THOMAS K. F. CHIU

Empowering K-12 Education with AI

Preparing for the Future of Education and Work

First published 2025

ISBN: 978-1-032-81155-0 (hbk)
ISBN: 978-1-032-81154-3 (pbk)
ISBN: 978-1-003-49837-7 (ebk)

Introduction to Transforming K-12 Education with Artificial Intelligence

One

DOI: 10.4324/9781003498377-1

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

Introduction to Transforming K-12 Education with Artificial Intelligence

One

AI transforms classrooms into playgrounds of discovery, empowering students to dream big and shape their exciting futures!

Thomas K. F. Chiu

1.1 INTRODUCTION

Artificial intelligence (AI) is on the verge of profoundly transforming global economics and shaping the future workforce. According to a report published by the International Monetary Fund, around 40% of the worldwide workforce is susceptible to the influence of AI. This percentage is divided into 60% in advanced economies, 40% in emerging markets, and 26% in low-income countries (Cazzaniga et al., 2024). AI has the capacity to replace specific occupations, but it also has the ability to generate new positions, thus revolutionizing the employment landscape. Numerous current occupations will undergo changes, necessitating individuals to adjust and get additional abilities, especially in areas such as critical thinking, problem-solving, creativity, and empathy. The *Future of jobs report* (2023), published by the World Economic Forum, predicts that over the next five years (2023–2027), more than 75% of companies plan to adopt AI-related technologies. It also estimates that 44% of workers will experience disruptions in their skills, and that by 2027, 60% of workers will need training in AI, analytics, and creative thinking. However, currently, only half of workers have sufficient access to training opportunities.

AI challenges the traditional belief that technology only impacts middle- and low-skill employment (Cazzaniga et al., 2024; Holm & Lorenz, 2021). With its sophisticated algorithms, AI can now enhance or even replace high-skill positions that were previously considered immune to automation. AI possesses cognitive abilities that allow it to efficiently analyze large volumes of data, identify patterns, and make

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informed judgments (Holm & Lorenz, 2021; Morandini et al., 2023). Consequently, even occupations that need advanced skills, which were previously thought to be safe from automation due to their complexity and dependence on specialized knowledge, are now at risk of being disrupted (Cazzaniga et al., 2024). Highly educated professionals have typically been responsible for jobs that need delicate judgment or intricate data interpretation. However, these jobs may now be enhanced or even substituted by advanced AI algorithms. This change undermines the prevailing belief that technical advancements generally lead to a decrease in middle- and low- skilled professions. Instead, it indicates a more extensive and profound transformation of the labor market compared to earlier technological revolutions, with potential to amplify inequality, both within and across different occupations (Capraro et al., 2024; Cazzaniga et al., 2024).

To prepare for this AI-driven future, there is a global effort to introduce upskilling and reskilling educational programs early, emphasizing AI literacy and competency, and the ability to collaborate effectively with AI systems (UNESCO, 2022, 2023, 2024). These programs move AI from higher education and professional to mainstream education (i.e., K-12 education), embracing the idea of "AI for all" (Chiu et al., 2022). Most of them concern the areas educating young students in AI knowledge (Chiu, 2021a; Touretzky et al., 2023; Wang & Lester, 2023); leveraging AI to foster student growth (Chiu, 2024a, 2024b); enhancing teacher AI competencies (Celik, 2023; Sperling et al., 2024; Yau et al., 2023); redesigning assessment with AI (Xia et al., 2024); fostering future skills development for life and jobs with AI (Chiu, 2023); and promoting the inclusive and equitable use of AI in education (Roshanaei et al., 2023; Xia et al., 2022). However, currently relatively few initiatives focus on AI in K-12 contexts, leading to this book. This chapter gives you an overview of AI in K-12 education, in particular the ways in which students are currently being prepared for life and work in the AI era.

To prepare for this AI-driven future, there is a global initiative to implement early upskilling and reskilling educational projects. These projects prioritize the development of AI literacy and competence, as well as the capacity to collaborate effectively with AI systems (UNESCO, 2022, 2023, 2024). These projects aim to bring AI from higher education and professional settings to mainstream education,

specifically K-12 education, embracing the idea of "AI for all" (Chiu et al., 2022). The majority of these projects focus on designing the K-12 AI curriculum (Chiu, 2021a; Touretzky et al., 2023; Wang & Lester, 2023), using AI to support student growth (Chiu, 2024a, 2024b), improving teacher AI competency (Celik, 2023; Sperling et al., 2024; Yau et al., 2023), redesigning assessment approaches with AI (Xia et al., 2024), developing future skills for life and jobs with AI (Chiu, 2023), and promoting the inclusive and equitable use of AI in education (Roshanaei et al., 2023; Xia et al., 2022). However, there are currently only a limited number of projects that specifically target the use of AI in K-12 educational settings, which is the reason for the creation of this book.

This chapter provides an overview of AI in K-12 context, specifically focusing on how students are now being prepared for life, study, and work in the AI era.

1.2 AN OVERVIEW OF AI TERMS AND PEDAGOGICAL CONCEPTS

This chapter explores several terms and concepts from the domains of AI and education. Some policymakers, teachers, educational researchers, and AI practitioners may lack familiarity with certain terms and concepts used in this book. This section aims to enhance readers' broad comprehension of 13 AI terms and eight pedagogical principles by providing an overview of each. Several terms and concepts in this field have sparked academic controversy and have supporters as well as critics. However, the objective of this section is not to extensively explore opposing perspectives. This should not be regarded as a comprehensive investigation.

