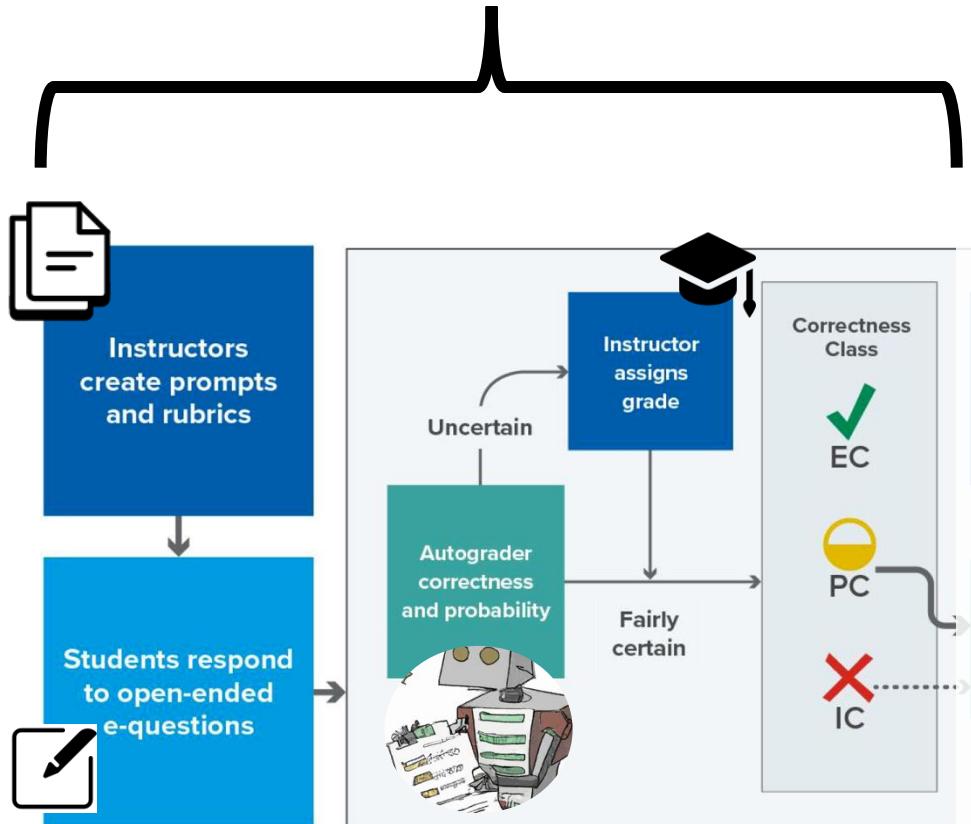


Quick, Write!

Question: How would you describe the value of this kind of formative assessment? For students? For Instructors?

(Seriously, just share whatever comes to mind; we'll use them in a moment)

Does it... work?



"Scoring" Agreement:

- Instructors $\approx 0.7 - 0.8$
- TA's $\approx 0.6 - 0.7$
- Our custom AI ≈ 0.7

Human-in-the-Loop Combination:

- $0.85 - 0.9$ *with deferral control*

Threshold	Deferral Rate	Simulated HIL Accuracy
0.68	9.5%	0.855
0.75	13.2%	0.861
0.80	16.0%	0.871
0.85	20.2%	0.884
0.90	25.6%	0.899

Students: “*What’s in it for me??*”

(translation: I thought he said formative assessment)



- Comparative Judgments (CJ)
- Evaluate other responses
- Give (& get) feedback

p.s. it's the same QR code as “Quick, Write!” so you can either scan OR just refresh the page.

