What Should K-12 Students Know About Artificial Intelligence?

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Supported by NSF DRL-1846073.
“Artificial Intelligence is such a part of every child’s life that learning about it in school is an entitlement of all children.”

Miles Berry
Roehampton University
AAAI Symposium,
K-12 Working Group Advisory Board
K-12 Computing Education

Worldwide, we are making progress on integrating computing into K-12:

- **Israel** started working on National standards in 1995
- **United Kingdom:**
  - Computing At School
  - **First country in the European Union** to mandate computer science classes for all children between the ages of 5 and 16.

- **18 European Countries**
  France, Spain, Switzerland, Slovakia, Finland, Poland, Portugal, Scandinavia, Italy, Estonia, Bulgaria, Cyprus, Czech Republic, Denmark, Greece, Ireland, Lithuania

- In progress: **US, India, China, Japan, Australia**
  - In the US: CSTA Computing Standards, CSForAll, Code.org
The AI4K12 Initiative, a joint project of:

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

**CSTA (Computer Science Teachers Association)**

With funding from National Science Foundation ITEST Program (DRL-1846073)
● 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 educators, researchers, and resource developers
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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.
Five Big Ideas in Artificial Intelligence

1. Perception
Computers perceive the world using sensors. Perception is the process of extracting meaning from sensory signals. Making computers "see" and "hear" well enough for practical use is one of the most significant achievements of AI to date.

2. Representation & Reasoning
Agents maintain representations of the world and use them for reasoning. Representation is one of the fundamental problems of intelligence, both natural and artificial. Computers construct representations using data structures, and these representations support reasoning algorithms that derive new information from what is already known. While AI agents can reason about very complex problems, they do not think the way a human does.

3. Learning
Computers can learn from data. Machine learning is a kind of statistical inference that finds patterns in data. Many areas of AI have progressed significantly in recent years thanks to learning algorithms that create new representations. For the approach to succeed, tremendous amounts of data are required. This "training data" must usually be supplied by people, but is sometimes acquired by the machine itself.

4. Natural Interaction
Humans are among the hardest things for AI agents to understand. Intelligent agents require many kinds of knowledge to interact naturally with humans. Agents must be able to converse in human languages, recognize facial expressions and emotions, and draw upon knowledge of culture and social conventions to infer intentions from observed behavior. Today's AI systems can use language to a limited extent, but lack the general reasoning and conversational capabilities of even a child.

5. Societal Impact
AI can impact society in both positive and negative ways. AI technologies are changing the ways we work, travel, communicate, and care for each other. But we must be mindful of the harms that can potentially occur. For example, biases in the data used to train an AI system could lead to some people being less well served than others. Thus, it is important to discuss the impacts that AI is having on our society and develop criteria for the ethical design and deployment of AI-based systems.

11x14 Poster available for free download at AI4K12.org
Adoption of the Big Ideas

- Now being adopted by curriculum developers in the US and elsewhere.
- Translations in Chinese, Korean, Turkish, Portugese

Chinese

5. 社会影响
AI的应用会对社会产生深远影响，包括对人类行为，运作，规则，组织和制度。我们所必需面对的是其带来的影响。例如，AI可能会改变人们的生活方式，工作方式和教育方式。这些变化可能会对社会产生深远影响。

4. 人机交互
智能代理将与AI系统进行交互，以完成任务。这些交互可能是口头的，书面的，或通过用户界面进行的。这种交互可以是自然的，也可以是高度定制的。智能代理需要理解人类的意图，并能够以适当的方式与人类交互。

3. 机器学习
计算系统可以从数据中学习，从而能够不断改进其性能。这种能力是AI系统的一个重要特征。通过机器学习，系统可以自动地发现数据之间的模式和关系，从而更有效地解决问题。

2. 表达与推理
智能代理（例如，决策支持系统）对表达和推理的能力非常重要。这些代理需要能够理解人类的意图，并能够根据这些意图进行推理和决策。智能代理需要理解复杂的逻辑和数学概念。

1. 感知
计算系统需要从外部世界获取信息，才能进行决策和行动。这种能力是AI系统的一个重要特征。通过感知，系统可以自动地收集和分析周围环境的信息，从而更有效地解决问题。

英文大意:

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Korean

5. 사회적 영향
AI의 적용 때문에 사회에 영향이 될 수 있습니다. 이를 위해 학습, 인공지능, 그리고 그리고 모든 것을 통해 인공지능의 역할을 해야 합니다.

