



# How to Teach AI Across K-12

Fred Martin, Associate Dean, University of Massachusetts Lowell

Deborah Seehorn, Former CSTA Chair &  
North Carolina Expanding Computing Education Pathways Lead



Supported by NSF DRL-1846073

Korean Software Education Conference  
December 2021





# Mission

- Develop national guidelines for teaching AI in K-12
  - Modeled after the CSTA standards for computing education.
  - Four grade bands: K-2, 3-5, 6-8, and 9-12
  - What should students know?
  - What should students be able to do?
- Develop a curated AI resource directory for K-12 teachers
- Foster a community of K-12 AI resource developers



# Steering Committee



Dave Touretzky  
Carnegie Mellon  
AI for K-12 Working Group  
Chair



Christina Gardner-McCune  
University of Florida  
AI For K-12 Working  
Group Co-Chair



Fred Martin  
UMass Lowell  
CSTA Chair of Board of  
Directors



Deborah Seehorn  
Co-Chair of CSTA  
Standards Committee



# K-12 Teacher Working Group Members



## Grades K-2

**Vicky Sedgwick (Lead)**  
Susan Amsler-Akacem  
Dr. April DeGennaro  
Charlotte Dungan

## Grades 3-5

**Kelly Powers (Lead)**  
Dr. Marlo Barnett  
Dr. Phillip Eaglin  
Brian Stamford

## Grades 6-8

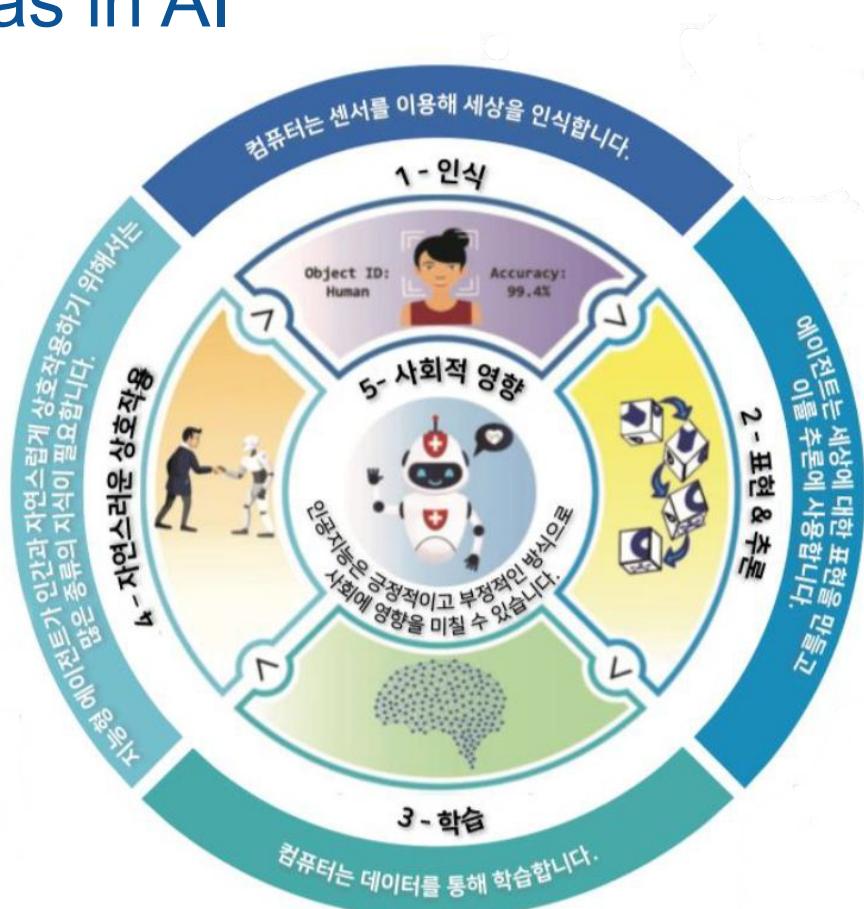
**Padmaja Bandaru (Lead)**  
Minsoo Park  
Juan Palomares  
Josh Caldwell  
Sheena Vaidyanathan

