Chapter 2

Considering the History of Technologies in Education, the Distinctiveness of AI Apps, and the Future of Educational Systems

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ABSTRACT

The emergence of ChatGPT and other AI apps has educators contemplating the impact AI technologies might have on their teaching and educational systems. The history of educational technology cautions against predicting a revolution in education. Yet, unlike prior technologies for teaching and learning, ChatGPT and other generative AI apps produce sentences, paragraphs, essays, reports, computer code, images, and videos as directed by human prompting. To determine how that technology might alter educational systems, this chapter analyzes historical events to derive lessons learned about the impact of prior technologies on education. Then this chapter discusses the distinctive features of ChatGPT and other AI apps, as applied to teaching and learning. Informed by those considerations and the current state of schools and colleges, this chapter discusses the future of educational systems in a world with AI apps and tools.

Keywords: History, educational technology, artificial intelligence (AI), future of education

INTRODUCTION

Today, in schools and colleges throughout the world, teachers and administrators are both intrigued and concerned by the emergence of AI apps, such as automated text generators. Often called *chatbots* or *conversational agents*, freely available text generators respond to human prompts in a conversational manner. Since computers, like toasters, have no sentience or moral purpose, person-to-machine exchanges with ChatGPT and other chatbots are qualitatively different than person-to-person conversations. Whereas human beings utilize their knowledge of language and intelligence to parse and reply to questions, contemporary chatbots leverage Large Language Models (LLMs), neural networks trained on billions of words in books, journal articles, magazines, web pages, and other sources. Details pertaining to LLM development and function, including the manner in which word associations and patterns in texts written by human beings are modeled in a computer network with over 100 million connections between nodes, the strengths of which are adjusted statistically during training (the inputting of the billions of words), appear in Clarke et al. (2023), Prakash (2023), and Wolfram (2023), for instance. For this chapter, we need only recognize that LLMs enable word generation by chatbots and that the technological sophistication and machine learning capacity of LLMs make chatbots remarkably adept at responding to questions. Indeed, chatbot responses rise to the level of human performance on multiple assessments.

In a comparison of English reading comprehension, the average score of Dutch students attending the most rigorous high school program in the Netherlands was 6.99, whereas ChatGPT-4 scored 8.3 on a 10-point scale (deWinter, 2023). On medical tests, ChatGPT-3 passed or nearly passed the three exams which comprise the United States Medical Licensing Exam (Kung et al., 2023), and ChatGPT-3.5 ranked between the 80th and 92nd percentiles on the past five Medical Specialty Exams (Oztermeli & Oztermeli, 2023). ChatGPT also attained minimal passes (grades of C+) on four law school final exams (Choi et al., 2023), but OpenAI (2023) reports that ChatGPT-4 scored in the top 10% of test takers on a simulated bar exam conducted by OpenAI collaborators, whereas ChatGPT-3.5 scored in the bottom 10%. On the final exam of the Operations Management course in a Master of Business Administration program, ChatGPT-3 received a grade in the B to B- range (Terwiesch, 2023). On an assessment typically given to instructional design students, ChatGPT was prompted to create a needs, task, and learner analysis for a specific instructional context, and the replies from ChatGPT were judged as sufficient to pass for graduate-level work (Parsons & Curry, 2023). Moreover, ChatGPT-4 attained the maximum score (5/5) on 9 of 15 AP exams, scored 4 on another four of those AP exams, and scored 2 on the other two AP exams (OpenAI, 2023). Those results, though imperfect, begin to convey the overall quality of replies provided by ChatGPT. In addition, ChatGPT responds correctly or appropriately to questions about economics, project management, nursing, and water polo, for instance. ChatGPT also writes poetry and prose in the styles of famous poets and authors, with variable success. Overall, the generative capabilities and acceptable, if not laudable, performance in question-answer exchanges across a vast array of topics make ChatGPT and other LLM-based conversational agents breakthrough technologies in person-machine conversations.

Even though ChatGPT often performs well on particular question-answer tasks, it generates unsatisfactory responses at times. In particular, ChatGPT may provide incorrect answers or *hallucinations* or fabricated information such as references to sources that do not exist. When developing the GPT-4 model, OpenAI (2023) implemented a post-training process involving reinforcement learning from human feedback, which improved performance significantly over that of GPT-3.5. Overall, chatbot performance is sufficient for many tasks. Hence, ChatGPT diffused rapidly and is used for a wide variety of purposes. For example, with a suitable prompt, ChatGPT will display key factors causing economic collapse in the 1930s in North America, provide step-by-step directions to connect a specific motor controller to a particular microprocessor, or provide examples demonstrating how one might include figurative language in a story. Since chatbots make mistakes at times, users are left to decide whether the responses are suitable for their purposes. Gundle (2023), a clinical psychologist, advises against the use of chatbots to seek advice on dating, for instance, but some people do use them for that purpose. However beneficial or dangerous, the machine learning algorithms and generative AI techniques utilized by contemporary chatbots enable person-to-machine conversation at all hours every day. How should we regard such indefatigable machine interlocutors? What impact will ChatGPT and other LLMs have on elementary, secondary, and higher education globally? How might educational practices of the past century be enhanced by machine tutors? How might K-12 schools and colleges adapt?

Fortunately, we can turn to history and analyze the effects of prior technologies on schools and colleges to inform our views about the possible impact of chatbots and other AI apps on contemporary educational systems. Accordingly, this chapter begins with a brief history of technologies in education, which reveals the remarkable stability of educational systems over multiple decades. Second, this chapter describes the variety and distinctiveness of AI apps for teaching, learning, and productivity, which includes discussion of how instructors and students can implement new instructional methods using ChatGPT and other AI apps and tools. Then, drawing on the history of educational technology and in light of the distinctiveness of AI apps, this chapter discusses how educational systems might change in this world with generative AI. One year has elapsed since generative AI apps first diffused widely around the world. Hence, the story of its impact is emerging. The way forward in educational systems will be determined in part by the reactions of students, faculty, and administrators to AI apps and technologies (Alsharif et al., 2024, this volume), which will vary locally and globally. The journey ahead is likely to be enjoyed more by those who are willing to use AI apps and discover how to innovate with them than by those who recoil at the mention of machine learning, generative AI, ChatGPT, or DALL-E.

