THE OHIO STATE UNIVERSITY
CENTER ON EDUCATION AND
TRAINING FOR EMPLOYMENT

AI Literacy

What Students Should Know About Artificial Intelligence

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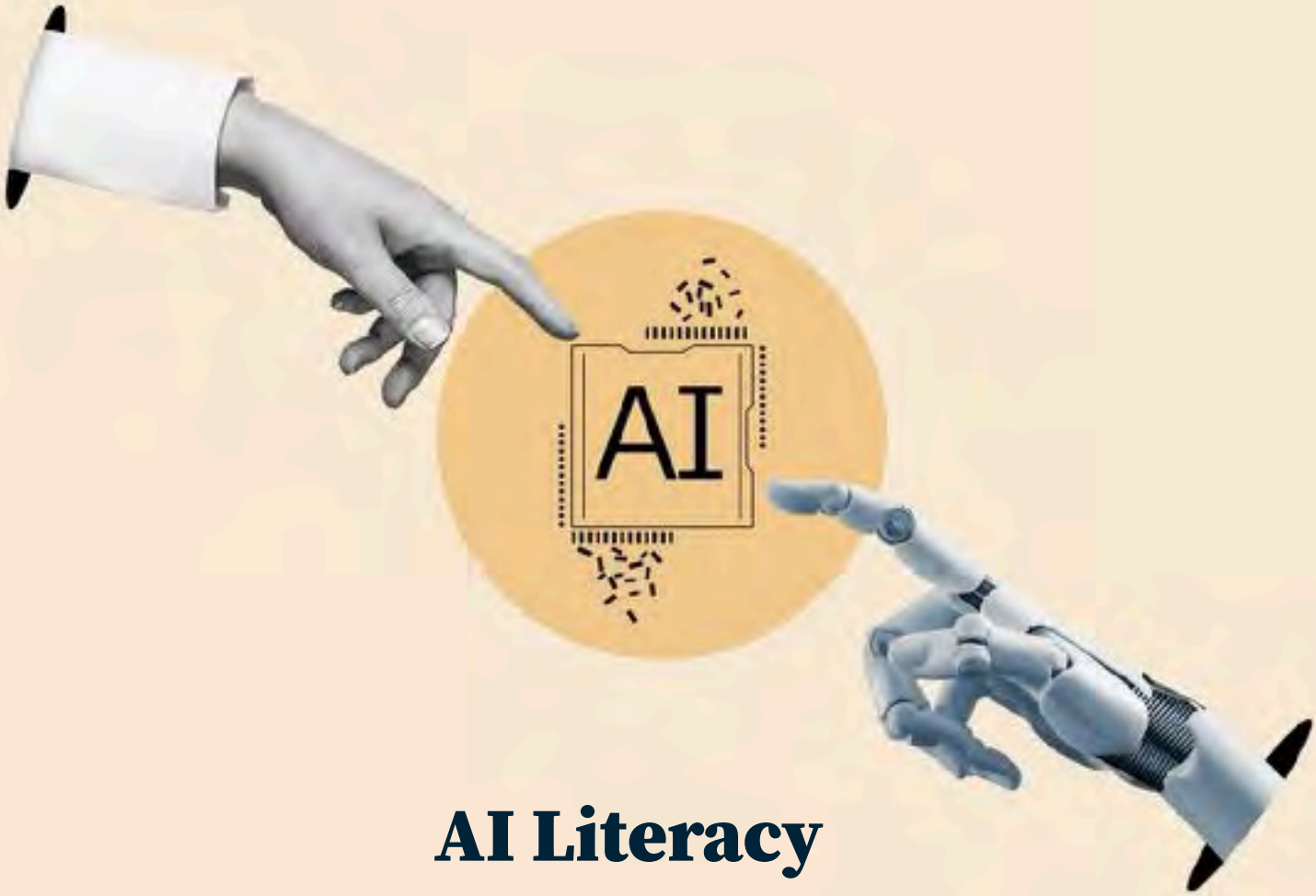

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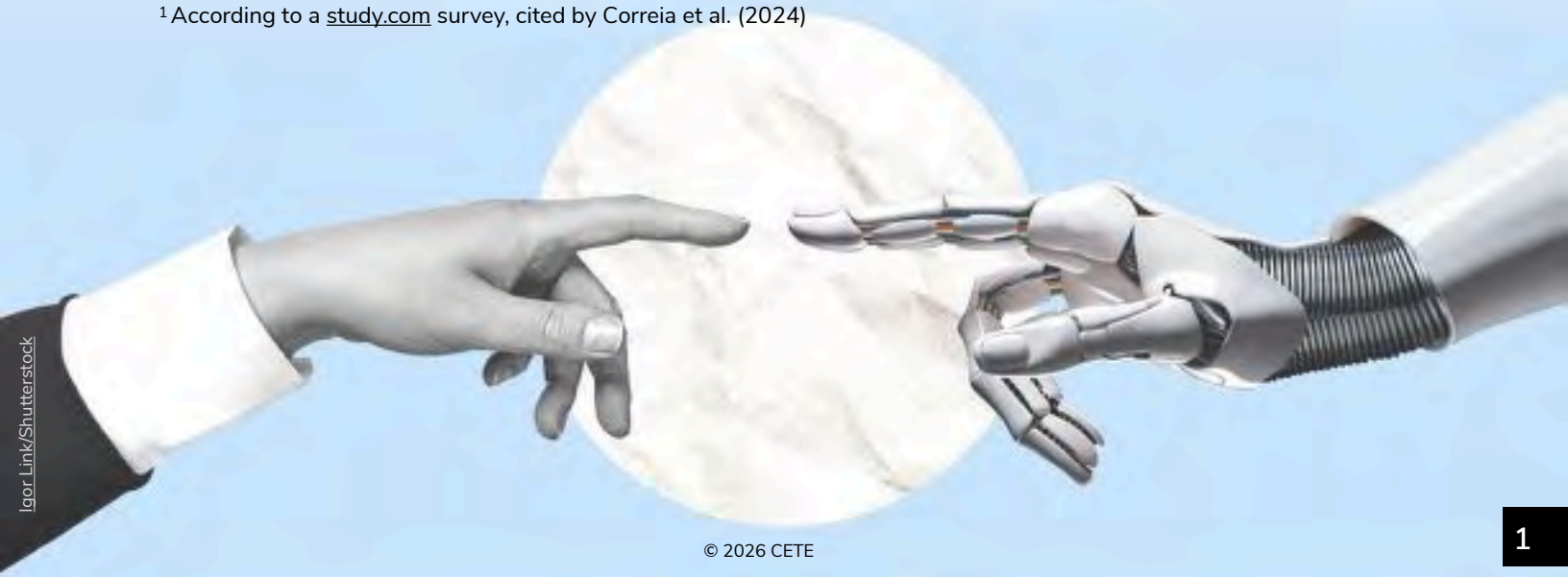
Contents

Why AI literacy?

Artificial intelligence (AI) is all around us. From the digital assistants in our phones to the recommendation engines driving music- and video-streaming services, our everyday lives are shaped by complex statistical models and predictive algorithms, many of which have been operating invisibly in the background for years. The wide release of generative artificial intelligence (genAI) tools, such as ChatGPT, in late 2022 has helped to bring artificial intelligence to the foreground. The generational leap in the capabilities of these tools has prompted their inclusion in countless computer and smartphone applications, making genAI nearly impossible to avoid.

Corporations, organizations, and institutions have begun adopting AI-powered systems for nearly every business purpose imaginable, from inventory tracking and supply-chain management to recruiting and hiring to sales and customer service. In the education sector, AI tools have sparked both excitement and fear among educators, parents, and school administrators alike. Education-focused AI systems and tools promise to transform the classroom and offer each teacher a teaching assistant and each student a personal tutor. At the same time, many students see genAI chatbots as shortcuts to learning, providing quick answers to homework problems and writing assignments. In the year following the public launch of ChatGPT, survey data showed that the vast majority of college students—more than 89 percent—had experimented with genAI tools to complete at least one writing assignment[1].

[1] According to a study.com survey, cited by Correia et al. (2024)



Igor Link/Shutterstock

Given the near ubiquity of AI tools in their lives, it is clear that today's students need guidance in understanding artificial intelligence. More than that, tomorrow's workforce will need to be able to take advantage of AI tools and systems in order to navigate an AI-enhanced workplace. Beyond issues of workforce readiness, AI literacy should now be considered a fundamental citizenship skill, necessary for full participation in a modern, digitally connected society.

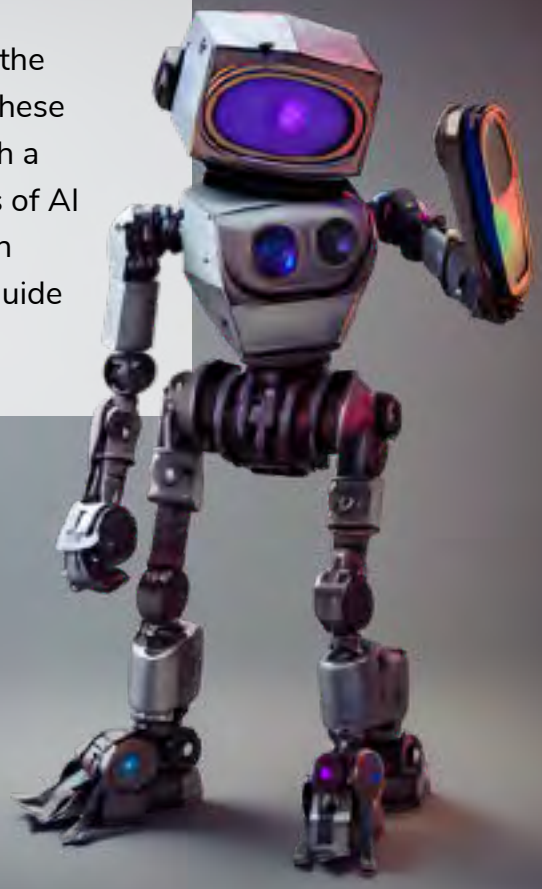
Protecting Cognitive Independence

In this age of deepfakes and the rapid spread of AI-generated misinformation, students need to be able to understand artificial intelligence and recognize how it can be used for deception and manipulation. AI-literacy skills allow students to distinguish reality from fiction or fabrication and maintain their autonomy.

Fostering Digital Citizenship

AI literacy skills enable the critical thinking, empathy, and self-awareness that form the backbone of digital-citizenship education and help to ensure educated, respectful, and safe interactions in a digitally connected world. AI is not just a tool. It is a societal force, the impacts of which can be felt across sectors, including finance, commerce, healthcare, and communication.

Informed digital citizens are those that can fully engage in the ethical questions surrounding the use and deployment of these systems. They combine media and information literacy with a foundational understanding of the underlying technologies of AI to recognize of the unequal impacts these technologies can have across communities and the need for regulations to guide the development of these powerful systems.



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Seeing into the “Black Box”

An uninformed user is likely to see artificial intelligence as a sentient, magical “black box,” capable of creativity, logic, and reasoning, serving up content recommendations and seamlessly generating text, images, and other media. AI literacy provides students with the understanding that inside the “black box” is a complex statistical model that requires input to produce a data-driven prediction.

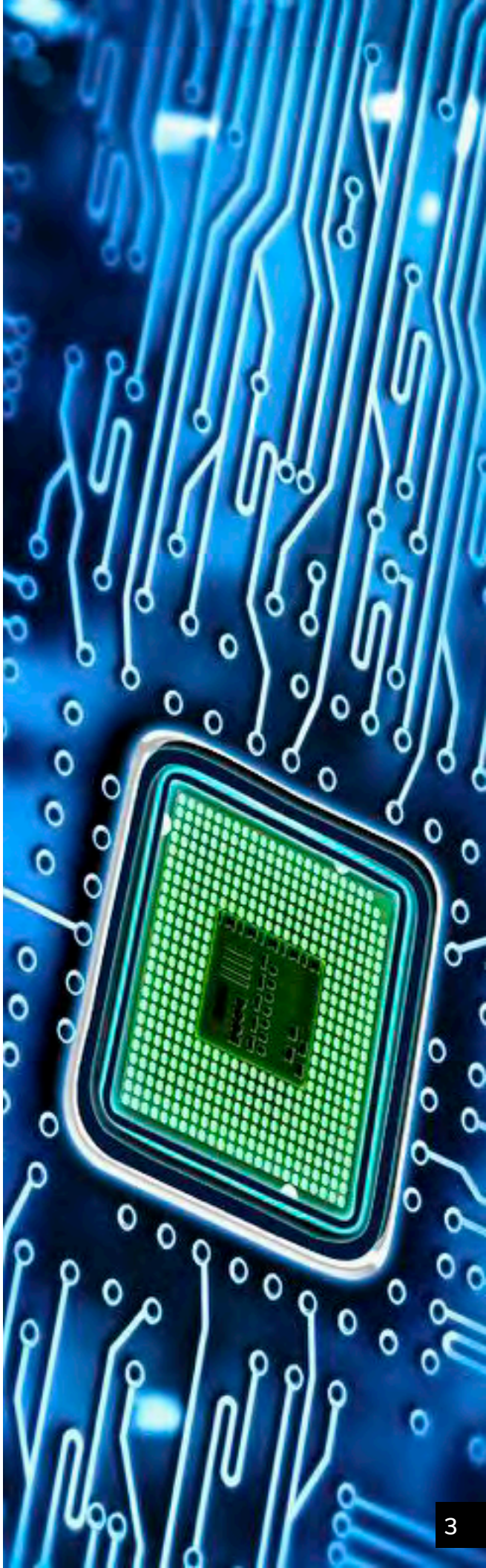
AI literacy has the power to demystify the machine. It allows students to rely on technical understanding to critically evaluate the potential and the limitations of AI models and tools. It prepares students to examine the outputs from these tools and assess their value and validity.

Amplifying Human Creativity

Generative artificial intelligence may be capable of generating novel content, but it cannot be considered “creative” on its own. AI literacy enables the understanding that *humans* bring creativity to the equation. By learning about AI systems and developing technical skills, AI-literate students can use AI platforms as *tools,* enabling their own human ingenuity by lowering the barrier to entry for coding, artistic expression, and complex problem-solving.

Ensuring Equitable Access

If only a select few understand how to wield artificial intelligence, current inequalities related to internet access and interacting online will only get worse. In other words, the existing digital divide will widen into a chasm. AI literacy helps to ensure that the power of these technologies does not remain in the hands of the few and instead is accessible to all students. AI should be available for everyone, not just those with tech-savvy backgrounds.



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About This Guide

The competencies outlined in this guide are not intended to be an exhaustive catalog of every possible interaction a student might have with artificial intelligence. AI is a rapidly evolving field, and the specific tools, interfaces, and challenges of tomorrow may look very different from those of today. As such, this framework should be viewed as the foundation of a living document. Think of it as a flexible baseline or an informed starting point, rather than a rigid checklist. Anyone using this in the classroom will likely add to this foundation, expanding the list of competencies as AI technologies and our understanding of their impact on society evolve.

It is important to note, however, that the knowledge and skills listed here were not chosen arbitrarily. This list has been rigorously curated based on current pedagogical research and emerging scholarship regarding what students need to know and be able to do in order to fully participate in an AI-enabled and interconnected society. These standards prioritize higher-order thinking skills, such as critical evaluation, ethical reasoning, and systems thinking, indicated by research as essential for fostering agency and understanding. While specific software platforms and tools may change, these cognitive skills and ethical foundations will remain relevant and vital to understanding and using artificial intelligence.

(bkgd) Aristal/Pixabay

Broad Learning Outcomes

The competencies listed here are grouped and organized into learning outcomes, overarching statements that summarize the knowledge and skills students should have to be considered AI literate. These "big ideas" incorporate a number of specific skills.

For example, AI-literate students should have foundational knowledge related to artificial intelligence. Within this learning goal, several individual skills can be identified, such as being able to define the term *artificial intelligence* or recognize AI systems at work in everyday life.

Competencies Focusing on Individual Skills

These individual skills are the competency statements, each of which focuses narrowly on specific knowledge or a single skill that AI-literate students should be able to demonstrate. Within each outcome are two to three competencies.

Focusing on a single skill enables targeted assessments that provide students with the opportunity to demonstrate mastery. For knowledge-oriented competencies, these assessments might take the form of test questions, in-class discussions, or assignments and classwork. For example, student groups could be asked to work collaboratively to compose a definition for *artificial intelligence* in their own words. Skill-oriented competencies, on the other hand, may require performance assessments to fully measure student proficiency. In order to demonstrate mastery of AI-prompting techniques, for example, students could be asked to use generative AI tools in the creation of synthetic media.

From Classroom Practice to Real-World Applications

Background information is provided for each of the competencies listed, highlighting why each competency is important and how each relates to —or prepares students for—the needs of an AI-enabled workplace. In addition, sample assessment strategies are included to better define what different levels of proficiency or mastery look like for students across grade levels.

(bkgd) Aristal/Pixabay

Understanding AI

Students should have foundational knowledge related to artificial intelligence and an understanding of how AI technologies work together in different aspects of their lives.

An essential first step in becoming AI literate is being able to describe artificial intelligence and define its impact and effect. When students can conceptualize AI, they stop viewing it as magic, chatbots are not seen as sentient, and the action of predictive algorithms is made visible, no longer an unseen, unknowable force driving decisions in their lives.

Competency: Define *artificial intelligence*

What it means: being able to understand and describe what artificial intelligence is using students' own words (Ng et al., 2022; Lintner, 2024)

Why it matters: Having the ability to craft a definition helps to shift the student mindset from being passive users of AI as "magic" technologies to active users of AI as powerful computational tools. It also helps students craft the vocabulary to discuss essential AI-related topics, such as privacy, bias, and AI's impact on society.

Demystification and grounding Being able to define the term *artificial intelligence* helps students to distinguish between narrow AI (i.e., the tools that we use today, such as recommendation engines and genAI chatbots) and general AI, the hypothetical "thinking" machines of the future.

(t) Thomas Breher/Pixabay

Understanding AI (continued)

Demystifying the technology through the creation of a working definition reinforces the idea that artificial intelligence is a tool created by humans, with specific limitations and functions. Students learn to see an AI chatbot as a complex computer application programmed to communicate with natural-sounding language rather than an autonomous agent possessing human-like consciousness.

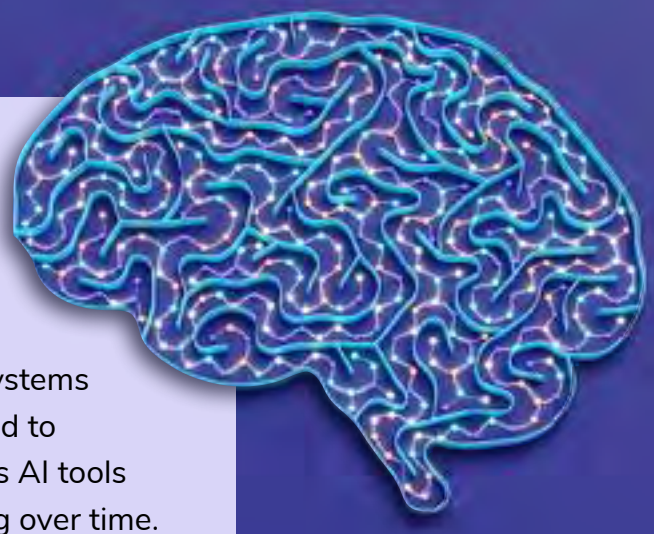
Creating transparency in daily life A solid definition acts as a lens through which students can spot AI—or recognize its influence—in their environment and everyday life. If they don't know what AI is, they won't recognize it when they are interacting with it. Understanding AI's use in recommendation engines, for example, allows students to learn how social-media feeds, streaming video and music platforms, and even GPS routes are all powered by algorithmic outputs, not neutral presentations of reality.

Understanding AI's limitations Students' definitions of AI should involve some comprehension of *how* it works on a basic level (e.g., pattern matching, data processing). This understanding allows students to grasp the concept that AI is only as good as the data used to train it. By seeing AI in terms of complex math, statistics, and probability, students are less likely to blindly trust a chatbot's answer as absolute truth. Such a definition also helps to prevent the common mistake of attributing human emotion or intent to the machine.