Prototype: Dr. Anna Fergusson (University of Auckland, NZ)



Matt Beckman



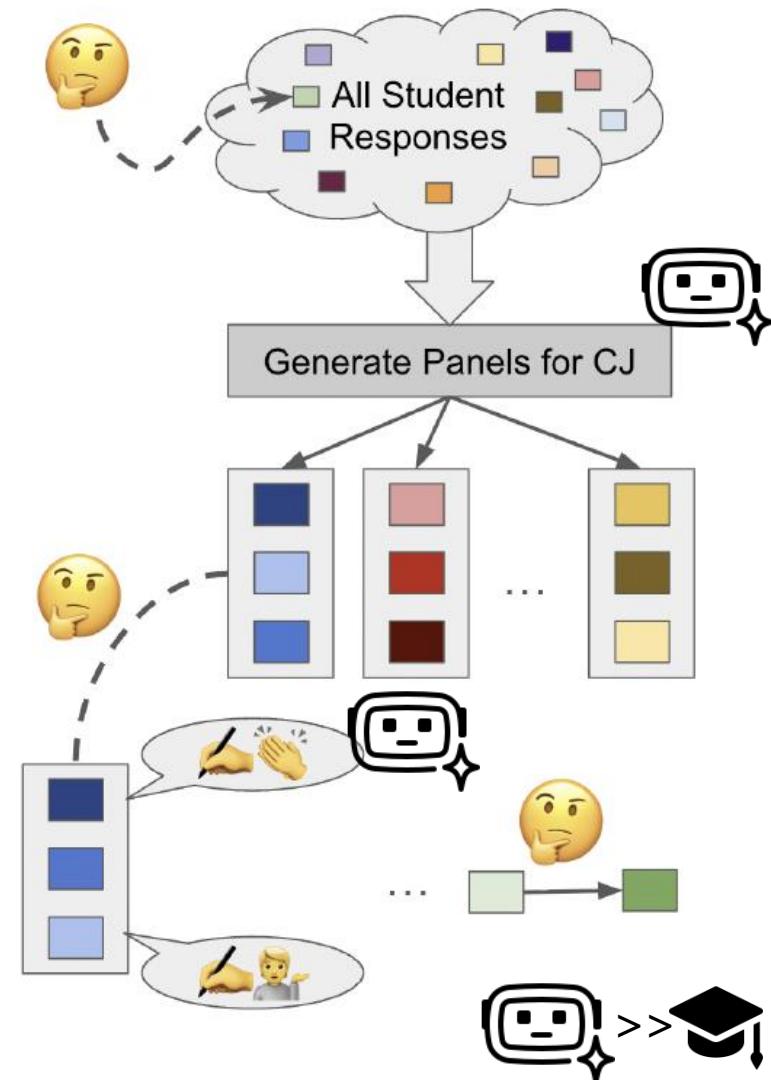
Wenpeng Yin



ChanMin Kim



Neil Hatfield Anna Fergusson



Stay tuned!

- How do LLM / AI models handle linguistic diversity?
- How best to cluster LLM representations of student responses?
- New learning theory for formative comparative judgement (CJ)?
- How does choice of responses for CJ influence critical thinking?
- How does AI-supported CJ influence critical thinking?
- Are there constraints on task & rubric implementation?
- And many other interesting questions

Acknowledgments

- US National Science Foundation (NSF DUE-2236150; DUE-2417294)
- Penn State Center for Socially Responsible Artificial Intelligence
- Penn State Social Science Research Institute (SSRI) Seed Grant
- Strategic partnership between University of Auckland and Penn State University
- Students, instructors, and institutional partners that contributed data and permitted us to use it for our research (Penn State IRB: Study 00022615)

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- Wei, Beckman, Pearl, & Passonneau (in review). Concept-based Rubrics Improve LLM Formative Assessment and Data Synthesis. <https://arxiv.org/pdf/2504.03877>