A HISTORY OF TECHNOLOGIES IN EDUCATION

Since the introduction of radio and television, technology enthusiasts have often vastly overestimated the impact of technologies in education (Saettler, 2004; Watters, 2021). During the past century, advances in technology produced radios and televisions, which enabled the transfer of information through audio and video. Given that Gutenberg invented the moveable-type printing press around 1440, it took nearly five centuries for the mass distribution of information to occur in a form other than text and images on paper. Indeed, radios and televisions revolutionized information transfer. Also, in the past century, computers and devices for digitizing text, images, audio, and video radically changed both the transmission and processing of information. All of those technological advances resulted in greater access to information in schools. With such revolutionary changes, many enthusiasts predicted massive and profound benefits in education. However, there is much more to teaching and learning than access to a device for receiving and transmitting information. The new technologies were often beneficial to teachers and students but did not have the impact fathomed by technology enthusiasts. Over time, instructors integrated the devices into their teaching practices, which resulted in evolutionary changes to educational systems.

According to innovation diffusion theory advanced by Rogers (2003), new devices and ideas diffuse through a social system as individuals make personal decisions about whether to accept or reject the innovation. Rogers (2003) found that those decisions are based on multiple factors, including the following five factors: (1) *Observability*, opportunity to view the technology in operation; (2) *Trialability*, opportunity to personally test the functionality of the technology; (3) *Complexity*, perception of the time and effort needed to learn how to use the technology; (4) *Relative advantage*, perceived benefit of the new technology compared to alternatives; and (5) *Compatibility to values*. In such light, when a new technology emerges, instructors need time to ensure that it will be better than alternative approaches for helping their students acquire particular instructional objectives. Since many technologies are designed for the masses, not strictly for educators, instructors might also need to create instructional materials for transmission through devices, for instance. Even in the case of an innovation developed for educational purposes, instructors still need to conclude that it will fit their teaching style and be of greater benefit to students than alternative approaches. Then early adopters need to communicate with other teachers their experiences using the new technology with students. Since that professional development process can occur only when instructors are not engaged in lesson planning, teaching, and grading, for instance, multiple months and years often elapse while a technology diffuses through an educational system.

The following cases of instructional radio and television, digital calculators, computer-assisted instruction, information and communication technology, and Massive Open Online Courses (MOOCs) bring attention to factors that affect the diffusion of technological innovations as well as illustrate how the decisions of educators regarding innovations contribute to the stability of educational systems. In some of the following cases, the new technology was found to be unsuitable for instruction and rejected by educators. When deemed acceptable, the willingness of educators to expend the time necessary to engage in professional development to learn how to integrate the technology into their teaching practices enabled its diffusion through schools over time. This accounts in part for the stability of educational systems.

Instructional Radio and Television

In the 1920–1950 period, proponents of instructional radio anticipated revolutionary learning gains. The rationale advanced by George Zook and others was that any inexpensive device capable of transmitting information to large numbers of people effectively would surely result in great educational benefits (George Zook in Marsh, 1937; Saettler, 2004). Yet, even with large investments in educational radio programming by the U.S. Department of Education and private companies, many people realized that while information delivery was sufficient for generating awareness and piquing interest, mass information delivery of audio was insufficient for learning. This lesson was learned again by enthusiasts of instructional television (TV). As in the case of radio, funds were widely available to create instructional TV programs from approximately 1955 to 1965, and expectations were high that delivering a combination of audio and video would revolutionize education. Instructional TV was expected to solve the problem of overcrowded classrooms due to teacher shortages, but it failed to meet such high expectations. As Heinich (1991, p. 63) noted, "the television people got caught up in the delivery system and thought all one needed was a dynamic personality and a camera." Indeed, there is more to instruction than information delivery by talking head. One key lesson to learn from the history of instructional radio and television is that technological breakthroughs do not automatically revolutionize education. Indeed, they might have little impact on educational systems. A second lesson is that a revolution in education requires more than inexpensive, effective, and rapid transmission of information to many people.

Digital Calculators

The invention of digital calculators and the capacity to mass produce affordable ones by the mid-1970s were important milestones in the prelude to the information era. Many people readily learned the simple number pad interface and arithmetic calculations were performed much faster and more accurately than they were in the past. In schools, debates ensued over whether to permit students to use a calculator (Pendleton, 1975; Rudnick & Krulik, 1976). There was extreme division over this issue between people on opposing sides and, perhaps at times, within individuals themselves. Many parents and teachers were genuinely concerned, even fearful, that the use of calculators would result in children losing or never acquiring fundamental arithmetic capability. On the other hand, preventing children from using calculators would deprive them of opportunities to use the tool to increase efficiency at complex math tasks and to address real-world problems. This dissonance was captured in a survey by the *Mathematics Teacher* magazine, which revealed that 72% of respondents (teachers and non-teachers) opposed the use of calculators in Grade 7 classrooms, while 96% agreed that the use of calculators would enable the pursuit of real-world problems and increase student motivation (Pendleton, 1975).

Now, half a century after the introduction of calculators, the adaptations teachers made when calculators arrived have been clear for some time. Crucially, professional development opportunities provided teachers with engaging activities that fostered student learning in their classrooms, which improved teacher attitudes toward the use of calculators in schools (Bitter, 1980). Additionally, research has played a role in resolving questions about the effects of calculator use in schools (Banks, 2011). In 1979, the U.S. National Council of Teachers of Mathematics (NCTM) issued a position statement promoting the use of calculators in schools, and Boards of Education in some states eventually required the use of calculators on state exams (Banks, 2011). Over time, as fears diminished about possible harm to students and teachers learned more about how to help students solve problems with a digital calculator (which is truly much better than a slide rule in many ways), the acceptance of calculators in classrooms became normal. Schools evolved.