Asking ethical questions You cannot debate the ethics of something you cannot define. To begin to understand how or why AI systems might exhibit bias, students must fist have a working definition that shows a basic understanding of how AI systems are trained on human-generated data. Such a definition also helps to clarify who is responsible when things go wrong (e.g., the developer, the deployer, or the end user), shifting students away from blaming "the algorithm."

(t) Gerd Altmann/Pixabay

Understanding AI (continued)



Instructional and Assessment Strategies

Elementary grades: Students can begin to develop this competency by examining tools, objects, and systems in their lives, categorizing them as being "smart" (i.e., powered or enabled by AI) or "just useful." Students should understand that traditional computer systems and applications are "just useful" because they are limited to following a set of pre-programmed instructions, whereas AI tools and systems have the capability of learning and adapting over time. Similarly, voice assistants and recommendation engines on streaming-media platforms are "smart" because they learn from and adapt to the user over time, while appliances like a microwave or washing machine are just useful machines.

Middle grades: Students can continue to develop their understanding of AI technologies by engaging with and training simple AI tools, such as Google's Teachable Machine. Students should begin to understand that AI systems can learn and recognize patterns. Students can demonstrate their understanding through the use of a Frayer Model[2] graphic organizer, providing a definition for *artificial intelligence,* detailing facts about and characteristics of AI tools and systems, and listing both examples and non-examples. The correct identification of examples and non-examples is a valid measure of students' proficiency.

High school and beyond: Older students should be able to distinguish between narrow AI and general AI as part of their understanding of what artificial intelligence is and how it works. Instruction related to these concepts can be supported by discussions of how artificial intelligence is portrayed in popular media and comparing those portrayals to real-life AI tools and systems. To assess student understanding and measure competence, have students develop definitions and descriptions of artificial intelligence for different audiences, such as young children or tech-savvy adults.

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[2] A four-square graphic organizer designed to help students develop deeper understanding of concepts by connecting definitions to examples, characteristics, related words, etc.

(tr) Apple Creator Studio

Competency: Recognize AI in everyday life

What it means: being able to list examples of the use of different artificial-intelligence technologies and describe the function of these technologies (i.e., why they are being used) (Lintner, 2024)

Why it matters: Artificial intelligence is often invisible by design. Students' ability to see these technologies—and their effects—empowers them to navigate their digital world with open eyes, enabling them to protect their privacy, autonomy, and grasp on reality.

Building algorithmic agency AI is rarely labeled "AI" in the real world; it is hidden behind user interfaces, "smart" features, and curated feeds. If students cannot recognize it, they are operating in—and potentially being manipulated by—a digital world they cannot fully see or understand. Students should recognize that the content they consume online is often *chosen for* them, not *found by* them. Social-media video feeds exist within a "filter bubble," with AI-driven prediction and recommendation surfacing certain viewpoints while hiding others. In addition, these algorithms drive engagement in an effort to encourage specific behaviors (e.g., buying a product, watching another video, visiting a website). When students see this AI-powered manipulation for what it is, they can pause and reclaim their decision-making power and autonomy.

Recognizing data collection AI doesn't just "exist," it feeds on data. Identifying the use of AI is often the first step in recognizing risks to privacy and data security. When students engage with a free "smart" tool, they should be able to recognize it as an AI-powered system that requires their personal data to function. You cannot consent to data collection if you don't realize you are interacting with a system that collects it. Seeing AI in daily life enables informed consent.

Identifying synthetic media and non-human interactions Recognizing the multitude of examples of AI applications with which we interact every day creates an opportunity for skepticism. Knowing, for example, that synthetic media is commonly shared online, students can develop the reflex to ask, "is this real?" when seeing an image, watching a video, or hearing a voice recording. Similarly, students need to know when they are speaking to or chatting with an AI agent or bot—especially in areas like sales or customer service—to avoid wasting emotional energy or expecting human empathy where none exists.

(bkgd) Gerd Altmann/Pixabay; (br) Vân Tấn/Pixabay

Understanding AI (continued)

Instructional and Assessment Strategies

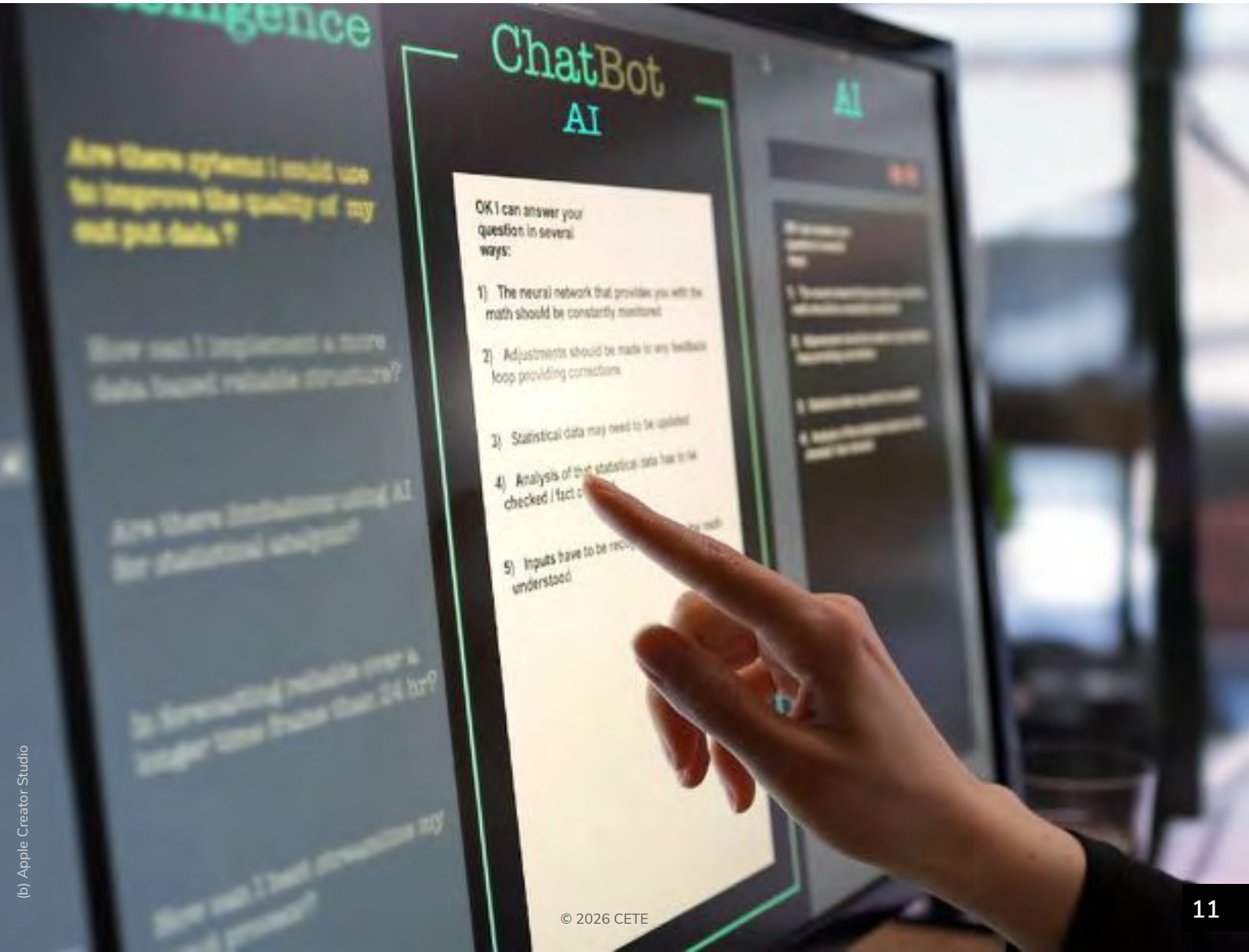
Elementary grades: For younger students, the influence of recommendation algorithms can be especially difficult to see. Students can develop this competency by thinking about what AI can learn from different decisions they make. Have students think about AI algorithmic data collection as being similar to the way they learn about their friends' and family members' likes and dislikes. An AI "scavenger hunt" can be used to assess this competency. Ask students to identify frequently "invisible" AI applications and tools. Give students a list of items to "hunt" for, such as "something that unlocks with a face," "something that suggests a movie or a song," "something that speaks or reacts when you say its name," or "something that corrects your spelling." By connecting these technology functions to the underlying AI systems that power them, students can demonstrate recognition of the ubiquity of artificial intelligence.

Middle grades: Students at this age can effectively learn about the influence of AI-powered algorithms and recommendation engines by carefully observing how their choices affect recommendations. For example, instructors can create a new profile on a video application and share it with the class, having students take note of the "default" suggested videos. Then, have students suggest a topic to search for and select 5–10 videos on a that topic. Students should quickly see a noticeable change in what the site recommends. This competency can be assessed with a student journal of algorithmic manipulation: Have students log every time they feel an AI is trying to "nudge" them, sharing a trigger (e.g., "I looked at a pair of shoes") and the suspected AI reaction (e.g., "I was shown an ad for a different shoe brand 20 minutes later").

(bkgd) Tung Lam/Pixabay

Understanding AI (continued)

High school and beyond: Students can add to their understanding of AI in everyday life by considering how AI systems collect data through surveillance. Students can begin to consider the trade-offs between privacy and convenience when it comes to using AI tools. For example, in order to use a GPS application for driving directions, users must constantly share their location while using the app. The combined location data from all users is what enables the AI system to provide the best directions possible. To assess student understanding of this concept have them work in groups to identify a AI-powered system or device that collects data (e.g., doorbell camera, smart thermostat, streaming-music or video app), examine its terms of service to determine what data are being collected, and report their findings to the class.



(b) Apple Creator Studio

Understanding AI (continued)

Competency: Understand AI as a collection of technologies

What it means: being able to list AI-empowering technologies (e.g., computer vision, natural-language processing, machine learning) and identify how combinations of these technologies work together in different artificial intelligence systems and tools (Ng et al., 2022; Lintner, 2024)

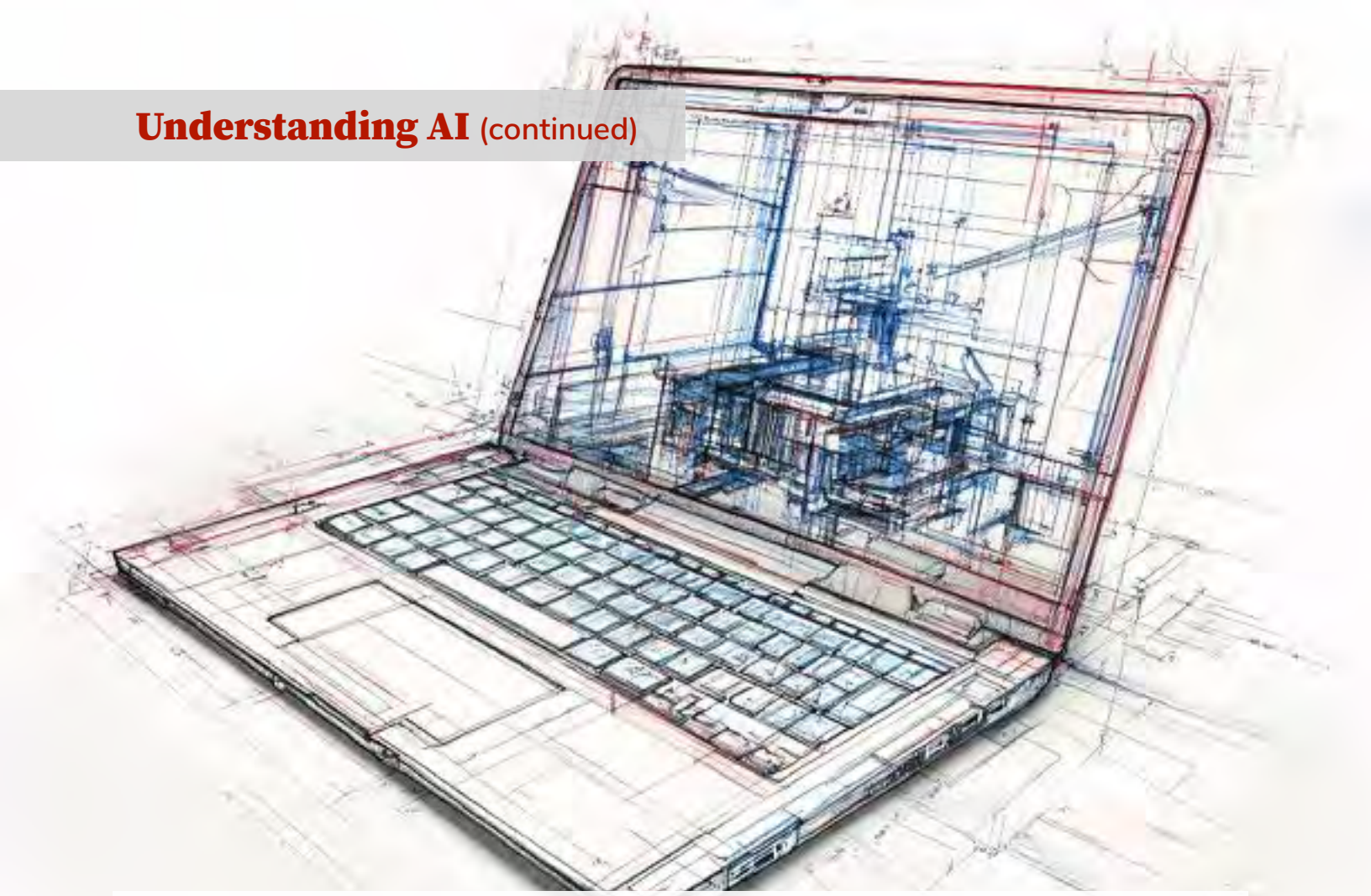
Why it matters: Seeing AI as a collection of inter-operational technologies helps students to recognize that *artificial intelligence* is an umbrella term used to describe a large number of related tools and systems, further demystifying AI. It also helps students understand how scientific and technological advancement often involves building upon the discoveries and achievements of others.

Engineering and science instead of "magic" When students treat AI as a monolith, they see it as a single "super brain," which can reinforce the idea that it is unknowable and magical. By seeing it at a collection of technologies, they not only see the whole as a sum of its parts, but they can have a better appreciation for the engineering-design process. Earlier AI-related inventions like natural-language processing enable the conversational functionality of today's genAI chatbots.

Selecting the right tool for the job Each AI system or tool combines different underlying technologies for a specific purpose. The AI within a self-driving car system, for example, combines computer-vision technology, route-planning algorithms, and robotic controls for steering. A genAI chatbot, on the other hand, combines natural-language processing with a large-language model, making it ideal for creating text.

Students need to be able to identify AI tools with the right functionality for the task at hand. For example, AI tools based on large-language models (LLMs) are notoriously bad at mathematical reasoning. Students with this understanding will have more realistic expectations about what questions LLM-based tools can and cannot answer.

(r) Apple Creator Studio



Reducing anthropomorphism Seeing AI as a collection of specialized tools and technologies breaks the illusion of artificial general intelligence (AGI) and reinforces the understanding that AI systems are not all-knowing thinking machines. It's harder to humanize a "tool" than it is to humanize a vague "intelligence." It reinforces that AI systems are engineered software products, not digital beings.

Instructional and Assessment Strategies

Elementary grades: The goal of this competency is to move students beyond the idea of AI as a single "brain" and help them conceptualize it as a toolbox of distinct technologies, each with its own specific functions and limitations.

Instruction related to this competency should encourage students to think about *function* first, connecting what an AI *does* to the technologies that drive it. For younger students, comparisons between human body parts used for sensing (e.g., eyes, ears) or thinking (i.e., the brain) and AI technologies (e.g., computer vision, audio processing, pattern recognition, rule following, machine learning) can introduce this concept. This competency can be assessed by having students connect a task an AI might complete (e.g., "driving a car," "unlocking a phone by looking at your face," "writing a poem") with the tools/technologies needed to complete that task (e.g., "camera/vision," "language/writing," "motion/robotics").

(t) Vilius Kukanauskas/Pixabay

Understanding AI (continued)

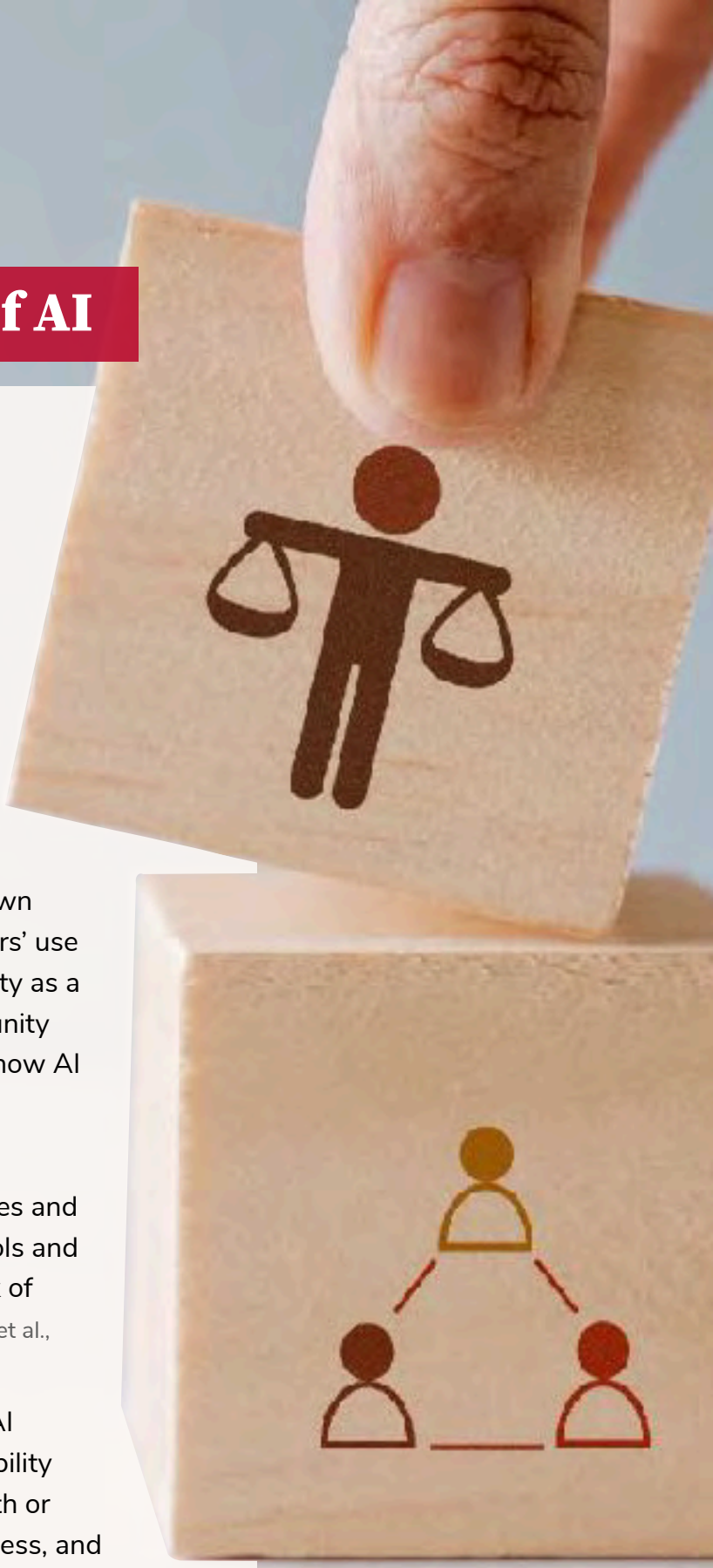
Middle grades: Once students understand the concept of different AI technologies, they can start to focus on the specific components, what they do, and how they work together. Instruction for this competency at this grade level can focus on specific capabilities and limitations of each underlying technology. For example, students should recognize that large-language models cannot see or interpret visual data. Similarly, computer-vision systems lack the functionality to communicate. Teaching activities at this grade level can include pairing problems (e.g., "a student needs to summarize a science article" or "a farmer needs to spot weeds in a field") with imagined AI systems that include the technologies needed to solve that problem (e.g., computer vision, natural-language processing, large-language models, robotics). Assessment for this competency should connect to real-world applications. For example, students should be able to connect underlying AI technologies with examples of AI systems in the real world that use those technologies.