1.2.1 AI Terminologies

- **Artificial intelligence (AI)** evokes thoughts of the science fiction action film *The Terminator*, released in 1984; nonetheless, it has been a topic of discussion for about seven decades. The term "artificial intelligence" was first introduced in 1956 by Marvin Minsky and John McCarthy. The popularity of AI has increased due to the emergence of big data and the rapid advancement of computing power (Haenlein & Kaplan, 2019). The definition of AI has expanded and evolved over time, and now refers to the development of machines capable of performing tasks that typically require human

intelligence. These tasks include visual perception, speech recognition, decision-making, language translation, and problem-solving. At its core, AI aims to create machines that can mimic, augment, or potentially surpass human cognitive abilities.

- **Generative AI** is a type of AI technology that can produce various types of original content, including text, images, audio, and synthetic data, in response to prompts or inputs
- **Machine learning** is a subset of AI that enables machines to learn from data and improve their performance on specific tasks without being explicitly programmed. It involves the use of algorithms that analyze and identify patterns in data, allowing the system to make predictions or decisions based on new inputs. Three major types of machine learning are supervised, unsupervised, and reinforcement learning.
- **Deep learning** is a subset of machine learning based on artificial neural networks with multiple layers, and can learn complex patterns in large amounts of data.
- A **neural network** is a computer system modeled on the human brain and nervous system. It consists of interconnected nodes (neurons) that process information using a connectionist approach.
- **Big data** refers to extremely large and diverse collections of structured, unstructured, and semi-structured data that grow exponentially over time. It is characterized by volume, velocity, value, variety, and veracity**.**
- **Natural language processing** is a branch of AI that focuses on the interaction between computers and humans using natural language, and enables machines to understand, interpret, and generate human language.
- **Computer vision** is an interdisciplinary field that deals with how computers can gain high-level understanding from digital images or videos, aiming to automate tasks that the human visual system can do.
- **Speech recognition**, also known as automatic speech recognition (ASR) or speech-to-text, is a technology that enables computers to process and convert spoken language into written text.
- **Large language models** are advanced AI models trained on vast amounts of text data, capable of understanding and generating human-like text across a wide range of topics and tasks.

- An **algorithm** is a set of step-by-step instructions for solving a problem or completing a task.
- A **sensor** is a device that detects changes in its environment and sends the information to a computer.
- **Intelligent tutoring systems** are computer systems that provide immediate and customized instruction or feedback to learners.

1.2.2 Pedagogical Concepts

- **Self-regulated learning** is the process by which students actively control and regulate their own learning through the use of cognitive and metacognitive strategies. It involves setting specific learning goals, selecting appropriate strategies, monitoring progress, and making adjustments as necessary.
- **Interdisciplinary learning** is an educational approach that integrates knowledge and skills from multiple disciplines to explore a common theme, issue, or problem. It encourages students to make connections across subjects, fostering a deeper understanding and promoting critical thinking.
- **Project-based learning** is a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge.
- A **real-world problem** refers to a complex issue or challenge that exists outside the classroom and has practical implications in everyday life. It requires critical thinking, analysis, and problem-solving skills to address effectively, often involving multiple perspectives and potential solutions.
- **Formative assessment** refers to a variety of methods that teachers use to evaluate student comprehension, learning needs, and academic progress during a lesson or unit. It is an ongoing process that provides real-time feedback, allowing teachers to adjust their teaching strategies to better meet students' needs.
- **Summative assessment** is a method of evaluating student learning, skill acquisition, and academic achievement at the conclusion of a defined instructional period, such as the end of a unit, course, or program. It is designed to measure what students have learned against specific learning objectives and is typically used to assign grades or determine whether students have met educational standards.

- **Design thinking** is a human-centered, iterative process used to solve complex problems by understanding users' needs and experiences. It involves five key phases: Empathize, Define, Ideate, Prototype, and Test. This approach encourages collaboration across disciplines and emphasizes creativity and innovation, allowing teams to develop solutions that are desirable, feasible, and viable.
- **Bloom's taxonomy** is a hierarchical classification system used to define and categorize cognitive skills and learning objectives.

1.3 AI IN K-12 CONTEXTS

AI in K-12 contexts has become increasingly important in the past decade. There have been demands for the development, evaluation, and enhancement of AI curricula and instructional design (Chiu et al., 2022; Touretzky et al., 2023; Wang & Lester, 2023), as well as a greater focus on the development of AI-based educational technology (Bommasani et al., 2021; Kasneci et al., 2023; UNESCO, 2023). There are two aspects to consider: (i) AI education and (ii) AI in education.

AI education refers to the teaching of AI disciplines (Casal-Otero et al., 2023; Chiu et al., 2022; Touretzky et al., 2023). It equips students with essential AI knowledge and skills for the future, making them proficient in using and understanding AI technologies. The knowledge and skills are often referred to AI literacy. This includes machine learning, big data, computer vision, natural language processing, speech recognition, and ethics (Chiu et al., 2022; Touretzky et al., 2023). Due to the absence of AI topics in K-12 education, it is necessary to develop a new curriculum (Chiu et al., 2022; UNESCO, 2022). Schools must allocate sufficient space to implement this curriculum. The implementation strategies include subject-specific and interdisciplinary approaches, such as building on existing computer science-related curricula and integrating AI into mathematics, physics, humanities, and art subjects (Chiu & Chai, 2020).

AI in education refers to the use of AI to facilitate and enhance several areas of the educational process, such as learning, teaching, evaluation, and administration (Bommasani et al., 2021; Chiu, 2023, 2024b). It focuses on how AI can be integrated into the classroom to improve personalized learning experiences, automate grading, and provide real-time feedback to both students and teachers (Hwang et al., 2020; Kasneci et al., 2023). Although AI presents considerable

potential for bolstering and improving learning and teaching in K-12 education, its integration necessitates thoughtful examination of teacher and student capabilities, educational equity, and appropriateness of AI tools. The primary emphasis should be placed on using AI as a tool to augment human instruction, rather than as a replacement for teachers.