Additional Images

- [Ai-Practise Schematic] Sy-Miin Chow
- [Autograder Schematic] Becky Passonneau, Matthew Beckman, Dennis Pearl
- [ChatGPT] <https://openai.com/index/chatgpt/>
- [Chess] <https://www.facebook.com/WIONews/posts/todayinhistory-1997-ibms-deep-blue-defeats-garry-kasparov-in-chess-match/2358635227680432/>
- [Classroom Photos] Matthew Beckman
- [Comparative Judgment Schematic] Matthew Beckman, Anna Fergusson
- [ELIZA] <https://en.wikipedia.org/wiki/ELIZA>
- [Elon Musk Tweet] <https://www.bbc.co.uk/newsround/64210050.amp>
- [Google Photos Screenshot (& Adaptation)] Matthew Beckman
- [Grading Robot] Dall-E
- [History of eLearning] <https://elearningindustry.com/history-of-elearning-infographic-education-2012>
- [Jeopardy] <https://blog.ted.com/how-did-supercomputer-watson-beat-jeopardy-champion-ken-jennings-experts-discuss/>
- [Icons for “Edit” / “Documents” / “Graduation” / “Robot”] <https://icons8.com/icons>

AI Support for Teaching and Learning (at scale)

Matthew D. Beckman
Department of Statistics

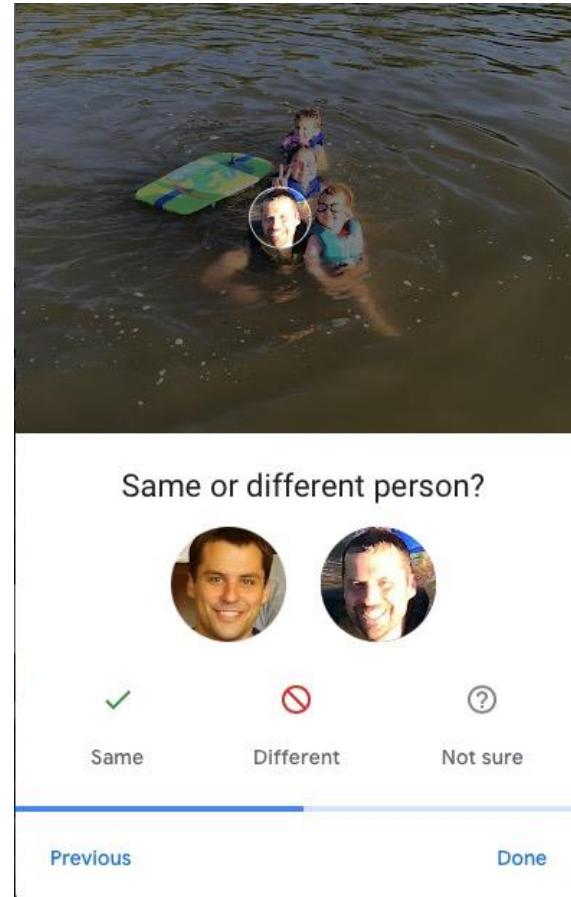
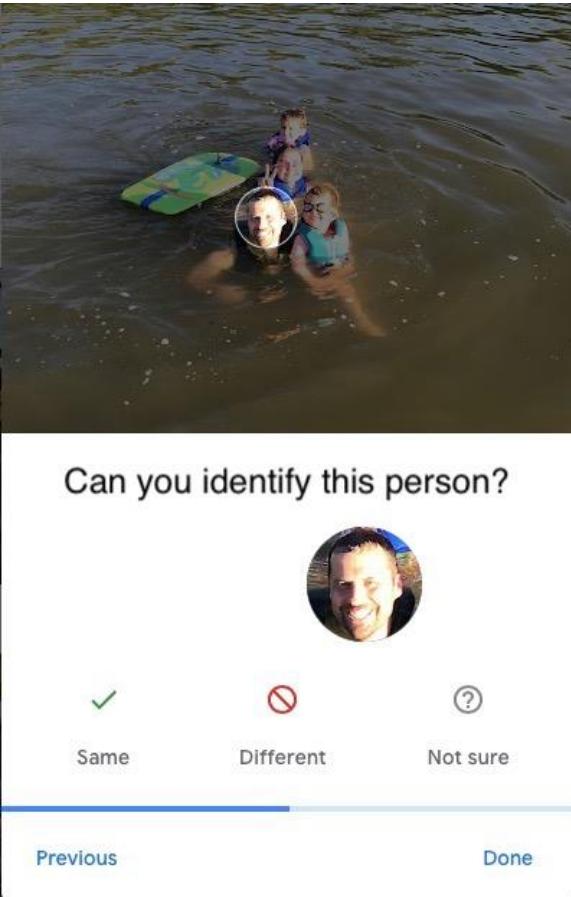
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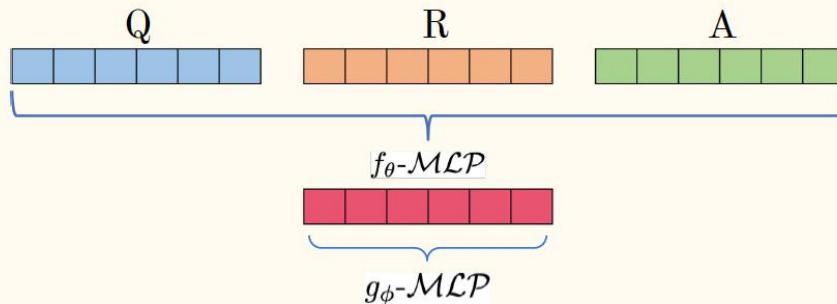
Backup Slides