## Grades 9-12

**Dianne O'Grady-Cunniff (Lead)**  
Jared Amalong  
Dr. Smadar Bergman  
Kate Lockwood

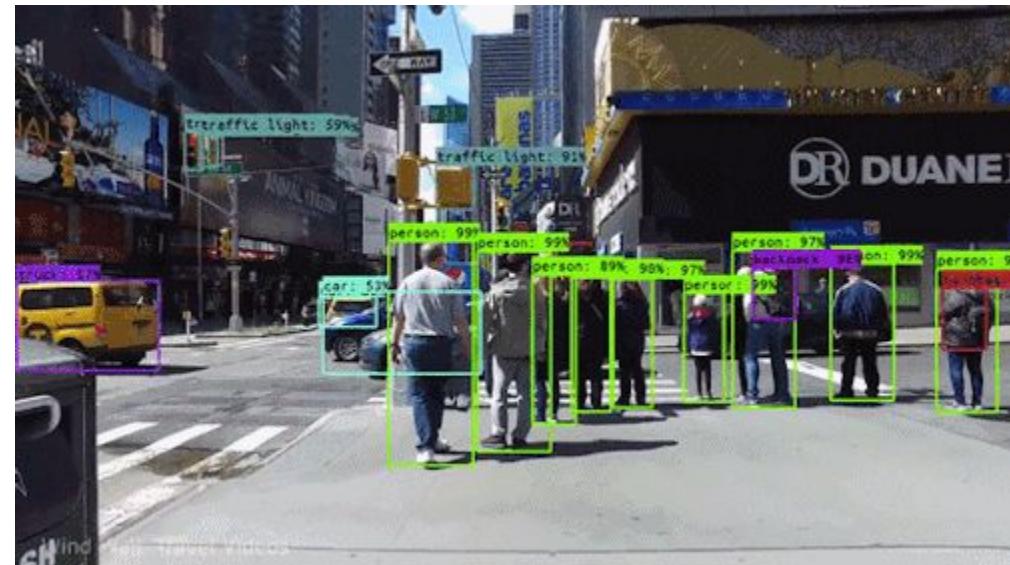
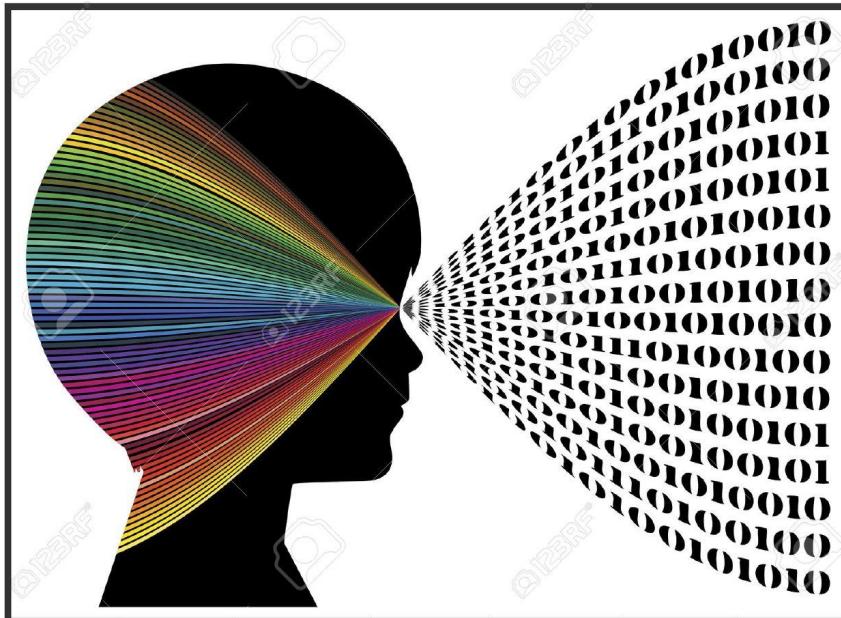
# Five Big Ideas in AI

- Organizing framework for the K-12 guidelines.
- 5 Big Ideas are enough to cover the richness of the field, but small enough to be manageable by teachers.
- CSTA experience shows 5 is a good number.
- Not necessarily the way AI practitioners view their field, but appropriate for the needs of the K-12 audience.



# Big Idea #1: Perception

*Computers perceive the world using sensors.*



Perception is the extraction of *meaning* from sensory signals.