4. 인공지능과 인간의 상호작용
인공지능이 인간과 상호작용하는 데 사용됩니다. 이러한 상호작용은 자연어 처리, 인공지능, 그리고 모든 것을 통해 인공지능의 역할을 해야 합니다.

3. 기계 학습
계산 시스템이 데이터를 통해 학습하고, 그것을 사용하여 문제를 해결할 수 있습니다. 이러한 학습은 문제를 해결하는 데 도움이 될 수 있습니다.

2. 표현과 추론
인공지능 시스템이 인간의 문제를 해결할 수 있습니다. 이러한 모듈은 정보를 이해하고, 이를 기반으로 추론하고, 문제를 해결하는 데 도움이 될 수 있습니다.

1. 인식
계산 시스템은 외부 환경에서 정보를 수집하여, 이를 인식하고, 이를 사용하여 문제를 해결할 수 있습니다. 이러한 인식은 정보를 이해하고, 이를 기반으로 추론하고, 문제를 해결하는 데 도움이 될 수 있습니다.

Turkish

5. Sosyal Etkiler
AI'nin uygulaması toplumda birçok etkiye neden olabilir. Bunlar içerdğe eğitim, yaşam tarzı ve iş yöntemleri olabilir.

4. İnsan ve Makine Arasındaki İlişki
AI sisteminin insanlarla iletişim kurması gerekmektedir. Bu iletişim, doğal dil işleyicisi ve yapay zeka teknolojileri aracılığıyla sağlanabilir.

3. Makine Öğrenmesi
Bilgisayar sistemleri veri akışı ile öğrenir ve bu öğrenme süreçleriyle problemleri çözer. Bu süreç, belirsizliklere ve veri açıklığına dayanır.

2. Tanımlama ve rêve
AI sistemleri, verilerden bilgi çıkarabilir ve bu bilgiyi kullanarak karar verme yeteneğine sahiptir. Bu yeteneğin önemi, olası olan olayların analizinde bulunabilir.

1. Algı
AI sistemleri çevresel dünyayı algılayabilir ve bu algıları kullanarak karar verme yeteneğine sahiptir. Bu yeteneğin önemi, olası olan olayların analizinde bulunabilir.
Big Idea #1: Perception

*Computers perceive the world using sensors.*

Perception is the extraction of *meaning* from sensory signals.
Big Idea #1 – Examples of Perception

- Speech recognition
- Computer vision:
  - object recognition
  - face recognition
  - license plate readers
  - scene understanding
- Other forms of perception e.g., music recognition, or interpreting sonar, radar, or LIDAR data
Big Idea #1 – Major Concepts

- Human senses vs. computer sensors
- Going from sensing to perception
- Types of perception: vision, speech recognition etc.
- How perception works: algorithms
- Limitations of computer perception
- Intelligent vs. non-intelligent machines
Big Idea #1 – What should students be able to do?

Grades K-2:
● Identify sensors on computers, robots, and intelligent appliances.
● Interact with intelligent agents such as Alexa or Siri.

Grades 6-8:
● 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 (possibly with Scratch plugins, or Calypso).

Grades 3-5:
● Describe how sensor inputs are used in perception.
● Demonstrate a limitation of computer perception.
● Build an application using perception (possibly with Scratch plugins, or Calypso).

Grades 9-12:
● Describe the domain knowledge underlying different forms of computer perception.
● Demonstrate speech recognition difficulty in handling homophones and other types of ambiguity.
Big Idea #1 Activities

Can Cozmo perceive a face and remember it?

*Teach Cozmo to recognize your face.*

Explore facial recognition using Cozmo’s Explorer mode.

Teach Cozmo to recognize your face.

Test Cozmo to determine how well he uses AI for facial recognition.

Tinker with Cozmo in different lighting and facial accessories to explore the limits of Cozmo’s perception.

Can Cozmo perceive a happy or sad face?

*“Perception is more than seeing”*

Write a program using Cozmo to respond if Cozmo perceives that a face is happy or sad?