High school and beyond: At the higher grades, students can begin to deconstruct AI's "black box" and consider how these underlying technologies function, how they are trained, and how they compare with one another. Instruction at this level could include contrasting different types of AI systems (e.g., generative AI vs. predictive AI), their purpose (e.g., creation of new data vs. classification of existing data), and how the technologies for the two systems compare, noting how they are similar and how they are different. Assessment for this competency could include research activities into the underlying technologies with students working in groups to pitch a new AI tool to solve a specific problem, describing the underlying technologies in their pitch and considering the risks associated with the application of each of the technologies.

Teaching Tip: When students describe artificial intelligence, their use of terms like "thinking" or "acting," may indicate some level of anthropomorphism. Remind students that these tools may *seem* alive with responses that have human-like qualities, but the output from AI is the product of statistical models and algorithms.

(bkgd) Gerd Altmann/Pixabay; (inset, br) Nurdin Bekkeldiev/Pixabay

Ethical Implications of AI



Students should recognize the ethical implications related to the creation, deployment, and use of artificial intelligence tools and systems.

Moving from understanding AI to considering the ethical implications of AI represents the shift from knowledge to behavior. If students understand how AI works but lack the ethical framework to guide its use, they can unintentionally cause harm to themselves, their communities, and the information ecosystem. Beyond the implications of their own behavior, students need to consider how others' use of AI affects them, their community, and society as a whole, because they are future voters, community members, and policy-makers who will shape how AI is integrated into their world.

Competency: Apply AI ethics

What it means: understanding moral principles and codes of conduct that dictate the use of AI tools and systems and making choices that limit the risk of harming themselves or their communities (Ng et al., 2022)

Why it matters: Teaching students to apply AI ethics ensures that they develop the responsibility necessary to use technical skills, engaging with or deploying AI in ways that preserve truth, fairness, and human dignity.

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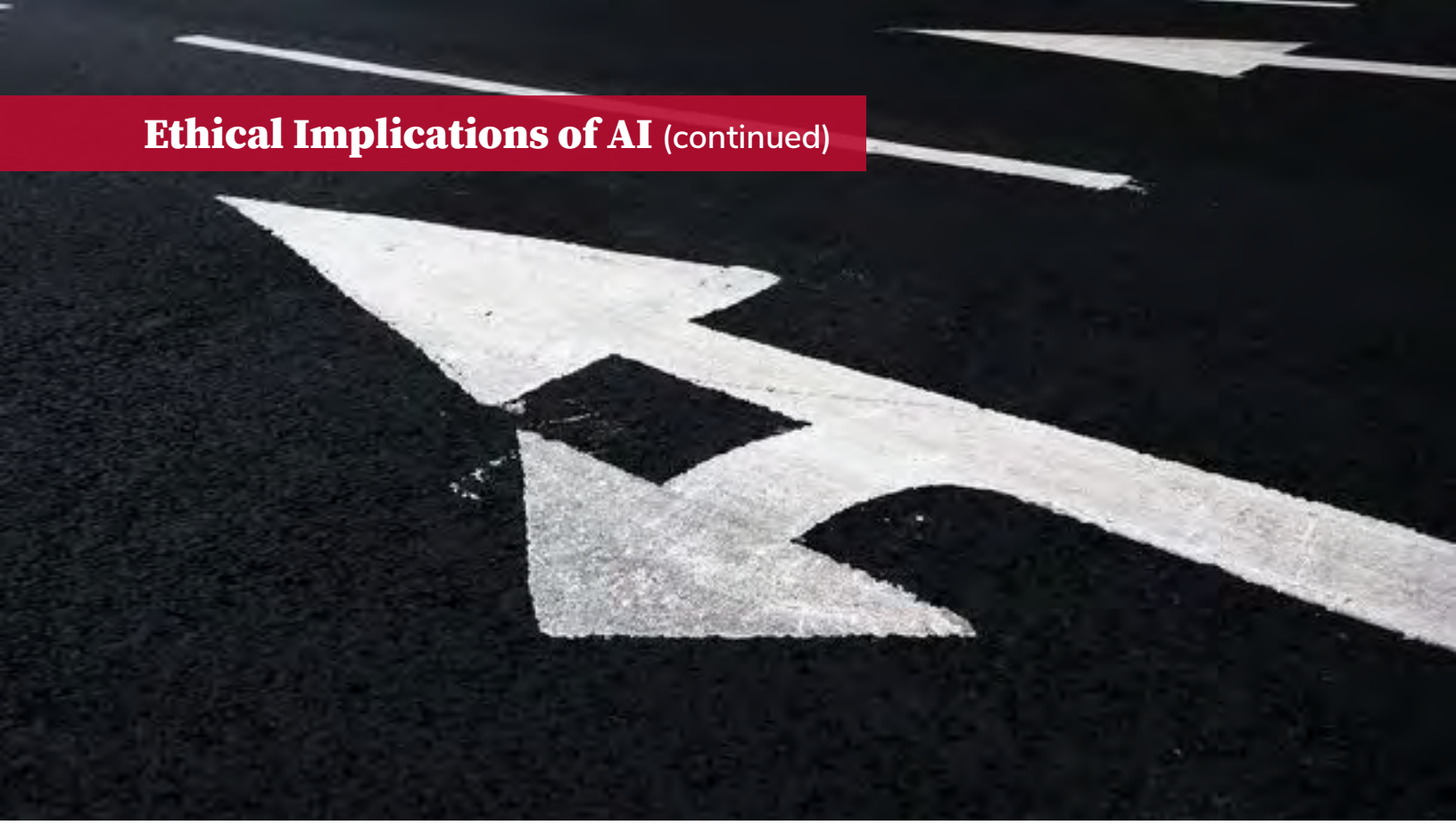
Ethical Implications of AI (continued)



Moving from "Can I?" to "Should I?" Technology often moves faster than public policy and regulation. AI presents students with numerous situations where they *can* do something (e.g., clone a celebrity's voice, create a deepfake video of a classmate, have a genAI chatbot write an essay for a homework assignment) that is not strictly illegal but is ethically fraught. This competency gives students the internal guardrails to make reasonable decisions even when no one is watching, to pause and consider the effects of their actions.

Practicing academic integrity The most immediate application of AI ethics for most students is the question of honesty and authorship, especially when it comes to coursework. Students need to learn that using AI without disclosure is a form of deception. Applying ethics means knowing how to cite AI tools and give credit where it is due. It also involves accepting responsibility for the output, making the AI user ethically liable for errors, hallucinations, or bias.

Combatting bias and inequity Students should understand that AI training data are biased because they were created by humans who are inherently biased. AI outputs should not be accepted as inherently neutral. Instead, they should be analyzed for their potential to exhibit bias and perpetuate stereotypes. Applying AI ethics means considering these issues both in the creation of AI prompts and in the analysis of AI output.

(t) Apple Creator Studio

Ethical Implications of AI (continued)

Instructional and Assessment Strategies

Elementary grades: Younger students' exposure to ethical questions is likely limited to discussions of honesty and understanding the difference between right and wrong. Concepts like the "Golden Rule" can support students' understanding of AI ethics by helping them see the importance of equitable treatment and build upon their understanding of fairness. This competency can be assessed with "red light, green light" scenarios, having students use red and green cards or flags to vote on different uses of AI that might be considered ethical (i.e., "green light"), such as asking an AI to help think of ideas for a story, or unethical (i.e., "red light"), such as having AI make an unflattering picture of a classmate.

Middle grades: As students continue learning about AI and the ways in which it can be used, they can begin to focus on issues of consent and AI-enabled modes of spreading misinformation, such as deepfakes and digital impersonation. Instruction in this area should include examples of consent and discussions of why it's important. One possible assessment strategy could be a group activity in which students create an AI ethics checklist outlining acceptable behavior.

High school and beyond: Instruction for older students should focus on personal accountability and a "human-in-the-loop" governance strategy when using AI systems.[3] Instruction in this area could include students' review of AI-generated content and synthetic media to identify potential cultural stereotypes, examples of bias, and hallucinations or misinformation. Students should recognize their responsibility for anything they publish, which is especially important when AI is involved. Assessment in the higher grades can include case studies in which students are presented with a complex, realistic cases involving AI use. The ideal case studies have no clear "right" answer, leaving it up to students to consider ethical implications when assessing the case, supporting their verdict with sound reasoning.

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[3] The term human-in-the-loop refers to a system or process in which AI is prevented from acting entirely autonomously because humans are either active participants or decision-makers or they have the power to review/override decisions made by AI.

(bkgd) Gerd Altmann/Pixabay

Ethical Implications of AI (continued)

Competency: Assess the societal implications of AI

What it means: being able to articulate how AI systems and tools have an uneven impact on communities and populations, recognizing that benefits from the application of AI for one group might be paired with harm caused to another (Touretzky et al., 2019; Chiu et al., 2024)

Why it matters: Technology is not neutral; it shapes the world it inhabits. By learning how to assess the societal impact of AI, students move from passive users to active citizens, well positioned for advocacy and capable of demanding AI systems that serve the public good, rather than just corporate bottom lines or efficiency goals.

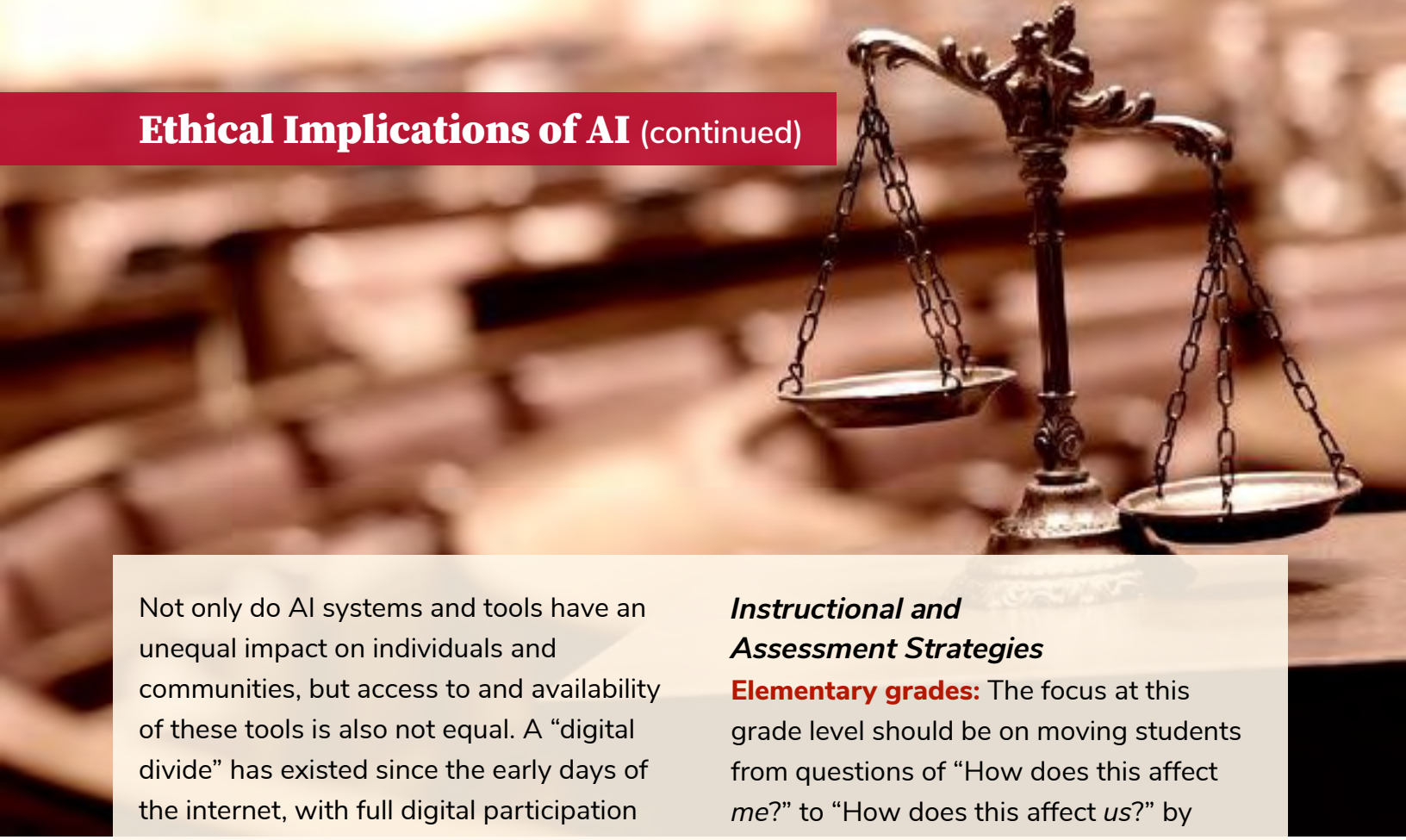
Informed civic participation Ethical use of AI requires an understanding of the broader picture, taking the ethics conversation surrounding AI from a focus on individual choices to an assessment of broader impacts, from "How should I use this?" to "What does this *do* to us?" or "How does this affect society?". When learning about AI-powered algorithms and recommendation engines, students should consider how these systems can affect public opinion, amplify polarization, create echo chambers, and serve to increase the spread of misinformation.

Students should also consider how AI is being used by governments for surveillance activities, predictive policing, and resource allocation and management. AI-literate citizens need to be able to assess trade-offs between efficiency and civil liberties. You can't vote on AI policy if you don't fully understand its impact.

Identifying systemic inequality Because it is trained with biased data, AI output has the potential to perpetuate bias and spread cultural stereotypes. The speed with which AI systems operate gives AI the power to automate discrimination: A racist human can harm many people over their lifetime, but a biased hiring algorithm can reject thousands of applicants in seconds. The belief that technology is inherently neutral or that AI systems operate on "objective math," amplifies this problem, perpetuating historical inequalities in housing, lending, employment, and criminal justice.

(r) Apple Creator Studio

Ethical Implications of AI (continued)



Not only do AI systems and tools have an unequal impact on individuals and communities, but access to and availability of these tools is also not equal. A "digital divide" has existed since the early days of the internet, with full digital participation requiring broadband access and sufficient computing technology. This divide is made worse in the age of AI because of the speed requirements of internet access, the technology necessary to support the use of AI tools, and financial barriers such as subscription fees and pay walls that keep the latest tools out of reach for many with limited resources.

Considering the environmental impact

One often-overlooked aspect of AI use is the environmental cost. Massive data centers that power artificial intelligence consume enormous amounts of electricity and water. Students should be able to weigh the benefits of AI-powered tools and systems against the carbon footprint of the physical facilities required to support these systems.

Instructional and Assessment Strategies

Elementary grades: The focus at this grade level should be on moving students from questions of "How does this affect *me*?" to "How does this affect *us*?" by considering issues of fairness and shared costs. Instructional strategies for younger students can include readings that provide examples of unintentional discrimination.[4] Students can discuss how applying rules that might seem fair can lead to unintended consequences. By understanding AI systems as computer programs that are essentially just a list of rules, students should begin to understand how the impact of AI is potentially unfair. Assessment strategies of this competency can include student discussions about fairness, impact, and energy usage. For example, have students work to create a diagram that shows where AI "comes from," which could include a cord going from a computer into a wall, then to a power pole, then to a data center with many computers.

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[4] This instructional strategy could be used with a wide range of topic- and age-appropriate literature. For example, Mantchev, L., Strictly No Elephants for K–2 students.

(t) corgarashu/Shutterstock

Ethical Implications of AI (continued)

Middle grades: Students can extend their understanding of unequal impacts of AI to the workplace and how AI's use affects different career fields in different ways. One strategy for teaching this concept might be to hold an AI "career fair:" Have students brainstorm possible job roles and then discuss whether robots, computers, or AI could help with or take over any parts of each job. Simulation activities are a great way to assess this competency for older students. For example, students could take on the role of mayor or city planner and think about using AI to solve a problem, assessing potential benefits and social costs (e.g., risks to privacy, unequal treatment of citizens, mistakes made by AI, environmental costs).

High school and beyond: Older students should consider topics such as policing, hiring practices, and finance, and how the application of AI in these areas can have significant negative impacts on communities and groups of people. Role-playing and simulation strategies can help students to recognize how efficiencies can often come at the cost of equity or civil liberties. Numerous articles and news stories can be found online to support case studies and debates as assessment strategies, allowing students to consider groups being targeted, harmed, or treated unfairly by the use of artificial intelligence.

(bkgd) SewCreamStudio/Shutterstock; (br) AI-generated/Google Gemini

Ethical Implications of AI (continued)

Competency: Evaluate AI transparency

What it means: being able to discern the extent to which users of artificial intelligence disclose the use, inner-workings, and effects of the AI systems being used and whether those disclosures are made in a way that can be understood by the widest audience possible (Jobin et al., 2019; Larsson & Heintz, 2020; Walmsley, 2021)

Why it matters: AI systems can be powerful tools for manipulation and harm, especially when users trust their use without question. Students who can evaluate AI transparency are better positioned to demand explainability from AI users, which is essential in being able to advocate for their individual rights.

The importance of showing your work

Evaluating AI transparency safeguards against "blind faith" in AI and ensures that the use of these technologies is done publicly and out in the open. AI systems and tools that provide users with an explanation of the output and includes links to data sources are fundamentally more transparent than those providing only answers without attribution. Transparency in these contexts supports learning and slows the spread of misinformation.

(b) Dragon Images/Shutterstock

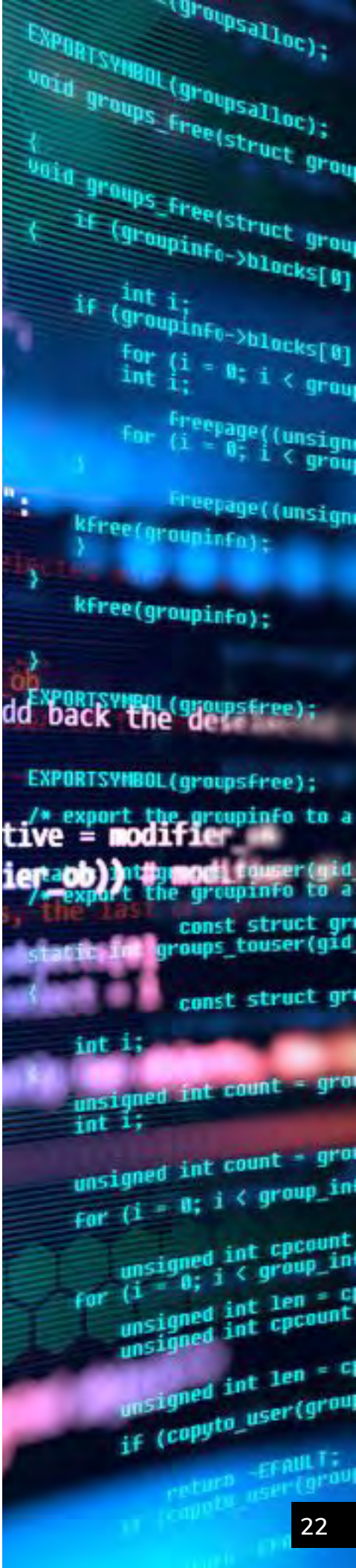
Ethical Implications of AI (continued)

Looking inside the "black box" Tech companies are often secretive when it comes to their AI systems, opting to protect trade secrets over providing plain-language explanations about how their models work. When AI is a "black box," it's easier to see their functionality as magic or something unknowable. Students should learn to evaluate AI-tool transparency for two reasons: (1) First, they should recognize that a lack of transparency requires more skepticism on the part of the user; and (2) second, when the logic is made visible to the end-user, AI errors can be explained and "correct" answers can be better understood (i.e., AI models might be right for the wrong reasons).

Looking "under the hood" Transparency can provide a window into possible sources of error for AI models and systems. Students should learn to ask questions like "What data were used to train this AI model?" or "How might the training data contribute to this output?" when using AI tools. For example, if AI image-generation tools were trained only on Western art, it will likely not create images representative of Eastern cultures.