# Big Idea #1 – What should students be able to do?

## Grades K–2 (5 to 8 years-old)

- Identify sensors on computers, robots, and intelligent appliances.
- Interact with intelligent agents such as Alexa or Siri.

## Grades 6–8 (12 to 14 yo)

- Explain how sensor limitations affect computer perception.
- Explain that perception systems may draw on multiple algorithms as well as multiple sensors.
- Build an application using multiple sensors and types of perception (e.g., with Scratch plugins or Calypso).

## Grades 3–5 (9 to 11 yo)

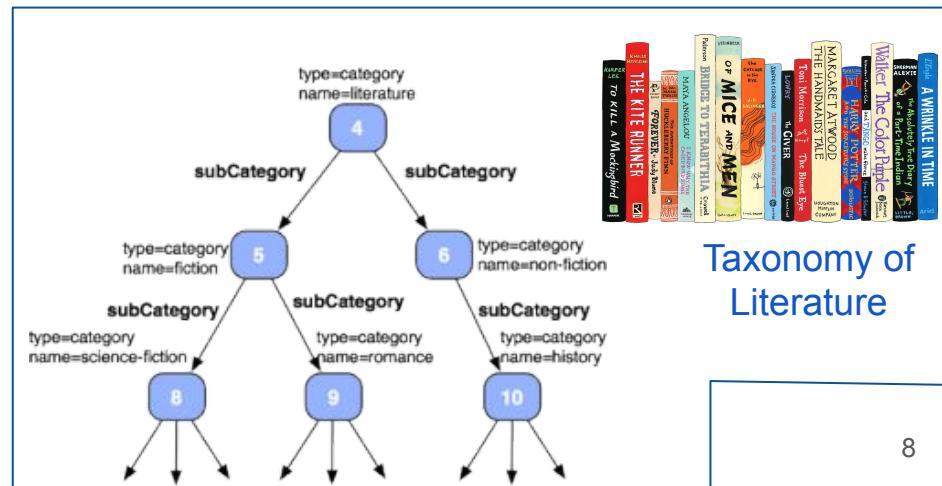
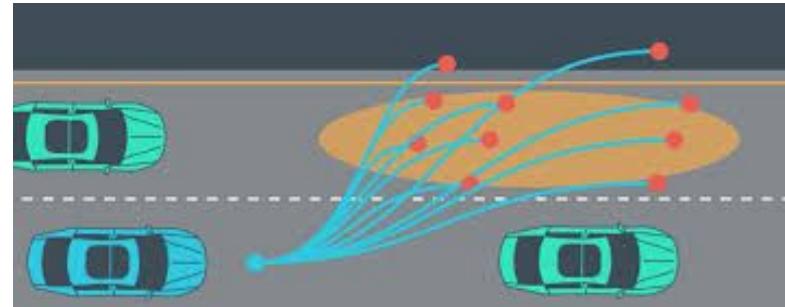
- Describe how sensor inputs are used in perception.
- Build an application using perception (e.g., with Scratch plugins or Calypso).

## Grades 9–12 (15 to 18 yo)

- Describe the domain knowledge underlying different forms of computer perception.
- Demonstrate speech recognition difficulty in handling homophones and other types of ambiguity.

# Big Idea #2: Representation and Reasoning

*Agents maintain representations of the world, and use them for reasoning.*



# Big Idea #2 – What should students be able to do?

## Grades K–2 (5 to 8 years-old)

- Draw a map of the classroom or school and compare the map to the actual room or school building and grounds.
- Use a decision tree to make a decision

## Grades 3–5 (9 to 11 yo)

- Create/design a representation of an (animal) classification system using a tree structure.
- Describe how AI representations support reasoning to answer questions

## Grades 6–8 (12 to 14 yo)

- Design a graph model of their home or locations in their community and apply reasoning to determine the shortest path to key locations on their map

## Grades 9–12 (15 to 18 yo)

- Draw a search tree for tic-tac-toe
- Describe the differences between types of search algorithms

# Big Idea #3: Learning

*Computers can learn from data.*



# Big Idea #3 – What should students be able to do?

## Grades K–2 (5 to 8 years-old)

- Learn from patterns in data with “unplugged” activities
- Use a classifier that recognizes drawings.
- Use Google Autodraw or Cognimates Train Doodle to investigate how training sets work to identify images and discuss how the program knows what they are drawing

## Grades 6–8 (12 to 14 yo)

- Identify bias in a training data set and extend the training set to address the bias
- Simulate the training of a simple neural network

## Grades 3–5 (9 to 11 yo)

- Modify an interactive machine learning project by training its model.
- Describe how algorithms and machine learning can exhibit biases.

