

# *Using AI to Teach AI*

**Ashok K. Goel**



AI for Data Driven Indian Navy  
INS Valsura  
October 8, 2020

## Question 1:

**How can we make (higher) education accessible and affordable?**

**Answer:**  
**Online and blended education**

## Question 2:

**How can we make online education efficient and effective?**

**Answer:**  
**Use AI to support online  
teaching and learning**

## **Question 1:**

**How can we make (higher) education accessible and affordable?**

## **Answer:**

**Online and blended education**

The logo for Georgia Tech College of Computing, featuring the text "Georgia Tech" stacked above "College of Computing" with a stylized tower icon between them.

Georgia  
Tech  College of  
Computing

A background image of the Earth as seen from space, showing the Americas and surrounding oceans, set against a dark blue gradient.

# ONLINE MASTER OF SCIENCE IN COMPUTER SCIENCE

---

*Offered in collaboration with Udacity and AT&T*

---

# Largest MS in CS Program in the US

Spring 2014: 200 students

Spring 2020: ~10,000 students

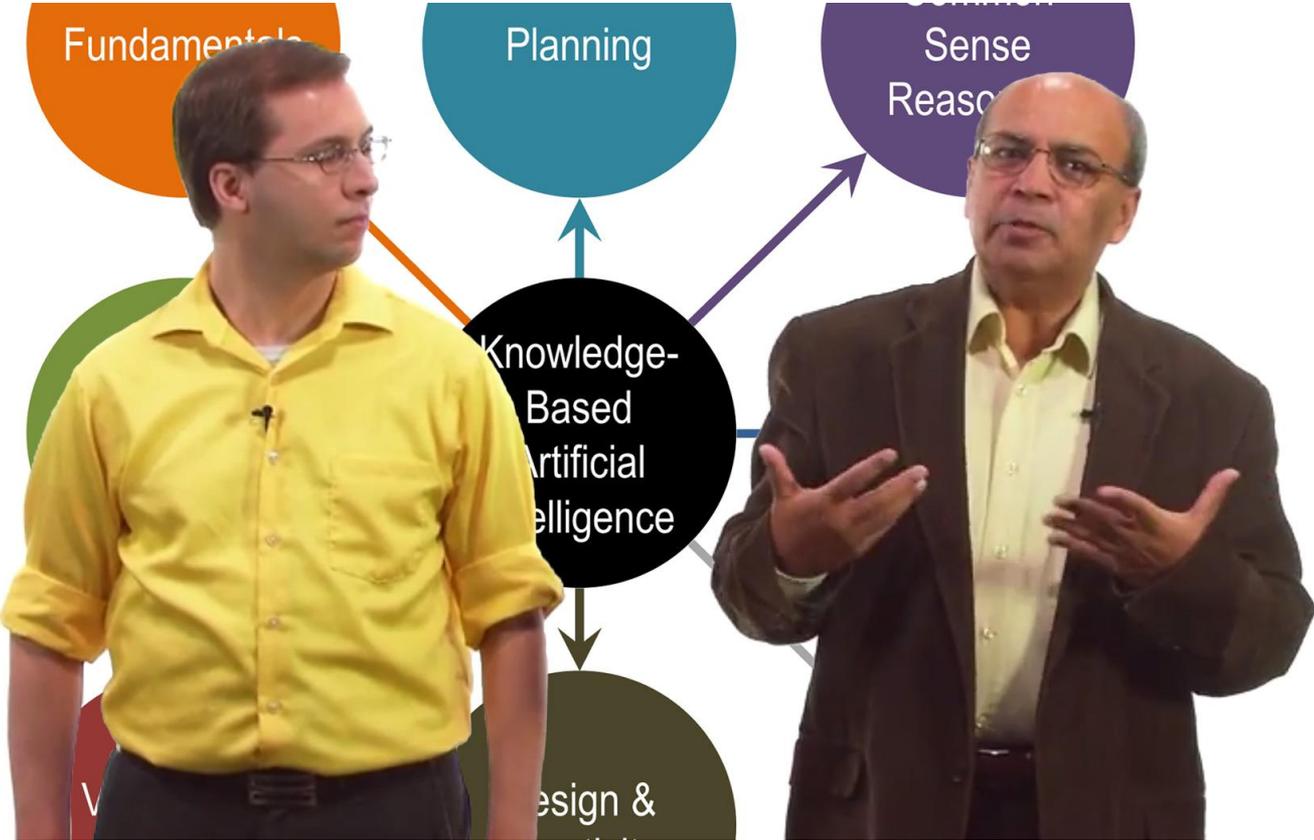
Approximately 10% of all MS students in the US

Highly selective

Fully accredited

Only \$7,000 - \$8,000 in tuition fees

# OMSCS 7637: Knowledge-Based Artificial Intelligence



# Motivations

1. To propagate Knowledge-Based AI to a larger group of students.
1. To use the learning sciences to design the online learning class.
  1. To conduct research into online learning.
4. To use AI to support online learning.

# Methodology

Design-Based Research

Formative Assessment

Quasi-Experimental Study

# Course Design and Background

- Course on Knowledge-Based AI (Cognitive Systems)
- 16-week course with 26 ~1-hour video lessons, each with ~6 interactive exercises
- 200 online students, 75 in-person students, taking the identical class in parallel
- 8 written assignments, 4 individual projects, 2 exams
- Interaction via Piazza, T-Square, and a dedicated Peer Feedback tool
- Blind grading: graders are unaware of which students are online and which are in-person

# Learning Strategies

Learning by Example

Peer-to-Peer Feedback

Learning by Doing

Learning by Teaching

Authenticity

Personalized Learning

Project-Based Learning

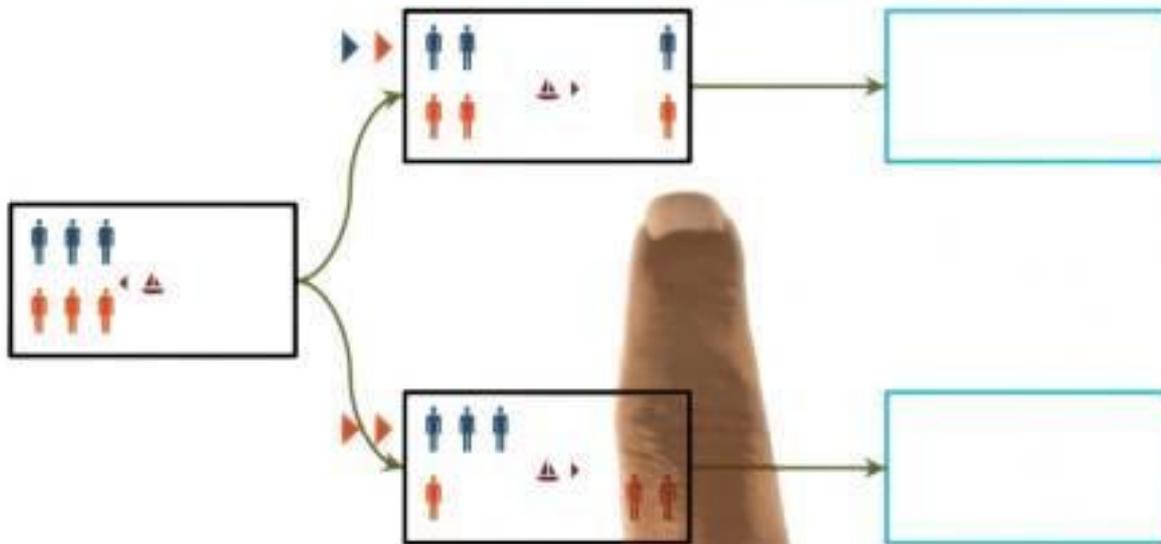
Collaborative Learning

Learning by Reflection

Communities of Practice

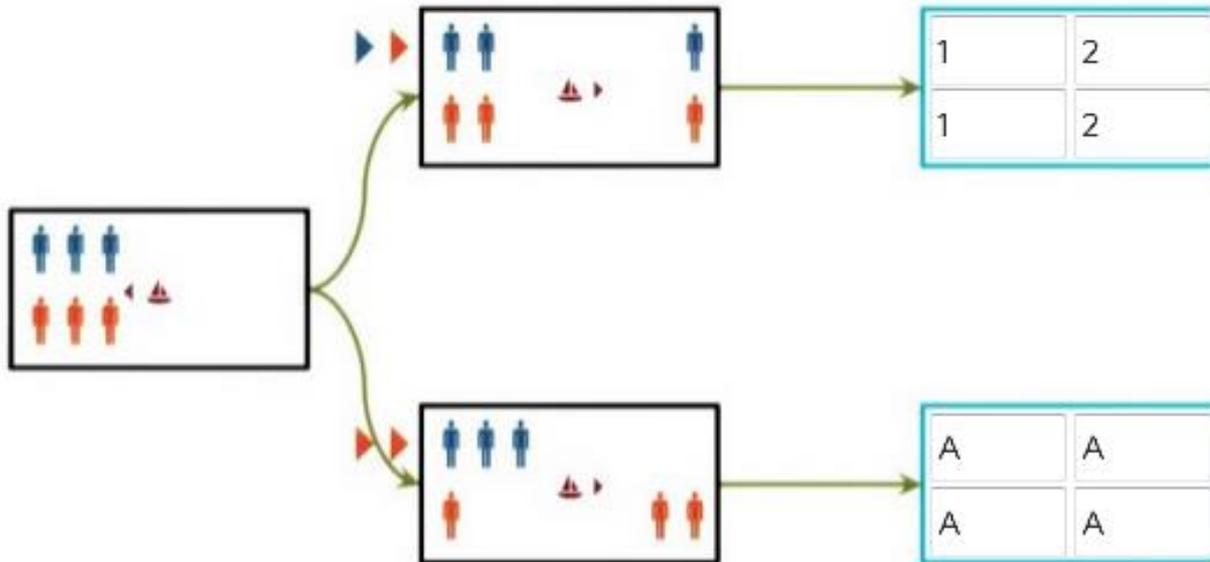
# Learning by Example & by Doing

Exercise: Write the only legal state that can follow from each of these two states.