Understanding the *intent* behind AI models is an important part of transparency. Students should also be asking "Why did the AI show this to me?", especially when conducting internet searches. Some AI-powered search engines might prioritize sponsored content, which means the results provided by AI may be attempting to sell a product, rather than showing the best or most accurate search results.

Accountability for AI-powered decisions Perhaps the most important reason to demand transparency is that it enables accountability on the part of the user or deployer of AI tools. For example, if AI tools are used in screening applicants for a job, not only does the company need to be transparent about the use of those tools, but that transparency should extend to explainability about *how* AI-screening decisions are made. Users need this level of transparency to understand how they are affected and, if necessary, contest the decision. Transparency shifts blame to the *people* using AI away from the AI tool itself.



(r) Apple Creator Studio

Ethical Implications of AI (continued)

Instructional and Assessment Strategies

Elementary grades: A great analogy to help younger students understand AI transparency is the transparency we already demand for the ingredients in food products. You can demonstrate this analogy by placing snacks in brown paper bags. Label some of the bags "Food" while labeling the others with the names of the actual items inside them (e.g., "Fruit Snacks," "Pretzels," "An Apple"). Asking students which bags they'd choose helps them to recognize the importance of transparency when it comes to making decisions that affect their lives. A way to assess this competency for younger students might be to have them develop strategies for identifying when an AI is in use. Clues such as "sponsored" tags in search results, "automated support" labels for AI-powered chat agents, or "magical" icons and imagery for AI-powered tools are small hints at AI transparency.

Middle grades: As students continue to learn about how to productively use AI tools, they should consider the power and importance of citations within genAI output. To drive this point home, provide students with two sample AI outputs for the same question, one with just a text response and one with links and/or footnotes citing reputable sources. Students should see the value of the latter and recognize it as a form of transparency. To assess students' understanding of this competency, have them interrogate a genAI chatbot to provide the specific data source used to generate output. Then, students can evaluate the AI tool's level of honesty and transparency.

Teaching Tip: Whenever you use AI to generate an image or diagram or when you use AI-generated text as an example, be sure to include a citation (e.g., "*AI-generated image/ChatGPT*"). This can help to normalize being transparent about how and when students have used AI tools to support their own work.

(t) Stockbyte/Getty Images; (inset) Erce/Shutterstock

Ethical Implications of AI (continued)

High school and beyond: For older students, a good analogy for AI-model transparency is the "nutrition label" found on packaged food products or the "data privacy label" some app stores use for smartphone applications. Introduce the concept of "Model Cards" as an emerging industry standard for AI systems and tools and have students research the information that is included on Model Cards for different publicly available genAI tools. To assess this competency, have students work in groups to research tech companies and their AI tools to create a transparency scorecard. Have student groups present their findings, rating the tech companies' openness and the availability of plain-language information describing how their AI models and tools work.

Teaching Tip: The Stanford Institute for Human-Centered Artificial Intelligence (HAI) creates an annual report, called the AI Index, that tracks AI research, the technical performance of current AI models, the ways AI impacts the environment and the economy, and the tech companies that develop artificial intelligence systems. This report can inform classroom discussions and support older students' understanding of AI technology.

(bkgd) Apple Creator Studio

Technical Literacy

Students should exhibit technical skills related to the use of AI tools and the interpretation of the outputs they generate.

If understanding what generative artificial intelligence is and how it works is the theory, then prompting skills and interpreting the output of genAI tools is the practice that applies that theory. Composing high-quality prompts represents a high-level communication skill that combines critical thinking, problem solving, and engineering design. It teaches students to plan carefully, identify goals and metrics for meeting those goals, structure their thoughts to articulate complex needs, and iterate to refine solutions.

Competency: Apply prompt engineering strategies

What it means: being able to compose instructions for a generative AI tool and refine it through an iterative process to achieve desired results (Song et al, 2024)

Why it matters: Effective prompt engineering is the difference between passive users of AI tools and active architects of the output, forcing students to be precise in their word choices, logical in the way they compose the prompt, and iterative in their refinement, all of which are strategies that contribute to effective communication.

Garbage in, garbage out To write an effective prompt for a genAI tools, students must first have a clear understanding of what they want. They cannot be vague. This means considering the intended audience and purpose of the output, setting parameters for what the AI model produces, and providing all necessary details. A rich vocabulary enables the creation of a prompt with the specificity necessary to generate the desired output.

(t) Apple Creator Studio

Technical Literacy (continued)

Developing metacognitive skills Because prompting is an iterative process, the instructions for genAI tools often become a dialogue between the chatbot and the student, forcing students to analyze their own thinking process. Students must compare the output responses from the AI tool to their intentions and goals. In cases of incorrect or inaccurate outputs, students must diagnose the cause, asking questions of themselves about the quality of the prompt, such as "Is this prompt too broad?" or "Did I forget an important detail or constraint?". The iterative loop of *Prompt* > *Critique* > *Refine* becomes a powerful critical thinking exercise.

Prompt engineering is rarely a "zero-shot" process, with complex tasks often requiring examples the students must find or prepare in advance and include with their instructions. Strategies like "Chain of Thought" prompting[5] require the student to break-down complex problems into logical steps. Students must understand each of the steps of the assignment before they can ask the AI to perform them.

Shifting from consumer to director

Students' role with online content is often one of consumption, receiving text, videos, and other content to learn or entertain themselves. They have little to no control over the format or style of the content. With generative AI and prompt engineering, students become active participants in the generation of media. This empowers them to ask for not just specific topics or types of content but also for styles and qualities that speak to them personally. For example, students can set the reading level or the format. They can direct the AI tool to adopt a persona, like having a personal content creator.

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[5] This prompting strategy typically involves asking a genAI chatbot to break a request into steps to illustrate the reasoning used to generate an output. This can be paired with "one-shot" or "few-shot" prompting strategies, providing one or more examples for the AI to use in generating a response. See Codeacademy for more information.

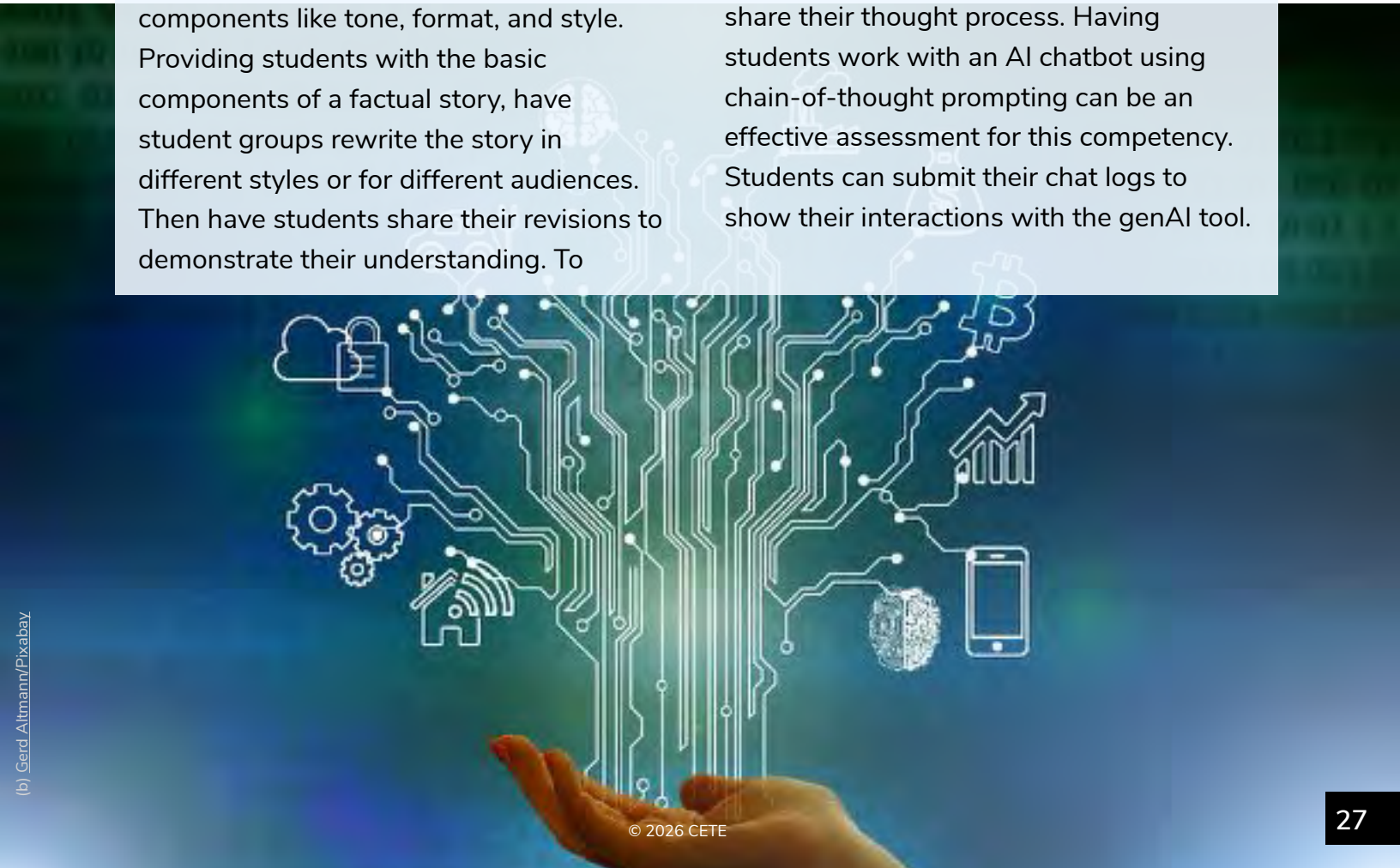
(bkgd) AI generated/Google Gemini

Instructional and Assessment Strategies

Elementary grades: A key instructional focus for the elementary classroom should be highlighting the need for specificity in instructions. Have the students give instructions for making a peanut-butter-and-jelly sandwich to the teacher (or a volunteer), who responds to their instructions very literally. Students should quickly learn that vague instructions can lead to disastrous results, such as putting peanut butter on both sides of a single slice of bread or incorrectly assembling the sandwich.

Middle grades: Building from a clear understanding of the importance of specificity, older students can consider components like tone, format, and style. Providing students with the basic components of a factual story, have student groups rewrite the story in different styles or for different audiences. Then have students share their revisions to demonstrate their understanding. To assess student proficiency with prompt engineering, have them work in groups or as a class to compose a prompt for a specific purpose (e.g., writing an email to parents describing an upcoming field trip). Students' prompts should indicate the AI role or personal, as well as the format and tone of the output. Have students test their prompts and critique the results as a class.

High school and beyond: Older students can start to explore different prompting methods, such as chain-of-thought prompting. Demonstrate chain-of-thought logic by presenting students with a complex math word problem, having students identify individual steps needed to solve the problem. As students work through each step, encourage them to share their thought process. Having students work with an AI chatbot using chain-of-thought prompting can be an effective assessment for this competency. Students can submit their chat logs to show their interactions with the genAI tool.



(b) Gerd Altmann/Pixabay

Technical Literacy (continued)

Competency: Apply ethical principles when writing AI prompts

What it means: being able to consider the morality and broader ramifications of the requests they make of AI systems and tools (Ng et al., 2022)

Why it matters: The ethics of genAI use starts at the keyboard. Students need to understand the consequences of their interactions with AI, especially those they initiate with a prompt. A well-crafted prompt protects their privacy (and the privacy of others), avoids manipulation of the AI model into perpetuating stereotypes or biases, and respects the creative rights of humans when requesting synthetic media and content.

Enabling accountability It's easy to "blame the algorithm" when people are negatively affected by AI, but artificial intelligence is a tool wielded by humans. Students should think about how *they're* using AI and the effects their use might have on others. AI tools reflect the intent and biases of their users. If a student uses AI to create output that is biased or harmful, they are active participants in the unethical use of artificial intelligence.

Bias injection AI tools are predisposed to creating biased output because they are trained with data that reflect the biases of human creators. But even when AI data are relatively neutral, students can inadvertently force AI to produce biased results by writing loaded prompts. For example, a prompt that exhibits a specific point of view, such as asking why a political figure is "untrustworthy" or why a policy is "unfair" might cause the AI model to hallucinate or cherry-pick facts and figures to confirm the premise of the prompt.

(r) Gerd Altmann/Pixabay

Technical Literacy (continued)

Avoiding biased portrayals Students should be aware of how racist or classist caricatures or gendered tropes can result from prompts that lack context or rely on lazy stereotypes (e.g., "Write about someone who grew up in a bad neighborhood" or "Describe a typical teenage girl"). Students need to provide AI tools with specific, nuanced character details that avoid perpetuating stereotypes.

Respecting intellectual property and creative rights Students need to understand the difference between appreciation and appropriation. When creating artistic prompts, students should consider how phrases like "in the style of" go beyond inspiration and enable plagiarizing the voice, style, or brand identity of living, working creative professionals.

Say "no" to jailbreaking Generative AI tools have "guardrails" limiting what users can do in an effort to prevent harm or illegal behavior. Many of these limitations can be circumvented by clever prompting intended to "jailbreak" the AI. Even if unsuccessful, attempting to trick an AI into bypassing its security features is a violation of digital citizenship, showing a lack of ethical responsibility.

Instructional and Assessment Strategies

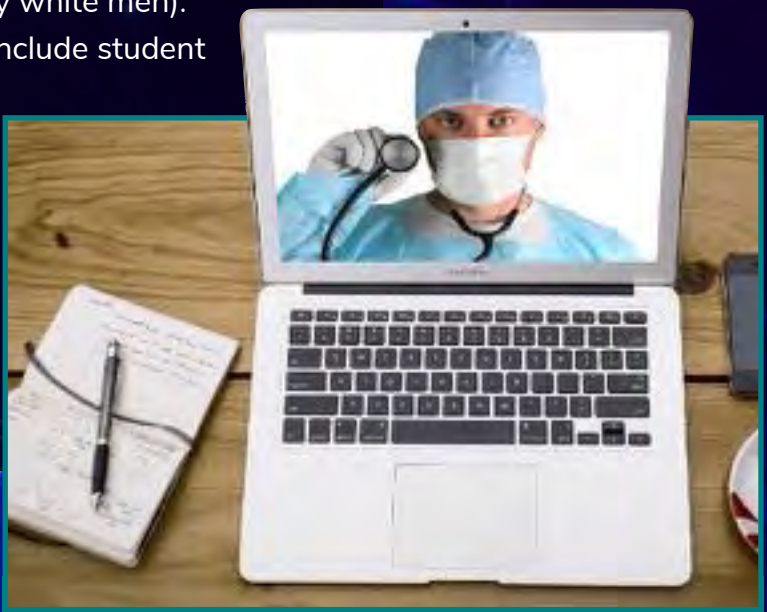
Elementary grades: Thinking about the ethical ramifications of prompting starts with conversations about right and wrong. Instruction in this area shares quite a bit with good-citizenship and anti-bullying education, encouraging students to think about "funny" versus "mean" and what crosses the line. It is important for students to understand that asking a computer to do something inappropriate or say something mean is really not different than the students doing it themselves. Having students work in pairs or small groups to evaluate and rewrite offending prompts can be an effective assessment strategy.

(bkgd) vierra/Shutterstock

Technical Literacy (continued)

Middle grades: For older students, a good starting place for instruction is considering the ramifications of sharing personally identifiable information (PII) with publicly available AI tools. Explaining to students that AI tools remember everything you tell them and are terrible at keeping secrets can be an effective strategy for instruction. Have students brainstorm a list of appropriate and inappropriate information to use in an AI prompt. Correcting example prompts with PII can be an effective strategy for assessing students' proficiency with this concept.

High school and beyond: As students learn about biases and stereotypes, they can explore how they can be inadvertently reproduced by AI tools and how poorly written prompts can manipulate AI chatbots into reproducing them. Instruction in this area should first review students' understanding of possible gender-based or cultural stereotypes that might be perpetuated by AI models. Students should be able to identify some of the most common examples (e.g., image prompts for "CEOs" or "doctors" producing output dominated by white men). Assessment of this competency should include student discussion about the connections between user *intent,* digital-citizenship behaviors, and the wording of prompts, with ethics-violating prompts indicating negative intent and showing a clear violation of one or more digital-citizenship principles.



Instructional Idea: It may be helpful to demonstrate the ways in which stereotypes can be perpetuated by AI models. As a class demonstration, compare the output from several AI image-generation tools when requesting images of a "teacher," "family," "doctor," "nurse," or "scientist." Have students identify the bias and suggest how prompts could be edited to reduce the biased output.

(bkgd) Connie Schneider/Unsplash; (inset, br) Tumiso/Pixabay

Technical Literacy (continued)

Competency: Critically evaluate the output generated by AI tools

What it means: being able to review the output generated by an AI tool and discern whether it adequately meets the parameters defined by the prompt, determine the extent to which it exhibits bias or perpetuates stereotypes, and assess its factual validity or accuracy (Long & Magerko, 2020; Searson et al., 2024)

Why it matters: GenAI tools prioritize content writing style over factual accuracy. These tools are "confident liars" that generate misinformation that sounds plausible or reasonable. They also reproduce the flawed worldview inherent in their training materials. Teaching students to rigorously fact-check, critique, analyze, and edit the output from AI protects them from misinformation and reinforces the value of research and human expertise.

Detecting hallucinations Generative artificial intelligence chatbots often speak confidently, but they do not *know* anything. They predict words and combinations of characters to compose and complete sentences. This can lead to factual inaccuracies and completely fabricated content, often stated with a great deal of confidence. Students need to verify any factual information—dates, names, historical events, scientific claims—produced by an AI chatbot.

Analyzing AI output for bias Students should be on the lookout for societal biases and cultural stereotypes in the output generated by AI models, noticing gender, racial, or ethnic over- and underrepresentation, especially in images reproducing specific job roles. When generating an images of doctors, students will notice that women of color are underrepresented. Similarly, prompts for stories or news-type articles about business owners are likely to be dominated by "he/him" pronouns. Students should be able to evaluate whether AI output is reproducing a Western-centric view, ignoring global contexts and alternative perspectives.

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Technical Literacy (continued)

Deconstructing AI-generated arguments Generative AI tools are adept at creating grammatically correct writing that adheres to typical writing structures (e.g., a five-paragraph essay, a research paper, a business letter), but while the words and syntax may be perfect, the internal logic may be flawed. GenAI tools do not always use consistent reasoning and can contain contradictory arguments or unsupported claims. Students should be able to analyze the output from these tools to evaluate the quality of the underlying substance of the output.

Beyond flawed or incoherent logic, AI output can also contain bad math. The large language models (LLMs) at the heart of generative AI tools are notoriously bad at mathematical reasoning. As a result, genAI chatbots will confidently provide the wrong answer to a math problem or computer-programming code that fails to function as desired. Students should recognize that these word-selection prediction algorithms should not be used as substitutions for calculators or programming-specific tools.

Considering quality and voice As students review the output from genAI chatbots, they should think about their own "voice," comparing that to the sometimes robotic-sounding output from AI. Does AI overuse certain words and phrases? Is the language too formal? Not formal enough? Does the output match the intended purpose? Critical evaluation of AI output includes reflection on the reason the content was generated in the first place and the extent to which the genAI output meets that purpose. Students should see genAI output as a "first draft." They should edit the AI output and craft something that matches their own personal style and voice.

(b) Gorodenkoff/Shutterstock

Technical Literacy (continued)

Instructional and Assessment Strategies

Elementary grades: A focus for younger students in teaching this competency should be fact-checking and reinforcing the understanding that AI tools often state misinformation with a great deal of confidence. Games like "Two Truths and a Lie" can be used to encourage students to use common sense and employ research skills to verify statements before believing them. This competency can be assessed by having students work in small groups to review a report or story and identify factual errors by crossing them out or circling them. This type of assessment strategy also aligns with grade-appropriate reading and language-arts standards.

Middle grades: Fact-checking skills developed in the elementary grades can be built upon and further developed in older students by having them not just identify factual errors but also correct them. Students should be introduced to the term *hallucination* at this level and should work in groups to find examples of hallucinations in student-prompted AI-generated output. This competency can be assessed by having students research and employ journalistic standards when fact-checking, such as citing two independent sources when verifying factual claims or debunking factual errors. Students at this level can also be challenged to think about what information might be *omitted* from AI output, which is the beginning of understanding bias in the form of under- or overrepresentation of racial, cultural, or ethnic groups in AI output.