These two aspects are crucial in preparing students with the requisite skills and knowledge to thrive in their future education and job market. However, critics express fears and anxieties about the unfamiliar, leading some teachers to be hesitant when it comes to engaging in AI experimentation. Upon closer examination of these concerns, they appear to be nothing more than a vicious cycle of optimism versus pessimism, well-prepared versus ill-prepared teachers, and well-resourced versus ill-resourced environments (Sanusi et al., 2022, 2024; Shen et al., 2024).

Accordingly, the two primary barriers at the outset are the availability of an AI curriculum and the capacity of teachers (Chiu, 2021a; UNESCO, 2022, 2023, 2024). The AI curriculum serves as a guide for determining what to teach and how to organize learning activities, helping to align teaching strategies with learning objectives. Currently, the AI curriculum for K-12 is still being developed (Chiu et al., 2022). Furthermore, the successful integration of AI depends on teachers' proficiency in utilizing these technologies (UNESCO, 2024). Numerous teachers face a shortage of essential training and support, making it difficult to confidently incorporate AI into their teaching practices (Yau et al., 2023). They are unclear about their roles in AI-enabled learning environments for designing instructions and assessments.

To enable K-12 education to benefit from AI in every area, the initial step is to transform the curriculum by including AI elements and redefining the roles of teachers and students in the learning process. In the subsequent sections, we will delve into these topics, providing guidance to commence your AI endeavor in K-12.

1.4 TRANSFORMING THE K-12 CURRICULUM BY INCLUDING AI ELEMENTS

AI teaching in K-12 schools is a global effort. The United Nations Educational, Scientific and Cultural Organization (UNESCO) published

a report titled *K-12 AI curricula: A mapping of government-endorsed AI curricula*, which revealed that 15 countries and regions, namely Armenia, Austria, Belgium, Bulgaria, China, Germany, India, Jordan, Republic of Korea, Kuwait, Portugal, Qatar, Saudi Arabia, Serbia, and the United Arab Emirates, have implemented government-led AI curricula. Therefore, it is essential to introduce AI into the K-12 curriculum.

Curriculum frameworks serve as a tool for teachers to define the specific knowledge material related to AI, and are crucial in the context of teaching new topics. Without frameworks, teachers lack guidance on what content to teach. This section focuses on four frameworks specifically designed by various partners to guide the creation of AI curriculum. It is important to note that these frameworks are not associated with any particular products.

1.4.1 Five Big Ideas in Artificial Intelligence

In 2018, the Association for the Advancement of Artificial Intelligence (AAAI), the Computer Science Teachers Association (CSTA), and AI4All established a collaborative working group that proposed the Five Big Ideas in Artificial Intelligence framework (Touretzky et al., 2019, 2023). This framework was established based on five fundamental concepts outlined in the CSTA K-12 Computer Sciences Standards.

The five big ideas are:

(i) **Perception:** Machines use sensors to collect data on their surroundings, and perception refers to the process of understanding the collected data.

(ii) **Representation and reasoning:** Agents maintain cognitive representations of environments and use them to make choices; representations serve as the primary foundation for the reasoning process, enabling machines to act as reasoners.

(iii) **Learning:** Machines have the ability to continuously learn from data and improve their performance based on the data they receive, such as through machine learning, neural networks, and deep learning.

(iv) **Natural interaction:** Machines need to communicate with humans naturally, so they need to understand human language, emotion, and culture, for example, through large language models and co-pilot in ChatGPT.

(v) **Societal impact:** AI is a disruptive technology that has both positive (benefits) and negative (risks) effects on our society. This technology causes a lot of changes and concerns, such as the future of work, ethical considerations, and societal impact.

The working group created a poster that has been translated into 15 languages to date and formed at least part of the basis for the development of curricula in multiple contexts (UNESCO, 2022). Overall, the five big ideas assist teachers and researchers in establishing the essential knowledge and skills of AI and determining the necessary AI content.

1.4.2 AI4future

The curriculum framework AI4future was created in 2019 through a collaborative and interdisciplinary effort involving engineering and education professors from the Chinese University of Hong Kong, K-12 leaders, and industry partners (Chiu et al., 2022). They collaborated in the development of the curriculum framework for students in grades seven to nine (see Figure 1.1).

The framework consists of three tiers. The innermost level, shown by the white circle, depicts a foundational understanding of AI. It is important for K-12 students to acquire a clear understanding of the definition of AI. The literature has multiple definitions of AI, some of which are excessively technical or challenging for young students. This framework provides a brief overview by stating that AI consists of three main components: machine learning, big data, and cloud computing. Given the pervasive presence of AI applications in our daily lives and workplaces, it is essential for students to acquire knowledge regarding the ethics and implications of AI. The middle category, presented in the light grey circle, signifies that students acquire knowledge regarding perceptual machine and human language intelligences, as well as the integrated intelligences of AI. Perceptual machine and human language intelligences involve a range of abilities, including computer vision for visual perception, natural learning processes for reading and writing, speech-to-text for auditory perception, and text-to-speech for verbal expression. The integrated intelligences include AI reasoning, simulation (e.g., problem-solving simulation), and cognitive processes like content production and generation. The dark grey