Human-in-the-Loop Intuition



Relation Network Intuition

Motivation for a Relation Network



- Many short-answer datasets have triples
 - Question prompt
 - Rubric OR Reference answers
 - Answer from student
- Transformers are less practical
 - Datasets are often relatively small
 - Learning a single vector can efficiently capture relational structure

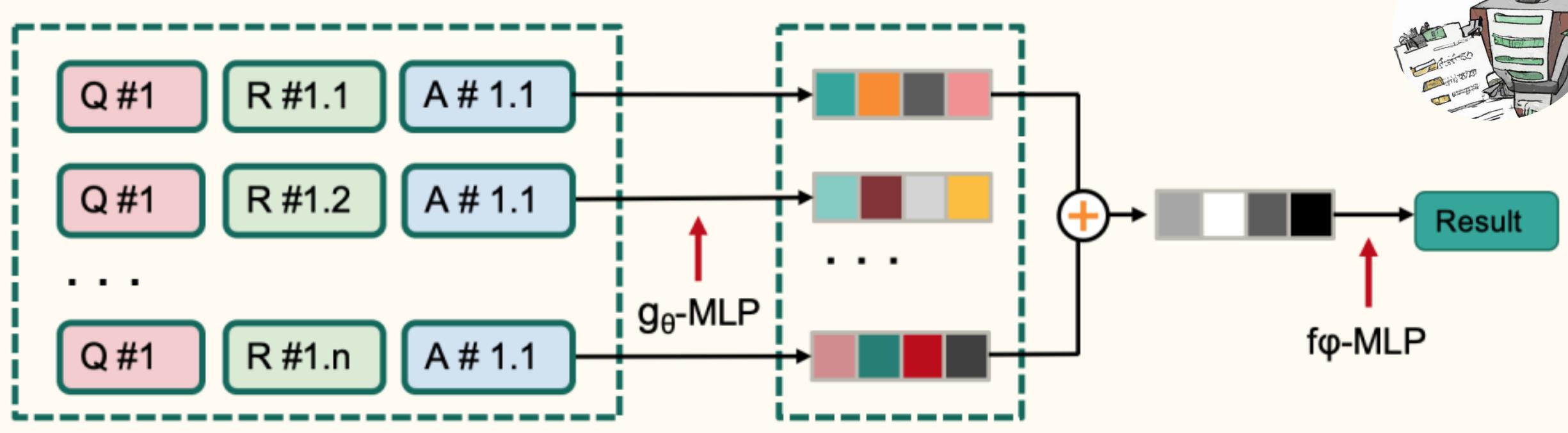
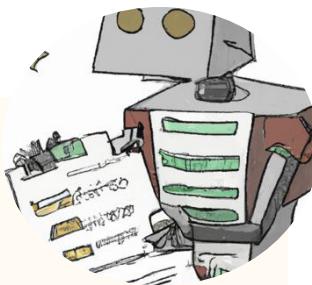
Q: Susan has samples of 5 different foods. Using only the results of her experiment, how will Susan know which food contains the most sugar? (Gas volume is evaluated by tube)

R: Susan should compare the amount of gas in each bag. The bag with the most gas contains the food with the most sugar.