High school and beyond: Older students should move beyond simple factual errors and develop an understanding of how bias is perpetuated by AI models. A demonstration of AI bias with a whole-class discussion can be an effective way to teach this content. Start by having AI generate an article about a controversial or sensitive topic. Then, have the class read the output and interrogate it for bias. Have students look for omission by asking questions such as, "Whose point of view is missing?". Then have students look for "loaded language" that perpetuates a specific point of view. For example, if the AI-generated article is about gentrification, does it use terms like *urban renewal* or *neighborhood revitalization* instead of *displacement*?

(r) Apple Creator Studio

The Promise and Limitations of AI

Students should be able to describe both the benefits and the drawbacks related to the use and deployment of artificial intelligence tools and systems.

There are tasks that artificial-intelligence tools are very good at, such as identifying and reproducing patterns or reviewing grammar and syntax for technical errors. Some specialized AI tools are capable of generating high-quality, photorealistic images. Others can generate computer code. Each tool has its own specific strengths and weaknesses.

Beyond questions related to an individual tool's or model's functionality and technical accuracy, one must consider how AI is used within society to ensure it is being used reasonably and responsibly, playing to its strengths. AI systems cannot be counted upon to make fair or unbiased decisions without human input. AI systems are limited in their complexity and lack uniquely or distinctly "human" qualities, such as compassion, creativity, and empathy.

(t) Headway/Unsplash

Competency: Recognize the strengths and weaknesses of AI

What it means: being able to identify both those tasks that are well-suited to AI generally and to specific AI tools and those tasks that are not well-suited to AI systems and tools (Mills et al., 2024; Luterbach et al., 2025)

Why it matters: Students who can recognize the strengths and weaknesses of AI generally and of specific AI tools are better positioned to develop a "manager mindset," learning to delegate suitable tasks to AI while reserving tasks for themselves that require uniquely human skills and abilities. This mindset enables the deployment of AI as an assistant, rather than a crutch or liability.

Employing strategic delegation Students should be able to consider different AI tools and ask themselves if that tool's capabilities are appropriate for the job at hand. For writing tasks, for example, students should recognize that some AI tools, like most genAI chatbots, are very capable when it comes to summarizing text or reviewing content for errors, but they lack the genuine creativity necessary to create novel content. AI-powered video-creation tools can create realistic animations of known objects, but they struggle to create new and unique elements, often failing to capture the imagination of human creators.

By taking individual AI tools' strengths and weaknesses into account, students can plan an AI-enabled workflow, saving creative tasks for themselves and selecting the appropriate AI tools as needed for repetitive tasks and work that AI systems do well.

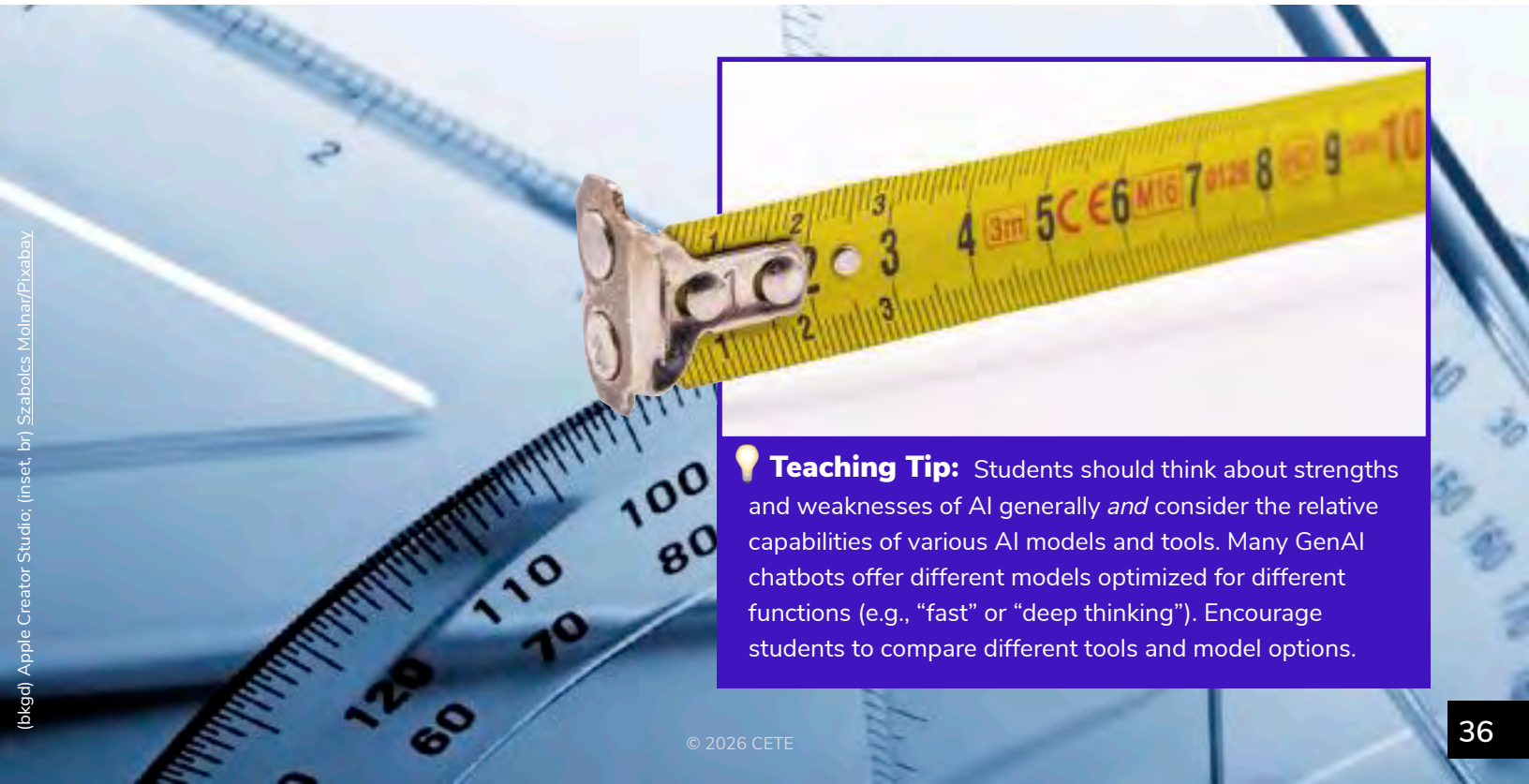
Common sense and the illusion of competence AI's ability to speak confidently when presenting information makes it especially important for students to be able recognize AI models' weaknesses. Knowing, for example, that generative AI systems and the models on which they're based often lack "common sense," potentially recommending dangerous activities or presenting scenarios that are physically impossible, forces students to rely on their own judgment and intuition when evaluating AI output.

(bkgd) Joshua Woroniecki/Pixabay

Similarly, genAI's strength lies in grammar and sentence construction, not its ability to reason or understand. Students need to recognize that language fluency is not the same as factual accuracy. Again, students should learn to rely on their own research and fact-checking abilities, which is only possible when they accept this as a weakness of AI.

Instructional and Assessment Strategies

Elementary grades: The primary focus for younger students should be to reinforce the notion that artificial intelligence is a specialized tool rather than an all-knowing oracle by having them consider the tasks for which an AI would be useful and activities at which an AI tool is likely to be incompetent. To reinforce the strengths and weaknesses of AI tools remind students that while artificial intelligence tools and systems can do some things faster or better than people, the reverse is also true. Have students keep "score" for a theoretical showdown between an AI and a human by creating a two-column chart comparing "Robot Wins" with "Kid Wins." Provide students with a list of activities—or have students suggest actions or tasks—and assign each one to the appropriate column, based on who would "win" the matchup. Example tasks could include defining words or explaining concepts (robot), comforting a sick friend or relative (kid), predicting the weather (robot), or inventing a new, delicious flavor of ice cream (kid). Students should recognize humans' superior ability to perform emotional, creative, or physical tasks, compared with an AI's higher ability in rapidly performing data-related or computational tasks.



(bkgd) Apple Creator Studio; (inset, br) Szabolcs Molnar/Pixabay

Teaching Tip: Students should think about strengths and weaknesses of AI generally *and* consider the relative capabilities of various AI models and tools. Many GenAI chatbots offer different models optimized for different functions (e.g., "fast" or "deep thinking"). Encourage students to compare different tools and model options.

The Promise and Limitations of AI (continued)

Middle grades: Once students start to understand that there are specialized tasks for which an AI tool can be useful, you can further develop a "manager mindset" by having students consider the division of labor for a complex project. Start with a classroom discussion about a hypothetical project, such as creating a video game. Have students brainstorm some of the tasks that would likely be part of the project. For each one, have students decide if it makes sense to have a person complete the task or if it would save time and effort to assign it to an AI tool. For example, coming up with the *idea* behind the game or planning the story are tasks that require human creativity. An AI tool could be used, however, for high volume or repetitive tasks (e.g., "Generate a list of 50 character names") or structure tasks (e.g., "Write the computer code for making characters jump").

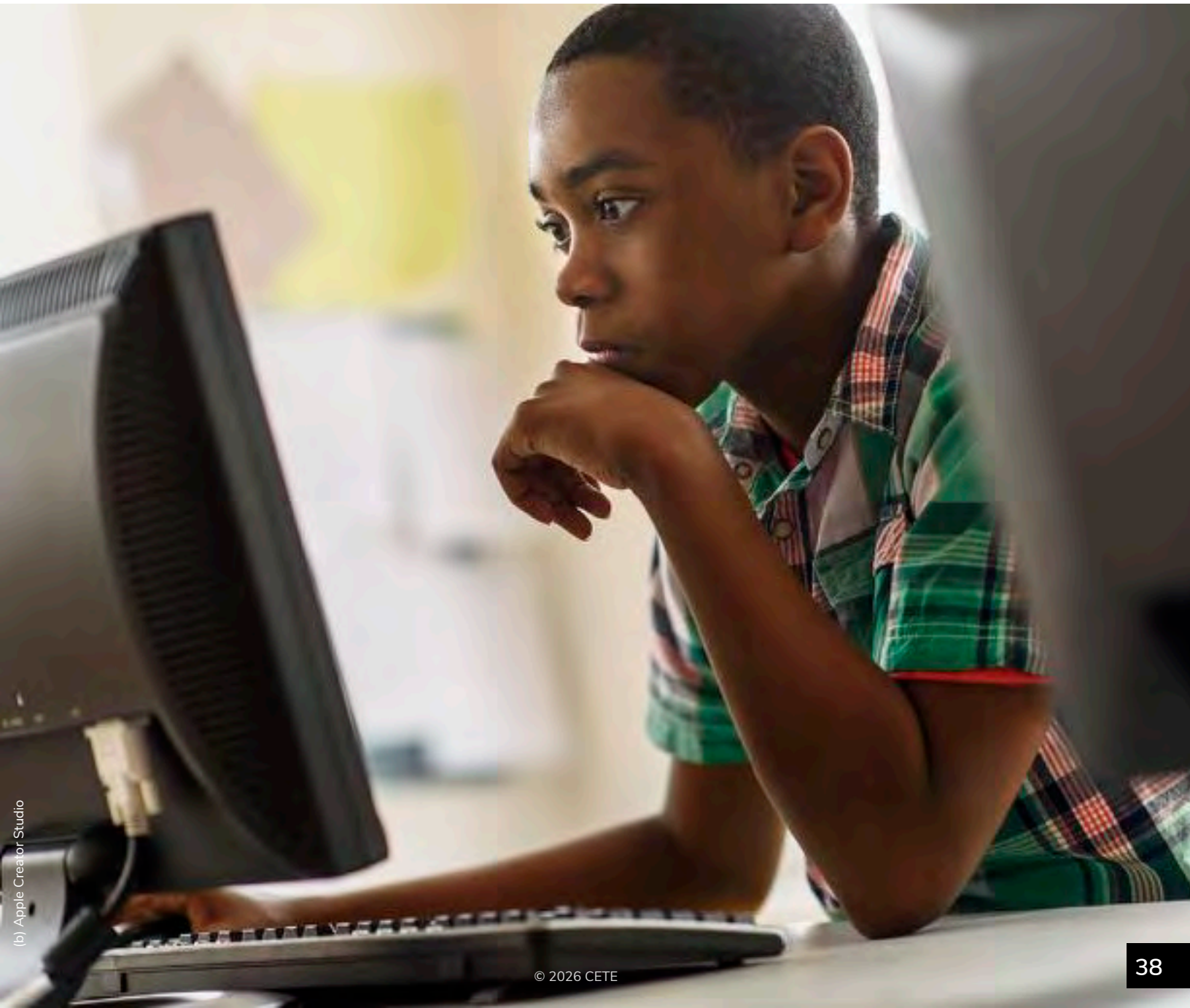
Assess students' proficiency related to the competency by having them categorize daily tasks by whether they are best completed by AI alone, a human alone, or as human-AI collaborative endeavor. Students should be able to articulate their reasoning for each of their choices, defending why certain tasks require a human, explaining how AI can be used for specific tasks, or describing why a human and AI working together would be beneficial.

High school and beyond: For older students, the goal should be to identify AI limitations through experimentation, allowing them to map specific boundaries of AI use. Most generative AI chatbots struggle with "common sense" or physical logic puzzles. Students could brainstorm prompts and experiment with chatbots to highlight nonsensical responses from AI tools. For example, telling a genAI chatbot that you need to wash your car and then asking it to suggest "the best way to get to a car wash that is approximately 100 meters away" will often result in the chatbot recommending you walk there, which is illogical if your goal is to get your car washed.

(r) Apple Creator Studio

The Promise and Limitations of AI (continued)

Similarly, students can brainstorm prompts that require personal experience or emotional understanding, such as asking an AI to write a highly personal essay about how it feels to lose a family member or a beloved pet. Students should be able to critique the AI's response to such prompts and recognize that the language fluency of an AI model is not a substitute for lived experience. Students who exhibit a high degree of proficiency in this competency will be able to articulate specific structural limitations of different AI tools and models.



(b) Apple Creator Studio

Competency: Analyze AI tools and systems for bias, fairness, and equity

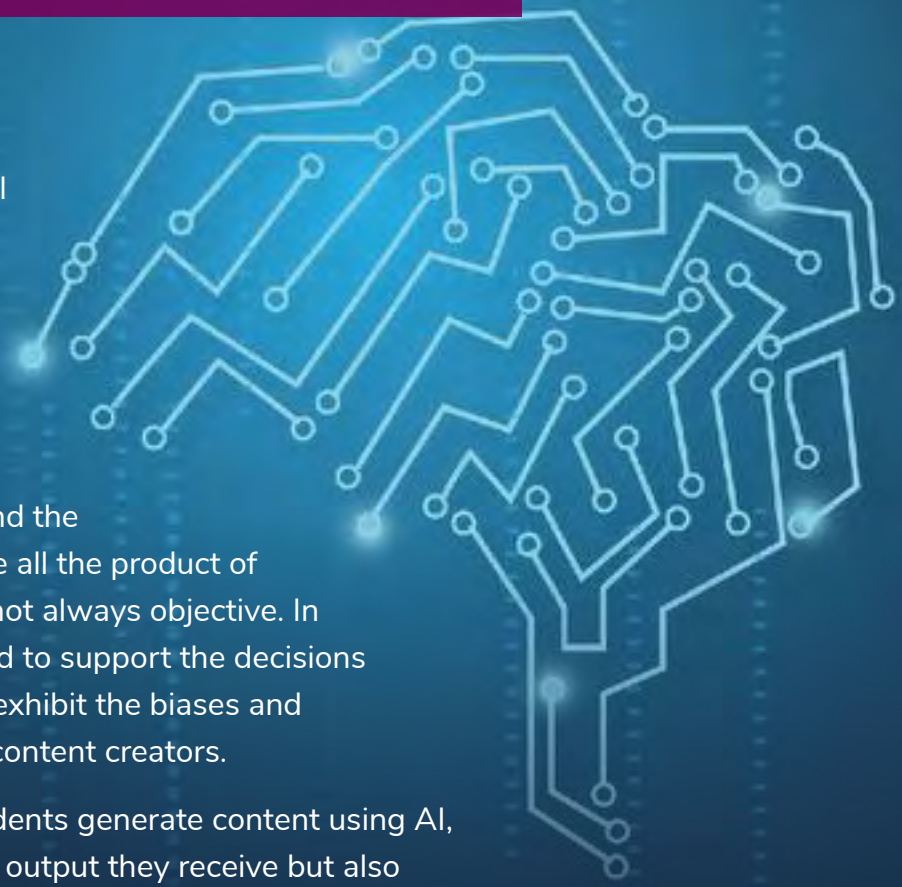
What it means: being able to evaluate the output from AI to detect biases, identify and describe examples of mis- (and missing) representation, and describe the need to equitable solutions (Guzman & Lewis, 2020; Searson et al., 2024)

Why it matters: AI tools are mirrors that reflect societal prejudices because they are trained on flawed and biased data. If students cannot analyze these tools for bias, they risk automating and amplifying discrimination, enabling technological "progress" at the cost of civil rights.

Debunking the myth of technology neutrality It is easy for students to see AI tools as "neutral" or "objective" because at their core they are computers and as such lack the motivations, desires, and flaws as humans. This viewpoint is especially common once students learn how AI models work, since statistical models are essentially "math," and math feels inherently objective. In reality, the models are trained on data that are created by flawed humans, making those data inherently flawed themselves. In addition, while mathematical operations might not have opinions or exhibit political ideologies, the *way* math is used can be politically motivated. Specific statistical analyses and carefully chosen data can be used to support nearly any point of view.

(t) Apple Creator Studio

The Promise and Limitations of AI (continued)



Mathwashing is the tendency to assume objectivity just because a computer was used or a statistical or mathematical model was applied in making a decision. Students need to learn that the analysis of data is not objective "truth." The data that were chosen to collect, the way those data were analyzed, and the conclusions that can be drawn are all the product of human choices, and humans are not always objective. In the case of AI, the data being used to support the decisions and train the models are likely to exhibit the biases and prejudices of human writers and content creators.

Identifying exclusion When students generate content using AI, they need to consider not just the output they receive but also what might be missing. Are there points of view not represented? Are there groups of people that cannot be found or seen in the output? If, for example, an AI-generated image features mostly white faces and elements of Western culture, students should be able to ask themselves, "Who is missing here? Who is not represented?".

Beyond the outputs of generative AI, students should be thinking about concepts of inclusion and exclusion in other uses of artificial intelligence. For example, some AI-powered fitness trackers measure "fitness" solely by counting steps. A student who is analyzing this use of AI should ask, "What does this mean for someone in a wheelchair? How does this use of AI affect them?". Similarly, some facial-recognition systems fail to correctly identify people with darker skin tones. Students should be able to ask, "What are the implications of using facial recognition for proctoring a test or neighborhood surveillance? What are the impacts to different people?".

(bkgd) Alexandra Koch/Pixabay

Amplified algorithmic bias This competency connects to ethics-related outcomes and competencies because it asks students not just to think about the potential for bias in the outputs from or decisions made by AI systems, but also to consider the broader societal impacts of these examples of bias. As previously discussed, the deployment of AI tools and systems has the potential to automate bias. Students need to understand that human bias is often slow, especially compared with the instantaneous effect from AI. AI bias is instant and scalable.

Instructional and Assessment Strategies

Elementary grades: For younger students, the goal of this competency is to move students from seeing AI as "objective math" to recognizing that it is a system created by humans and therefore capable of reproducing humans' flaws, amplifying prejudices and perpetuating stereotypes. One way to do this is to connect the concept of fairness to representation, teaching students that computers only know what we show them. If a computer has never seen an apple, it can't draw an apple. If it only has seen *red* apples, then all the apples it draws will be red. Similarly, if it has only seen pictures of men as doctors, it will only draw and describe doctors as male.

Reinforce this concept by conducting a live demonstration using AI tools, having AI generate images of dancers, doctors, nurses, or builders/construction workers. Use the results as a basis for a class discussion by asking questions such as, "Do all doctors look like this?" or "Who is missing from this picture?" Students should recognize that the images for one type of career tend to represent a small number of people. In addition to unequal gender representation in the AI-generated images, people with different body shapes and sizes, people with disabilities, and people of color will also often be underrepresented. Students should be able to recognize and identify a lack of diversity in AI output.