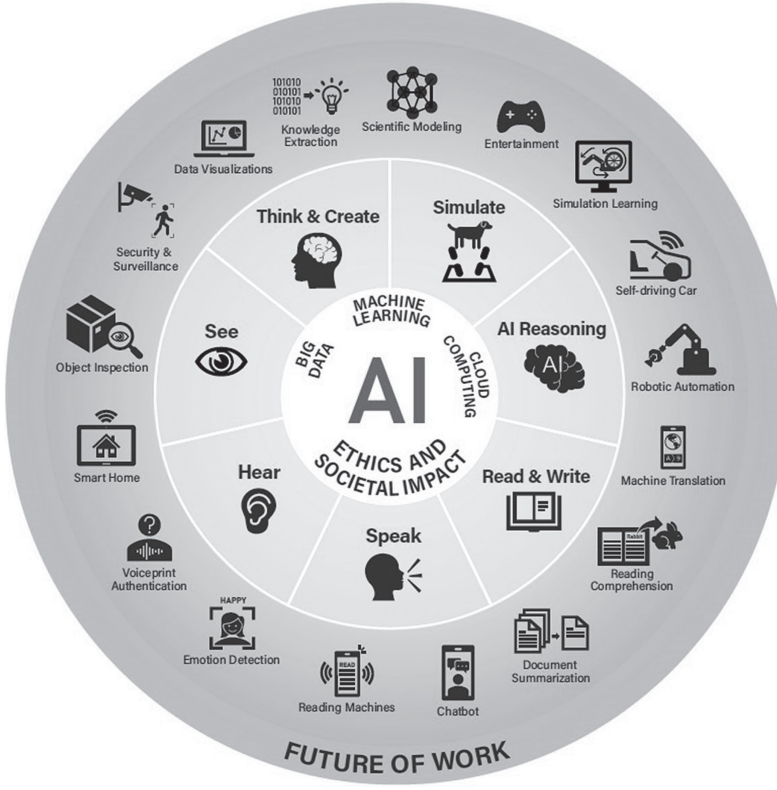

Figure 1.1 Infographic for the K-12 AI curriculum
Source: Adapted from Chiu et al. (2022).

circle at the outer level signifies the need for students to acquaint themselves with AI applications in light of the anticipation that they will engage with and make use of AI in the future. At this level, students should possess the ability to acknowledge the transformative impact of AI on the future workforce. This enables students to adequately prepare for their prospective professional endeavors. Finally, the team evaluated the curriculum's efficacy by gauging students' AI readiness, awareness, and understanding.

1.4.3 A Holistic Framework

Other than identifying content and learning outcomes, Chiu's (2021) holistic approach added pedagogy and teacher perspective to the

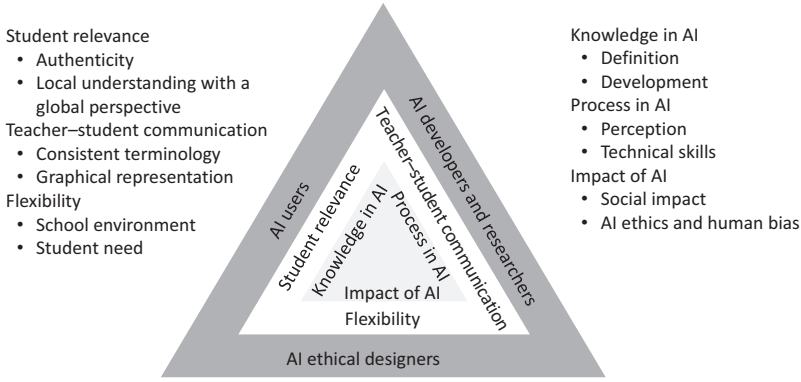

Figure 1.2 A holistic framework for designing K-12 AI education
Source: Modified from Chiu (2021).

framework (see Figure 1.2). The framework has three levels. The innermost level (light grey) shows the basic contents: knowledge of AI, processes in AI, and the impact of AI. The middle level (white) provides three pedagogies for AI learning: teacher–student communication, student relevance, and flexibility. The outermost level (dark grey) outlines the learning outcomes in relation to the various roles of AI in society, including users, developers, researchers, and ethical designers. In this framework, pedagogy and learning outcomes are more explicit for teachers and students.

1.4.4 AI Literacy Framework

Long and Magerko (2020) conducted a scoping review study to identify key 17 competencies and 13 design considerations for AI literacy. The competencies include recognizing AI, understanding intelligence, interdisciplinarity, general vs. narrow AI, AI strengths and weaknesses, machine learning steps, human role in AI, and data literacy. Long and Magerko (2020) identify common themes among AI professionals regarding the knowledge that non-technical individuals should possess. This review was driven by articles published in engineering journals before or in 2020. Their suggestions prioritize an engineering approach rather than an educational perspective. In our opinion, these suggestions are better suited for higher and adult education than K-12 schooling due to their highly technical nature.

They acknowledged these constraints and suggested a forthcoming reassessment of the competencies.

Overall, these four curriculum frameworks guided us to identify the content or materials for teaching AI in K-12. However, the interdisciplinary nature of AI prevents them from offering insights into how various subjects could contribute to AI education and how the complexity of literacies relates to AI literacy. They also did not specify how to assess student learning, despite the fact that assessment is part of the curriculum. Some of them lack specific design for K-12 contexts. These lead to our recommendations on student AI literacy and competency frameworks (Chapter Two), interdisciplinary approaches to AI teaching (Chapter Four), and student AI learning instruments (Chapter Five) in this book.