## Grades 9–12 (15 to 18 yo)

- Train a neural net (1-3 layers)  
*TensorFlow Playground*
- Trace and experiment with a simple ML algorithm

# Big Idea #4: Natural Interaction

*Intelligent agents require many types of knowledge to interact naturally with humans.*



Humans are among the hardest things for AI agents to understand.

# Big Idea #4 – What should students be able to do?

## Grades K–2 (5 to 8 years-old)

- Identify words in stories that have positive and negative connotations.
- **Recognize and label facial expressions into appropriate emotions (happiness, sadness, anger) and explain why they are labeled the way they are.**

## Grades 3–5 (9 to 11 yo)

- **Identify how humans combine multiple inputs (tone, facial expressions, posture, etc) in order to understand communication.**
- Describe some tasks where AI outperforms humans and tasks where it does not.

## Grades 6–8 (12 to 14 yo)

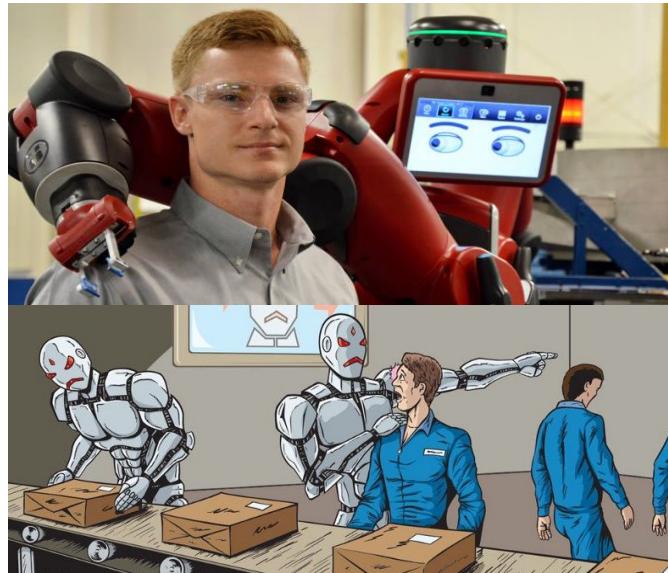
- **Construct a simple chatbot.**
- Explain and give examples of how language can be ambiguous.
- Reason about the nature of intelligence, and identify approaches to determining whether an agent is or is not intelligent.

## Grades 9–12 (15 to 18 yo)

- Demonstrate how sentence parsers handle ambiguity.
- Explore the Google Knowledge Graph
- **Identify and debate the issues of AI and consciousness.**

# Big Idea #5: Societal Impact

*“Artificial Intelligence can impact society in both positive and negative ways.”*



# Big Idea #5 – What should students be able to do?

## Grades K–2 (5 to 8 yo)

- Identify common AI applications encountered in their daily lives
- Discuss whether common uses of AI technology are a good or bad thing

## Grades 3–5 (9 to 11 yo)

- Explore how behavior is influenced by bias and how it affects decision making
- Describe ways that AI systems can be designed for inclusivity

## Grades 6–8 (12 to 14 yo)

- Explain potential sources of bias in AI decision making
- Understand tradeoffs in the design of AI systems and how decisions can have unintended consequences in the function of a system

## Grades 9–12 (15 to 18 yo)

- Critically explore the positive and negative impacts of an AI system
- Design an AI system to address social issues (or explain how AI could be used to address a social issue)

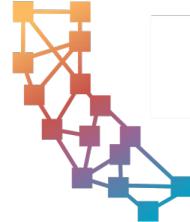
# U.S. States Plan to Implement AI in K-12 Education

- Two-day State of AI in the States Workshop January 28 & 29, 2021
- State Breakout Work Sessions
  - Vision setting
  - Implementation planning
- Regular check-in webinars - 3-month, 6-month, 9-month
  - State Updates
  - Collaborative discussions in breakout sessions
- <https://ai4k12.org/news/the-state-of-k-12-ai-education-in-your-state-a-planning-workshop/>