Create an event such that Cozmo’s backpack turns a color if the student is sad.

Create an event so that Cozmo turns a color if the student is happy.

Extend the challenge to have Cozmo perform an animation that matches the student’s mood.
Big Idea #2: Representation and Reasoning

Agents maintain representations of the world, and use them for reasoning.
Big Idea #2 – Examples of Representation & Reasoning

● Path planning for self-driving cars
  ○ Map of the city; description of the scene around car; goal: find best path to the destination

● Internet Search
  ○ Representations - content of web pages
  ○ Reasoning - choosing which pages to return in response to a query

● Playing chess, checkers, backgammon, go
  ○ Representations - board state
  ○ Reasoning - finding the best move

● Designing a school bus route
  ○ Representations - list of students and where they live; list of buses and seating capacities
  ○ Reasoning - assigning students to buses and deciding the order in which the stops are made
Big Idea #2 – Major Concepts

- Types of representations
- Types of reasoning algorithms
- Representation supports reasoning: algorithms operate on representations
- Families of algorithms and the work they do
- Limitations of common reasoning algorithms
Big Idea #2 – What should students be able to do?

Grades K-2:
- 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:
- 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:
- 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.
- Create/design a representation of an (animal) classification system using a tree structure.

Grades 9-12:
- Draw a search tree for tic-tac-toe.
- Describe the differences between types of search algorithms.
Big Idea #2 Activities

Build a decision tree to classify a set of animals.
(grades 3-5 or 6-8)

Complete the representation of a game and trace a minimax algorithm to determine a strategy to win.

[Diagram of a decision tree classifying animals]

https://aca.edu.au/resources/decision-trees-classifying-animals/ with trading cards

https://towardsdatascience.com/tic-tac-toe-creating-unbeatable-ai-with-minimax-algorithm-8af9e52c1e7d
Big Idea #3: Learning

Computers can learn from data.
Big Idea #3 – Examples of Machine Learning

Personal experience:
● Training your phone to recognize your face.
● Netflix learning what movies you like.

Industrial applications:
● Training a speech recognition system.
● Training a machine translation system: Google can translate between more than 100 different languages.
● Image search: training a classifier to recognize pictures of people, animals, vehicles, etc.
Big Idea #3 – Major Concepts in Machine Learning

- Machine learning vs human learning?
- Different types of machine learning
- Fundamentals of neural networks
- How training data influences learning (discuss bias in training data)
- Limitations of machine learning
Big Idea #3 – What should students be able to do?

Grades K-2:
- 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 3-5:
- Describe and compare the three different machine learning approaches: supervised, unsupervised and reinforcement learning.
- Modify an interactive machine learning project by training its model.
- Describe how algorithms and machine learning can exhibit biases.

Grades 6-8:
- 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 9-12:
- 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 – Examples of Natural Interaction

- Intelligent assistants such as Alexa and Siri
- Conversational agents (chatbots)
- Intelligent tutoring systems that provide for adaptive education
- Gesture and facial expression recognition

Pressing questions about the capabilities of AI for natural interaction:
- Can computers exhibit common sense reasoning comparable to people?
- Can a computer ever be conscious or self-aware?
Big Idea #4 – Major Concepts in Natural Interaction

- Natural language understanding
- Common sense reasoning
- Consciousness and philosophy of mind
- Natural interaction applications
- Human-robot interaction
- Limitations of AI for natural interaction
Big Idea #4 – What should students be able to do?

Grades K-2:
- 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.
- Experiment with software that recognizes emotions in facial expressions and in words.

Grades 3-5:
- 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:
- 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:
- Demonstrate how sentence parsers handle ambiguity.
- Explore the Google Knowledge Graph.
- Identify and debate the issues of AI and consciousness.
Big Idea #4 – Activities

K-2: Facial Expressions & Natural Language

Grades 6-8 & Above: Chatbots / Smart Assistants

Chatbots
Create a chatbot that can answer questions about a topic of your choice.
Teach a computer to recognise questions
Difficulty: Intermediate
Recognising: text
Tags: sentiment analysis, supervised learning
Big Idea #5: Societal Impact

“Artificial Intelligence can impact society in both positive and negative ways.”
Big Idea #5 – Examples of Societal Impact of AI

- **Ethics:** what sorts of applications are desirable/permissible?
  - Transparency and accountability of AI systems
  - Competing definitions of “fairness”
  - Values tradeoffs, e.g., privacy vs. security; who should own your data?