(b) fuzah25/Shutterstock

The Promise and Limitations of AI (continued)

Middle grades: Once students can recognize the bias in AI-generated content, the focus can move to understanding *why* AI makes biased choices. Have students work in groups, with each group assigned one or more professions (e.g., doctor, CEO, nurse, flight attendant, scientist, ballet dancer, professional athlete, teacher). Each group should use AI image generators to create 10 images of their assigned profession(s), tracking the representation in the AI output. As groups share their data, they will likely discover massive skews (e.g., 10/10 "CEO" images depict white men; 9/10 images of "nurses" depict women).

Repeat the activity, only this time have students use an image-search tool to find real-world images or stock photos of their assigned profession(s). Have students track the representation found in the first 10 results on the page. They will likely see similar results. Use their findings to start a discussion about how AI models are trained. Explain to students that AI is not intentionally prejudiced. It is not "thinking" racist or sexist thoughts. Instead it is just reproducing what it's seen in the images used to train it. Remind students that their image search results are examples of the data used to train the AI models.

The competency can be assessed by having students write a short report directed to the "creators" of the AI tool(s) they used to generate the images. Students should state their findings from their image-generation experiment and explain *why* they think the AI made the choices it did, describing the results of their image search as typical "training data." Students should be able to correctly link biased AI-generated output to biased human-created data it was trained on.

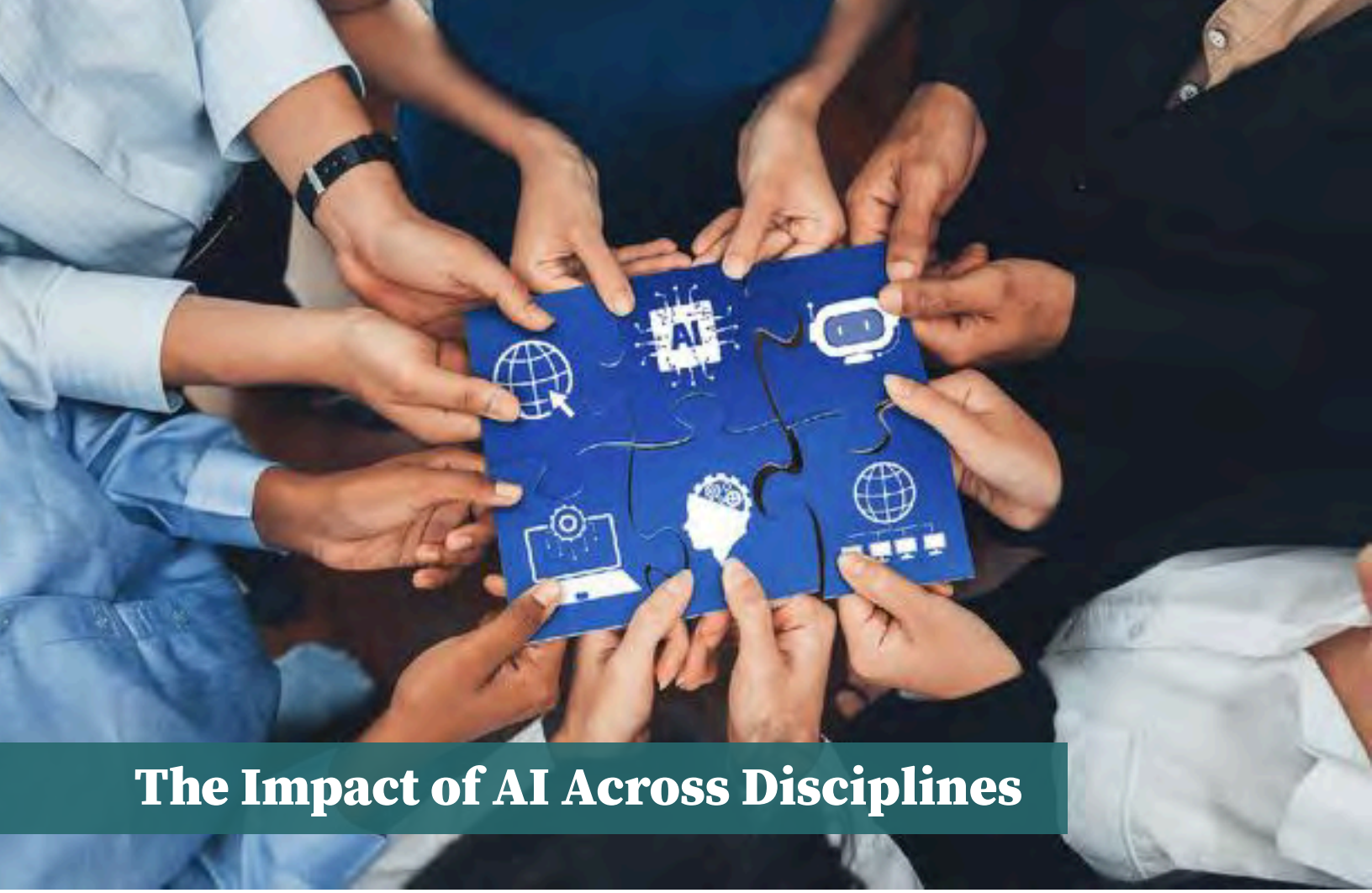
(r) Bjarstin/Pixabay

The Promise and Limitations of AI (continued)

High school and beyond: Older students should begin to look beyond generative AI tools to recognize how biased AI systems amplify systemic discrimination. Beyond chatbots and tools aimed at individual users, embedded artificial intelligence systems are responsible for high-stakes decisions in education, hiring, and the criminal justice system. Engage students in these concepts with a hypothetical hiring scenario. Tell the class that a company HR department has started using an AI tool to screen resumes. Explain that the AI has been trained to look for traits from the most successful employees over the past 50 years. For example, many high-performing workers attended private school and participated in team sports, such as lacrosse or soccer, so the AI eliminates any applicants who didn't attend that school or play those sports. Students will undoubtedly recognize this as unfair, despite it being based on "objective" math or statistics. Use the resulting discussion to introduce concepts of equality and equity, comparing the two.

Assess the competency by having students research real-world examples of algorithmic bias and writing a short report explaining how AI tools and systems contribute to unequal (and often unfair) treatment of different people. Students should be able to successfully articulate how this seemingly neutral technology can result in systemic discrimination.

(b) Andrii Yalanskyi/Shutterstock



The Impact of AI Across Disciplines

Students should explore the impact of artificial intelligence across disciplines, recognizing similarities and differences in the use and effect of AI in different fields.

By examining how artificial intelligence is used in different career fields and areas of study, from commerce and finance to healthcare and medical research, students can learn to recognize that many of the same ethical issues and societal impacts apply to the use of AI regardless of sector. In each case, the specific application of AI may differ, but the risks and benefits may be similar or even identical.

Competency: Understand and describe the impact of AI in different societal sectors

What it means: being able to identify and list common ethical issues and societal impacts of AI use across multiple aspects of society, such as commerce, security, finance, and healthcare (Ng et al., 2022; Chiu et al., 2024)

(t) Summit Art Creations/Shutterstock

The Impact of AI Across Disciplines (continued)

Why it matters: Artificial intelligence looks different in a hospital setting than it does on a banking website, but while the specific application of AI may differ, the risks and benefits are often very similar or even identical. This is in part because of the biases found in AI training data and the unequal impacts of technological advancement across different communities.

Professional adaptability and workforce readiness By seeing that AI is used broadly across a number of different societal sectors, students are able to consider their own career goals and recognize the important of AI skills and knowledge regardless of field. Because the uses of AI tend to be similar even in disparate career areas, students can see how AI literacy can be broadly applicable to any number of careers and a necessary component in workforce development.

Legal literacy and civic responsibility Similar to how recognizing the use of AI in their everyday lives made students aware of the potential for manipulation or deception from AI in seemingly innocuous applications (e.g., music-recommendation engines or social-media feeds), seeing the use of AI in a wide array of fields prepares students for the legal and political realities of living in an AI-enhanced society. Students need to understand how AI is being used in healthcare, for example, in order to make informed decisions about their own medical care and well-being.

If students do not know how AI is being used to make decisions that affect them, they will not be prepared to advocate for their own rights and fair treatment under the law. Students need to understand how AI is used across disciplines to consider issues of accountability and responsibility. Who owns the copyright of an AI-generated song? Who is at fault in a motor-vehicle accident involving a self-driving vehicle? Questions like these are especially important as students engage civically, participating in elections and voting for representative who will be writing and enacting laws that address some of these issues.

(b) Summit Art Creations/Shutterstock

Instructional and Assessment Strategies

Elementary grades: For younger students, this competency can be introduced by highlighting how AI can be used as a tool for many people working in different fields. After discussing the basics of what AI is and the function of some basic AI technologies (e.g., computer vision, recommendation engines, map planning, natural language processing), have students brainstorm how these technologies might support the work that people in different careers already do. You can facilitate this discussion by printing and displaying or projecting pictures of different people at work (e.g., a delivery driver in a truck, a doctor talking to a patient, a gardener working in a greenhouse). Have students identify what the person in the picture is doing and then brainstorm ideas of how different AI tools could be created to support that work. For example, a delivery driver might use AI to plan the best route for making deliveries; a doctor might use an AI to transcribe notes or read medical scans; while a gardener might use an AI tool to identify plant illnesses or spot insect infestations.

(b) Apple Creator Studio

The Impact of AI Across Disciplines (continued)

To provide additional challenge with this activity, students could conduct research or identify some of the underlying technologies that support these different tasks. For example, an AI tool that is identifying plant illnesses or interpreting medical scans is relying on computer vision to "see" the problem; an AI transcribing notes is using natural-language processing to interpret the speech of the user; and an AI route-planning application is using GPS data and an algorithm to find the most efficient route. Students should be able to recognize that many of the same technologies are used across careers, with the end result or benefit being slightly different, because each use of AI is specifically tailored for a particular career or job role.

Middle grades: For older students, the focus should be on the trade-offs and disruptions that come with employing AI across different industries. Students should understand that AI adoption has the potential for significant benefits in different sectors, but it also brings with it risk and serious challenges. To drive this point home, students can engage in a news broadcast "special report" on the impact of AI. Have students work in groups, with each group assigned a different sector (e.g., transportation, healthcare, retail/commerce, entertainment, banking/finance, law/public safety). Have students conduct research and present a two-minute segment for a news program, highlighting at least one benefit and one concern or challenge. For example, when considering the entertainment industry, a benefit might be that AI can generate realistic human-sounding voices for narration and voice-over, but this brings with it the challenges of loss of work by voice actors and the potential legal rights issues related to studios using AI-generated versions of real actors' voices.

To assess students' development of this competency, you can give students a specific writing or discussion prompt about the benefits of AI (e.g., "Hospitals are using AI to diagnose patients faster."). Have students respond to the prompt with a short "Yes, but…" paragraph in which they successfully identify potential challenges or issues with the use of AI from the prompt (e.g., "Yes, this is a great advancement because a faster diagnosis leads to a faster treatment, but it also increases the risk of misdiagnosis if the AI is not properly trained or monitored.").

(bkgd) Apple Creator Studio

The Impact of AI Across Disciplines (continued)

High school and beyond: Students at this level should no longer see AI as a "computer science" concept and should instead recognize it as an interdisciplinary force that is actively reshaping career fields and industries such as medicine, commerce, law, and agriculture. They should be able to see the systemic ripple effects of AI across sectors, from its impact on the global economy to how it is reshaping legal systems in the U.S. and abroad. One way to introduce this concept is for students to participate in a future-thinking exercise: Have students pick a job sector and research how AI is expected to impact that sector in the next few years. For example, students might read news reports that entry-level legal positions are being replaced by AI, which makes finding a job difficult for junior lawyers and recent graduates.

Have students draft a presentation or write a proposal for government or industry regulations to address this problem. Students should be instructed to strike a balance—simply banning AI use is rarely a realistic option—and find a way to protect human workers and consumers while leaving space for industry innovation.

Assess students' understanding of the concept by having them summarize their research findings. Students should be able to detail a real-world deployment of AI, identifying the economic impact (i.e., who makes money and who loses money), determining liability or responsibility for potential mistakes made by AI, and imagining how the deployment of AI will likely change in the next few years.

(r) Jakub Żerdzicki/Unsplash

The Impact of AI Across Disciplines (continued)

Competency: Recognize the human role when describing the impact of development, deployment, and use of AI systems and tools

What it means: being able to articulate how humans create, train, test, deploy, and use AI systems and tools (Ng et al., 2022; Hornberger et al., 2023)

Why it matters: AI is not magic, nor is it a naturally occurring phenomenon like the weather. If students recognize the role of humans in the development, training, and deployment of AI systems, they are better able to dispel the myth of objectivity, recognizing AI's unequal impacts on communities. This competency also enables accountability by recognizing that AI is not autonomous and its use is not accidental.

Dispelling the notion of AI as an "invisible hand" It's easy to see artificial intelligence as an unseen, unknowable force acting on society, affecting individuals and communities. In reality, however, it's a product of humans, used humans who are making the conscious decision to deploy AI systems across different aspects of their personal and professional lives. The ways in which humans select and engage with artificial intelligence systems determines the impact those systems will have on themselves and others.

Assigning accountability When AI is viewed as an autonomous entity, it becomes a scapegoat. Students have likely seen headlines such as, "AI replaces 10,000 jobs" on news sites, but this framing fails to capture the human element of the story. A more accurate headline might be, "Company executives deploy AI systems choosing to lay off 10,000 employees." Artificial intelligence isn't to blame for the impact to the workforce; it's the company management that made the conscious decision to deploy AI for the purpose of reducing labor costs.

(bkgd) Apple Creator Studio

Similarly, people often blame "the algorithm" for what they see on social media feeds, but "the algorithm" doesn't exist in a vacuum. Human programmers created the algorithm for a purpose. Company executives chose to spend resources developing the algorithm. The decision to use the algorithm was made by human managers, and they are the ones who ultimately deserve blame for the effect the algorithm has on users.

Reinforcement learning Students need to understand not only how their use of AI can affect themselves and others, but also how that use has a direct impact on the very AI tools they are using. Modern genAI chatbots learn from the feedback they receive from users. The output for each prompt is followed by "thumbs up" or "thumbs down" buttons that users can use to help train the models to perform better. When students interact with these feedback mechanisms, they are training the model, which affects its future performance.

Recognizing opportunities for reclaiming agency When AI is an unknowable force, it feels inevitable and users feel helpless. By recognizing the role of humans in AI, students can recognize how humans control the system, creating opportunities for reform. Human-controlled systems can be monitored and regulated. Humans can fix AI errors, audit the effects of algorithmic bias, and shut down AI systems that cause harm. Human-in-the-loop strategies for AI management are effective, but they are only possible when you recognize the role of humans within the use and deployment of AI systems.

(b) Apple Creator Studio

The Impact of AI Across Disciplines (continued)

Instructional and Assessment Strategies

Elementary grades: For young students, the goal should be to establish the idea that computers do not have their own thoughts, wants, or ideas. One way to reach this goal might be to show students a video of a helpful or useful robot, such as a robotic vacuum cleaner or a manufacturing robot. Alternatively, read students a story about a fictional helpful robot. Lead a discussion in which students discuss the work that went into creating the robot, from designing the internal mechanisms to writing the computer programs that control the robot's operations. Students should develop the understanding that the robots are human-made systems that are instructed to perform specific functions.

Use discussion questions to encourage students to think about concepts of responsibility related to AI. For example, after showing a video of a robot vacuum, ask, "If the vacuum knocks over a table and breaks a lamp, whose fault is that?" Have students debate whether it is the fault of the robot, the manufacturer, the programmer, or the end user.

To assess understanding, provide the students with various hypothetical actions "caused" by AI and have them identify the human choices behind the actions. For example, for "A learning app gives a gold star for answering a question," students should recognize that programmers created the app. Similarly, for "A smart speaker told a funny joke," students should understand that a human wrote the joke.

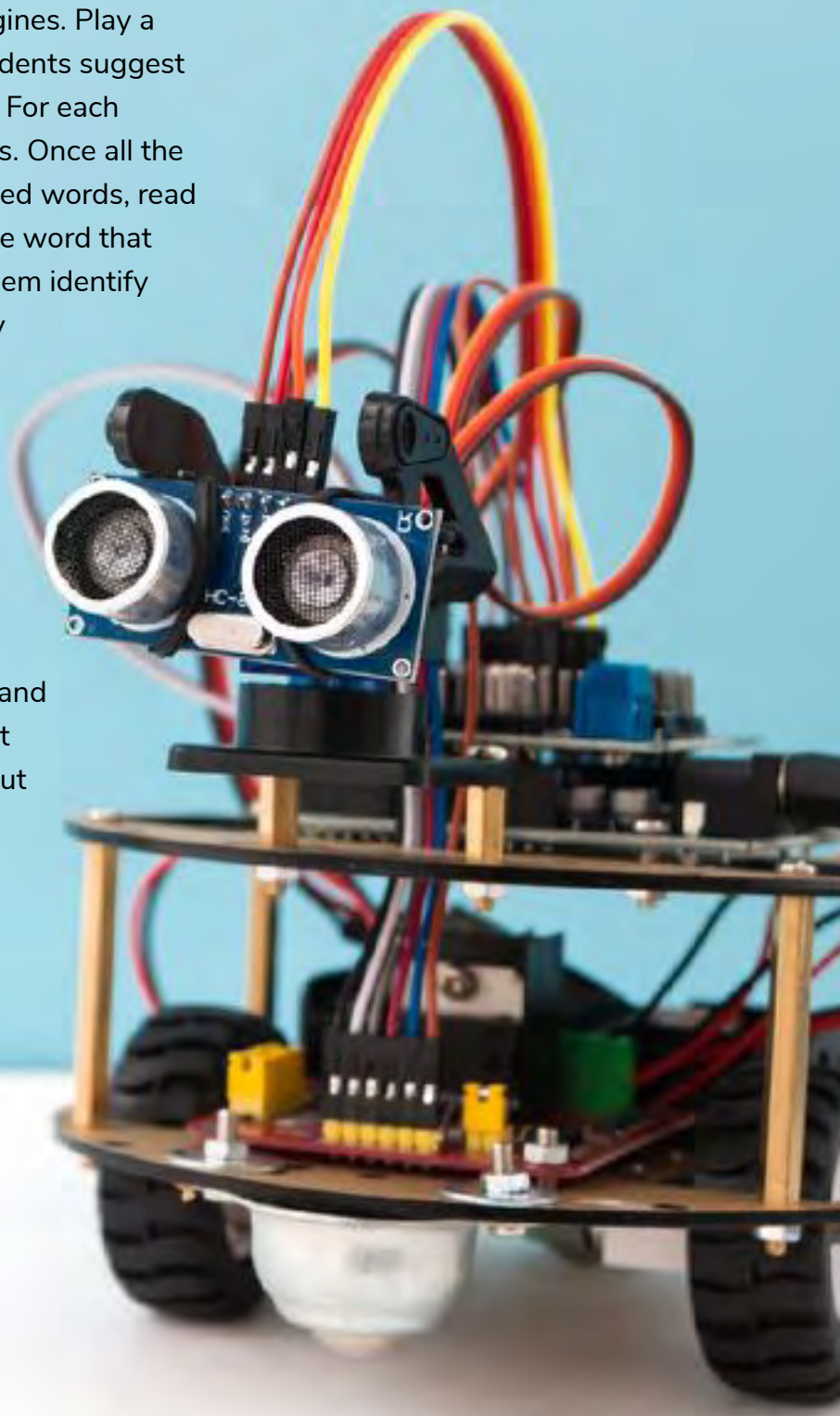
Instructional Idea: To demonstrate how image-generation AI models are trained, play a game of *"Muffin or Chihuahua?"* with students. Quickly flash 20 or more blurry or out-of-focus photos of chihuahuas or blueberry muffins on the board, displaying each for just a few seconds. Have students frantically write down "dog" or "muffin" for each one. After a few minutes, as students begin to get tired and bored, explain to students that this type of training is performed by humans who review and identify thousands of images each hour.