# California

## CS Updates

- Expecting a state CS Coordinator to start in 2022
- Awaiting state guidelines on use of \$15M funding for CS teacher credentialing



## Awareness

- ✓ Inspirit AI gave a CSTA presentation in July on teaching algorithmic bias
- ✓ Came up with [Hour of AI](#) for May
- ✓ Drafted a [Getting Started Guide](#)
- Reach out to CA state level math, science, language arts, organizations to present the AI literacy & Five Big Ideas.
- Incorporate [CS+Env Lit](#) and Data Science available from UCSD
- AI CTE pathway

## Community

- ✓ Organized leadership of 11 CSTA chapters
- ✓ We've been meeting monthly!
- Create AlforCA website and logo
- CSTA chapter outreach: draft an offer of AI sessions that we can give to all 11 chapters.
- Identify how to leverage future industry partners, and reach out to potential industry partners.**

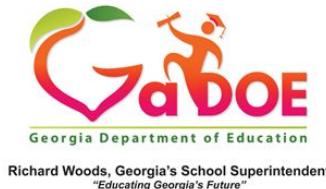
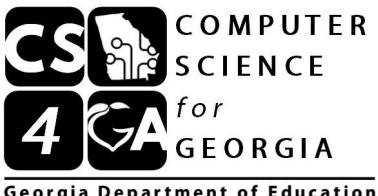
## Accessibility

- Collect resources for AI in CA
- Create [crosswalk](#) among the Five Big Ideas in AI, CA CS standards, and other core subject areas.
- UCSD undergraduates working on create projects/lessons using the AI-robot kit
- UCSD AI Literacy course (Spring)
- UCSD Pathway2AI group is working on to create AI video series to promote the understanding of AI technology applications among teachers and students (focused on high school)
- Stanford AI Literacy group is working on creating high-school curriculum materials



# Georgia State Updates

- High School AI pathway approved
- AI4GA grant was funded by NSF to create curriculum and PD for middle school AI instruction
  - Exploring existing curriculum to include in project
- AI task force plans to meet again after the semester ends/transitions



Richard Woods, Georgia's School Superintendent  
"Educating Georgia's Future"



# Maryland

Current observations:

- **AI is an excellent entry point into computer science for diverse subject areas.**
- **The math monolith appears to be shifting to more consideration of Data Science**
- **How do we create a skills progression for CS that includes concepts in AI, Cyber, and Data Science?**



*The challenges of communication:*

Understanding AI is integral to understanding how our world works. Our goal is to educate informed citizen.

# Maryland



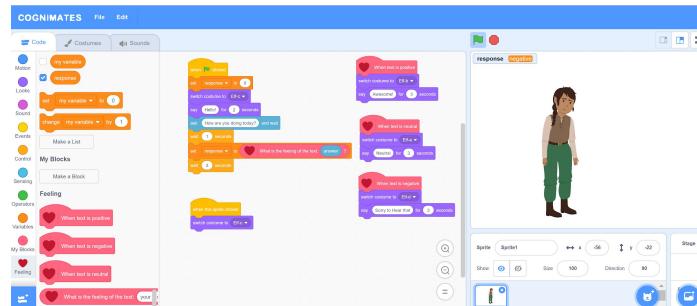
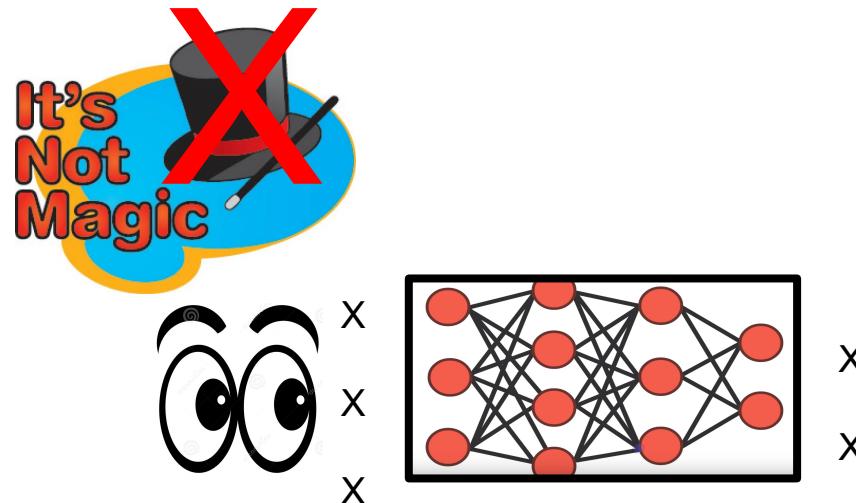
- BCPS CTE Artificial Intelligence/ Machine Learning CTE Pathway in development. AACPS starting theirs.
- **Planning our second AI Symposium to include K12 & higher ed**
- First middle school pilots happening this school year
- Doing pilot **AI in ELA**, over 50 HS english teachers applied