1.5 REDEFINING THE ROLES OF TEACHERS AND STUDENTS IN THE LEARNING PROCESS

AI will transform the roles of teachers and pupils in traditional schools. It has the ability to function as a virtual teacher, personalizing learning experiences to individual students, automating the grading of assignments, offering immediate feedback, and generating educational resources for students (Chiu, 2023; Hwang et al., 2020; Kasneci et al., 2023; Zhang & Aslan, 2021). For instance, an AI-powered language learning application has the capability to monitor a student's progress in learning, detect recurring errors, and suggest specific assignments to improve areas of weakness. The application might additionally provide immediate oral feedback and adjust the lesson difficulty based on the student's performance, resulting in a tailored learning experience that meets their specific needs.

What actions may teachers take in the context of personal learning? To achieve successful integration of AI, it is essential that we have a comprehensive understanding of the specific roles played by students, teachers, and AI in the learning process.

1.5.1 The Roles of Teachers and Students in Traditional Classrooms

Teachers play multiple vital roles in traditional classrooms, each contributing to the overall educational experience and development of students. Here are some key roles.

- **Knowledge imparters:** Teachers offer explicit guidance, delivering content knowledge and ensuring students comprehend the curriculum. They adhere to a particular curriculum and modify it to cater to the needs of their students.
- **Facilitators:** Effective teachers also foster interactive learning experiences, promoting student engagement and active participation. They assist students in cultivating critical thinking, problem-solving, and collaboration abilities through a range of classroom activities.
- **Authority figures:** Teachers maintain control over the classroom environment, setting rules and expectations to create a structured learning atmosphere. They maintain discipline and oversee student behavior to promote an optimal learning environment.
- **Evaluators:** Teachers assess student learning through tests, quizzes, homework, and other forms of evaluation, and provide feedback and grades to measure student progress. They use both summative and formative assessments methods to gauge student understanding and guide instruction.
- **Role models:** Teachers serve as role models, influencing students' values, attitudes, and behavior. They help with character building and ethical development. Beyond academics, teachers mentor students, providing guidance and support in personal and academic matters.
- **External parents:** Teachers often act as external parents, offering emotional support and encouragement. They help students navigate personal challenges and foster a sense of security and trust. They provide advice and guidance, helping students set goals and make informed decisions about their future.

Students play several important roles in traditional classrooms that contribute to their own learning and the overall classroom environment. Here are some key roles of students in traditional classrooms:

- **Active participants:** Students are expected to actively engage in lessons, participate in discussions, and contribute to group activities. They ask questions to clarify their understanding and deepen their learning.

- **Collaborators**: Students often work in pairs or small groups, collaborating with peers to solve problems, complete projects, or discuss concepts. They learn from each other, sharing knowledge and perspectives that enhance the learning experience.
- **Self-regulators:** Students are responsible for managing their time effectively, balancing homework, projects, and study schedules. They set personal academic goals and work towards achieving them, fostering a sense of ownership over their learning.
- **Reflective learners:** Students reflect on their learning processes and outcomes, identifying strengths and areas for improvement. They use feedback from teachers and peers to inform their future learning strategies.
- **Knowledge constructors:** Students build new knowledge by connecting it to prior knowledge and experiences, making learning more meaningful. They analyze information, evaluate sources, and develop their own understanding of concepts.
- **Responsible individuals:** Students are expected to follow classroom rules and contribute to a positive learning environment. They learn to respect authority, cooperate with teachers and peers, and contribute to a supportive classroom culture.
- **Communicators:** Students articulate their thoughts and ideas clearly, whether in discussions, presentations, or written assignments. They practice active listening, engaging with the perspectives of others and responding thoughtfully.
- **Help seekers:** Students are encouraged to seek help from teachers or peers when they encounter difficulties, fostering a collaborative learning environment. They learn to use available resources, such as textbooks, online materials, and tutoring services, to enhance their learning.

1.5.2 Potential Roles of Students, Teachers, and AI in Self-regulated Learning

This section explores how AI transforms the dynamics between students and teachers by analyzing their involvement in self-regulated learning (SRL). SRL is a crucial skill that young students must cultivate, particularly in the context of digital learning during the post-COVID era and the rise of AI (Chiu, 2022; Chiu et al., 2023).

SRL has undergone significant development in the last 30 years. It is distinguished by the presence of internally generated thoughts, feelings, emotions, and actual behaviors that are guided by personal goals (Pintrich, 2000). Zimmerman and Moylan (2009) introduced a social cognitive model of self-regulated learning (SRL) that is an iterative cycle comprising three phases and six distinct phases: forethought, performance, and self-reflection. Each phase consists of two stages. During the forethought phase, task analysis includes the establishment of objectives and the development of a strategic plan. Meanwhile, self-motivation beliefs encompass self-efficacy, outcome expectations, interest and value in the task, and goal orientation. The performance phase consists of two cognitive stages: self-control, which includes self-instruction, time management, task strategies, help seeking, self-consequences, and environmental structuring; and self-observation, which involves metacognitive monitoring. During the self-reflection phase, self-judgment entails assessing oneself and attributing outcomes to personal causes, while self-reaction involves feeling contentment and experiencing emotions towards oneself. In the SRL iterative cycle, students must engage in goal setting, strategic planning and execution, time management, plan and progress evaluation, and strategy adjustment. Students must have self-awareness, self-monitoring, and self-motivation.

AI has the significant capacity to enhance student SRL by empowering them to assume responsibility for their own learning (Ilishkina et al., 2022; Jin et al., 2023; Xia et al., 2023). Students have the ability to work together with AI to receive feedback and comments that are specifically tailored to their unique learning styles and needs. They also can acquire answers and ideas to help them overcome any issues they may be facing (Chiu et al., 2023; Darvishi et al., 2024).