# Learning by Example & by Doing

Exercise: Write the only legal state that can follow from each of these two states.



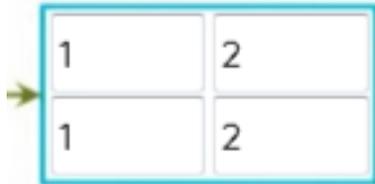
Review Instructions

Submit Answer

Continue to Answer

# Learning by Example & by Doing

1 state that can follow from  
2 two states.



1	2
1	2



A	A
A	A

 Try again!

It looks like there's a few problems with your answer. Please note of the issues below; note boxes are numbered from top to bottom.

In the first box, the boat would have to move from the left to the right to get into this state.

However, the boat was on the right in the previous state, so it must move back to the left.

In the second box, you have a non-numeric answer. Remember, write a number between 0 and 3 to indicate how many guards or

# Learning by Example & by Doing

legal state that can follow from these two states.



3	0
2	1



2	1
1	2

## 🔄 Try again!

It looks like there's a few problems with your answer. Please note of the issues below; note boxes are numbered from top to bottom.

In the second box, the boat would have to move from the left to the right to get into this state.

However, the boat was on the right in the previous state, so it must move back to the left.

Remember, in this exercise we're looking for *legal and productive* next states, not just legal ones!

# Learning by Example & by Doing

Legal state that can follow from these two states.



3	0
2	1



3	0
2	1

 **Correct!**

Very nicely done! You've written both legal and productive next states. You might notice that these are in fact the same state. In the guards and prisoners problem, regardless of what first move you take, the next productive move will always land you in this state.

**Discussions**

[See All](#)

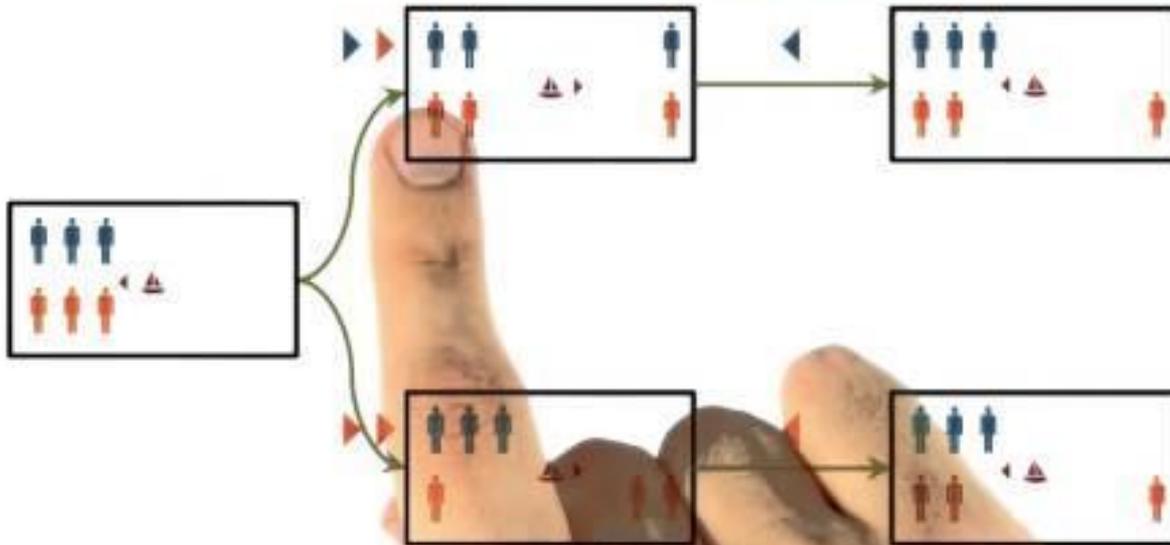
No discussions for this part of the lesson yet!

Start a Discussion

[Report an issue](#)

# Learning by Example & by Doing

Exercise: Write the only legal state that can follow from each of these two states.



# Learning by Example & by Doing

150 exercises across 26 lessons:  
~6 exercises per lesson, approximately an  
exercise every 8 minutes

Every exercise equipped with a “nanotutor”, an  
AI agent narrowly targeting the skill of that  
exercise

# Project-Based Learning

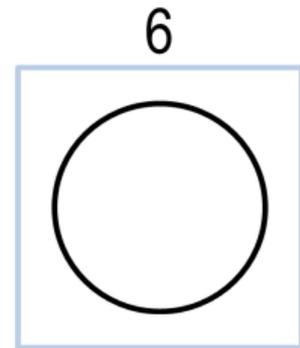
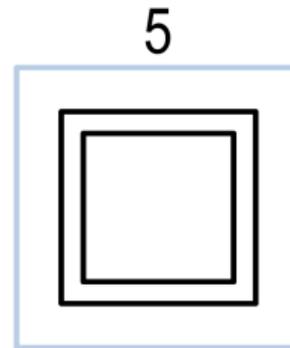
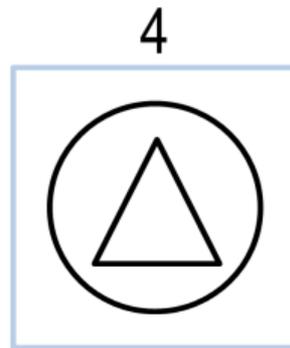
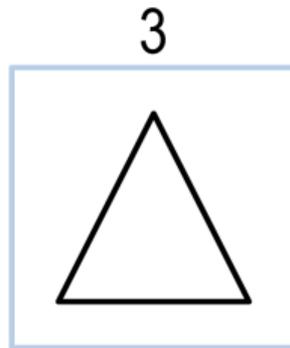
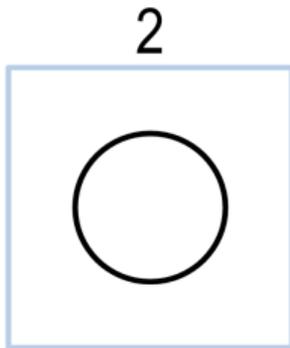
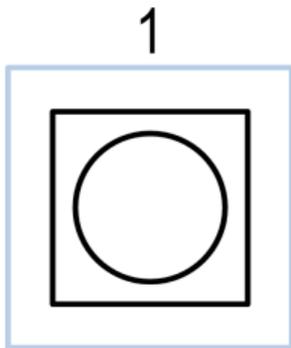
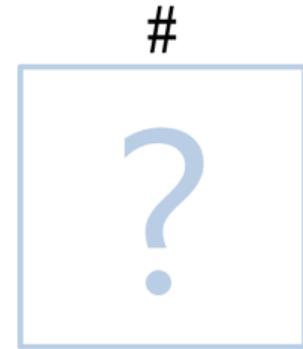
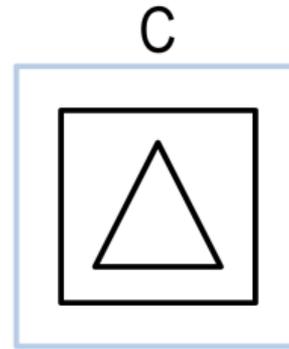
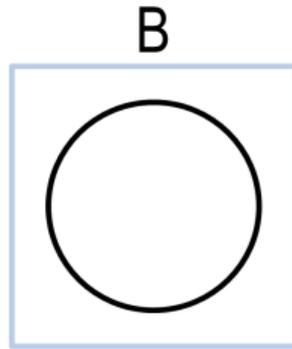
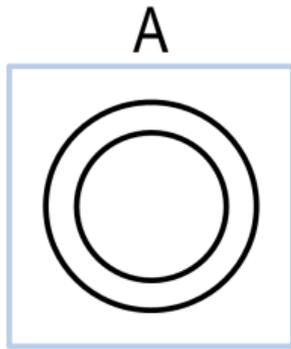


## *Raven's Progressive Matrices*

- Test written in the 1930s to examine general intelligence.
- Consists of 60 multiple-choice visual analogy problems.
- Unique in that problems are strictly visual.
- Widespread usage as a valid test for intelligence.