Today, elementary school students still learn to add, subtract, multiple, and divide numbers. Once those skills have been mastered and verified as attained, students may begin to use calculators. However, even in Grades 11 and 12, there are times when we, as a society, find value in prohibiting the use of calculators to verify the attainment of fundamental mathematical skills. For example, the SAT prohibits the use of a calculator on one portion of the math test but permits its use on the other portion of the test (College Board, 2023). The initial debates over whether to permit student use of calculators were resolved by prohibiting the use of calculators when students are attaining fundamental arithmetic and mathematical skills. Moreover, students cannot use calculators during tests to verify the attainment of those fundamental skills. The use of calculators is permitted at all other times.

As noted above, when digital calculators became available and affordable, parents and teachers were concerned that the use of the device would prevent the development of the capability to add, subtract, multiply, and divide numbers. Yet, by the early 1980s, calculators were in virtually every home (Seitz & Parks, 1982). Given the ubiquity of calculators and in recognition that their unique features help students address complex mathematical problems, as well as real-world problems, teachers eventually learned how to integrate them into their instruction. Over approximately one decade, most individuals resolved whatever dissonance they had with the use of calculators in the classroom. It became evident that children would attain and retain the skill to add, subtract, multiply, and divide, provided teachers prohibited use of the device when children first learned those skills. Furthermore, when verifying the attainment of fundamental arithmetic skills, teachers and others resolved when to prohibit the use of calculators.

Computer-Assisted Instruction

Since radios and televisions permit only the delivery of information, one might wonder whether a device that also offered cost-effective delivery and automated control of the instructional method would revolutionize education. Indeed, many developers of computer-assisted instruction in the 1960–1990 period anticipated great learning gains relative to traditional instruction. In the early 1960s, with a terminal consisting of a monitor and a keyboard, some learners connected to multimillion-dollar mainframe computers to run instructional software. In particular, the Programmed Logic for Automatic Teaching Operations (PLATO) system and the Time-Shared Interactive Computer-Controlled Information Television (TICCIT) system enabled engagement in lessons to learn mathematics, chemistry, physics, English grammar and spelling, as well as English as a Second Language (ESL) and languages such as Danish, French, German, Italian, Spanish, Swedish, and Thai. By 1980, vacuum tubes and transistors in early computers had been replaced by integrated circuits, and some instructional programs in TICCIT were being ported to microcomputers (Merrill et al., 1980).

Throughout the 1970s and 1980s, there were very large public and private investments in the production of computer-assisted instruction because instructional software was expected to radically improve education. However, as educators and researchers began testing the instructional systems, it became apparent that the results were not going to meet expectations. In fact, many subject matter experts found computer-assisted instruction to be shallow, uninspiring, and absolutely unsatisfactory (Klopfer, 1986). Speaking on behalf of content teachers, Walbert (1989, p. 281) noted that "the computer was not the 'dream' teaching tool it was once thought to be." On the other hand, proponents regarded instructional software as extraordinarily beneficial for learning. In the educational technology discipline, a media methods debate ensued to resolve whether computer-assisted instruction was more or less effective than traditional instruction was.

In the end, Clark (1983, 1991, 1994) won the debate against the Kuliks (Kulik, et al., 1983; Kulik et al., 1985), Kozma (1991), Petkovich and Tennyson (1985), and others by citing research showing no significant difference in learning when comparing traditional instruction to computer-assisted instruction. Learning is sufficiently complex that multiple perspectives can still be brought to the debate, which calls into question whether instructional methods can always be separated from devices, as Clark contends but Luterbach opposes (Clark, 2005; Luterbach, 2005a, 2005b). Setting that intricacy aside, the media methods debate essentially resolved that, with respect to learning, instructional methods matter much more than the delivery system. In the words of Clark (1983, p. 445), "Media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition." Knowing that result is often key to critical examination of claims that technologies enhance learning. Many believed that instructional software would change education profoundly, but the passage of time has made it evident that computer-assisted instruction did not revolutionize educational systems. Time, effort, and financial investments in computer-assisted instruction advanced educational systems in an evolutionary manner. Having considered the case of computer-assisted instruction, which regards the computer as a tutor, the next section discusses the effects on education of the computer as a tool and a tutee, which exhausts the three roles of a computer in education (Taylor, 1980).

Information and Communication Technologies

It would be difficult to overstate the impact of computers as tools in schools, which began around 1980 when schools and colleges started buying microcomputers. The massive widespread adoption of desktop and laptop computers accelerated through the 1990s due to the benefits of the World Wide Web, which brought WebQuests (Dodge, 1995; March, 2003), and the proliferation of freely available instructional materials. In the early 1990s, Lewis J. Perelman (1992) predicted the end of education because, in his view, the availability of free instruction meant that everyone could learn anything at any time. We still have schools and colleges, and teachers have continued to adapt to technological developments. The transformation from a society in which information was distributed on paper to one involving mass development and the distribution of digital media marks the transition from the industrial era to the information era. This has also been described as a transition from a literate society in which books were used to improve literacy worldwide to a post-literate society in which information transmission by paper ceded to digital transmission in largely literate societies (Ulmer, 2003; Graham & Dugmore, 2022). Given the introduction of mobile phones in the late 2000s, schoolteachers, as well as college faculty (Farias-Gaytan et al., 2023), faced more disruptions in their classrooms but adapted through professional development activities.