Continuing to develop **AI learning pathway for teachers**. Looking at microcredentials and badging as a way for teachers to choose their own pathway to CS expertise. Building our facilitator pool. Moving content to hybrid

1. Introduction to AI 1 credit
2. Applying AI 1 credit
3. AI and equity 1 credit ,<-- not yet offered
4. Teaching advanced AI in high school with Python 1 cr.

# Guidelines for supporting K-12 students

1. **Use transparent AI demonstrations that help students see what is going on inside the black box: it's not magic!**
2. **Help students build mental models of what is happening under the hood in AI applications.**
3. **Encourage students to develop AI applications using AI services.**



# Student Activity Considerations

- **Experiment with AI agents** to investigate their behavior
- Encourage students to **build their own AI applications**
- **Explore case studies of AI-related societal issues** from multiple perspectives

- These activities promote understanding of:
- How AI works
  - Limitations of AI
  - Systems thinking (AI systems are built from smaller components)
  - Sources of bias in AI
  - Societal impacts of AI systems

# Selected K-12 AI Activities and Resources

- Video explaining how robots use AI by examining the fictional robot WALL-E. The video was produced by three women in the robotics PhD program at Carnegie Mellon. <https://www.youtube.com/watch?v=vxhO7oq3-dY>
- **AI glossary for beginners** The CompTIA Artificial Intelligence (AI) Advisory Council has compiled a comprehensive list of words and phrases that anyone interested in learning more about AI should be familiar with. From adversarial machine learning to unstructured data, learn the basic terminology for artificial intelligence technology at [AI Terminology: A Glossary for Beginners](#).
- Google is AI first: Top 15 AI projects powering Google products by Cem Dilmegani <https://research.aimultiple.com/ai-is-already-at-the-heart-of-google/>
- AI4K12 Resources Webpage <https://ai4k12.org/resources/list-of-resources/>
- Ai for Teachers Community Website <https://aiforteachers.org/>

# 2022 Revised National Curriculum (Planned revisions)

School Revision	Elementary (K1~K6)	Middle (K7~K9)	High (K-9~K12)
Course Implementation	Two-fold increase in the number of hours for “digital literacy and computational thinking” <b>(17 hours → 34 hours)</b>	Mandatory “Informatics” (CS) course encouraged to be organized for <b>more than 68 hours</b> in all middle schools (vocational training in the technology field will be available as an elective course)	<ul style="list-style-type: none"><li>Advanced Informatics course(CS) will become a mandatory subject</li><li>“Technology and Home Economics” → “Technology, Home Economics, and <b>Informatics</b>”</li></ul>
Curriculum restructuring	Fundamental concepts and principles of Artificial Intelligence (AI) will be added to the current basic software literacy education curriculum	<b>“Learning about AI” part will be reinforced</b>	New subjects covering AI and Big data will likely be established

**Note: both standards and curriculum/learning activities for different grades (Details are not polished yet)**

# Advice as you embark on this journey

Provide extensive ongoing professional development opportunities for teachers—which are collaboratively led by teachers

Rely on teachers' knowledge about what's possible to teach and when (e.g., to create learning progressions)

Explore cross-curricular connections between AI and other disciplines

Build a community of teachers to share experiences and effective practices

**Now the fun begins:  
bringing AI to teachers and their students!**

**Visit us:**  
**AI4K12.org**

**Join the mailing list:**  
Visit [aaai.org/Organization/mailing-lists.php](https://aaai.org/Organization/mailing-lists.php)



# Acknowledgments

**AAAI** (Association for the Advancement of Artificial Intelligence)



**CSTA** (Computer Science Teachers Association)



With funding from National Science Foundation ITEST Program (DRL-1846073)

**Carnegie Mellon University**  
School of Computer Science