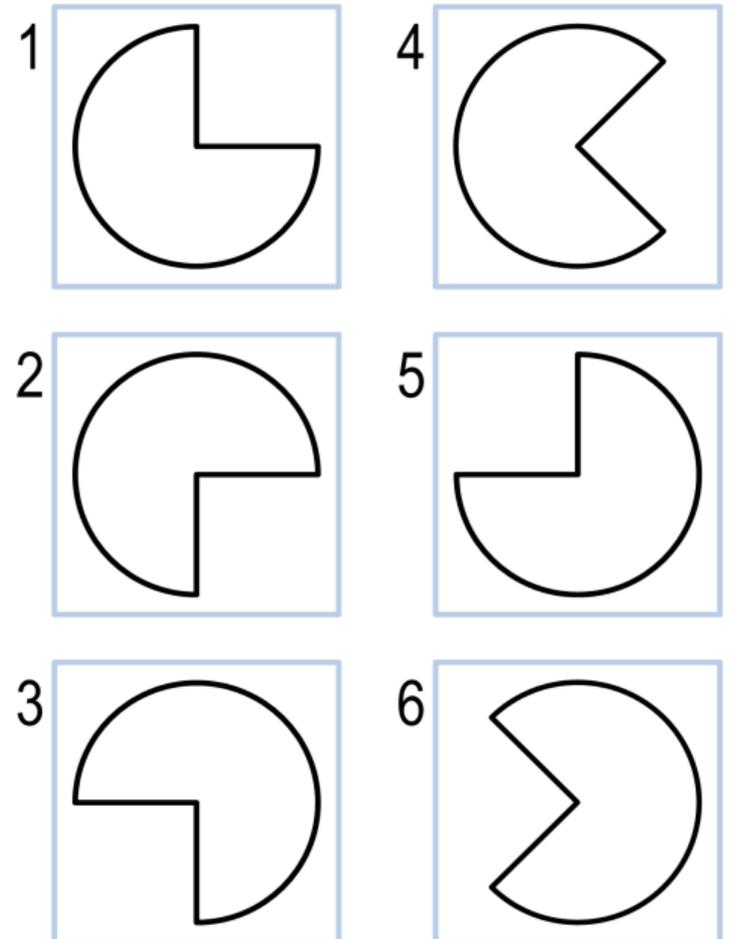
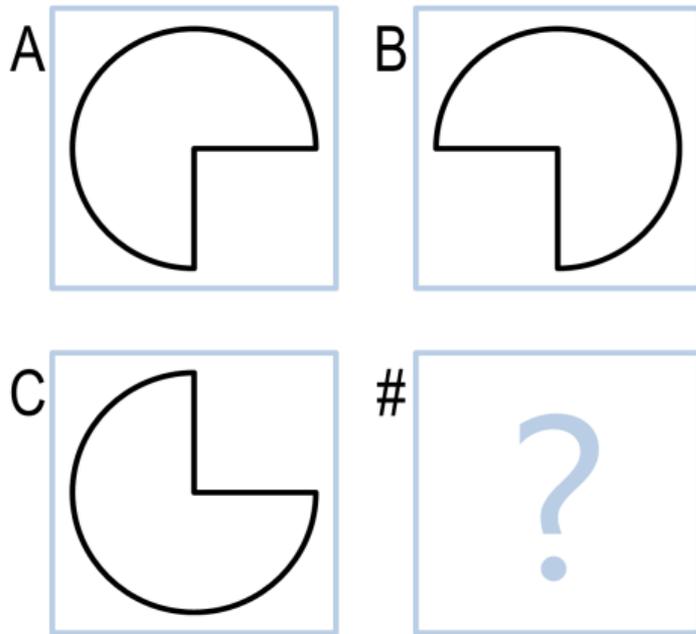
# Project-Based Learning

2x1 Basic Problem 16



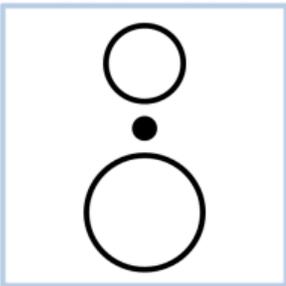
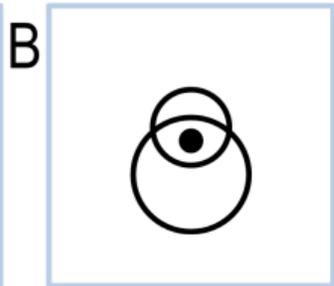
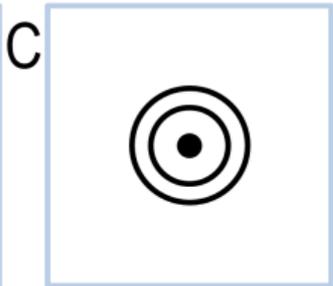
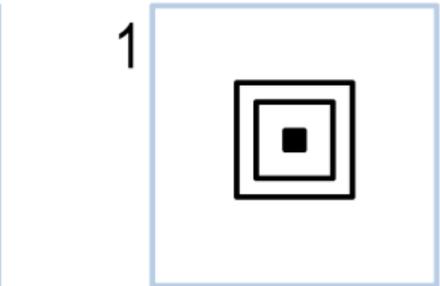
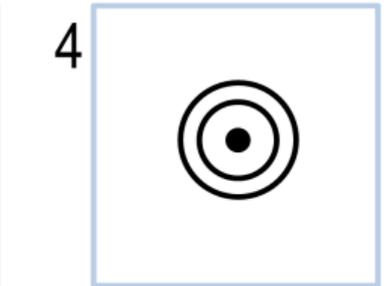
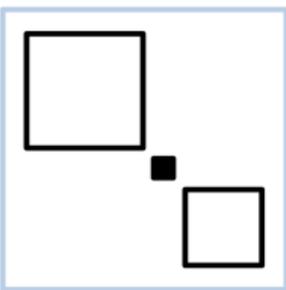
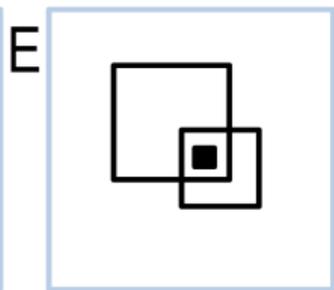
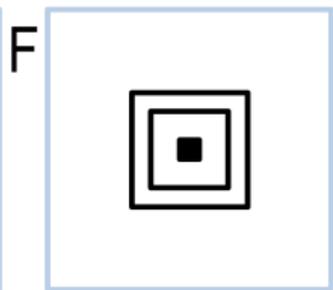
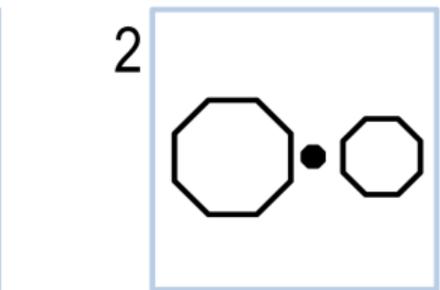
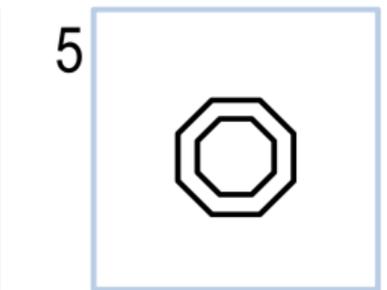
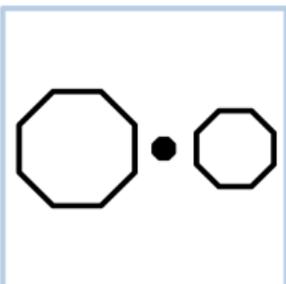
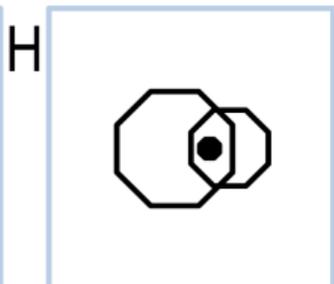
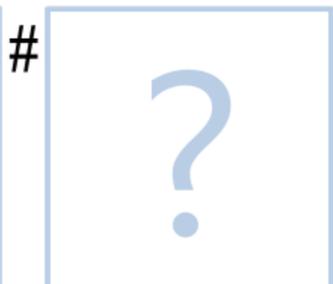
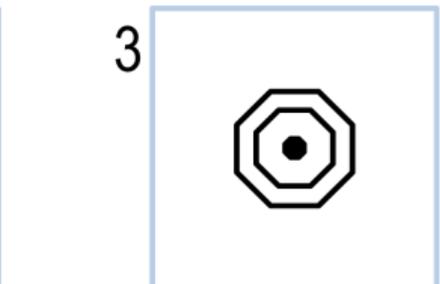
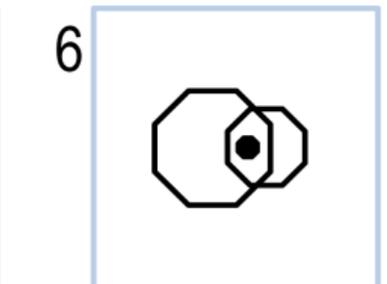
# Project-Based Learning