(r) Gerd Altmann/Pixabay; (inset) neurabites.com

The Impact of AI Across Disciplines (continued)

Middle grades: Beyond initial programming, AI systems require significant training. While some of this training is automated, fine-tuning algorithms requires human-supervised training. To explain this concept, remind students that generative AI chatbots are essentially next-word prediction engines. Play a game of Mad Libs as a class, having students suggest nouns, verbs, and adjectives as needed. For each blank, make a list of student suggestions. Once all the blanks have at least four or five suggested words, read the story aloud. Have students select the word that makes the most sense logically. Have them identify the words that are the funniest—usually the ones that make the least sense. Explain that a similar method is used to train the language models that power AI chatbots.

Assess students' understanding of the content by having them identify different human roles involved in the development or deployment of AI tools and systems. Students should recognize that humans not only program these tools, but they also created the data and supervised the training of AI models to ensure they operate correctly.



(bkgd) artist/source

The Impact of AI Across Disciplines (continued)

High school and beyond: Students at this level should move beyond understanding that humans create, program, and train AI systems to recognizing that AI behavior is the result of reinforcement learning from human feedback (RLHF). Explain that genAI chatbot users are presented with "thumbs up" or "thumbs down" buttons to rate the quality of the response. Because people generally respond positively to—and tend to "upvote"—friendly and polite text, chatbots have become increasingly helpful and tend to heap praise on the user (e.g., starting replies with "That's a great question!"). In other words, the actions of everyday users of AI affect its behavior and operation for everyone.

The human role in AI deployment also includes accountability. Assess students' understanding of this concept by having students rewrite headlines and new stories that scapegoat AI and blame the tools and systems for negative outcomes. For example the headline, *"Will AI Replace Your Job?"* could be revised to reflect humans' role: *"Will Business Executives Combine Layoffs with Deployment of AI Systems?"*

(b) dee.karen/Shutterstock

Competency: Understand and describe the role of data in the impact of AI use

What it means: being able to explain AI training data and articulate how it contributes to the functionality of AI tools and systems (Hornberger et al., 2023)

Why it matters: The quality of the output of a system is directly tied to the quality of the input. In the case of AI, flawed and biased training data lead to perpetuation of bias in generated output. By understanding the role of data in AI, students are better positioned to question the collection, quality, and ownership of those data, rather than simply accepting AI output as an objective creation.

Making AI learning visible To fully understand how AI systems work, students need to understand the role of data and recognize that modern generative AI tools aren't preprogrammed with responses and interactions. Instead they are trained with data to learn patterns from examples and reproduce those patterns in novel ways. The quality of the examples affects the quality of the output generated.

Highlighting the importance of data In the AI ecosystem, data becomes a form of currency. So-called "free" AI tools are often made available at no cost because the tech companies that deploy them are able to harvest data from users. Individual users are "paying" for the use of the tool with personal data (e.g., photos, text, voice, feedback and ratings), which can then be harvested to train future models. Students should think about this when they use AI models and tools, considering issues of data sovereignty, and asking questions like, "Who owns the essay I just uploaded in this AI chatbot?".

Without access to data, AI tools cannot function. For example, maps apps regularly harvest users' location data, even when they are not actively using navigation functionality. Millions of devices provide real-time location data, including parameters such as speed and direction, which the models use to determine relative levels of traffic on different streets and plan the most efficient routes from one location to another.

(bkgd) Apple Creator Studio

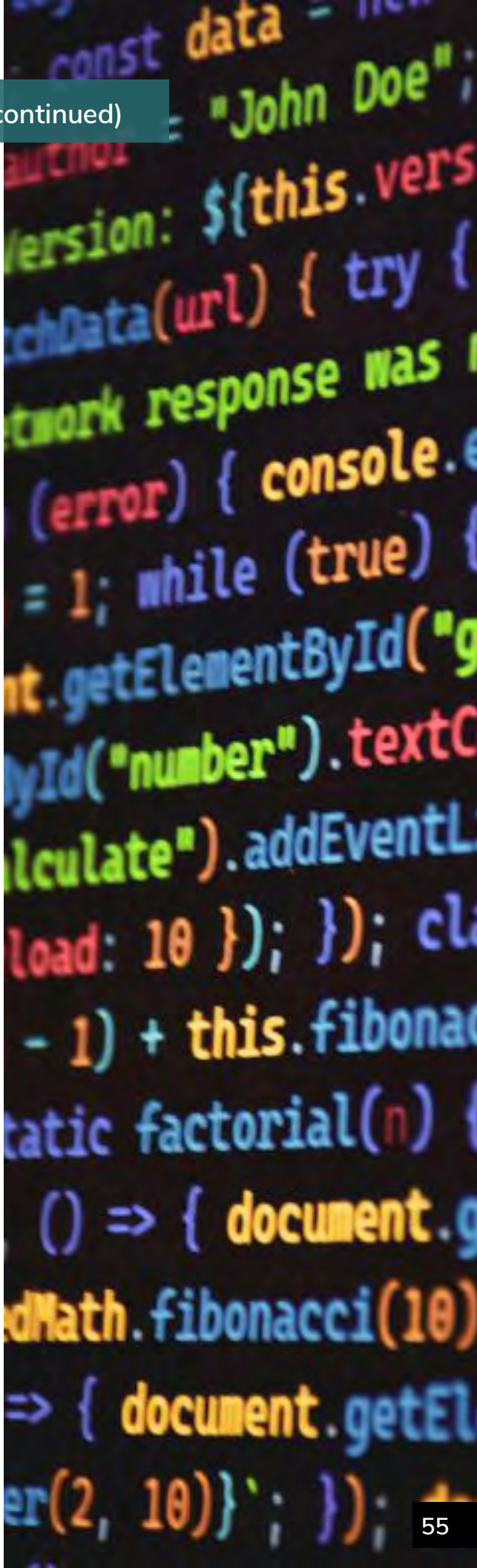
The Impact of AI Across Disciplines (continued)

Ethical questions and data quality Students need to understand that AI models are trained with human-created data, which are inherently flawed. If a company uses hiring data and employee records from the past 50 years when training an AI-powered human-resources system, for example, they are potentially—and inadvertently—training that model to exhibit discriminatory practices, since the employees from a half-century ago are not likely to be representative of today's hiring practices.

In addition, students should understand that AI models are often trained on copyrighted books, artwork, and computer code without the consent of the original creators. The knowledge contained in these data sources is essential for the AI tools to function, but its use raises serious ethical questions about what constitutes "fair use" and where the line should be drawn when defining theft of intellectual property.

Instructional and Assessment Strategies

Elementary grades: Students need to understand the role of data in AI in order to recognize AI as a system built on information—and often, human bias. Introduce the competency to students by discussing how AI tools are trained and how they learn. Divide the class into groups. Give each group the same set of 20–30 images and have the students work together to categorize each photo as being "pretty," "scary," "majestic," "dull," and "interesting." Inform students that each photo can have only one category. When students have finished, have them compare results. Through a wrap-up discussion, students should begin to understand that the category each image was placed in is the result of the opinions of each group. Encourage students to consider the implications of an activity like this being used to train AI models.



(r) Peaky Frames/Unsplash

To assess students' understanding of the importance of high-quality data for AI, display an image dataset showing four pictures of sheepdogs and one picture of a mop.[6] Ask students to identify the one image that stands out. Ask what would happen if all the images were labeled *sheepdog* when training an AI. Students should recognize that bad data—including inaccurate labels—will affect performance of an AI model.

Middle grades: The focus at this grade level should include the concepts of "garbage in, garbage out" and algorithmic bias. One way to demonstrate these ideas is by intentionally "poisoning" the data used in recommendation engines, such as those found on video-sharing and music-streaming sites. Start by creating a new account and selecting only one type of music or video content (e.g., only classical music or videos about cars). Once the site consistently recommends content similar to your previous selections, have the class brainstorm what other content types might change the recommendations (e.g., heavy-metal music or children's videos). Select these other content types and track how long it takes for the algorithm to change its recommendations.

Discuss with students how AI reproduces patterns found in the data used to train it. Students should recognize the importance of "clean" data. Encourage students to consider how our own biases might affect the output produced by AI tools and systems.

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[6] The ideal pictures will look very similar at first glance. See neurabites (Lee, 2021) for additional examples (e.g., fried chicken or poodle, shar-pei or towel).

(b) Thanadon88/Shutterstock

The Impact of AI Across Disciplines (continued)

High school and beyond: For older students, begin to expand the conversation to include concepts of ethics, data privacy, large-scale datasets, and automated discrimination. Drive student understanding of these concepts with real-world case studies or highly realistic scenarios demonstrating the impact of biased data on AI decisions. For example, describe a situation in which a company uses AI tools to screen resumes and job applications. Explain that the AI is basing decisions on the names, backgrounds, work experience, and education of its most successful employees over the past 100 years. Use this scenario as the basis for a class discussion encouraging students to consider problems with the company's strategy. Students should recognize that the company's workforce may have lacked diversity 100 years ago, which means the AI will likely show bias toward white, male applicants. Students should also recognize the potential socio-economic bias inherent in showing preference for candidates who had attended specific schools or received certain degrees.

(bkgd) patpitchaya/Shutterstock

Rights and Responsibilities

Students should understand personal and societal rights and responsibilities related to the use and deployment of artificial intelligence tools and systems.

While discussions of ethics often include concepts of responsibility and accountability, it's important for students to also consider their own rights as it relates to artificial intelligence and its use. Individuals should be protected from harm or discriminatory practices automated by AI. They should have autonomy over the data they share and how those data are used. At the same time, tech companies and those who deploy AI systems need to consider how they can ensure these rights are protected when developing and launching new tools.

Competency: Understand and demand contestability

What it means: being able to recognize AI-mediated or AI-automated decisions that might have a negative impact on individuals and articulate why humans deserve the right to appeal such decisions (Walmsley, 2021)

(t) Apple Creator Studio

Rights and Responsibilities (continued)

Why it matters: An algorithm should never have the final say on any aspect of human life. This competency arms students with the confidence to say, "This decision is wrong, and I would like a human to review it," preserving the democratic principle that citizens are accountable to laws and people, not computers and code.

The right to an explanation Anyone who is affected by a decision made or mediated by AI should be able to get a clear, plain-language explanation of how that decision was made. The concept of "innocent until proven guilty" is at the core of the U.S. justice system. The same concept should apply to AI-based decisions, such as AI-based test-proctoring or surveillance systems that flag "suspicious behavior."

Requiring human-in-the-loop governance Demanding contestability means insisting that a *human being,* and not just another piece of software, review the decisions made by automatic AI systems. Only humans can understand context and exhibit empathy. A human must be a part of any system in which AI can deny people opportunities or otherwise negatively affect them. Students should recognize the potential negative impact of AI-automated hiring practices, AI-powered surveillance and monitoring, and AI-determined loan and credit decisions and be able to articulate why humans need to be the final arbiters of such decisions.

Instructional Idea: A key to being able to demand contestability is the recognition that computer systems and AI tools are not infallible. To drive this point home, generate images with genAI tools and have students point out flaws and errors they notice (e.g., incorrect proportions, missing or distorted faces, extra or missing limbs, etc.). Lead a discussion by asking, "If the computer makes a mistake here, where else might it make a mistake? Is it okay to tell the computer it's wrong?"

(bkgd) Apple Creator Studio; (insect) AI-generated/DALL-E 2, OpenAI

Instructional and Assessment Strategies

Elementary grades: In the context of AI literacy, contestability is the ability for a human to challenge, appeal, or demand an explanation for an AI-generated decision. It moves students from being passive recipients of algorithmic output to active, critical agents. Teaching this requires creating a classroom culture in which "The computer said so" is never an acceptable final answer. One effective strategy for managing this switch is a role-playing activity in which the teacher or a student makes seemingly arbitrary, unfair playground or classroom rules (e.g., "Only people wearing blue can use the slide"). Students can then take turns "contesting" the rule, explaining why it is unfair and suggesting a revision or an alternative rule (e.g., "Everyone who wants to use the slide should form a single-file line").

Middle grades: Once students understand that AI systems can make mistakes and that humans have the right to point out those mistakes and demand fairness from AI systems, the instructional focus should move to the need for human supervision and intervention in the deployment of AI tools, such as AI chatbots and autonomous AI agents. Students can learn this through self discovery by using genAI chatbots for research or computer-vision identification (e.g., identifying plants or animals in an image). Have students find cases where the AI is confident but wrong. Lead a class discussion using those examples to have students brainstorm what information they would need to successfully "argue" with the AI. Instruct students to adopt a "manager" mindset when using AI tools, encouraging them to "push back" on an incorrect or suspect response from an AI chatbot by asking questions such as "What is your source?" or "How sure are you about your response?" or "Can you explain your reasoning?"

(r) Tingey Injury Law Firm/Unsplash

Rights and Responsibilities (continued)

High school and beyond: Older students should begin to look beyond individual AI-user interactions to understand systems of recourse, AI-rights policies, and the impact of transparency on individual users' rights. Introduce these concepts through a whole-class mock-trial activity in which one student plays the role of an applicant who was denied college admission because of a decision made by an AI system. Other students can play the roles of the college admissions officer, the AI developer, members of the jury, the judge, and the attorneys for both the student and the college. The person affected must argue for their right to a human review of their application by identifying or specifying how their application data might have been misinterpreted. The AI developer needs to explain how their AI tool came to the decision, and the college admissions officer must justify the use of AI. The jury can decide if the person affected successfully made their case.

An effective assessment for this competency would be for students to work in groups to draft a "Student Bill of Rights for AI" for their school. They must include policies for AI use and a specific process for how a student can challenge a grade if an AI tool was involved in the decision-making process.

(bkgd) Joe Yates/Unsplash

Competency: Use AI for creative problem solving

What it means: being able to design solutions to complex problems that can be solved or addressed using artificial intelligence, articulating what the AI tool or system is expected to do and how it addresses the problem (Ng et al., 2022)

Why it matters: AI does not solve problems on its own, but it can be a powerful tool to address some of the world's most complicated issues. This competency allows students to see themselves as co-creators, working *with* AI applications, which are not all-knowing answer machines, but tools that enable creativity and ingenuity.

Brainstorming and rapid prototyping The nature of artificial intelligence makes it the perfect tool for thinking through a large number of ideas in a short period of time. With AI-powered simulations, students can come up with a solution, determine how their solution meets the criteria of the problem while remaining bounded by given constraints, and think through the testing process, iterating on their initial designs. AI can "build" and "test" their solutions in simulated environments, saving time, materials, and construction costs while allowing students to repeatedly test potential solutions.

AI can support the rapid development of many solutions and creative proposals, serving as a sounding board and a partner for divergent thinking. AI tools can instantly generate 50 unique angles on a topic, allowing the user to push past their initial ideas quickly. At the same time, through the use of personas, AI tools can play a"devil's advocate," critiquing students' ideas, which allows them to refine their thinking and forces them to develop responses to real critiques their peers or teachers might have.

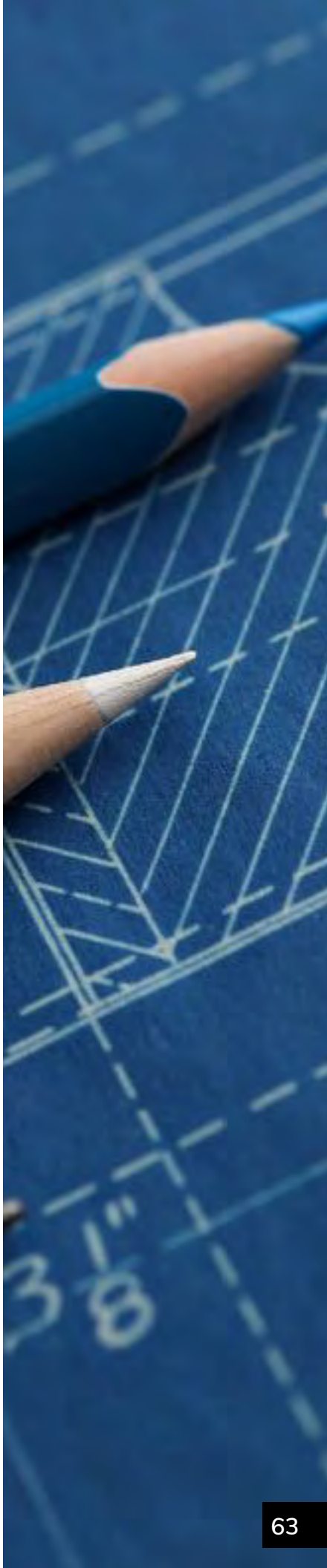
(b) Apple Creator Studio

Multimedia and interdisciplinary solutions Complex problems are rarely solved by one, simple idea. AI excels at finding patterns across different fields. Students can use AI to find analogous solutions from unrelated fields and apply those solutions in novel ways to new problems. It also empowers multimodal expression, letting students to find the best medium to solve a particular problem or issue, rather than rely on only the modes of expression in which they already excel.

This competency recognizes the responsibility we all have to use the power of AI for tackling real-world problems, moving students from using AI as a "magic answer machine" to engaging with it as a collaborative partner. Creative problem solving with AI involves iterative prompting, combining AI outputs with human intuition, and using the technology to bypass technical barriers to reach higher-level design through human-AI co-intelligence.[7]

Instructional and Assessment Strategies

Elementary grades: The key to developing this competency is ensuring that students recognize the skills and abilities that are uniquely human, such as creativity or making critical judgments, and differentiating those abilities from the things AI tools and systems do well, such as performing complex calculations and processing data. AI can be used to brainstorm a list of solutions to a problem, but it takes a human to evaluate which solutions are viable. Demonstrate this fact by having students work with age-appropriate AI models to generate a list of possible solutions to various classroom problems (e.g., cables from headphones get tangled when they're stored or the chairs make a lot of noise scraping on the floor). Have students work in groups to review the proposed solutions to the problem and work with the AI chatbot to refine their solution. Then have students sketch their solution, noting the supplies they'll need. Once approved, students can construct and test their AI-collaborative solutions, iterating on their designs as needed.



(r) Apple Creator Studio

[7] The concept of *co-intelligence* merges uniquely human skills and attributes with the functions well suited to AI. Boussioux et al. (2024) propose a crowd-sourcing co-intelligence model to creatively solve complex problems.

Rights and Responsibilities (continued)

Review students' solutions as part of a whole-class discussion. Students can demonstrate knowledge related to this competency by correctly categorizing steps in the development of each solution as something AI could do alone, something that humans could do alone, and something that involves collaboration between a human and AI.

Middle grades: Older students should begin to recognize that AI's potential can be used to create solutions that aren't possible with humans alone. A hands-on prompting activity can be used to support students' understanding of this competency: Provide students with a list of real-world or realistic global problems that AI could be used to solve (e.g., plastic waste in the ocean or rising carbon emissions from transportation), have them work in groups to select one problem and use AI to devise a solution. Encourage students to start with relatively simple prompts and then iterate on their prompts, adding more detail each time. Students should see a correlation between the effectiveness of AI as a tool and the quality of the AI's responses and the amount of effort and human-input required.

As students refine their solutions using AI tools, they should conduct additional research, create sketches and diagrams for their solutions, and prepare a final presentation sharing their chosen solution. Assess students' understanding of how AI can be used for creative problem solving by examining not just their final solution materials but by reviewing their prompt logs as well. Students should be evaluated on how they edited, challenged, or reorganized the AI's draft to fit their specific needs and best address their chosen problem.

(b) Apple Creator Studio

Rights and Responsibilities (continued)

High school and beyond: The focus at this grade level should be complex system design and human-AI co-creation. Encourage students to follow a three-step creative loop: spark, sift, and synthesize. For the initial phase, students should use AI to generate a wide range of "raw materials" (e.g., ideas, sketches, outlines). Students then sift through these initial results, using critical thinking to select and combine the best pieces for the most effective solutions. Students add the “human element” in the final synthesis step, applying a contextual lens, using emotional intelligence and higher-order thinking, and creating and executing a plan for the final product.