Figure 1.3 shows our human–AI collaboration framework for self-regulated learning. The framework delineates the tripartite relationships between students, teachers, and AI, specifically the student–teacher, student–AI, and teacher–AI interactions. The relationships demonstrate their collaboration in facilitating students throughout the three phases of the SRL process: forethought, performance, and self-evaluation.

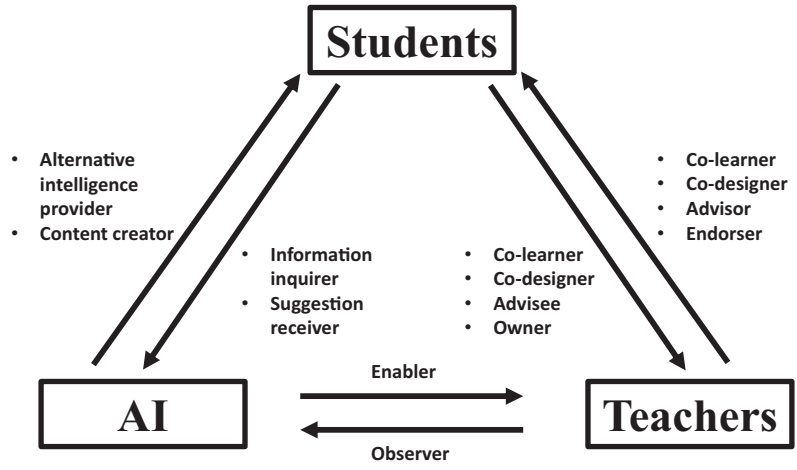

Figure 1.3 Our human–AI collaboration framework for self-regulated learning

Student–teacher relationships involve four reciprocal roles.

- **Co-learner vs. co-learner:** Both students and teachers serve as co-learners, acquiring knowledge from new outputs generated or suggested by AI. This includes responses to science inquiries generated by ChatGPT and personalized recommendations for mathematics learning from a learning system (Havukainen et al., 2024; Tan et al., 2023). The outputs are variable, and hence both students and teachers may lack familiarity (i.e., they are learners). They must collectively acquire knowledge using AI and see how the outputs can enhance the students' SRL process. Thus, students and teachers assume these roles during the three stages of SRL: forethought, performance, and self-evaluation.
- **Co-designer vs. co-designer:** Both students and teachers serve as co-designers (Cviko et al., 2015; Havukainen et al., 2024). Collaboration between students and teachers may be necessary to devise effective learning strategies with AI. For instance, students can utilize outlines created by ChatGPT for project-based learning to formulate their own learning strategies (Chiu, 2024b). AI enhances students' learning experiences by providing opportunities for multimedia content production and introducing novel viewpoints (Chiu

et al., 2023). Through the use of AI tools, students are given the ability to assume responsibility for attaining their academic goals by employing learning tactics that go beyond traditional classroom strategies. Under the guidance of educators, students can leverage AI to customize their learning strategies to accomplish learning goals and align with their personal interests. Thus, students and teachers assume these responsibilities in forethought and self-evaluation, as these two phases prioritize the (re)planning of learning strategies.

- **Advisee vs. advisor:** Within the K-12 school setting, students who are in the process of developing their SRL skills necessitate guidance and counsel from their teachers. In this connection, students serve as advisees while teachers assume the role of advisors. Teachers may be required to assist students in navigating AI-generated content, such as prompt engineering (Lo, 2023). Additionally, teachers may need to collaborate with students to verify the accuracy of AI-generated content through critical thinking, fact-checking, and source validation (Ali et al., 2021). Teachers have the responsibility of enabling communication between students and AI, as well as assisting in the validation of content. Students and teachers assume these responsibilities during the three phases of SRL.
- **Owner vs. endorser**: Learning is not without boundaries in K-12. As owners of their education, students are accountable for their own learning. As endorsers, teachers are responsible for ensuring that students are progressing in the correct direction. Students are given the freedom to choose how they interact with the content and exercises and show their comprehension. It is important for students to have the ability to independently and actively influence the course of their own learning. This can potentially enhance their level of motivation (Chiu, 2022). Teachers act as gatekeepers, responsible for ensuring that students are making progress in line with the learning objectives (Goodwin & Oyler, 2008). For example, the utilization of ChatGPT for educational purposes necessitates careful consideration of ethical problems. Teachers should instruct students to become healthy, ethical, moral, and responsible users and developers of AI (Ali et al., 2021; Chiu, 2023). Given the importance of ethical issues in responsible learning with generative AI, both students and teachers assume these roles during the three phases of SRL

Student–AI relationships involve the participation of both students and AI, with each party assuming two distinct roles.

- **Information inquirer and suggestion receiver:** When utilizing AI for learning, students assume both an active and a passive role. Students, who actively seek information, use AI to give themselves ideas, proposals, suggestions, solutions, feedback, and comments. They also use AI to create the multimedia materials they desire and to edit their work (Ali et al., 2021; Khosravi et al., 2022). The external information and content are crucial for inquiry and project-based learning that can be connected to SRL. Through the use of AI such as ChatGPT, students actively pursue ideas for creating goals and planning, seek support in implementing their plans, and seek feedback on evaluating their performance. The passive role is that of a recipient of suggestions. Personalized learning systems can provide students with recommendations regarding learning content and test items (Raj & Renumol, 2022; Chiu et al., 2023). Students should exercise their independence in determining whether or not to adhere to the recommendations. They assume these responsibilities during all three stages of SRL, with a special emphasis on goal setting and planning.
- **Alternative intelligence provider and content creator:** AI tools have a dual role in this student SRL. Being an alternative intelligence provider, AI has the ability to offer student information from multiple perspectives. For example, ChatGPT provides information beyond the scope of a school setting; personalized learning systems deliver targeted resources to students, including website links, online articles, and videos (Chiu et al., 2023; Raj & Renumol, 2022); AI tools can translate articles from students' unfamiliar language to their native language (Ducar & Schocket, 2018). The information provided by AI should be viewed as an alternate kind of intelligence that presents various viewpoints, rather than being seen as the ultimate solution or answer. Meaningful learning entails the integration of new external information with preexisting knowledge to generate new knowledge (Mayer, 1996). Hence, AI tools are indispensable for delivering a wide range of novel information to students during all three stages of SRL. Put simply, students have the ability to enhance their work by acquiring diverse forms