- **Effects:** what are the likely impacts of AI technology on society?
  - Robot servants, rescuers, and companions
  - Economic disruption; changes in the nature of work
  - Effects of unintended biases in decision systems

- **AI and Culture**
  - How will our culture change when we live with Intelligent machines?
Big Idea #5 – Major Concepts around Societal Impact

- AI technologies are changing business, healthcare, education, and government.
- Use of AI is an economic driver that makes new services possible and businesses more efficient.
- Humans make numerous technical and ethical decisions when developing AI applications.
- AI technologies impact communities and people in different ways.
- Ethical standards are needed for AI systems that make decisions about people.
- AI and robotics will change the way people work, create new jobs, and eliminate some jobs.
Big Idea #5 – What should students be able to do?

Grades K-2:
- 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:
- 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:
- 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:
- 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)
Resources
AI Books for Toddlers

Tinker Toddler Books by Dr. Handeep Dhoot
“AI+ME” is an online experience intended to provide young learners with the basics of AI. The lesson takes about one hour to complete. This is the first publicly available course introducing students to the “Five Big Ideas in AI” as defined by the AI4K12 Initiative.

Target Audience: Elementary School
● Teach a machine using your camera.
● Live, in the browser.
● No coding required.

https://experiments.withgoogle.com/teachable-machine
What’s A Deep Neural Network?

The network has tens of millions of parameters, called “weights”.

Image from www.mathworks.com
Machine Learning for Kids
https://machinelearningforkids.co.uk

1. Collect examples of things you want to be able to recognise

2. Use the examples to train a computer to be able to recognise them

3. Make a game in Scratch that uses the computer's ability to recognise them

It is being built by Dale Lane using APIs from IBM Watson Developer Cloud.
Cognimates offers AI extensions for Scratch, such as:

- speech recognition
- sentiment analysis
- visual pattern detection
- robot control

Created by Stefania Druga, Personal Robots Group at MIT Media Lab, directed by Cynthia Breazeal
Calypso for Cozmo

- A robot intelligence framework that incorporates multiple AI technologies:
  - Computer vision; face recognition
  - Speech recognition and generation
  - Landmark-based navigation
  - Path planning
  - Object manipulation

- Rule-based pattern matching language inspired by Microsoft’s Kodu Game Lab

- Teaches computational thinking: “Laws of Calypso”, idioms, etc.

- Web site: https://Calypso.software
Tesla dashboard image
WAICY: World Artificial Intelligence Competition for Youth

2018 WAICY Stats:

5+ Time zones
200+ Students
50 Teams
(20+ remote participation)

“S.T.E.A.M.-Powered A.I.”
- 50/50 Rubric
- Winning Project

East to West
Energy Transportation
Median Age: 8

C.A.R.E.
Healthcare
Median Age: 15

AI Ninja
Home Assistant
Median Age: 7

Earthquake
Search and Rescue
Median Age: 12
TensorFlow Playground

https://playground.tensorflow.org

AI4All: Online Student Portal

http://ai-4-all.org/open-learning

The AI4All Open Learning platform will offer a series of online AI courses for high school students. As of summer 2019, the first course is in beta test. This courses focuses on the basics of machine learning.
Professional Development Course

Artificial Intelligence Explorations and Their Practical Use in Schools

www.iste.org/learn/iste-u/artificial-intelligence

Course Dates:

Summer 2019 Session: June 3 - September 13
Enrollment period: *Now until July 12*

Fall 2019 Session: October 14, 2019 - January 27, 2020
Enrollment period: *Now until October 28*

Course Details:

› Grade Level: 6-12
› Course Length: 30 hours
› Cost: $224 Member / $299 Non-member
› Course Style: asynchronous with instructor

ENROLL NOW

ENROLL A GROUP
It’s time for all of us to think about AI in K-12.

Visit us:
http://AI4K12.org

Join the mailing list:
Visit AI4K12.org for the signup link
Questions?