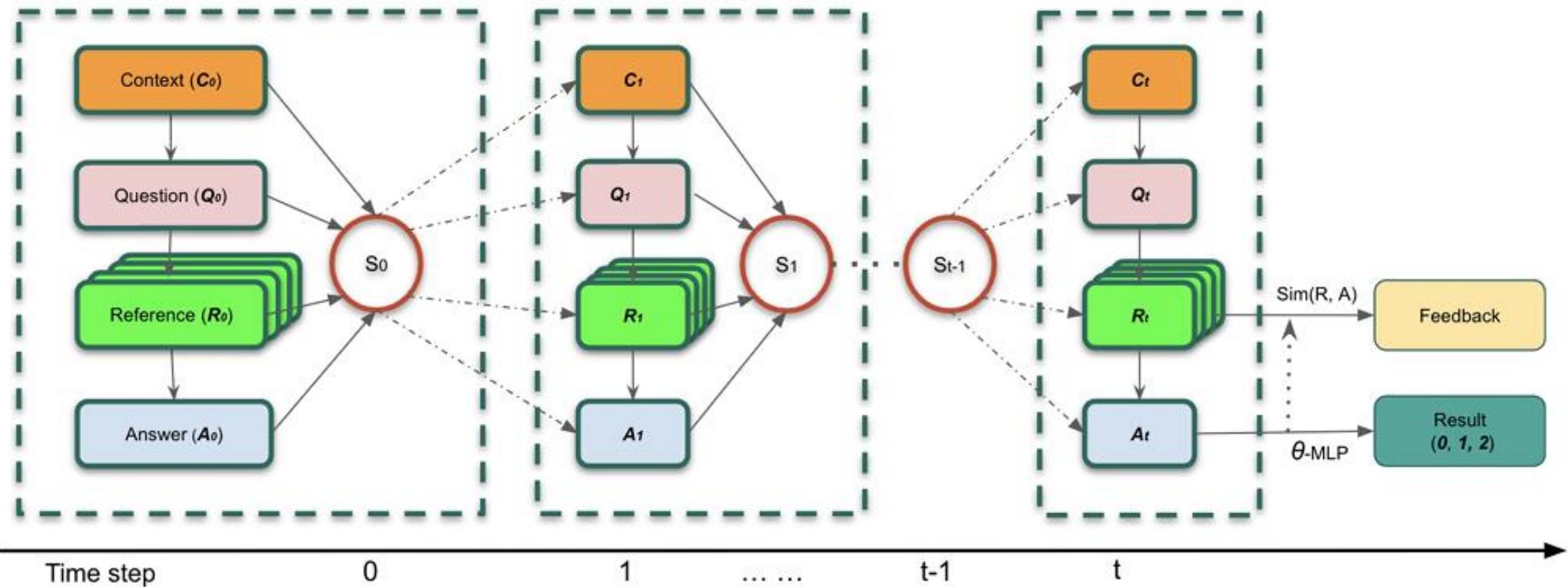
A: Susan will know how much sugar is in the foods by putting each bag in a volume tube. When her finder stops after pushing the top, the bottom of the part she pushes down will be on a number. That number is the milliliters of sugar in the food. Whichever number is the highest, that means that food has the most sugar.

Credit: Becky Passonneau

Semantic Feature-wise Transformation Relation Network (SFRN)



Answer-State Recurrent Relation Network



We'd love your feedback!

