Artificial Intelligence

Design Brief for Standards Writers

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This design brief focuses on the following learning outcomes for the Algorithms, Programming, Data and Analysis, and Preparation for the Future topic areas described in the *Reimagining CS Pathways* report that are closely related to content from the Artificial Intelligence for K–12 (AI4K12) framework:

- **AL.3** Describe the difference between traditional algorithms and artificial intelligence/machine learning (AI/ML) algorithms and, at a high level, describe how AI/ML algorithms work
- **PR.5** Use prompt engineering, code generation tools, or other AI technologies to plan, write, test, and debug code
- **DA.3** Describe, at a high level, the role of data in AI/ML applications
- **DA.12** Assess societal impacts of data analysis and related ethical issues (e.g., biased data used to train AI systems, attribution related to products of generative AI)
- **PF.1** Identify pathways and careers that involve computing
- **PF.7** Assess societal impacts and related ethical issues of emerging and future developments in computing (e.g., the impact of quantum computing on security)
- **PF.8** Evaluate the use of emerging technologies (e.g., generative AI) for accuracy and to meet specific needs
- **PF.10** Create a plan to apply an emerging technology to meet a need using principles of human-centered design

Design Recommendations

Based on our analysis of overlaps between the AI4K12 framework and the Computer Science Teachers Association (CSTA) K–12 Computer Science Standards, we have the following recommendations for the revised CSTA Computer Science standards in Artificial Intelligence.

Grade Band	Design Recommendations
Elementary	**Representation:** Students should identify examples of representation and explain how information is represented in programs. **Societal Impacts/Ethics:** Students should explain how AI is used in daily life, how AI has impacted society, and how to develop AI that is inclusive of diverse groups of users.
Middle	**Representation:** Students should explain how artifacts (e.g., sound) are digitally represented in a computer. **Societal Impacts/Ethics:** Students should explain how people's goals and values can influence the design of AI, how the design process can incorporate those goals and values, and how AI can show biases toward different cultures. **Programming Using Generative AI:** Students should use generative AI to aid their programming of novel applications.

Grade Band	Design Recommendations
High	**Representation:** Students should explain how information is structured about people, places, or things. **Societal Impacts/Ethics:** Students should evaluate the design of AI systems to ensure that those systems include a plan for accountability and a respect for privacy. Students should use an ethical design process to design AI, explain ethical dilemmas that might arise due to AI, and predict how AI can change society. **Machine Learning:** Students should define and explain basic concepts of machine learning (e.g., supervised learning), and identify examples of human learning that are similar to machine learning algorithms. **Programming Using Generative AI:** Students should use generative AI to program novel applications.

For more information on these design recommendations, go to https://csteachers.org/k12standards/research. See the following sections of *Comparison of CSTA Standards to Other Standards and Frameworks*: AI4K12 Guidelines (pp. 12–16) and Artificial Intelligence (pp. 67–68).

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Aligned Learning Progressions

Aligned Artificial Intelligence Learning Progressions for CSTA K–12 CS Standards and AI4K12 Framework

	Summary of Related CSTA K–12 CS Standards	Summary of Related AI4K12 Guidelines
K–2	**1A-AP-09** Model the way programs store and manipulate data by using numbers or other symbols to represent information.	**2-A-i LO[1]:** Construct a map of a home, school, or neighborhood. **EU[2]:** The map is not the territory. A map is a *representation* of a territory. **2-A-ii LO:** Give examples of symbols you encounter in daily life. **EU:** Concepts can be represented using symbols in place of words. **2-A-iv LO:** Identify the features that make each object in a collection unique and create a table of features to organize the objects. **EU:** Objects can be described in terms of the features they possess.
	1A-IC-16 Compare how people live and work before and after the implementation or adoption of new computing technology.	**5-B-i LO:** Identify devices in daily life that use AI technologies. **EU:** AI technologies are part of any device that includes speech recognition or computer vision, such as smartphones, intelligent home assistants, and modern automobiles. **5-C-i LO:** Identify current uses of AI and how they have impacted society. **EU:** Society has undergone changes because of AI and this will continue in the future.
3–5	**1B-IC-18** Discuss computing technologies that have changed the world, and express how those technologies influence, and are influenced by, cultural practices.	**5-A-iii LO:** Create a model card for a classification or prediction model. **EU:** Model cards support transparency by explaining the intended use, training dataset, accuracy, and limitations of the model. **5-B-i LO:** Describe how AI-powered services are used in daily life. **EU:** AI-powered services are used to look up information, to provide voice interfaces to many kinds of apps, to make recommendations based on a person's interests, and to make cars safer. **5-C-i LO:** Identify changes in how sectors of society operate due to the introduction of AI. **EU:** Every sector of society is changing (or will change) as a result of the introduction of AI.

[1] LO: *Learning objective* defines what students should be able to do (AI4K12, 2022).

[2] EU: *Enduring understanding* defines what students should know (AI4K12, 2022).