Student understanding can be measured with a performance assessment in which students apply this creative loop in a real-world context. Have students work in groups to identify a community need, problem, or issue (e.g., food deserts or a lack safe, walkable neighborhoods). Have students conduct research, and then use AI to analyze data from their research and provide initial solution concepts. As student groups sift through the AI output and synthesize a solution, they can also use AI tools to generate a logo/brand for a non-profit organization. Groups can present their solutions along with a business proposal. A post-project reflection can illustrate students’ understanding of how AI extends their creativity and supports critical thinking to help generate solutions to problems.

(bkgd) Apple Creator Studio

Our Future with AI

Students should consider current artificial-intelligence technologies and predict the future of artificial intelligence and its effect on society.

The rapid growth, development, and deployment of artificial intelligence tools and systems in the past few years has underscored their importance in everyday life. Artificial intelligence is no longer a speculative technology but a pervasive force shaping labor markets, governance, culture, and everyday decision-making. From convenience in route planning and trip scheduling to support of educational outcomes to automating cybersecurity and data protection, AI touches every aspect of our lives. Staying current on these technologies—and envisioning how they will change, grow, and affect society—is essential for AI-literacy.

Competency: Imagine future AI tools and systems

What it means: being able to extrapolate potential advances in AI technology and articulate how those advancements might impact society, describing both potential benefits and drawbacks (Long & Magerko, 2020; Ng et al., 2022)

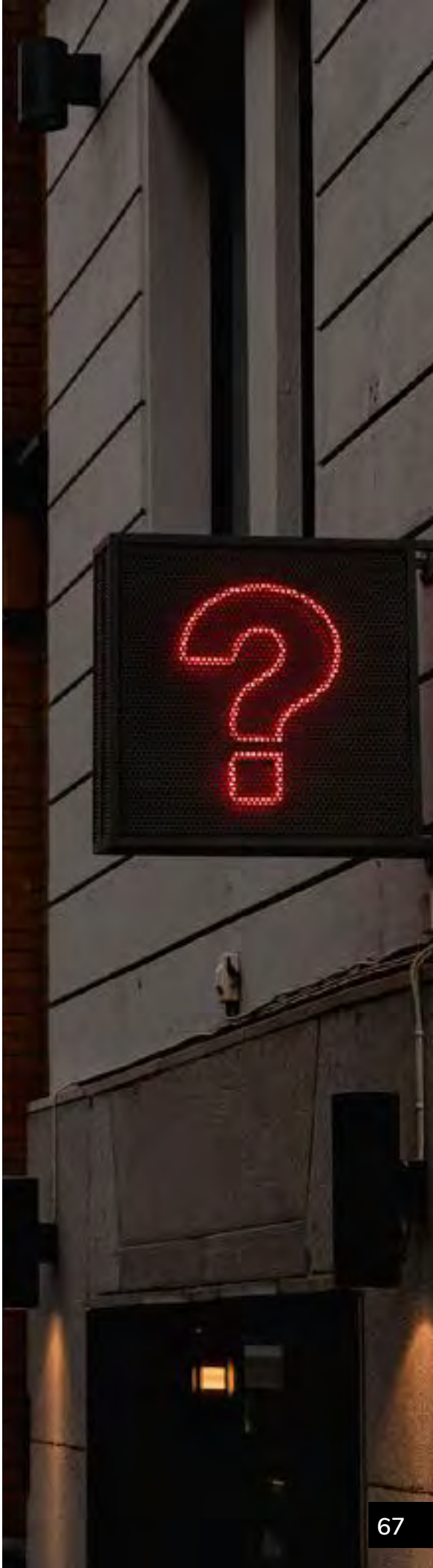
Why it matters: If students only learn about AI as it exists today, their knowledge will be obsolete by the time they graduate. This competency empowers students to look beyond the horizon and anticipate the possible benefits and risks associated with technological advancement, combining historical and contemporary knowledge with both logic and creativity.

Our Future with AI (continued)

Acknowledging an unwritten future Technology adoption—especially very rapid adoption like we've seen with generative artificial intelligence—can sometimes give the impression that the advancement of technology is inevitable, almost predetermined. If students can imagine the future of artificial intelligence, they can consider different paths that future might follow. They will be better positioned to see AI, like all technology, as a tool implemented by humans, supporting human connection rather than replacing it, empowering people rather an taking something away from or happening to them.

Future casting for AI technologies AI-literate students understand what AI technologies can do *now.* They understand the functionality, the benefits, the promise, and the drawbacks. They see how different AI technologies can work together for a specific purpose, from self-driving vehicles to unlocking computers and mobile devices to generating text and images. Imagining a future gives students the opportunity to consider how those technologies might evolve in the future. They can see how today's AI technologies can be rearranged and assembled in novel ways to enable new functionalities and solve specific problems. They can predict how advancements in these technologies will enable the solving of more advanced problems for individuals, organizations, and society as a whole.

This type of future visioning also helps students to think about the potential downsides and plan for them—or work to counteract them. They can imagine the future impact of a technology and begin to debate the new ethical challenges these advancements might bring about. They can look for, consider, and even begin to plan solutions for the unintended consequences of advancement, identifying the second-order effects of tomorrow's AI-enabled world.



(r) Uladzislau Petrushkevich/Unsplash

Our Future with AI (continued)

Instructional and Assessment Strategies

Elementary grades: To get younger students to imagine future artificial intelligence, they need to consider what AI does now and how it is used as a tool. To reinforce the concept of AI as a tool, have students imagine a "smart" backpack for the year 2040. Ask students what problems it will solve and how it will make students' lives better or easier. Students might suggest, for example, that it will keep their lunch at the perfect temperature or remind students what to pack based on their schedule or their class assignments. Encourage students to draw a diagram of this futuristic, AI-powered backpack and label the various sensors it would need to function (i.e., a camera, a built-in clock/calendar, a thermometer).

A writing assignment or activity could be used to assess students' understanding of the impact of more powerful AI tools. Give students the following prompt: "If I had a robot to help me at home, it would help me by _____, and I would have more free time to _____." Have students write a story based on the prompt. If they struggle, encourage them to consider how the robot could help other family members with their work, chores, tasks, etc. When students share their stories, ask each student to identify at least is one thing their robot would not be able to do. Use their answers to fuel a discussion about the boundaries or limits of artificial intelligence.

(bkgd) Christopher White/Pixabay

Middle grades: While more advanced AI systems have the potential to improve lives, not all possible outcomes are positive. As students move beyond seeing of AI solely as a helpful tool, they should start to consider the unintended consequences surrounding continued deployment of advanced AI. Start by having students consider a local problem that future AI could solve (e.g., plastic litter in a local lake or park). Have students create a sales pitch or proposal for their AI-powered solution, including what data it will collect, how humans will interact with it, and how it will address the problem.

After they present their sales pitch, have students write a short story that considers the unexpected outcomes or unintended consequences. Ask students to brainstorm at least one way their proposed solution could "go wrong" if it was given bad data or manipulated by someone with bad intentions. Have students to share their stories as part of a digital storytelling project.

High school and beyond: Older students should be able to consider the use of AI across disciplines and societal sectors and how those uses will likely change in the near future. To develop this understanding with students, have them research an industry (e.g., medicine/healthcare, commerce, finance, law, art) to better understand how AI is currently affecting jobs within that industry. Have students brainstorm how the use of AI will change and grow in the next several years for the various roles and careers within that field. Then, hold a "Future of Work" conference, with students presenting their findings to the rest of the class. Encourage students to highlight uses of AI that do not simply *replace* existing job roles but instead *augment* or *improve* them.

Assess student understanding by asking about the capability of future AI (i.e., *What can this tool do that today's tools cannot?*), the constraints in place to prevent misuse or unintended consequences (i.e., *What prevents this tool from making mistakes or doing all parts of a job?*), and the consequences (i.e., *If everyone had these AI tools, how would the world change tomorrow?*).

(bkgd) Omar Lopez-Rincon/Unsplash

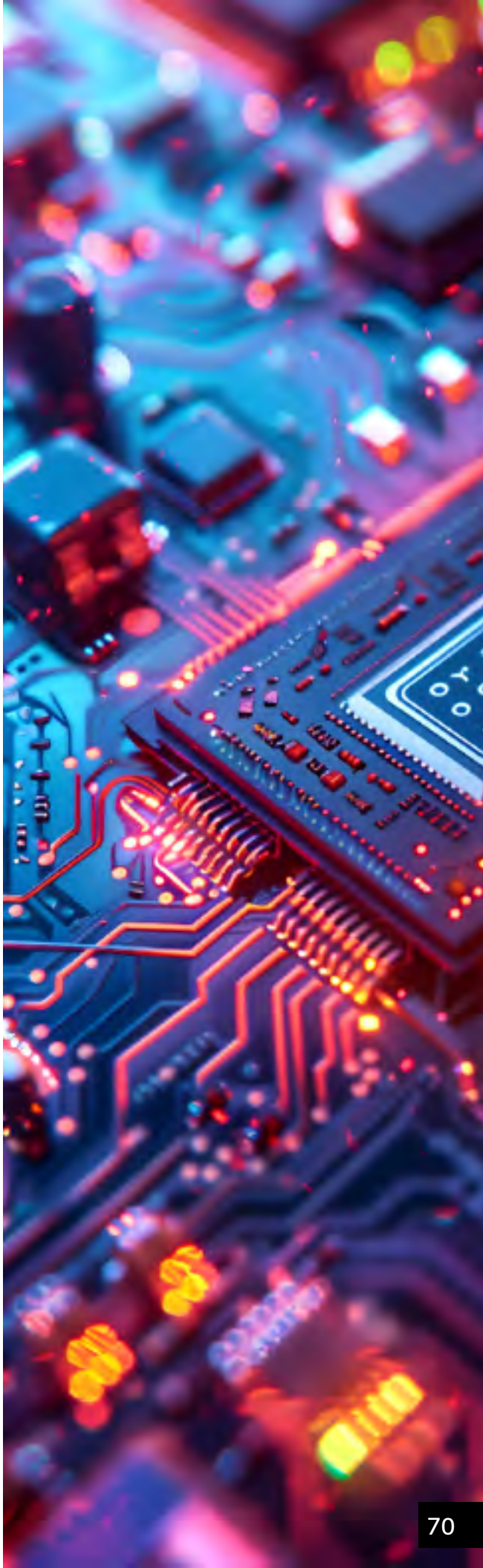
Competency: Engage in human-AI collaboration

What it means: being able to plan engagement and interaction with AI tools and systems based on identified strengths and weaknesses of both human users and AI tools, finding efficiencies and opportunities for innovation (Pinski & Benlian, 2023)

Why it matters: Beyond just accepting that AI is here to stay, students need to understand that an AI-enabled future will be one in which knowledge workers engage in a "hybrid intelligence" by weaving AI use into a natural workflow. This competency helps students shift from a "humans versus AI" mindset to a "humans plus AI" way of thinking, paving the way for digital fluency and workplace innovation.

AI partnership Humans have strengths, such as creativity and imagination, as well as skills related to emotional intelligence like empathy and compassion. AI tools and systems, on the other hand, excel at rapid completion of repetitive tasks, analyzing data, and generating content quickly and efficiently. Neither human nor AI is the "perfect" employee for any one job role; however, a smart human working *with* a properly trained AI model can be the perfect recipe for any number of career paths. Students need to learn to see AI not as competition or a replacement for human workers but as a tool that goes beyond *supporting* human work to *enhancing* it. AI can be a powerful tool to support critical thinking and enable *hybrid intelligence.*[8]

[8] Cukurova (2025) proposes another model for human-AI collaboration, *hybrid intelligence,* which envisions an evolution of AI use from (1) externalizing cognitive process through automation, to (2) using AI as a "trigger" to spark learning and make users' own mental models visible, and finally to (3) extending human cognition through high levels of human-AI interaction.



(r) Leo/Pixabay

A well-trained, specialized AI tool can provide the coding expertise of a programmer, the artistic skills of a graphic designer, and the writing ability of a journalist, but that AI tool still lacks the ability to think creatively, brainstorm, experience sparks of inspiration, or understand emotion. Humans can fill-in these gaps, adding real-world context, empathy, common sense, and creativity. Students need to frame their work with AI as a relationship in which they are the "pilot" and AI is the "co-pilot": The human is in charge and making the decisions, but the AI supports them in what they do and can take over with certain key tasks.

Collaboration and hybrid workflows The future of work will undoubtedly involve partnering with AI tools. Students can prepare for this type of collaboration not by generating outputs from genAI tools and accepting them as they are, but by engaging in a back-and-forth dialogue with AI tools, guiding, correcting, and refining the responses from AI until the output perfectly meets the needs of the project. Framing work as a "partnership" keeps students emotionally and intellectually invested in the work and positions the AI as an assistant or tool, rather than a shortcut to results.

Multitasking and, perhaps more importantly, *task switching*, are the key abilities that enable this competency. Students need to know how to work AI into a natural workflow, switching seamlessly between deep human thought for planning, AI execution for initial drafting and iterating on a solution, and back to deep human thought for editing and polishing. Beyond separating "human" tasks from "AI" tasks, students need to consider both *when* to hand off a task to an AI tool and *which* AI tool is best for the task at hand.

(b) Apple Creator Studio

Instructional and Assessment Strategies

Elementary grades: Human-AI collaboration is about more than just *using* AI tools; it's about teaming or partnering *with* AI, creating a relationship where the student acts as pilot while the AI serves as a powerful co-pilot. For younger students, this understanding can be supported through hands-on use of AI tools to co-author a story. Provide students with the prompt: "Once upon a time…". Have students finish the first sentence of the story in their own words, using their own ideas. Then, have them create a prompt for an AI chatbot[9] to write the next sentence in the story. The students should review the AI-generated sentence and decide if it "makes sense" for the story they have in mind. If not, they should edit the sentence as they see fit before writing the next sentence on their own. Have the students tell the AI chatbot how they edited the AI-created sentence and also provide the student-created sentence that follows, instructing the chatbot to write the next sentence in the story. Students should continue this back-and-forth co-writing activity, reviewing and editing the AI's responses before adding their own content, until the story is finished. Have students share their final stories with the rest of the class.

Reinforce the concept of human-AI collaboration by having students print-out their finished stories. Give each student three highlighters in different colors. Instruct students to use one color to highlight the sentences they wrote on their own. Inform students that the other two highlighters are for what the AI wrote: One color should be used to highlight the text that was generated by the AI chatbot that the student left as-is; the remaining color should be used to highlight sentences that were initially generated by AI but later edited by the student. Encourage students to reflect on the experience and examine the highlighted text to visualize how much of each story was AI generated, how much was written by a human author, and how much was "co-authored," with a human editing what the AI generated.

[9] You may need provide assistance in formulating the prompt or may wish to provide the prompt for students to ensure the AI is instructed to provide only one sentence. Alternatively, a customizable AI agent can be created and shared with students to provide the necessary framework for the activity.

(bkgd) Michaela/Pixabay

Our Future with AI (continued)

Middle grades: Another activity that engages students in human-AI collaboration is using AI as a debate partner. Have students prepare for a debate by researching a specific topic, either student-chosen or assigned. Once students feel that they are ready for the debate, have them "hire" an AI agent or chatbot to role-play the opposing side. Students must listen to the AI's arguments and rebut them using their own researched facts. A second student could moderate the debate and act as a fact-checker for the AI. Review students' prompt logs or chat transcripts to evaluate their ability to collaborate with AI. Students who are proficient in the competency will not always accept AI responses at face-value, and will instead "push back" or challenge the AI when appropriate.

Another method for assessing this competency is to lead a reflective discussion following an activity in which students made use of AI to support writing, research, or study. For writing activities, have students assess the quality, tone, and voice of the AI-generated content and consider the extent to which these things contributed to whether they kept or rejected AI-generated text. For research-related AI use, students should consider the factual accuracy of the content they got from the AI tools. Students should recognize the value of AI while simultaneously acknowledging the need for human intervention and decision-making.

High school and beyond: Have student groups use an AI to generate a solution to a complex problem (e.g., urban planning layout). Once they have an AI-generated solution that is sufficiently detailed, instruct students they are going to form a "red team" to evaluate the AI-generated solution. Have students thoroughly research and review the proposed solution to find flaws, biases, factual inaccuracies, and practical impossibilities. Have them draft a report and share their findings. Then, have students work with the AI tool to fix the issues they discovered.

(r) Apple Creator Studio

When providing instruction on human-AI systems, provide students with a three-level scale to measure the level of collaboration. At the lowest level, the AI does all or most of the work; the human copies and pastes the AI output and clicks "Submit." Students should recognize that this level should be avoided for schoolwork. If students struggle with understanding *why* this level should be avoided, use the analogy of going to the gym and lifting weights: You can pay someone else to go and lift the weights for you; the weights still go up and down, but you're not getting anything out of it.

A medium level of collaboration involves the human providing the initial idea. AI drafts a response, and the human edits. Students should recognize that while this level is acceptable, they can be even more collaborative. At the highest level of collaboration, the human and the AI engage in a back-and-forth dialogue, where the human constantly steers, corrects, and adds unique context the AI lacks. The final product is better than anything either the AI or the human could have created on their own. This should be the target for students' collaborative efforts involving AI. Encourage students to evaluate their own use of AI on this three-level scale when they use AI for schoolwork.

Teaching Tip: Students are often interested in using AI chatbots like a personal tutor or study coach, helping them to manage their time, plan projects, and break complex assignments into chunks. Research has shown[10] that when teachers encourage students to use AI for such tasks—and other uses of AI beyond getting quick answers—students experience higher rates of academic success. An AI-powered study coach can support learning, enable critical thinking, and improve study habits.

[10] See Patac & Patac (2025) or The Week (2023)

(bkgd) Apple Creator Studio; (inset) AI-generated; Google Gemini

AI Literacy Outcomes and Competencies

Outcome 1: Students should have foundational knowledge related to artificial intelligence and an understanding of how AI technologies work together in different aspects of their lives.

- Competency 1.1: Define artificial intelligence
- Competency 1.2: Recognize AI in everyday life
- Competency 1.3: Understand AI as a collection of technologies

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Outcome 2: Students should recognize the ethical implications related to the creation, deployment, and use of artificial intelligence tools and systems.

- Competency 2.1: Apply AI ethics
- Competency 2.2: Assess the societal implications of AI
- Competency 2.3: Evaluate AI transparency

Outcome 3: Students should exhibit technical skills related to the use of AI tools and the interpretation of the outputs they generate.

- Competency 3.1: Apply prompt engineering strategies
- Competency 3.2: Apply ethical principles when writing AI prompts
- Competency 3.3: Critically evaluate the output generated by AI tools

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(bkgd) artist/source

AI Literacy Outcomes and Competencies (Continued)

Outcome 4: Students should be able to describe both the benefits and the drawbacks related to the use and deployment of artificial intelligence tools and systems.

- Competency 4.1: Recognize the strengths and weaknesses of AI
- Competency 4.2: Analyze AI tools and systems for bias, fairness, and equity

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Outcome 5: Students should explore the impact of artificial intelligence across disciplines, recognizing similarities and differences in the use and effect of AI in different fields.

- Competency 5.1: Understand and describe the impact of AI in different societal sectors
- Competency 5.2: Recognize the human role in describing the impact of development, deployment, and use of AI systems and tools
- Competency 5.3: Understand and describe the role of data in the impact of AI use

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Outcome 6: Students should understand personal and societal rights and responsibilities related to the use and deployment of artificial intelligence tools and systems.

- Competency 6.1: Understand and demand contestability
- Competency 6.2: Use AI for creative problem solving

Outcome 7: Students should consider current artificial-intelligence technologies and predict the future of artificial intelligence and its effect on society.

- Competency 7.1: Imagine future AI tools and systems
- Competency 7.2: Engage in human-AI collaboration

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About CETE

The Center on Education and Training for Employment (CETE) occupies a unique position as a translational research center within the College of Education and Human Ecology at The Ohio State University, leveraging partnerships with a wide variety of organizations. The center collaborates with the Ohio State community; workforce development, artificial intelligence, education and training, and community engagement research communities; and other partners who engage CETE in funded projects to empower individuals, families, organizations, and communities. CETE's mission is to translate research into practices resulting in a prepared and effective workforce and healthy communities that support well-being and economic prosperity. CETE fulfills its mission by conducting applied research, development, evaluation, and policy analyses.

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