For more than 40 years, curricular standards in schools have been adjusted to align with new technologies. At every turn, teacher preparation programs have modified their instructional materials and methods. That continues today, as does teacher professional development in elementary, secondary, and higher education. Furthermore, thousands of research papers, teacher practitioner articles, books, and conference proceedings document numerous methods, benefits, and issues pertaining to the use of digital tools for teaching and learning. Within that diverse knowledge base, researchers and practitioners discuss a wide variety of topics, such as instructional simulations and games, Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), tablets, and smartphones, as well as instructional methods, such as behavioral instruction, constructivist instruction, project-based learning, problem-based learning, and peer collaboration (e.g., Bishop et al., 2020; Hughes & Roblyer, 2023; Langren et al., 2023; Smaldino et al., 2019; Spector et al., 2014). These efforts have contributed to teacher professional development since the introduction of microcomputers in schools and colleges in the early 1980s. The history lesson of note here is that instructors continually adapt and refine their pedagogical practices to keep pace with technological and pedagogical advances. Decade after decade, including the transition to a new era, teachers adapted by learning how to integrate technologies into their teaching practices to better prepare students for the future. In this manner, continuous professional development has a stabilizing effect on educational systems.

When the computer is in the role of a tutee, students direct the computer to follow their instructions. Seymour Papert (1980) led the way by encouraging students to hypothesize solutions to problems and then test their solutions by implementing them in *Logo*, a computer programming language. Then, Mitchel Resnick introduced the visual drag-and-drop programming environment, *Scratch*, which enabled children to program a computer (Resnick et al., 2009; Resnick, 2019). In 2006, Jeanette Wing introduced *computational thinking*, which became the term used to describe systematic problem solving with and without computers. Although initially slow to diffuse through school systems, efforts by Wing (2006), Brennan and Resnick (2012), Kong and Abelson (2019), Luterbach (2022), and others to promote computational thinking and provide relevant professional development have increased the knowledge and skills of teachers, which in turn enhanced student achievement. The computational thinking movement has also benefitted from curricular mandates that require the acquisition of computer science standards. Furthermore, instructional materials produced by organizations such as *Hour of Code* (Hourofcode.com, Code.org), *CS4All* (csforall.org), and *AI for All* (ai-4-all.org) have boosted the computational thinking skills of teachers and students. As before, this case includes instructors expending the time and effort necessary to learn how to integrate technologies into their teaching practices to better serve their students. This helps stabilize school systems and advances post-literate society.

Massive Open Online Courses (MOOCs)

As a final case, the introduction of Massive Open Online Courses (MOOCs) prompted predictions of a revolution in education, and some faculty and administrators were concerned about disruptions in their colleges. Today, even though learners can enroll in MOOCs for free or at low cost and can engage in instruction whenever they wish, the dropout problem is high, and the prevalence of MOOCs is declining (Basnet et al., 2022; Billsberry & Alony, 2023; Moreno-Marcos et al., 2020; & Reich & Ruipérez-Valiente, 2019). MOOCs provide yet another example in which the widespread availability of affordable and accessible instruction is insufficient to fundamentally alter educational systems.

Educational Systems Adapt Gradually as Teachers Integrate New Technologies

This brief history of technologies in educational settings presented multiple cases of unfulfilled expectations. Flicking the power switch on radios and televisions in classrooms resulted in the immediate flow of audio and video to students. Proponents of those technologies expected that flow to improve academic achievement considerably. Despite large investments in TV programming and the display of those programs in classrooms through the 1970s, the benefits of the TV programs were strikingly small compared to expectations. However, instructional TV programming was not a failure. School systems purchased TVs, and teachers built activities around the programming. Today, many classrooms are configured to display videos to students, and teachers engage them in discussions and activities pertaining to the videos.

Due to large investments over the past three to four decades, students have been able to readily access engaging and effective instructional materials in the form of digital videos, audio recordings, images, articles, web pages, electronic textbooks, simulations, games, and instructional apps. Again, the developers of those technologies, along with many legislators and parents, expected digital computers and software to improve achievement markedly. However, as before, the impact of the technologies did not meet the inflated expectations. Even though schools and colleges were not radically altered instantly, instructors learned how to integrate the technologies into their teaching practices over time. This gradual adaptation process improved and stabilized the educational systems. In such light, the assimilation of new technologies into educational systems was evolutionary rather than revolutionary.

DISTINCTIVENESS OF AI APPS FOR TEACHING AND LEARNING

Educational systems are resilient, and history often repeats; however, if a technology could significantly alter pedagogical practice favorably, perhaps by saving teachers substantial time on lesson preparation, instructional development, lesson delivery, or provision of feedback, fundamental change to schools and colleges might occur.

Instructors use ChatGPT and other AI apps for multiple purposes. To begin, they may use ChatGPT as a teaching tool to demonstrate how to be more productive when completing various tasks. Some instructors also guide students to use ChatGPT as a machine tutor, which presents content and offers feedback to students. In addition, instructors may seek to customize instruction for each learner through the use of intelligent tutoring and adaptive systems. Additionally, some instructors guide students to use a variety of AI apps for learning, such as *Conversly,* for foreign language practice, and *Tutorai.me,* for automating instructional delivery. Further, instructors may guide students to innovate with AI tools and technologies. In addition, some instructors augment their teaching practice through the use of generative AI apps such as DALL-E for automated image generation and *ClassPoint* for generating quiz questions from PowerPoint slides.

ChatGPT as a Teaching Assistant

To enhance teaching and the attainment of learning outcomes in teacher education, instructors can assign students, all of whom are either preservice or in-service K-12 teachers, tasks that enable them to evaluate the limitations and benefits of ChatGPT. For example, one assignment item might direct the entry of the prompts below into ChatGPT or another chatbot to determine how teachers might refine their lessons. After entering the prompts below, the assignment could also require preservice and in-service teachers to enter additional prompts pertaining to the attainment of specific learning standards for their students.