	Summary of Related CSTA K–12 CS Standards	Summary of Related AI4K12 Guidelines
3–5	**1B-IC-19** Brainstorm ways to improve the accessibility and usability of technology products for the diverse needs and wants of users.	**1-C-ii LO:** Discuss how domain knowledge needs to be broad enough to encompass all the groups an application is intended to serve. **EU:** Speech recognition systems need to accommodate different types of accents and alternative pronunciations. Music recognition systems must know about different musical genres.
	1B-IC-20 Seek diverse perspectives for the purpose of improving computational artifacts.	**1-C-ii LO:** Discuss how domain knowledge needs to be broad enough to encompass all the groups an application is intended to serve. **EU:** Speech recognition systems need to accommodate different types of accents and alternative pronunciations. Music recognition systems must know about different musical genres.
6–8	**2-DA-07** Represent data using multiple encoding schemes.	**1-A-iii [3–5] LO:** Explain how images are represented digitally in a computer. **EU:** Images are encoded as 2D arrays of pixels, where each pixel is a number indicating the brightness of that piece of the image, or an RGB value indicating the brightness of the red, green, and blue components of that piece.
	2-IC-21 Discuss issues of bias and accessibility in the design of existing technologies.	**5-A-i LO:** Evaluate the ways various stakeholders' goals and values influence the design of AI systems. **EU:** The behavior of AI systems is determined by the choices of the designers, which may involve tradeoffs between conflicting goals and values. If other stakeholders' perspectives aren't given sufficient weight, there could be negative consequences for users. **5-A-iii LO:** Evaluate ways that AI system designers can learn about and incorporate the values of their stakeholders into the design process. **EU:** AI systems need to align with the norms and values of the groups they aim to serve. Developers of AI systems need to understand that values vary across cultures and ensure these values inform the design of products they create. **1-C-ii LO:** Describe how a vision system might exhibit cultural bias if it lacked knowledge of objects not found in the culture of the people who created it. **EU:** Domain knowledge must take multiple cultures into account if an AI application is to serve diverse groups.

	Summary of Related CSTA K–12 CS Standards	Summary of Related AI4K12 Guidelines
9–10	**3A-DA-10** Evaluate the tradeoffs in how data elements are organized and where data is stored.	**2-A-iii LO:** Describe how schemas are used to structure information about people, places, or things in knowledge graphs. **EU:** A schema specifies the attributes of the concept being described, and its relationships to other concepts, e.g., the *Restaurant* schema inherits properties from the *FoodEstablishment* schema.
	3A-IC-29 Explain the privacy concerns related to the collection and generation of data through automated processes that may not be evident to users.	**5-A-ii [6–8] LO:** Evaluate how an AI system meets the design criteria of accountability and respect for privacy. **EU:** Accountability in AI systems means designers and decision makers take responsibility for the system's actions. Respect for privacy means the system does not act in ways that violate people's privacy rights. **5-B-ii [6–8] LO:** Critique uses of AI technology that can be used to surveil people or violate their privacy. **EU:** AI technologies endanger privacy by reducing the cost of implementing widespread surveillance and enabling new types of surveillance.
	3A-IC-24 Evaluate the ways computing impacts personal, ethical, social, economic, and cultural practices.	**5-A-iii LO:** Design an AI system using an ethical design process. **EU:** Ethical design, at all stages of the design process, considers the values of all stakeholders and upholds the principles of fairness, transparency, explainability, accountability, respect for privacy, and adherence to societal values. **5-B-i LO:** Explain the kinds of debates that might arise as AI technology continues to evolve and is further woven into our culture. **EU:** Some new AI technologies will pose challenges for cultural norms and expectations that society must identify and wrestle with. **5-C-i LO:** Predict how a sector of society is likely to change in the short and intermediate term as a result of AI technology. **EU:** Anticipating and planning for the changes new technology brings is important for the healthy advancement of society.

	Summary of Related CSTA K–12 CS Standards	Summary of Related AI4K12 Guidelines
11–12	**3B-AP-08** Describe how artificial intelligence drives many software and physical systems.	**3-A-i LO:** Define supervised, unsupervised, and reinforcement learning algorithms, and give examples of human learning that are similar to each algorithm. **EU:** Both supervised and unsupervised learning algorithms find patterns in data. Supervised learning uses features to predict the class label supplied by a teacher; unsupervised learning groups similar instances together, creating its own classes. Reinforcement learning uses trial and error to find a policy for choosing actions that maximizes the reinforcement signal.
	3B-IC-27 Predict how computational innovations that have revolutionized aspects of our culture might evolve.	**5-A-iii LO:** Design an AI system using an ethical design process. **EU:** Ethical design, at all stages of the design process, considers the values of all stakeholders and upholds the principles of fairness, transparency, explainability, accountability, respect for privacy, and adherence to societal values. **5-B-i LO:** Explain the kinds of debates that might arise as AI technology continues to evolve and is further woven into our culture. **EU:** Some new AI technologies will pose challenges for cultural norms and expectations that society must identify and wrestle with. **5-C-i LO:** Predict how a sector of society is likely to change in the short and intermediate term as a result of AI technology. **EU:** Anticipating and planning for the changes new technology brings is important for the healthy advancement of society.
	3B-IC-25 Evaluate computational artifacts to maximize their beneficial effects and minimize harmful effects on society.	**5-A-iii LO:** Design an AI system using an ethical design process. **EU:** Ethical design, at all stages of the design process, considers the values of all stakeholders and upholds the principles of fairness, transparency, explainability, accountability, respect for privacy, and adherence to societal values. **5-B-i LO:** Explain the kinds of debates that might arise as AI technology continues to evolve and is further woven into our culture. **EU:** Some new AI technologies will pose challenges for cultural norms and expectations that society must identify and wrestle with. **5-C-i LO:** Predict how a sector of society is likely to change in the short and intermediate term as a result of AI technology. **EU:** Anticipating and planning for the changes new technology brings is important for the healthy advancement of society.