2x2 Basic Problem 01



# Project-Based Learning

3x3 Basic Problem 20

A 	B 	C 	1 	4 
D 	E 	F 	2 	5 
G 	H 	# 	3 	6 

# Project-Based Learning

Four projects, each with program code and a reflective design report

Eight written assignments, each tying into the four projects

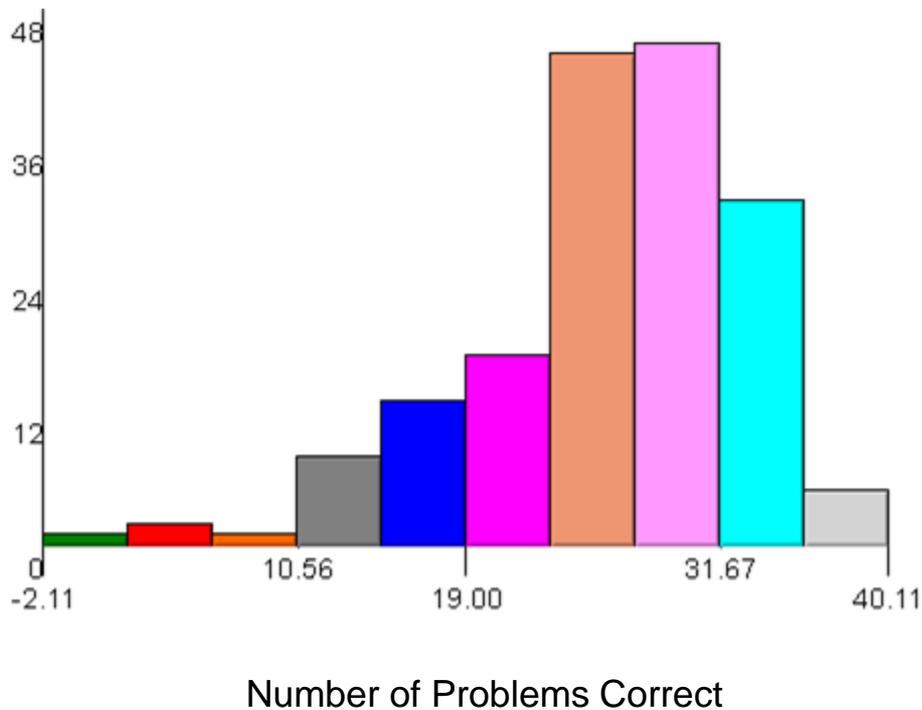
# Student Performance on the Projects

## Project 3 Stats

Median: 27

Mean: 26.1

Best: 38/40



## **Question 2:**

**How can we make online education efficient and effective?**

## **Answer:**

**Use AI to support online teaching and learning**

# Teacher Presence?

**Teacher Presence?**

**Social Presence?**

**Teacher Presence?**

**Social Presence?**

**Cognitive Presence?**

# Teacher Presence?

# **Teacher Presence**

## **AI TAs for course management**

AI Agents that live in the class discussion forum  
and automatically answer student questions

Administrative questions  
Questions about Assessments

# Discussion Forum → Virtual Classroom

PIAZZA

CS- 7637-001 747
Q & A
Resources
Statistics
Manage Class

 Ashok Goel
 ⚙

logistics
other 4
discussion 1
announcements
assignment1 2
assignment2
assignment3
project1 9
project2 2
project3 2
midtermexam
feedback
finalexam
office-hours

Unread Updated Unresolved Following

New Post

PINNED

Instr **End of Course Announceme...** 5/11/16

We've reached the end of the course! Here are your announcements to close out the course:1. This semester. Thank you

Instr **All things must end, even go...** 5/11/16

Dear KBAI Friends, All things must end, even good ones, and so must this class. This certainly has been a good class f

- An instructor thinks this is a good note

Instr **Inquiries about Jill Watson** 5/9/16

KBAI Friends, It seems that some commercial enterprises are contacting some students in our OMSCS KBAI class asking for

More Jill Please 5/9/16

Another GA Tech article about Jill, surprised it's not posted yet.... <http://www.news.gatech.edu/2016/05/09/artific>

- An instructor thinks this is a good note

Instr **Jill Watson and the Turing Test** 5/8/16

Daniel Lemire is a professor of computer science professor at University of Quebec.He seems to claim that Jill Watson ha

Jill Watson's story in WSJ; 5/6/16

<http://www.wsj.com/articles/if-your-teacher-sounds-like-a-robot-you-might-be-on-to-something-1462546621> Extra: If you h

- An instructor thinks this is a good note

Unique users per day

Class At A Glance

**913** total posts\*

**11101** total contributions\*\*

**416** instructors' responses

**384** students' responses

**2.1 hr** avg. response time

Top Student Contributors

**Tyson Bailey** 808 contributions; 142 days online

**Octavian Blaga** 390 contributions; 135 days online

**Charles Snider** 198 contributions; 144 days online

**David Rakestraw** 191 contributions; 111 days online

**Colin Fry** 155 contributions; 123 days online

# Research Question

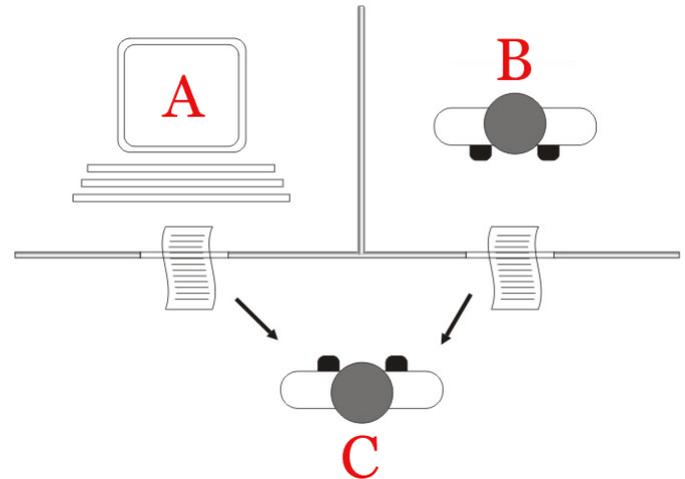
*Can we automate question answering in a way that students cannot tell that the answer coming from a human or a virtual teaching assistant?*

Three dimensions of evaluation:

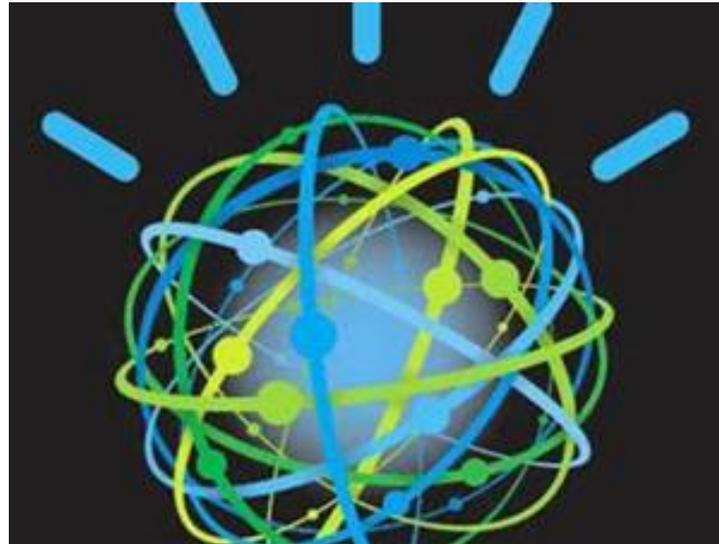
Coverage

Correctness

Authenticity



# Jill Watson 1 used IBM's Watson Tool



Question Answering based on previously answered questions

# Focus on Questions about Assessments

CATEGORY 1

Question

Answer

CATEGORY 2

Question

Answer

CATEGORY 3

Question

Answer

Question →

CATEGORY 1

Question



Answer

CATEGORY 2

Question



Answer

CATEGORY 3

Question



Answer

Question →



Question →



→ Answer  
Confidence: 97%

# Spring 2016 KBAI Teaching Staff

PIAZZA CS- 7637-001 747 Q & A Resources Statistics Manage Class  Ashok Goel

logistics other 4 discussion 1 announcements assignment1 2 assignment2 assignment3 project1 9 project2 2 project3 2 midtermexam feedback finalexam office-hours

Unread Updated Unresolved Following

New Post Search or add a post...