- Create a lesson plan for a teacher to help students in Grade 9 learn to recognize figurative language in literature and to use figurative language in stories they write.
- Create a worksheet on figurative language to distribute to students in Grade 9.
- Create a lesson plan for a teacher to help students in Grade 6 review the concept of a fraction, and to add and subtract fractions with common and uncommon denominators.
- Create a worksheet with 20 items that Grade 6 students could use to practice adding and subtracting fractions with common and uncommon denominators.
- How might a teacher use educational technologies to enhance physics lessons for high school students?
- What do historians seek to accomplish in their work?

At times, the results from chatbots will be unsatisfactory, owing perhaps to redundancy or lack of specificity, for instance, but at other times, helpful results will appear. Students can be directed to compare the results produced by chatbots to their own work.

ChatGPT as a Machine Tutor

Since ChatGPT is a conversational agent, it can become a tutor by entering a prompt that begins *Teach me*. For example, when prompted with *Teach me Python programming*, ChatGPT impressively divided the task of learning Python coding into seven components, beginning with installing a Python development environment. Then, ChatGPT provided a sample first program, the traditional print ("Hello, World)" statement. After describing how to run that program, ChatGPT presented and exemplified Python basics, including variables and data types; control flow statements, specifically the *if statement*, *for loop*, and *while loop*. The sixth component presented examples of functions, and the final section described the data structures, particularly Python lists and dictionaries. That succinct presentation introduced the key features of imperative programming languages (Luterbach, 2018, 2022).

ChatGPT's tutoring is not limited to presentations. When students practice coding, they can submit code to ChatGPT for feedback and ask for explanations of invalid code. For example, with the submission of the code and the prompt below, ChatGPT explained the error detected by the Python compiler and corrected the code.

```
multiplicand = 3
multiplier = 2
print (multiplicand, " * ", multiplier)
learnerResponse = input ("Enter answer: ")
```

Prompt entered into ChatGPT: In the Python code above, why am I getting the error, "name 'multiplicant' is not defined?"

In the reply, ChatGPT explained that the code contains a typo. In particular, on Line 3, multiplicant should be multiplicand. ChatGPT fixed the error and provided the corrected code, as shown below.

```
multiplicand = 3
multiplier = 2
print (multiplicand, " * ", multiplier)
learnerResponse = input ("Enter answer: ")
```

In this example, ChatGPT generated a valid response, but that is not always the case.

In addition to error checking, ChatGPT seeks to generate computer code when prompted to provide a program that accomplishes a specific task. The prompt can include a direction to provide code in one or more computer programming languages. In code generation trials, Sarsa et al. (2022) determined that OpenAI's Codex app produced sensible code most of the time, and in some cases, the code could be used without modification. Overall, though, they concluded that oversight is necessary in an educational setting to ensure that code generated automatically is suitable for students. Extrapolating this notion of oversight to other content domains seems worthwhile because chatbots have no internal mechanism for assessing the validity of the text generated by the chatbot.

While considering other content domains, what would happen if, for instance, a business, geography, psychology, or history instructor decided to change their role radically by increasing the time spent analyzing student work and providing feedback to students by 50%-90% and reducing the time spent on lesson planning by the same percentage? Conceivably, with little to no time spent on lesson planning, an instructor could begin class by entering a prompt into ChatGPT or any other chatbot and then read and discuss the reply with the students. When the instructor and students completed that discussion, the instructor could enter a new, perhaps related, prompt into ChatGPT and discuss that reply with the students, correcting any hallucinations and inaccuracies. The instructor could repeat that process until the end of class, interjecting humor throughout the session to enhance the joy of learning. The next day, students could be provided the prompt to enter into ChatGPT on their phone, tablet, or laptop, or the prompt could be entered into a computer with its screen projected for all students. Then, students could write a couple of notes about any text in ChatGPT's reply that surprised them or that might be inaccurate, for instance. The instructor would then ask students for their reactions to the text, correct any misconceptions, and interject humor. If the class meets four times a week, 50% of the lesson planning time would have already been saved. Teaching in real time is never simple, but a teacher's role could radically change if ChatGPT was the tutor or even just supplied course content in the manner described.

Customizing Instruction for Each Student

Adaptive instructional systems (AISs) use artificial intelligence (AI) methods to personalize instruction based on content, learner, and pedagogical models (Sleeman & Brown, 1982; Wenger, 1987). Dialog systems between students and pedagogical agent software can assist with assessment and learner modeling (Zapata-Rivera & Forsyth, 2022). Four decades of work in the field of Intelligent Tutoring Systems, which has connections to Learning Analytics and Educational Data Mining, has created a historical record that documents the effectiveness and challenges of human-computer dialog, machine learning for tutoring, cognitive tutors, and intelligent learning environments (Abdelshiheed et al., 2023; Aleven et al., 2006; Baker et al., 2016; Graesser & McNamara, 2010; Kulik & Fletcher, 2016; Lester et al., 2004; McNamara et al., 2019; Paladines & Ramírez, 2020; VanLehn, 2011). Contemporary systems document significant gains in learning, student engagement, and retention through course completion. For example, AISs have succeeded in providing effective instruction to improve the adaptability of Marine infantry squad leaders (Daly et al., 2022) and in simulated lifeboat training (Zeinali-Torbati et al., 2023), for instance. Also, Paradiso et al. (2023) documented a 58% decline in the number of students who received a grade of D, F, or withdrew from a mathematics course due to the use of an AIS for college algebra.

Innovating with AI Tools and Technologies

With AI tools and technologies, instructors can guide students to create innovative apps with or without coding. AI tools, such as *MindStudio.ai* and *LLMstack.ai,* provide access to LLMs with little or no coding. These tools provide a graphical user interface enabling the selection of an LLM, along with features to include documents or data relevant to the app. A teacher guiding students toward such innovative app creation might enhance the likelihood that the students would make a successful transition to a corporate environment. Davenport et al. (2023) describe two case studies in which employees used no code and low code tools to create innovative apps. To create an app with low code/no code tools, developers follow templates and routine procedures for the most part, but they can add their own variables and use predefined functions to provide access to proprietary documents, for instance. After sufficient testing, the app may be made available to others in the organization.