of intelligence at any time and in any location. Moreover, AI also serves as a content creator. AI can be utilized by students to create many forms of content, including posters, slideshows, films, and written text, for their self-SRL (Ali et al., 2021; Khosravi et al., 2022). Similarly, students should utilize AI for the purpose of creating ideas or outlining material, rather than depending on it to create finalized works (Chiu, 2024b). This role is crucial during the performance phase and mostly caters to the students' capacity of making.

Teacher–AI relationships involve both parties playing distinct roles.

- **Observer:** Teachers assume the role of observers in the relationships. Students should take the lead in the SRL process and create content based on their own demands. This will help them develop a strong feeling of ownership over their learning process (Dignath & Büttner, 2018; Dignath-van Ewijk et al., 2013). Teachers should utilize the generated information as a spark to initiate meaningful discussions with students. When promoting students' effective engagement with AI, teachers should largely assume the role of an observer and enable students to actively interact with AI. This role is present in all three phases.
- **Enabler:** AI tools function as facilitators. In traditional classrooms without AI, teachers serve as the primary providers of knowledge. Teachers offer students feedback and deliver all learning information and activities, while also facilitating debates on familiar topics. The debates and criticism may become increasingly based on personal opinions and perspectives. AI tools revolutionize the way teachers engage with students, enabling them to utilize new external resources to enhance student SRL from a more objective standpoint (Chiu, 2024b; Jin et al., 2023). Thus, AI tools aid teachers in creating more engaging discussion chances during the SRL process. This role is important in all three phases.

In summary, our framework for human–AI collaboration involves three types of relationships: student–teacher, student–AI, and teacher–AI. Each type has a specific number of roles: eight for student–teacher, four for student–AI, and two for teacher–AI. In all,

there are 12 distinct roles, with two of them being duplicates. The relationship between students and teachers is the most robust, whilst the relationship between teachers and AI is the least solid. These relationships depict the interactions among students, teachers, and AI tools. The proximity of relationships is indicative of the quality of their interaction. In the context of meaningful SRL, students play a central role, while teachers act as mediators and AI technologies function as external service providers. These guarantee that students derive advantages from AI-driven education. We anticipate that additional roles will be recognized as we gain a deeper comprehension of how humans engage with AI.

In addition, our framework indicates that AI does not support the roles of role models and external parents among the six functions of instructors in traditional classrooms. AI somewhat supports the roles of authority figures and knowledge imparters, while teachers are more frequently supported in the roles of assessors and facilitators. Students should actively engage in all the responsibilities they assume in traditional classrooms. These imply that students should increase their level of participation in classrooms that using AI, while teachers should be willing to delegate some of their responsibilities to AI.

1.5.3 How Teachers Support Student–AI Relationships During SRL with ChatGPT

1.5.3.1 Student SRL Activities with ChatGPT

Our human–AI collaboration framework for SRL is not limited to a particular AI tool. AI tools may do a variety of tasks, including creating videos, predicting learning outcomes, and generating essays. To help you understand how to use the framework, we used ChatGPT as a case to propose its student learning activities to foster SRL (student–AI relationships) and discussed how teachers support student–AI relationships. We collaborated with 30 K-12 teachers to suggest activities using three rounds of the Delphi method (see Table 1.1).

Twenty-two student learning activities with ChatGPT were suggested in the SRL process. Being information inquirers and suggestion reviewers, students can do the nine proposed activities in the stage of task analysis, with #1–5 being highly recommended; the

16 activities in self-control, with #6–15 being highly recommended; and the nine activities in self-judgment, with #16–22 being strongly recommended. There are no suggested tasks for the three stages of self-motivation beliefs, self-observation, and self-reaction. These findings suggest that students may be unable to use ChatGPT at all six stages, implying that student–AI relationships (how students interact with ChatGPT) cannot support all the stages.

1.5.3.2 Teacher Support from Self-determination Theory

Utilizing self-determination theory (SDT) as a foundation, teachers can effectively support students in the process of SRL (Chiu, 2021b, 2022, 2024b). We use this idea to examine how teachers address the SRL stages that AI is unable to assist with, hence enhancing the student–AI relationships.

SDT is a theory that explains human needs, motivation, and well-being within a social and cultural context (Ryan & Deci, 2020). It suggests that individuals have three innate needs: autonomy, competence, and relatedness. Satisfying these needs leads to better motivation and engagement in activities (Chiu, 2021b, 2022, 2024). The theory categorizes motivation sources and differentiates between autonomous and controlled motivation. Satisfying the three needs cultivates autonomous motivation, a high-quality form of motivation that leads to increased engagement and persistence in learning activities. Thwarting any of these three needs may disengage learning activities. This high-quality form of motivation sustains students' personal growth and well-being, potentially enhancing student engagement and learning performances (Chiu, 2022, 2024b; Luria et al., 2021; Xia et al., 2022, 2023).