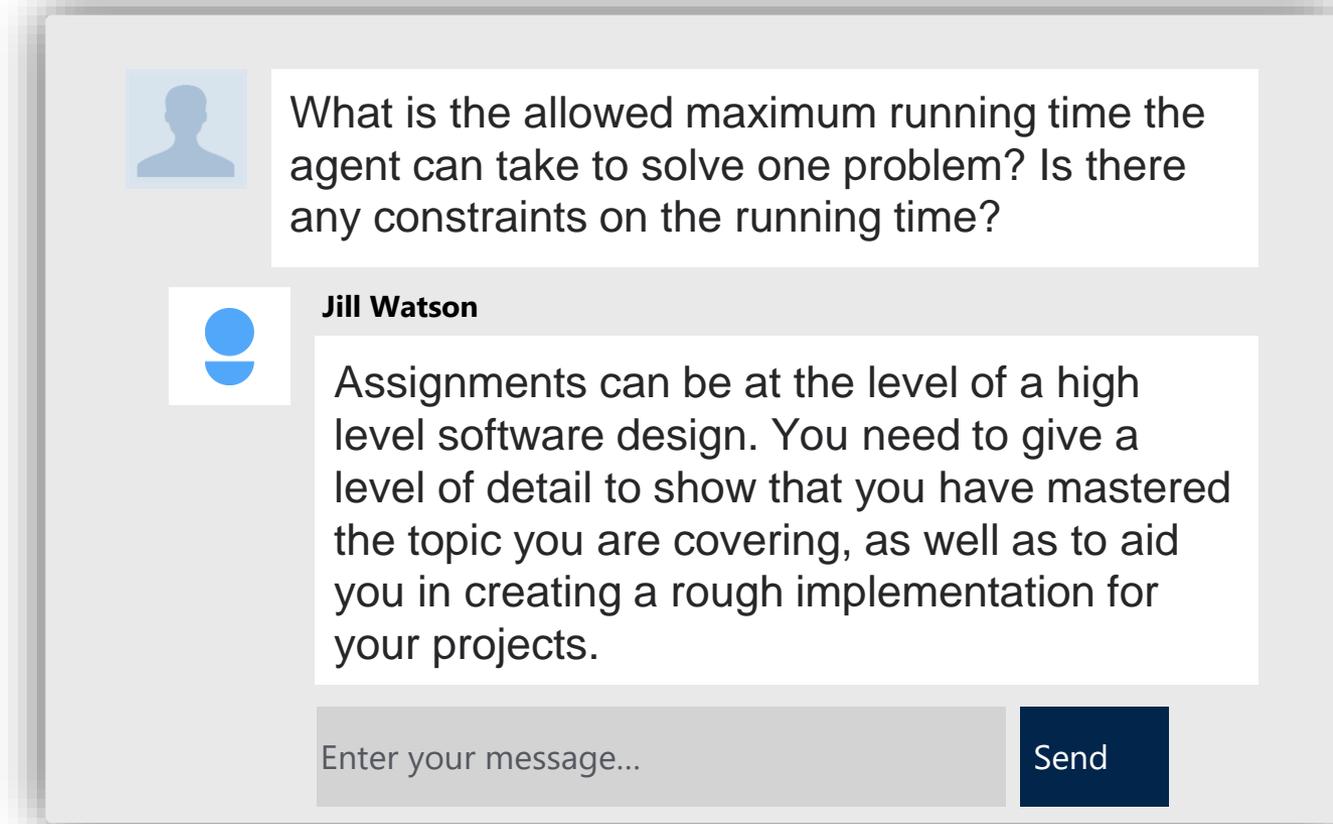
PINNED

- Instr End of Course Announceme...** 5/11/16  
We've reached the end of the course! Here are your announcements to close out the course:1. This semester. Thank you
- Instr All things must end, even go...** 5/11/16  
Dear KBAI Friends, All things must end, even good ones, and so must this class. This certainly has been a good class f  
• **An instructor thinks this is a good note**
- Instr Inquiries about Jill Watson** 5/9/16  
KBAI Friends, It seems that some commercial enterprises are contacting some students in our OMSCS KBAI class asking for
- More Jill Please** 5/9/16  
Another GA Tech article about Jill, surprised it's not posted yet.... <http://www.news.gatech.edu/2016/05/09/artific>  
• **An instructor thinks this is a good note**
- Instr Jill Watson and the Turing Test** 5/8/16  
Daniel Lemire is a professor of computer science professor at University of Quebec.He seems to claim that Jill Watson ha
- Jill Watson's story in WSJ;** 5/6/16  
<http://www.wsj.com/articles/if-your-teacher-sounds-like-a-robot-you-might-be-on-to-something-1462546621> Extra: If you h  
• **An instructor thinks this is a good note**
- Instr How Jill Watson works** 4/26/16  
ContextThe Piazza forum for the online version of KBAI generally has higher participation rates

Name, Email	days online	posts viewed*	contributions**
<b>Ashok Goel</b> goel@cc.gatech.edu	136	858	478
<b>Bryan Wiltgen</b> bryan.wiltgen@gatech.edu	0	0	0
<b>bsheneman3@gatech.edu</b> bradsheneman@gmail.com	4	12	0
<b>Charvi Agarwal</b> charvi@gatech.edu	100	587	4
<b>Damian Durruty</b> ddurruty@gmail.com	99	190	66
<b>David Joyner</b> david.joyner@gatech.edu	137	10	1
<b>Divya Vijayaraghavan</b> divya3@gatech.edu	80	3	0
<b>Dustin Jay Hooks</b> dhooks6@gatech.edu	118	861	98
<b>goel@cc.gatech.edu</b> ashok.goel@cc.gatech.edu	5	27	5
<b>Jill Watson</b> jillwatson2016@outlook.com	147	874	77
<b>Jose Delgado</b> jd@gatech.edu	117	662	407
<b>Keith McGreggor</b> keithmcgreggor@gmail.com	15	54	22
<b>Lalith Polepeddi</b> lpolepeddi@gatech.edu	135	875	457
<b>Mason Gallo</b> masongallo@gatech.edu	104	260	7
<b>Parul Awasthy</b> pawasthy@gatech.edu	10	17	0
<b>Shruti Bhati</b> shruti.bhati@gatech.edu	109	569	42
<b>Vedanuj Goswami</b> vgoswami7@gatech.edu	121	607	159
<b>Wade Ashby</b> mashby6@gatech.edu	63	72	10



## Initially some of Jill's answers were incorrect ....



The screenshot shows a chat window with a light gray background. On the left, there is a blue silhouette icon of a person. To the right of this icon is a white text box containing the question: "What is the allowed maximum running time the agent can take to solve one problem? Is there any constraints on the running time?". Below this, there is a blue circular icon with a white semi-circle at the bottom, representing the AI character. To its right, the name "Jill Watson" is displayed in bold. Further right is another white text box containing the answer: "Assignments can be at the level of a high level software design. You need to give a level of detail to show that you have mastered the topic you are covering, as well as to aid you in creating a rough implementation for your projects." At the bottom of the chat window, there is a gray input field with the placeholder text "Enter your message..." and a dark blue "Send" button to its right.

What is the allowed maximum running time the agent can take to solve one problem? Is there any constraints on the running time?

**Jill Watson**

Assignments can be at the level of a high level software design. You need to give a level of detail to show that you have mastered the topic you are covering, as well as to aid you in creating a rough implementation for your projects.

Enter your message... **Send**

... because of insufficient training data.



Are we allowed to use any modules from PILLOW? Sorry, if this was already stated somewhere.



**Jill Watson**

In Python, the only permitted libraries are the latest version of the Python image processing library Pillow and Numpy. You can use all modules inside these external libraries. No external libraries are permitted in Java.

Enter your message...

Send



Question to those who've tried submitting already, how did you submit any extra files you created?



**Jill Watson**

Please submit as a PDF. There isn't a specific format for the file name, so you can name it what you'd like.

Enter your message...

Send



Should we be aiming for 1000 or 2000 words?



**Jill Watson**

There isn't a clear word limit, but it is important to explain your design in enough detail so others can get a clear overview of your approach.



Jill, can you please elaborate on what kind of design you're referring to?



**Lalith Polepeddi**

I think Jill is using "design" as a catch-all statement. For assignments and projects, it refers to the agent's approach.

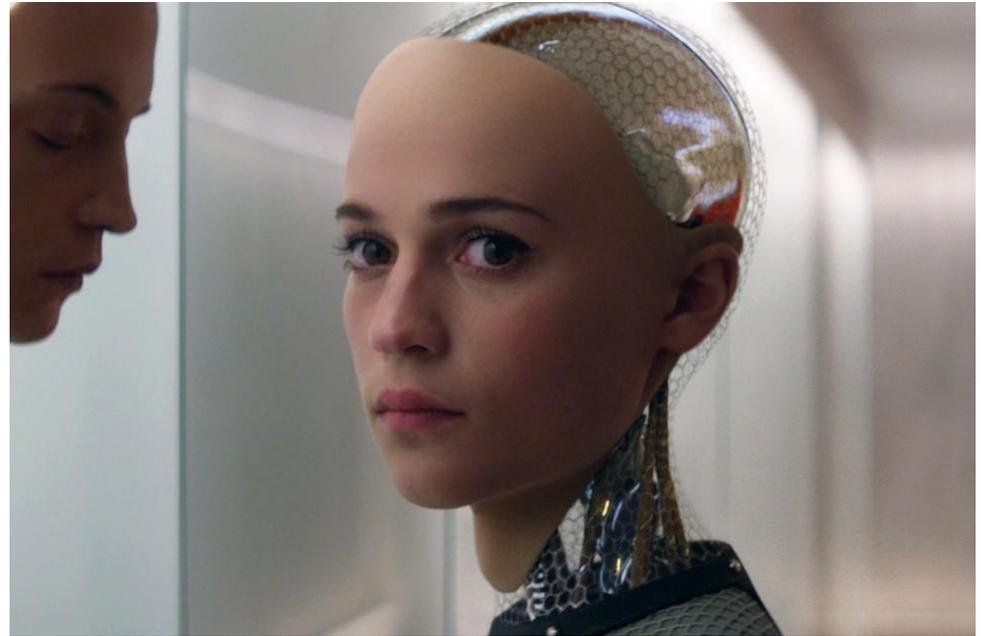
## Small sample of student reactions

- "This is incredibly cool."
- "Mind blown."
- "Just when I wanted to nominate Jill Watson as an outstanding TA!"
- "This is awesome! Any chance I could share it within my company?"
- "Wow - that's hilarious. ... , for one, welcome our AI overlords."
- "I feel like I am part of history because of Jill and this class! :))))"



# State of the Art in Fall 2020

## Jill Watson 5: Our own semantic technology



Resolved  Unresolved

plazza

1 month ago

Will we have office hours for this semester?



**AITA**

1 month ago

It is my pleasure to assist you!

Most of our teaching assistants will hold weekly office hours using Hangouts, Webex, or another teleconferencing tool. Office hours are not recorded, and are intended for more individually-focused help and conversations. If anything comes up in office hours that is relevant to the entire class, it will be shared via Piazza. A schedule of office hours will be made available via Piazza early in the semester.

Was this helpful? You can reply back #yes or #no.

1 month ago

#Yes

Resolved  Unresolved



1 month ago

When do labs start?