When complete control over data structures and data processing are desirable, coding is necessary. In this case, a programming student could connect to an Application Programming Interface (API) of an LLM and embellish the reply provided by the model. The Python code below retrieves text from the OpenAI language model called *text-davinci-003*, which is a relatively inexpensive model to use. With a different protocol and at a higher cost, text could also be retrieved from ChatGPT.

```
import os
import openai

openai.api_key = os.getenv("OPENAI_API_KEY")

myPrompt = input("Enter prompt: ")

response = openai.Completion.create(
   model="text-davinci-003",
   prompt=myPrompt,
   max_tokens=500,
   temperature=0)

print(response.choices[0].text)
```

Only six Python statements are needed to take care of initialization, retrieve the user's prompt, call the language model, and display its response. The student programmer could refine the reply from the language model by parsing the response.choices[0].text variable or by passing the text in the reply to a text-to-speech generator, for instance.

Enhancing Teacher Productivity and Effectiveness using AI Apps

There are numerous AI apps for teachers. For example, *MagicSchool* (magicschool.ai) enables teachers to differentiate instruction, create assessments, modify lesson plans, or create new ones. In addition, teachers can use *MagicSchool* to help produce newsletters and correspond with parents, for instance.

Instructors can also use *ClassPoint* to create questions from one or more PowerPoint slides and thereby transform a static presentation into an interactive learning experience. The questions generated can be aligned with Bloom's Taxonomy, which includes Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating.

When teachers create multimedia presentations and instruction, they may make their instruction more effective and appealing by including images, audio, or video. On those occasions, teachers may enter a prompt into DALL-E or other image generation software, such as *Stable Diffusion*, *Craiyon*, or *Midjourney,* to create an image relevant to attaining the instructional goal. Similarly, instructors might prompt AI apps to create audio and video scripts as well as produce audios and videos for distribution to students for instructional purposes. In those cases, instructors might use *Invideo.ai* or *Lumen*, for instance.

Using AI Apps and Tools in Schools and Colleges

With the introduction of chatbots and other AI apps in schools and colleges, instructors and students have new options for teaching and learning. As discussed above, ChatGPT could be a teaching assistant, a machine tutor, or a supplier of content curated by the teacher. Additionally, instructor productivity and effectiveness might increase through the use of a variety of AI apps. Furthermore, by guiding students to innovate with AI tools and technologies, teachers might change their role considerably if they typically provide direct instruction throughout class. Teachers who generally work as coaches or guides might converse less with students who engage more with ChatGPT or another conversational agent, such as GitHub Copilot Chat.

HOW MIGHT AI ALTER EDUCATIONAL SYSTEMS?

Everyone has some potential to change schools and colleges, but primary stakeholders have direct influence. Schoolteachers, department chairs, assistant principals, principals, and school board members have direct influence on K-12 schools, while adjunct instructors, professors, department chairs, deans, provosts, chancellors or presidents, and boards of trustees exert direct influence on colleges. To assist with reflections on how AI might alter educational systems, this section first considers issues that primary stakeholders must resolve to determine how to change their institutions. Then this section considers the decisions that some of those stakeholders have already made and the effects of those decisions on their institutions.

Influence of Schoolteachers, College Faculty, and Administrators

Moving forward, the trajectory of educational systems is likely to depend largely on schoolteachers, college faculty, and administrators in both K-12 schools and colleges. After all, those stakeholders have a duty to determine how best to serve their students. Strategic decisions will likely turn on their perceptions of the advantages and disadvantages of AI (Dempere et al., 2023; Fütterer et al., 2023). Evaluating the arguments for and against the use of AI technologies is nontrivial because it involves consideration of multiple factors, including relative advantage and compatibility with values (Rogers, 2003). Recalling the calculator case, nearly all respondents (96%) judged that calculators would be beneficial to students, but concern over the retention of fundamental arithmetic skills had 72% of respondents rejecting the use of calculators in Grade 7 classrooms (Pendleton, 1975). Strategic decisions about AI technology will involve much more than pitting a single perceived benefit against a single perceived threat. The strategic decision will also include deliberations about the use of AI technology across multiple content domains. This section considers two cases, writing instruction and computer programming.

Presently, some of the primary stakeholders in schools and colleges want writing to be taught in the future, just as it has been taught in the past to ensure that writing skills are developed continually through school and college. Others are noticing that the post-literate world now includes a tool, a capable chatbot, which can help writers (Dobrin, 2023). Some of those teachers, faculty members, and administrators believe that after students gain the fundamental skills to write sentences, paragraphs, and some essays on their own, it would be okay if they used ChatGPT, especially if there were still points at which writing would be assessed when students were not permitted to use the chatbot. Recalling Rogers (2003), changing writing instruction is compatible with the values of some educators, such as Nicolas (2023), but not with others, including Olejnik (2023).

The writing case is considerably more complex than the calculator case because learning to add, subtract, multiply, and divide takes a great deal less time than learning how to write, and verifying mastery of arithmetic operations requires only a simple comparison of the learner's response to the correct answer. Yet, even though it may well take years, schoolteachers and college faculty members will figure out how best to teach writing in a world with chatbots. Perhaps, as in the calculator case, as teachers retain pedagogical practices to ensure that students will continue to learn to write sentences, paragraphs, and essays, concern about losing the skill to write will diminish and that will make room for increased use of ChatGPT and other chatbots as writing assistants. If retention of skill is not the primary concern, then over the next decade or two, perhaps the defenders of all extant methods of writing instruction, including retention of the freshman composition course, will sense that students need not abstain from the use of a chatbot to share their cultural experience in writing and that they still become critical thinkers when a chatbot assists with the mechanics of writing. Such a change in values, if it comes, will likely occur gradually because some defenders of the status quo value retaining current forms of writing instruction greatly (Olejnik, 2023). They will need to become convinced that students will be okay if writing instruction changes. Research might assist somewhat in that regard, but the results of studies conflict at times, and the results are not always persuasive. For example, even though TVs have been in homes for approximately fifty years, there is still debate about the effect of TV viewing time on reading achievement despite data showing that there is no statistically significant effect when children six years of age view TV programming less than two hours a day (Supper et al., 2021). In such light, debates over how much writing practice without a chatbot that high school or college students need might well endure for decades.