In digital environments, teachers can support student need for (i) autonomy by allowing students to complete their assignments in multiple formats and providing students with multiple representations (video, articles, posters, discussion forums) of a learning material (Chiu, 2022; Luria et al., 2021; Nakata, 2023); (ii) competence by designing well-structured discussion forums and user-friendly interfaces (Chiu, 2022; Nakata, 2023); and (iii) relatedness by teaching using emotionally designed materials and communicating through visual aids such as photos and emojis (Chiu, 2022; Nakata, 2023).

1.5.3.3 Teacher Support in the Student–AI Relationship

As shown in Table 1.1, most of the activities satisfied competence and autonomy. Only one activity was found to support relatedness. These findings suggest that ChatGPT alone may not be effective in motivating student learning by satisfying their SDT needs. Teachers play an important role in addressing these gaps by fostering relatedness and using ChatGPT outputs to interact with students (teacher–student relationships).

It is recommended that teachers prioritize three stages in SRL: self-motivation beliefs, self-observation, and self-relations. The stages are linked to affection, beliefs, and non-digital skills, all of which are directly tied to student–teacher relationships. Given this, teachers can better foster relatedness in the stages. Teachers are advised to use student work, such as ChatGPT outputs, as a means of interacting with students. Because of its high level of relevance, the student-centered output better satisfies relatedness in the teacher–student relationships (Guilherme, 2019).

From the perspective of our human–AI collaboration framework, ChatGPT outputs are enablers and provide teachers with supplementary conversation topics. Teachers can co-learn and co-design the outputs with their students, as well as endorse and advise the outputs (Havukainen et al., 2024). Through engaging in such collaboration with students, teachers can effectively steer them towards a more diverse and objective SRL process. This collaborative approach not only fosters a sense of partnership between teachers and students, but also strengthens students' sense of ownership (Markauskaite et al., 2022). Both students and teachers can benefit from engaging in conversations over ChatGPT's output.

Overall, ChatGPT is a great AI tool that supports students' need for competence and autonomy in three of the six stages of student–AI relationships. Teachers can further foster SRL by engaging student–teacher relationships through teacher–AI relationships.

1.5.3.4 The Importance of Teacher Education

Redefining the roles of teachers and students in the learning process is necessary when integrating AI in learning and teaching. We need appropriate professional teacher development activities to ensure that integrating AI in K-12 context is at high quality level. To provide

Table 1.1 Suggested student activities for self-regulated learning with ChatGPT

#	Learning activities	SDT needs	Task analysis	Self-motivation beliefs	Self-control	Self-observation	Self-judgment	Self-reaction
It is recommended that students use ChatGPT to								
1	search for information	A	**		*		*	
2	get examples	A	**		*		*	
3	ask for definitions	C	**					
4	make lists or outlines	A	**					
5	compare their ideas	C	**					
6	get insight into complex problems	A	*		**			
7	summarize their own work	R	*		**			
8	visualize a problem	R	*		**			
9	generate questions for essays	A			**			
10	practice peer feedback	C			**			
11	prepare for tough conversations	C			**			
12	generate questions for discussions	A			**			
13	create multimedia content	C			**			
14	create articles	C			**			
15	edit articles	C			**			
16	check their answers	C			*		**	
17	generate review questions to check for their understanding	C	*		*		**	
18	create new problems for practice	C			*		**	
19	create challenging problems	C			*		**	
20	ask ideas for their improvement	C					**	
21	get feedback for their work	C					**	
22	compare their work	C					**	

Notes: **: strongly recommended, *: recommended; A: autotomy, C: competence, R: relatedness.

high-quality education with AI, we need to understand what competencies teachers require to motivate more students to study in higher education or work in the AI-related industry, as well as to address education equity. These lead to our recommendations on teacher AI competency (Chapter Three), interdisciplinary approaches to AI teaching (Chapter Four), and assessment literacy (Chapter Five), nurturing talents (Chapter Six), and education equity (Chapter Seven).

When integrating AI into learning and teaching, it is essential to redefine the roles of teachers and students in the learning process. Appropriate professional teacher development activities are needed. To provide high-quality education, we must understand the competencies that teachers need to possess. Teachers should be able to inspire a greater number of students to pursue higher education or seek employment in the AI sector, and promote inclusive and equitable education. These lead to our recommendations on defining teacher AI competency (Chapter Three), designing interdisciplinary approaches (Chapter Four), designing assessment (Chapter Five), attracting and retaining AI talent (Chapter Six), and promoting education equality (Chapter Seven) in this book.

1.6 CONCLUSIONS

This chapter provides an overview of how to empower K-12 education with AI to prepare for the future of education and work. We discussed the importance of integrating AI in the K-12 context. To embark on your journey with AI, we suggest that the first step is to transform our curriculum by including AI elements (AI education) and redefining the roles of teachers and students in the learning process (AI in education). The rest of this book will provide suggestions to commence your AI endeavor in K-12.

Actions you may consider taking

- Explain the significance of introducing AI in a K-12 context to your colleagues.
- Design and implement an AI curriculum for your students.
- Evaluate and revise your existing curriculum.
- Run professional development activities on the roles of teachers in learning.

- Create a self-reported questionnaire for students to reflect on our human-collaboration framework.
- Try our suggested student SRL activities in your classrooms.

Questions you may ponder

- How can we leverage students' AI literacy and competency to create a customized curriculum?
- What is the definition of teacher AI competency?
- What strategies can be employed to create instructional materials that facilitate multidisciplinary learning in the field of AI?
- How can we design instruction that is empowered by AI?
- Will AI exacerbate educational inquiry? If yes, what measures can be taken to mitigate it?
- What strategies may be used to promote more participation of K-12 students in the field of AI and increase their likelihood of pursuing careers in the AI industry after graduation?

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