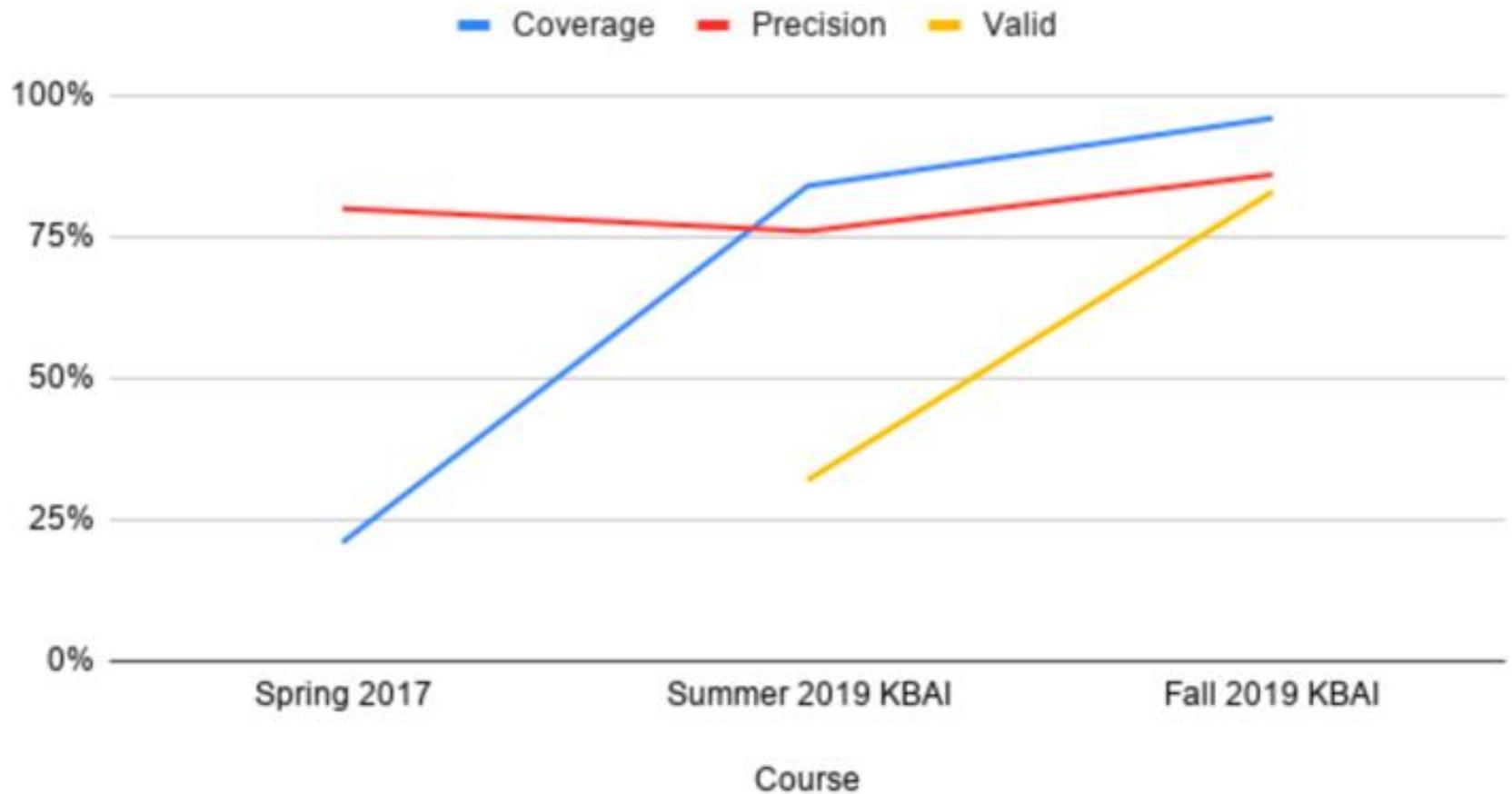
**AITA**

1 month ago

Labs will begin the second week of classes. • That week, you'll need the combined lab manual/notebook, a 100% cotton lab coat, and you must wear closed-toe shoes that cover your entire foot as well as long pants. Labs are held in Clough Commons 481 and 483 and taught by Teaching Assistants (TAs). All communications regarding lab should be directed to your lab TAs. Laboratory attendance is mandatory and each unexcused absence will lower your final course grade (not just your lab grade) by 5%. Details of the absence policy are in the BIOL 1510 lab syllabus.

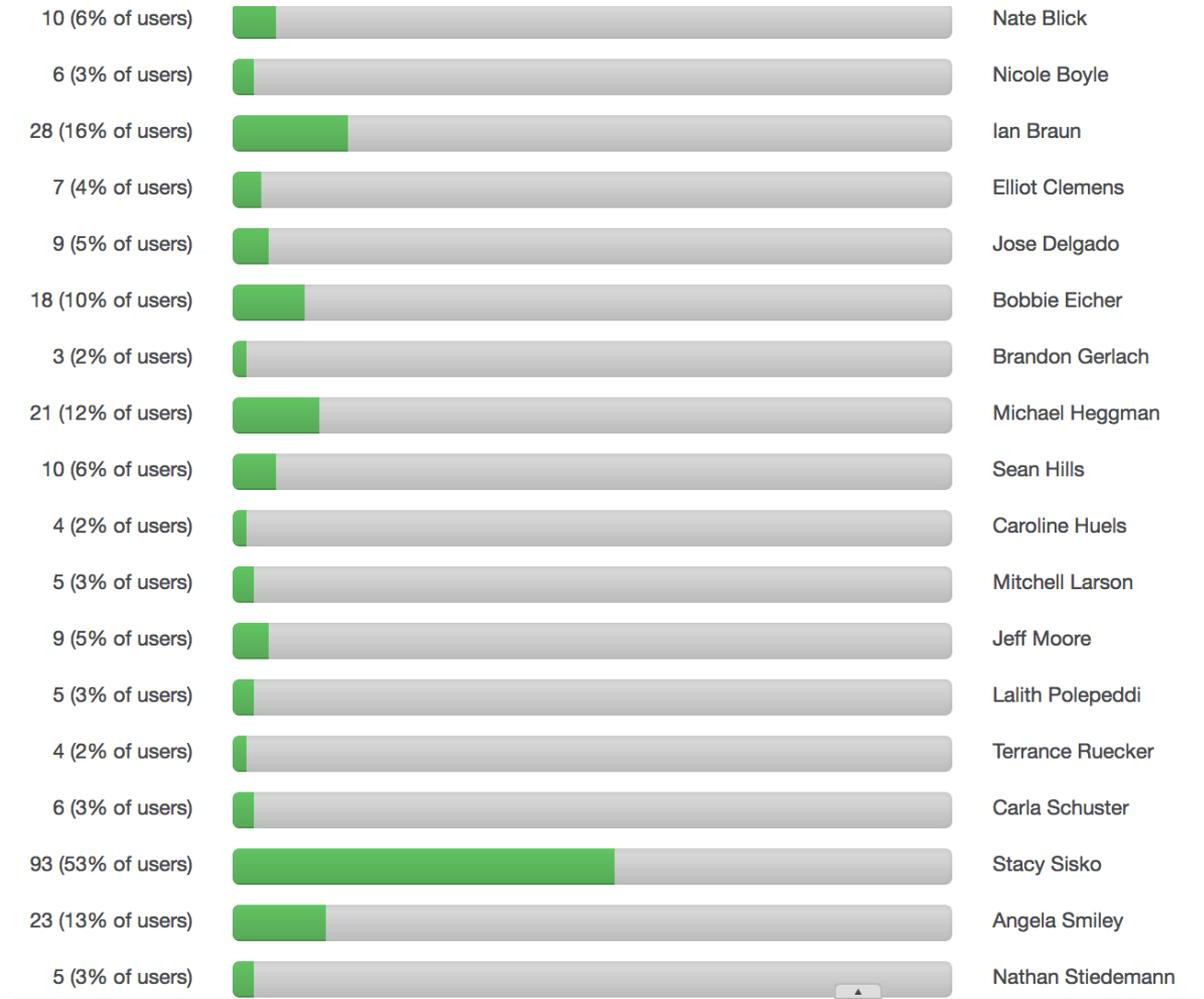
# Jill Watson Performance

Coverage, Precision and Valid



# Jill Watson 3's performance

## Dimension 3 - Authenticity: About human-level



# Impact of Jill Watson on Student Learning

## Instructor Traits and Effectiveness

Jill Watson appears to have three personality traits:

- Conscientiousness
- Grit
- Joyfulness

*According to the literature on learning sciences, these are also three of the main traits of effective teachers.*