The writing case has some parallels with teaching computer programming because programming students could use automatic code generation tools, such as GitHub CoPilot, Codex, ChatGPT, or Gemini, to perform their computer programming homework (Prather et al., 2023). One difference, though, might be general acceptance of the use of automatic code generators in practice (post-training) because automatic code generators have ushered in a new programming paradigm (Brady, 2023), whereas there is currently rejection of chatbots for the production of scholarly publications, as in the journal *Science* (Thorp, 2023), or ambivalence and draft policies (Harker, 2023; Hosseini et al., 2023). Critically, at times, novices must grapple with the complexities of writing prose or computer code without the assistance of a teacher, parent, sibling, friend, acquaintance, ChatGPT, or any other conversational agent to learn through practice and reflection. Ultimately, computer programming instructors resolve when students are permitted to use automatic code generators and when such use is not permitted. Additionally, as in the calculator case, at times, instructors may retain assessments of computer programming skills without access to automatic code generators.

One argument advanced in favor of banning the use of ChatGPT or automatic code generators is that students will cheat. First, large numbers of students earnestly seek to acquire skills that will benefit them the rest of their lives. Second, even when a student tricks an instructor into believing that the work submitted was original, there is no tricking the learning process. Students who cheat do not gain knowledge or skill, but students who practice and learn reap the benefits throughout their lives.

After sufficient practice, computer programming students will have gained the capability to modify the functions and statements produced by automatic code generators, which can create acceptable code in some cases but not always (Moradi Dakhel et al., 2023; Nguyen & Nadi, 2022). Similarly, after requisite practice, people who have learned to write sentences, paragraphs, and essays will have acquired sufficient competence and confidence to communicate in writing, and if they choose to use ChatGPT or another chatbot on some occasions, they will have the ability to enter worthwhile prompts and will be able to enhance the text generated by the chatbot through editing and rewriting. Since instructors across many disciplines require students to complete writing assignments, they also need to weigh the advantages and disadvantages of chatbots for their students. Communication between instructors and administrators is important for institutions to resolve how best to serve all students (Lin et al., 2024, this volume).

After the strategic decision is made at schools and colleges, one way or another, individual instructors will make tactical decisions about how best to serve their students, which could run contrary to their institution. Tactical decisions have much to do with considering characteristics of the learners, as well as the instructional goals, which vary markedly in both K-12 schools and colleges. Instructors with students in their teens or older might contemplate the use of chatbots to support the attainment of instructional goals and student self-regulation, which could dramatically alter the instructor's role. Instructors of younger students might turn to chatbots, MagicSchool, or other AI productivity tools to reduce the time spent on activities such as lesson planning and differentiating instruction.

Protection, Confusion, Modification, and Transformation in Educational Systems

In the one year since OpenAI made ChatGPT-3 available to the world, schools and colleges have made their initial assessments of the advantages and disadvantages of generative AI. As discussed previously, some educators and administrators are concerned about student cheating and ensuring that students continue to develop fundamental skills.

In some cases, concerns run very deep, even approaching the level of fear. Those educators and administrators foresee the potential demise of their schools and colleges due to AI technologies. For example, Geoff Barton, head of the Association of School and College Leaders in the United Kingdom, along with other school administrators, regards AI as the "greatest threat to education" because it makes learning trivial, increases cheating, and threatens students' mental and physical health (Woolcock, 2023). Furthermore, in their view, since governments move too slowly and technology companies cannot be trusted, AI technologies pose "very real and present hazards and dangers" (Woolcock, 2023). Protection is paramount here; these administrators prohibit the use of chatbots in their schools to prevent potential harm that could come to their students through the use of AI apps.

Since assessing the benefits and detriments of AI technologies can be confusing or perplexing, some teachers and administrators initially reacted to protect students by banning the use of ChatGPT. Then, they heard the voices of others in their school systems who allayed some of their concerns about generative AI apps and raised their own concerns about stagnation and academic freedom. They argued persuasively that schools ought to prepare students for the future and that instructors should have the freedom to consider the use of chatbots. Administrators acquiesced and permitted the experimental use of chatbots. Some of the largest school districts in the United States, along with many other school systems, followed this path, including the New York City and Los Angeles school districts (Banks, 2023; Singer 2023).

There are also schools, colleges, and government leaders who, while expressing some uncertainty about the implications of AI in education, regard AI technologies as important for progress and definitely want students to gain AI fluency. Consequently, they are open to modifications in teaching practice. This is evident in the report on AI in education issued by the Office of Educational Technology in the U.S. Department of Education (Cardona et al., 2023). This pathway of openness is also apparent in the research project *titled "Making AI Generative for Higher Education,"* which is a collaboration among approximately 20 universities and a nonprofit research center to collect and analyze data about challenges and opportunities in colleges due to generative AI. After drawing conclusions justified by the data analyses, the project intends to issue reports to share their findings (Cooper et al., 2023). Furthermore, whether they are part of that project or not, many universities are issuing guidance for instructors as they adapt to generative AI. Such guidance may be provided at the institution or academic department level.