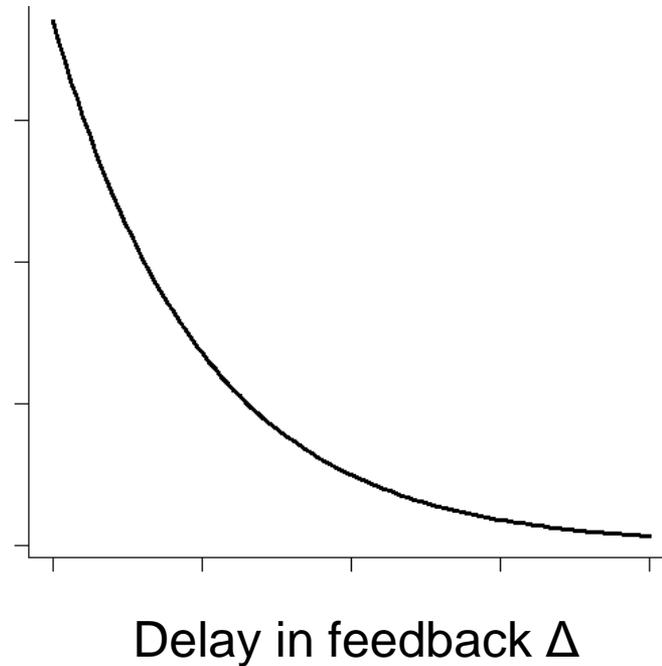


# Impact of Jill Watson on Student Learning

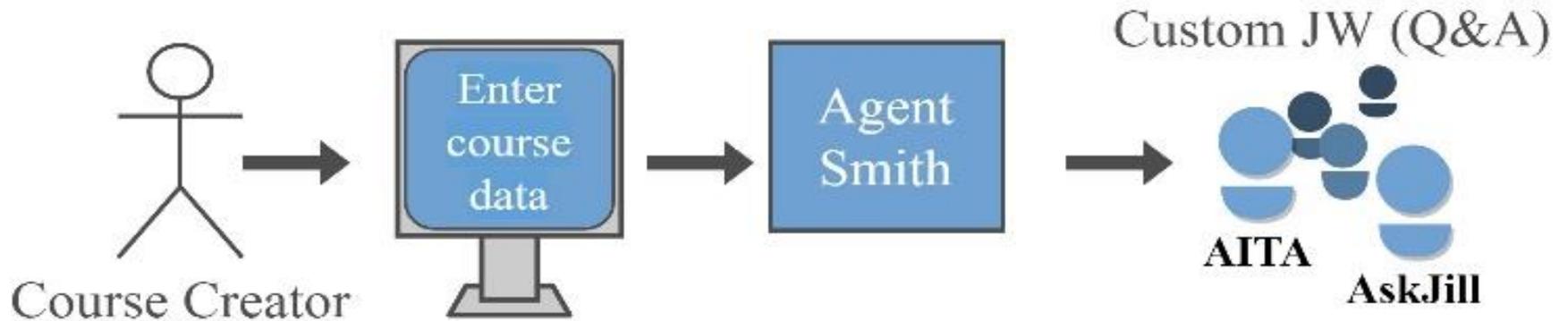
## *Student Performance:*

**Initial evaluation indicates that prompt feedback leads to enhanced engagement. Jill Watson is very prompt.**

Student  
Performance  
 $\pi$



# Agent Smith: Use AI to Create AI



**Teacher Presence**

***Social Presence?***

## Student Introduction



Whats your name?

Where are you located?

Why are you taking this class? I have always been interested in AI, and the research aspect should do me good for the future

What other OMSCS classes have you taken?

What else do you like to do?

What else would you like to share with us?

## Jill Watson's Response

Hi “.....”, nice to meet you. Before starting this program, I didn't know much about AI. I think you are going to enjoy this class. When I took it, it really changed how I think about AI.

Resolved  Unresolved

plazza

1 month ago  
What's your name?  
Where do you live? Chiang Mai, Thailand  
... #connectme <https://www.linkedin.com/in/>



**AITA**

1 month ago

Hey . Welcome to the course!

#ConnectMe

You might be interested in connecting with a few of your classmates.

**Timezone- HST:** A few of your classmates are located in your timezone (HST) and may be interested in forming a study group:

- in thread @9

- in thread @10

...

To learn more about your community, take a look at thread @34. It's good to have you here, we're looking forward to hearing your thoughts going forward.



1 month ago

Hey, we live in the same country! hit me up if you ever visit Bangkok.



1 month ago

Hi and , I live in Singapore. We are from the same timezone. Please connect with me on @gatech.edu or whatsapp +65 { or telegram @ or line ID: }



1 month ago

Hi, will sure do.

Resolved  Unresolved

plazza

██████████ 1 month ago . . . What do you do when you're not in the school? (Career, hobbies, etc.) Chess, basketball, soccer . . . I was on my way to becoming the first black African Chess Grandmaster then I took academics more serious :). #connectme



**i AITA** 1 month ago

Hey ██████████. Welcome to the course - we think you will enjoy it.

This semester, I've already been introduced to:

- 12 other classmates with an interest in chess.
- 20 other classmates with an interest in basketball.

. . .

### #ConnectMe

You might be interested in connecting with a few of your classmates.

**Hobby- chess:** A few of your classmates mentioned an interest in chess.

██████████ - in thread [@12](#)

██████████ - in thread [@12](#)

. . .

To learn more about your community, take a look at thread [@34](#).



1 month ago

Hello ██████████ - that is interesting that you were becoming that strong in chess!

Do you play anywhere online? I like to play on lichess.



1 month ago

. . . Hi ██████████, nice to meet you. I play on chess.com. We could have a game

there if you're interested!