Over the past year, generative AI has been a major theme at many conferences in education. While some presenters expressed uncertainty about the future of educational systems, others conveyed visions of revolutionary transformations to educational systems (Coffey, 2023; Feldstein, 2023). Beyond conferences, Stefania Giannini, Assistant Director-General for Education in the United Nations Educational, Scientific, and Cultural Organization (UNESCO), who speaks of living through at least four prior revolutions in education, anticipates that the one owing to AI in Education might have the greatest impact by far (Giannini, 2023). Furthermore, an expert panel in AI in Education stated, "Artificial Intelligence (AI), machine learning, educational robotics, and related technologies will have powerful impacts on the future of learning" (Roschelle et al., 2020, p. 1). That expert panel also recognized the need for additional research and often mentioned the potential for widespread impact in education due to AI, machine learning, and related techniques. Moreover, the Stanford Institute for Human-Centered Artificial Intelligence has been engaging in research to gain insights into the transformative potential of AI in education (Chen, 2023). Similarly, at the 2023 World Economic Forum, Kopp and Stjerne Thomsen (2023) discussed the potential for AI to accelerate a transformation in educational systems.

In higher education, a noteworthy example of a college in favor of AI in Education is the University of Florida, which is committed to building the first AI University in the United States (University of Florida, 2022, 2023). The University of Florida has made several changes to build its AI University. In particular, the University of Florida AI initiative has centralized the leadership of AI academic efforts, established a Center for the initiative, hired more than 100 additional AI faculty members across the 16 colleges at UF, and delivered more than 200 AI courses to thousands of students, as well as established certificates and micro-credentials. Plus, students and faculty members engage in numerous research projects supported by a supercomputer with more than 65,000 core processing units and an AI Pod with over 1100 GPUs. Moreover, the University of Florida AI initiative has resulted in numerous partnerships to produce AI curricula for K-12 students and to provide professional development to Florida K-12 teachers.

CONCLUSION

AI apps and tools are changing our lives. For some, that change might be perceived as minimal. Face recognition to open a phone is nice; relatively little spam in email is also a good thing; assistants in the form of *Siri*, *Cortana*, and *Alexa* are useful to a point, but apps for those purposes have been around for some time now. From that point of view, the impact of AI technologies might seem minimal. Alternatively, those who have improved their productivity through the use of AI apps might find the impact considerable, while a person earning a living innovating with AI technologies might regard its impact as exceedingly positive. According to the Gartner Hype Cycle of AI (Perri, 2023), generative AI is at the peak of inflated expectations, which might portend the beginning of a period of disillusionment. Regardless of the current level of excitement over AI in society, these technologies have both benefits and detriments (Dempere et al., 2023; Fütterer et al., 2023).

Instructors may benefit from AI apps and tools when they are used as teaching assistants or machine tutors. Additionally, AI technologies can help instructors differentiate instruction for students. Additionally, instructors can guide students to use AI tools and technologies to create innovative apps. Furthermore, Dempere et al. (2023) document the use of AI apps for research support and automated grading. Some concerns about AI technologies include cheating by students, biased results, possible economic hardship through job loss, uncertainty about the quality of results generated by chatbots, no identification of the sources that contributed to the production of the results generated by chatbots, and the absence of any method to determine those sources given current LLM technology. The benefits and concerns of AI technologies have instructors contemplating whether to integrate them into their teaching practices. An increase in AI fluency through attainment of AI literacy standards (Long & Magerko, 2020; Ng et al., 2021; UNESCO, 2022a) will foster more informed reflection on the benefits and detriments of AI technologies (Ford, 2018; Ng et al., 2021).

The previous section discussed differences in the trajectories of educational systems based on how those with direct influence on those systems resolved the question of whether the advantages of AI technologies outweigh the disadvantages. Similarly, individual choices determine personal trajectories. Things did not go well for Luddites, though after initially rebelling against the mechanization of the textile industry, some of them adapted their skills and ultimately supported the production of garments by machines (Dobrin, 2023). Importantly, unlike the dawn of web technologies, when the only development option required learning the HyperText Markup Language (HTML), there are already multiple entry points into AI. One option is to learn to use AI apps within one or more domains (e.g., chatbots such as *ChatGPT, Perplexity, Claude;* image generators such as *Midjourney, Craiyon, Stable Diffusion, DALL-E;* apps for teachers such as *MagicSchool, ClassPoint, Character.ai;* language learning apps such as *Babbel, Conversly, Duolingo, Rosetta Stone*). One could also learn the AI features of more common apps, such as the speech coach in Microsoft PowerPoint. There are also no code/low code tools to explore in addition to programming options. Furthermore, one could focus on one or more issues pertaining to AI technologies, such as machine biases (Schwartz et al., 2022), equal access and opportunity (Bojorquez & Martínez Vega, 2023; UNESCO, 2022b; UNESCO, 2022c), emotional effects of AI (Yalcin & Puntoni, 2023), benefits and detriments of AI (Darvishi et al., 2024; Maslej et al., 2023; Zhang et al., 2022), multilingual language models (Maslej, 2023; Nicholas & Bhatia, 2023), and augmented human performance (Eapen et al., 2023; Frasson et al., 2023). Lastly, in this chapter, we recall the past, consider the present, and peer into the future.

In educational systems, early adopters of AI technologies have been modifying their schools and colleges for a few years (University of Florida, 2022; Zimmerman, 2018). As increasing numbers of educators gain AI fluency, additional modifications will be made until educational systems restabilize. That is the most likely scenario given the history of technologies in education. Consider this scenario, though. What if, in two to three years, ChatGPT, GitHub Copilot, or another LLM-based app succeeds in responding to the following prompt? "Create an instructional app that uses animation to simulate a planet, comet, or asteroid orbiting the Sun and helps students learn how to calculate the average speed of the orbiting object." Then what change might come to home schooling and to educational systems?

NOTE

AI tools were not used in any way for the preparation of this chapter.

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