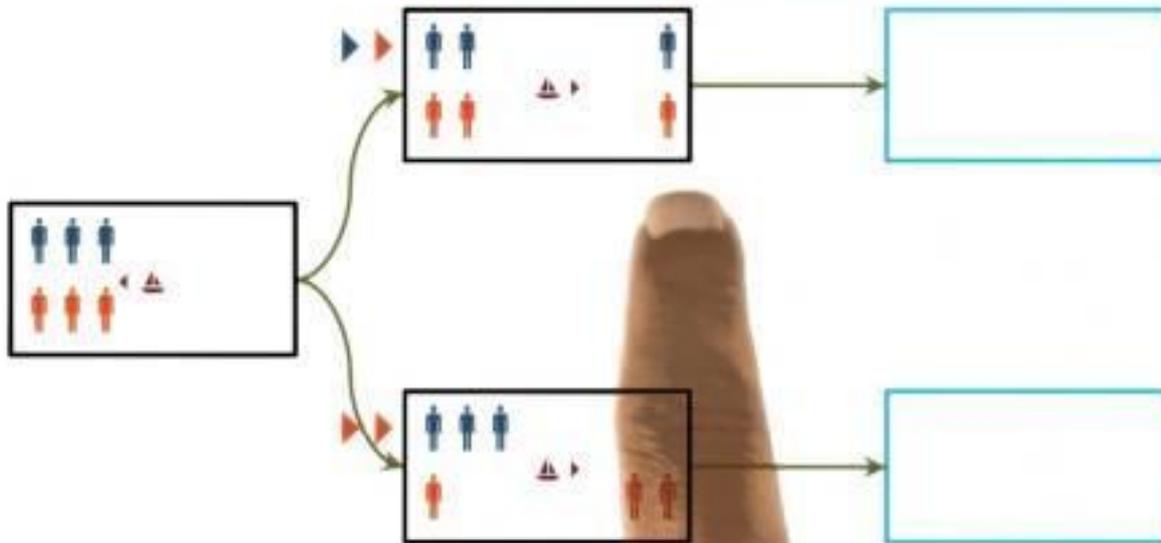
**Teacher Presence**

**Social Presence**

***Cognitive Presence?***

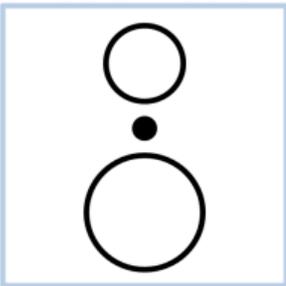
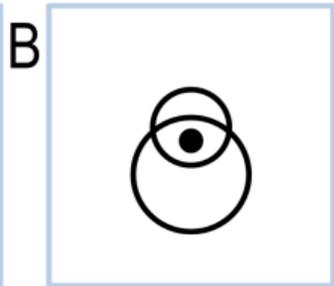
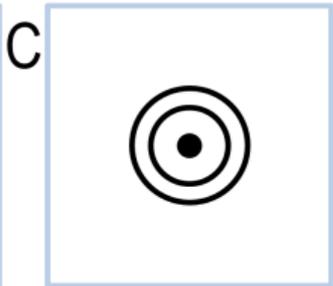
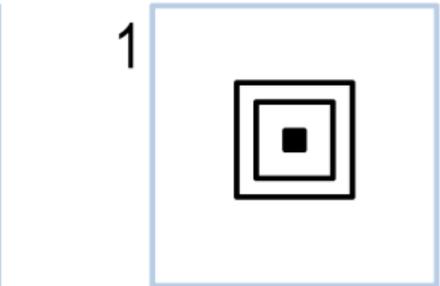
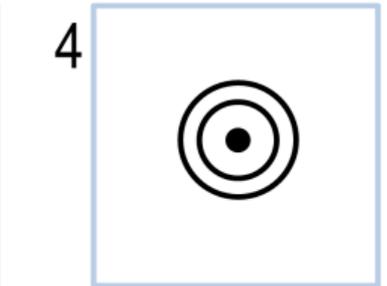
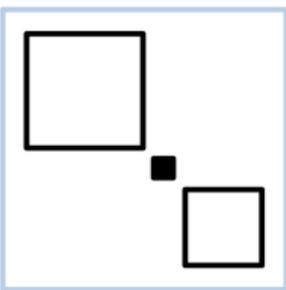
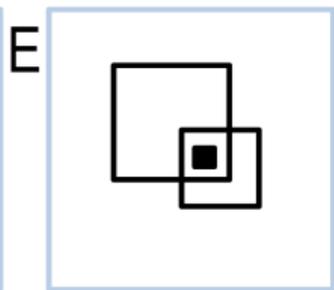
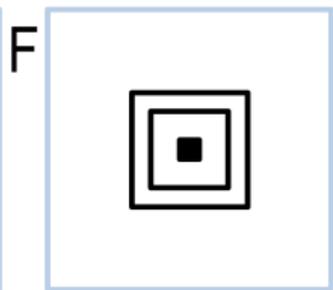
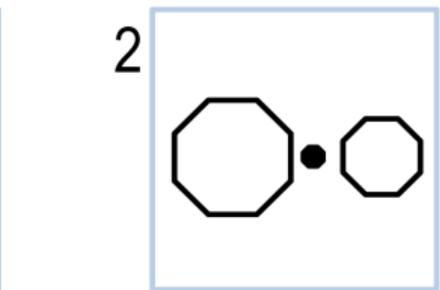
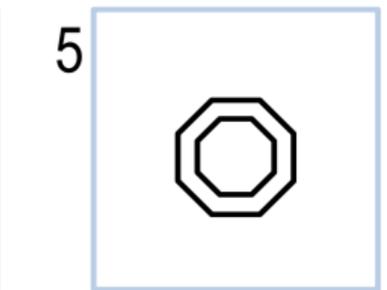
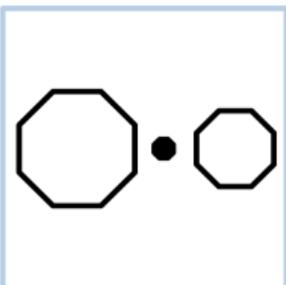
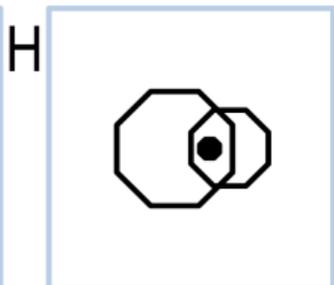
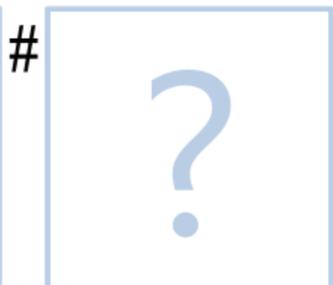
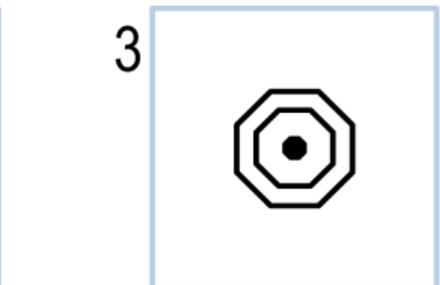
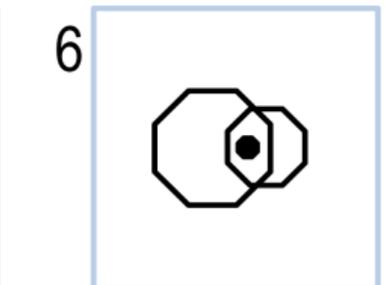
# Learning by Example & by Doing

Exercise: Write the only legal state that can follow from each of these two states.



# Project-Based Learning

3x3 Basic Problem 20

A 	B 	C 	1 	4 
D 	E 	F 	2 	5 
G 	H 	# 	3 	6 

# Some numbers from the online class

- Started in Fall 2014
- Offered each term (typically including summers)
- >6,000 students have completed the online KBAI course (interacted with the nanotutors)
- >3,000 students have interacted with Jill Watson
- >100 (human TAs)

# **Student performance in online classes: Completion ratio**

Completion ratio in the OMSCS class is about ~80%:  
Just slightly lower than the residential class

## Some numbers from the residential class

- Offered each fall
- ~100 students each term, >500 students since Fall 2014
- Blended Learning
- Same instructor, syllabus, structure, pace, assessments in online and residential sections
- Blind grading; TAs don't know whether assignment is from residential or online section

# Student Performance (KBAI class, Fall 2014)

	Maximum points	Online students (Mean)	Residential students (Mean)
Assignment 1	4	3.9	3.52
Assignment 3	4	3.95	3.53
Assignment 6	4	3.86	3.62
Project 2	100	92.74	89.64
Project 4	100	92.0	88.5
Final Exam	75	93.76	93.48
Final Grade	100	92.32	91.31

# **Student performance in online classes: Assessments**

Online students have typically performed about as well as the residential students.

But is this due to demographic differences between the student populations?

So in Fall 2018, we received permission from the Georgia Tech Provost to offer an online section for residential students.

# Self-Regulated Learning

## Social Psychology of Learning

1. Intrinsic Value
2. Cognitive Strategy
3. Self-Efficacy
4. Teaching Assistance

# Self-Regulated Learning

Fall 2017

N = 73

\* Mean  $\pm$  STD

Mean Diff.

Std. Error

p-Val

t-Stat

Effect Size

<b>Self-Efficacy</b>	<b>5.717 <math>\pm</math> 0.789</b> <b>5.444 <math>\pm</math> 0.789</b>	0.273	0.094	0.005	2.888	0.350
<b>Cognitive Strategy Use</b>	<b>5.665 <math>\pm</math> 0.777</b> <b>5.584 <math>\pm</math> 0.758</b>	0.081	0.087	0.357	0.928	0.115
<b>Intrinsic Value</b>	<b>5.764 <math>\pm</math> .964</b> <b>5.997 <math>\pm</math> 0.793</b>	-0.232	0.101	0.025	-2.294	0.28
<b>Confidence in Teaching Support</b>	<b>6.085 <math>\pm</math> .812</b> <b>5.829 <math>\pm</math> 0.831</b>	0.225	0.088	0.005	2.879	0.35

# Impact of Jill Watson on Student Learning

## Social Psychology of Learning

**Student Survey: 7-Point Likert Scale**  
( 1= not at all true of me,  
7= very true of me)



*All four measures were ~6 on the 1-7 Likert scale*

*Further, student's assessment of teaching support increased from 6.14 to 6.31 over the term (Spring 2017)*

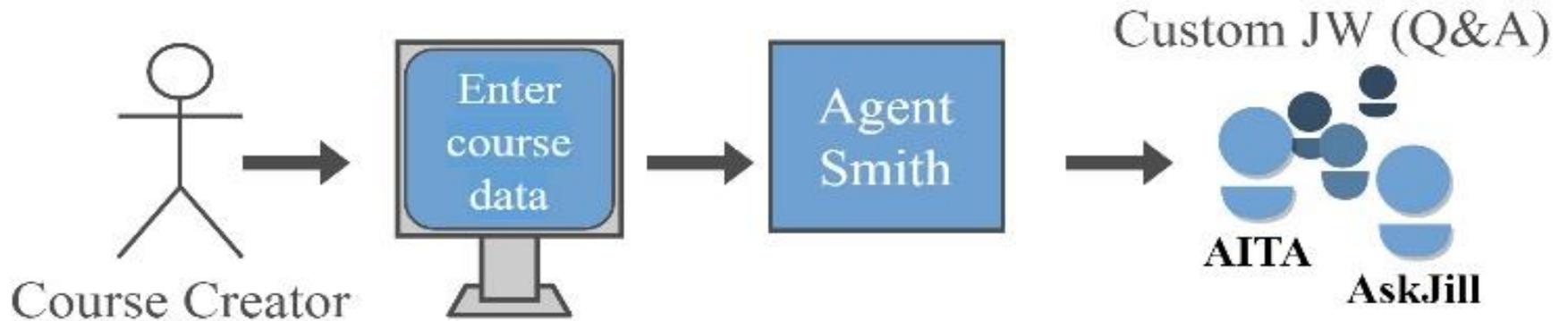
# Challenge 1: Technology: **Human-AI Interaction**



# Challenge 2: Medium: A Jill for every class and teacher, and every student and parent in the world



# Agent Smith: Use AI to Create AI



## Challenge 3: AI as an Actor: Human-AI Co-Existence



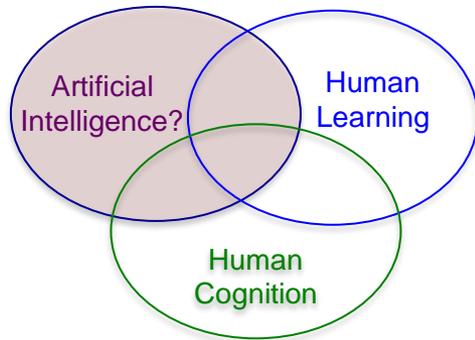
An (unplanned) social experiment in human interactions with AI's, and with one another in the presence of AI's.

How do humans perceive AIs? How do AI's perceive humans?

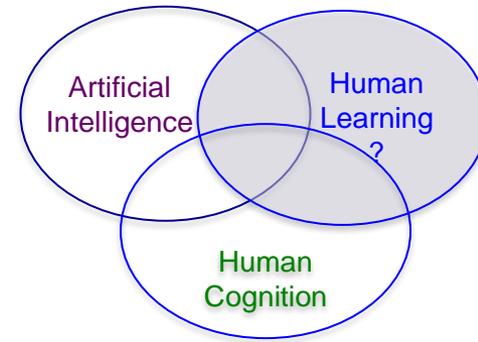
How do we construct ethical AI's? What does it even mean?

How will we – humans - live, work, learn and play with AIs?

# TWO OPPORTUNITIES



Q1: Given what we know of human cognition and learning, ***what new AI techniques can we invent*** to help make education more accessible and affordable, efficient and effective?



Q2: Given what we know of human cognition and AI, ***what new models of learning can we invent*** to help make learning more accessible and affordable, efficient and effective?

# Acknowledgements

